Technological Innovations and Climate Change: Heat Pumps: Evidence Submission

Kensa Group

Kensa Group Response

Introductory Comments

The Kensa Group specialises in the manufacture and installation of ground source heat pumps (GSHP). Based in Cornwall, the company is the long-established and undisputed market leader having supplied the appliances for over 40% of all UK GSHP installations in 2019. Established in 1999, the Kensa Group currently employs 110 staff which means it is likely the UK's largest employer solely focussed on the provision of low carbon heating systems.

In March 2020, Legal and General Capital took a significant minority stake in the Kensa Group to enable their own property businesses to benefit from the technology. The investment also means significant resource is currently being devoted to efforts to highlight the superior performance of GSHPs and to explain why the Government, the environment, the energy system and millions of householders would be best served by the widespread adoption of the technology.

The present CEO, Simon Lomax, joined the company in 2007 and chaired the trade body, the Ground Source Heat Pump Association, from 2013-16. Simon has witnessed all the major policy decisions over the past decade; some have been very peculiar. In 2007, GSHPs were the most popular low carbon heating technology before significant Government interference corrupted market preferences: they are now the least popular and that is an unintended and unwelcome outcome of misguided policy. Current thinking must change and it must change quickly.

Given the current muddled thinking, it is exactly the right time for the committee to consider options so that the post-Covid economic recovery can support the right interventions to maximise heat pump deployment.

BEIS officials should recognise that the optimum solutions are not necessarily those which are most popular or most straightforward. The market will often initially choose the path of least resistance but Government must see the 'bigger picture'. There are also climatic conditions in the UK, and other factors, which mitigate against the strategies being deployed elsewhere in Europe.

What is clear is that GSHPs provide far superior outcomes to ASHPs and there is no evidence to the contrary given the superior outcomes are based upon sound engineering principles. The running costs are lower so households will be more accepting of any switch and the carbon emissions are lower which supports the Government's ambitious net zero carbon target. The challenge is making these points understood. Policy officials often have no science or engineering qualification and are often swayed by superficial arguments presented by the majority. The Committee should have little difficulty appreciating that ASHPs are a sub-optimal solution in the UK.

To make the case, this response is split into two elements – a 3000 word summary in response to the Committee's questions, and more detailed supporting evidence in an Annex. The supporting detail is lengthy but it is hoped that the Committee will, at the very least, focus on Annex Points 1-7, which underpin the arguments to support the widespread deployment of GSHPs. It will prove to be the lowest cost heat decarbonisation strategy.

Naturally, Kensa would be happy to provide any additional information, make any further contribution or give oral evidence.

What steps can the Government take to increase uptake of heat pumps?

Despite the efforts of many ASHP manufacturers with substantial resources, deployment in the UK remains modest primarily because the technology is not efficient enough, reliable enough or durable enough to meet market requirements. ASHPs are not versatile, they are noisy – often so noisy that planning conditions prevent their installation – and their appearance is routinely regarded as disfiguring building facades. ASHPs cannot provide cooling but, more importantly, cannot utilise waste. They operate less efficiently at night, because it is usually colder, so cannot participate effectively in the demand-side response market. Their saving grace is that they are relatively cheap, and easier to install compared to GSHPs, but they are not especially useful: they are not suitable as a replacement for gas boilers, see Annex Points 1 and 2.

Against this backdrop, Government should recognise the optimal heat pump solution for the householder, the community, the environment and the energy system is not an ASHP: it is a small GSHP installed within each dwelling and linked to a shared ground array. This system architecture effectively mimics the existing mains gas model and is especially appealing when the cost of the GSHP's ground array is divorced from the upfront system cost to the householder. This elegant architecture, together with smart delivery models, is also being deployed; many entities, including energy companies, water companies, local authorities and pension fund managers, want to fund, own and maintain the underground infrastructure in return for income via a long-term connection fee.

Even allowing for a connection fee, this solution delivers lower running costs relative to both an ASHP and a gas boiler so will be welcomed by householders. More significant savings will accrue as the relative cost of gas and electricity is modified, in part by proposals contained in the Green Gas Levy – see Annex Point 5. Carbon savings are currently around 75% lower than a gas boiler with further savings as the generation of electricity continues to decarbonise up to 2050.

Crucially, the superior efficiency of a ground source heat pump, and its greater ability to operate at times suited to the electricity generation system, means the mass deployment of GSHPs will reduce the additional generating capacity required to support any electrification of heat strategy – see Annex Point 1.

The extensive deployment of GSHPs across the UK will result in the requirement for less generation capacity and less strengthening of the distribution network. This will mean huge cost savings for electricity bill payers. It would be far smarter to divert some of the savings to support private sector investment in shared ground arrays. Of course, once the cost of the ground array has been divorced from the heat pump purchase, GSHPs can be sold for similar prices to ASHPs but deliver far superior outcomes to every stakeholder. This is the optimum solution but requires some understanding from policy makers and some modest and short-term public subsidy.

To understand why this outcome should be preferred, Government must:

1. Recognise the very diverse performance characteristics of ground source and air source heat pumps without further delay. On the coldest day, ground source are almost twice as efficient. Government should appreciate the cost implications of these performance variances on necessary upgrades to the wider electricity system.
2. Embrace the private sector's desire to support the mass roll-out of ground source heat pumps with new business models that require only modest taxpayer funding of the ground array.
3. Introduce technology-specific subsidy support policies that recognise the long-term value of the ground array infrastructure and refine ECO policy to support GSHP installations, as intended. Support should persist for an extended period of 10 years.
4. Appreciate that early access to high volume opportunities in social housing retrofit and new build will allow the supply chain to reduce costs significantly which will allow the subsidy to taper downwards over the course of the support.
5. Re-set the levies on gas and electricity and make clear that gradual changes will persist for a prolonged period to set market expectations. Levies should be removed completely for electricity used to provide heat.

6. Understand the political appeal of a low carbon heating system that delivers lower cost heat and recognise that lower running costs will permit new business models capable of delivering appealing heat pump offers to private householders (currently served by gas) without any upfront contribution (from the householder) by the second half of the decade.
7. Acknowledge that mistakes have been made with past policies, employ more scientists and engineers in the heat policy teams, ensure that economists engage more openly with experts in industry and recognise that economic models should reflect the 100+ year life of the ground array.

Further information on these numbered points can be found in the Annex to this submission.

How can we ensure that the regulatory frameworks in place work together to guarantee heat pumps are used in the most effective places, alongside other technological solutions?

Government should understand that GSHPs can be deployed in virtually every UK building. Almost every property, from every era, is suitable and deployment should start in localities where the underlying geological conditions, or surface features, are most conducive to lower cost installations.

ASHPs do not have the same universal appeal. Regulations, which are rarely enforced, prevent their deployment in high density housing estates due to the potential noise nuisance and because they are unsightly. Individual ASHPs also cannot be installed easily on apartment blocks. Colder air temperatures in Scotland, and elsewhere, mitigate against their efficient performance in certain regions and the salty atmosphere in coastal environments cause significant corrosion that can dramatically shorten their lifespan.

ASHPs should not be regarded as the inevitable 'starter' heat pump technology even though they are often considered to be relatively simple and plumbers can install them without involvement with a ground array. Indeed, the opposite is true. GSHPs are easier to install than ASHPs if the ground array is already provided; plumbers have no involvement in the supply of the gas network, and they need not be involved in the supply of neighbour-hood scale ground arrays for GSHPs. Despite huge efforts from global companies, ASHP deployment numbers in the UK are still very modest simply because they are not efficient, quiet, reliable or durable, which means the running costs and ownership costs cannot appeal to the UK consumer. For these reasons, they should not be the technology that is central to the heat decarbonisation policy: they should be replaced by GSHPs.

Any Government decision to invest in the ground array infrastructure will ensure the market will naturally gravitate towards GSHPs.

In order to reach this understanding, Government must:

8. Accept that heat pumps can serve a wide range of buildings and immediately discontinue the suggestion (without any foundation) that heat pumps are only suited for well-insulated buildings.
9. Appreciate that GSHPs in heat networks are far more versatile as they can deliver cooling and can also utilise waste heat effectively.
10. Understand the current £16.5m Heat Pump Demonstrator project is poorly-timed and ill-conceived and will generally produce outcomes (e.g. higher running costs) which will be unhelpful to the heat pump sector given the focus is the displacement of gas boilers.
11. Understand that the successful implementation of GSHPs as the lowest carbon replacement for gas boilers in private properties on a street-by-street basis will require attractive offers and, potentially, some enforcement in order to maximise the economic benefits of shared ground arrays.
12. Recognise that the existing MCS-scheme provides adequate oversight but can be refined, particularly via a greater onus on manufacturers to take responsibility for the activities of their installer networks.

What steps can be taken to lower heat pump installation costs?

Costs can quickly fall by around 40%, but only if Government can deliver long-term policy which provides confidence that there will be a significant and sustained increase in heat pump deployment. In order to secure these savings, Government must:

13. Understand that the material/labour content for a heat pump is not the prime reason for the high prices (relative to a fossil fuel boiler): it is the extortionate cost to sell a novel technology to an uncertain public, a task made far more difficult by ever-changing and complicated public subsidy schemes.
14. Provide subsidy support to trigger deployment in high volume markets, notably social housing retrofit and new build, where a single decision maker can a) order many heat pumps and b) place 'repeat' orders. Now that the RHI is on the verge of closure, there is currently no available support outside of absurd 'competitions'.
15. Recognise that deployment of shared ground arrays is the lowest cost way of delivering GSHPs and develop policy which permits a street-by-street approach, starting with the areas with the most suitable geology, surface features or sources of waste heat.
16. Incentivise the use of cooling applications and the use of waste heat in order to reduce ground array costs.
17. Reduce or eliminate all sales taxes on GSHP installations.

What role should gas or hybrid heat pumps play in helping the UK reach the target of net zero emissions by 2050?

Hybrids featuring an ASHP and gas boiler should play no part in the heat decarbonisation strategy as they have no appealing outcomes. The superior 'hybrid' technology mix is a GSHP and a heat battery, as this will manage the peak load issue more effectively, and deliver lower running costs and lower carbon emissions. Gas boiler/ASHP hybrids have been promoted by the gas sector in a desperate bid to prolong the utility of their network. Any reasonable analysis of their potential would have identified their lack of appeal to any householder. They are a crude solution but it has found favour because most Government officials lack the necessary engineering credentials to differentiate between options. Worse, when Government did commission consultants to consider a future role for hybrids, stand-alone GSHPs or hybrids involving heat batteries were not modelled as a counter-factual.

Government must:

18. Understand that any hybrid featuring an ASHP and fossil-fuel boiler will be unwelcomed by householders as bills will increase and will deliver sub-optimal outcomes for the environment.
19. Acknowledge that the Committee on Climate Change is incorrect to suggest that an ASHP/gas boiler hybrid is necessary on occasions when there is no internal space for a hot water cylinder. Recognise that the GSHP/heat battery hybrid can be installed exactly where the ASHP would be sited: it requires no internal space.
20. Appreciate that the very best 'load-shifting' outcomes can be delivered by a more compelling 'hybrid' combination featuring a GSHP and a heat battery.

How can the Government tackle the current skills gap for designers, builders and installers of heat pumps?

The Kensa Group, by far the largest GSHP supplier, and the one with the longest heritage, has never encountered a 'skills gap'. The design and installation of heat pumps is straightforward. Manufacturers who seek to simplify the process, and who are prepared to engage with the plumbing community, will have no issues with a shortage of skills.

Unfortunately, too many manufacturers are content merely to 'box shift' product into the supply chain and have no involvement with the subsequent installation. Most of the problems can be avoided if there is an intent to make the manufacturer jointly responsible for installations.

To deliver the best outcomes, Government must:

21. Recognise its role is to provide policy decisions which guarantee a growing market: industry will then have motivation to provide the necessary support and training.
22. Appreciate that heat pump design and installation is not difficult especially if installers are supported by manufacturers and other parties.
23. Understand that the plumbing community does not welcome classroom-based learning, instead focus training on practical installation issues delivered by experienced installers and support manufacturers with their efforts to train installers.
24. Recognise that compliance with various 'quality schemes' appeals to new market entrants who are comfortable with management systems but penalises the long-established heating engineers who have little 'back-office' support.
25. Appreciate that ill-conceived grant schemes can deliver very unwelcome outcomes and hugely increase the challenge of training the installer community.

How can public awareness of heat pumps be improved?

There is no sense in promoting heat pump technology BEFORE it is appealing to the public. Right now, with regard to running costs, most heat pumps are not an appealing alternative to a gas boiler which is why the Heat Pump Demonstrator Project will deliver disappointing outcomes.

Industry will do all the necessary promotion once there is an appealing offer that will be acceptable to the public.

To secure this outcome, Government must:

26. Deliver immediate subsidy (in advance of regulation) to support installation in new build dwellings: it is vital that heat pumps are regarded as a modern and aspirational feature of a future-proofed home.
27. Specify heat pumps on all dwellings where Government has an interest, starting with military housing.
28. Implement a policy to remove all direct electric heating from all social properties by 2030.
29. Re-engineer the Heat Pump Demonstrator Project and re-purpose the scheme towards installations where the outcomes will be appreciated by householders.
30. Make clear the future cost increases to be imposed on gas.

Annex

The following supporting evidence correlates to the numbered bullets in the body of the summary document.

1. Government should be aware that any heat pump rollout programme which continues to be dominated by ASHPs will require far more generating and storage capacity because their efficiency is hugely compromised on the coldest day when heat demand will be at its peak.

   It will also be a far harder 'sell' to the public.

   At its most basic, it is odd to support any technology which uses freezing cold air to heat a home!

   When temperatures drop below freezing, an ASHP inevitably struggles as a heating appliance. In such conditions, their efficiency will barely exceed 150% whilst there will be periods when the appliance cannot operate in heating mode at all as it will need to de-frost. This activity either requires the use of an immersion heater or, bizarrely, the extraction of heat from the dwelling itself. And if the property requires additional heat beyond the reduced capacity of the ASHP, there is risk that the integral immersion heaters could all switch on which would challenge the grid.

   Overall year-round efficiency of an ASHP in a typical UK dwelling is around 240% meaning that 2.4 kWh of heat are delivered for every 1 kWh of electricity consumed by the heat pump.

Given the same freezing conditions, a GSHP does not have the same problem as the sub-surface ground temperature does not mirror the prevailing air temperature. Instead, it is effectively insulated. As a result, the source temperature for a GSHP on the coldest day can be up to 15°C warmer which means the heat pump has to do less 'work' to produce temperatures useful for home heating. This means less electricity is consumed by GSHPs which results in a higher efficiency: it also means there is no risk that back-up immersion heaters will be deployed. In over 20 years of manufacturing GSHP's, Kensa has never once fitted any back-up electric immersion heaters to any appliance: they are simply not required.

On the coldest day, **a GSHP will be almost twice as efficient as an ASHP** and the year-round efficiency will be around 300%.

Too often, the relatively modest difference in year-round efficiency is used to support an argument that ASHPs are the right mass market solution given they are simpler to install and lower cost as they do not need a ground array. This is a narrow analysis based upon unsuitable evidence. Government, and other stakeholders, must understand the impact of any mass rollout of ASHPs on the coldest day. The widespread implications of this performance 'gap' is seemingly not widely understood by BEIS officials, its consultants, the Energy Systems Catapult, the CCC or anybody else. Instead, they all persist in the view that a low cost ASHP must deliver the highest 'value' and best decarbonisation pathway without adopting a more holistic evaluation.

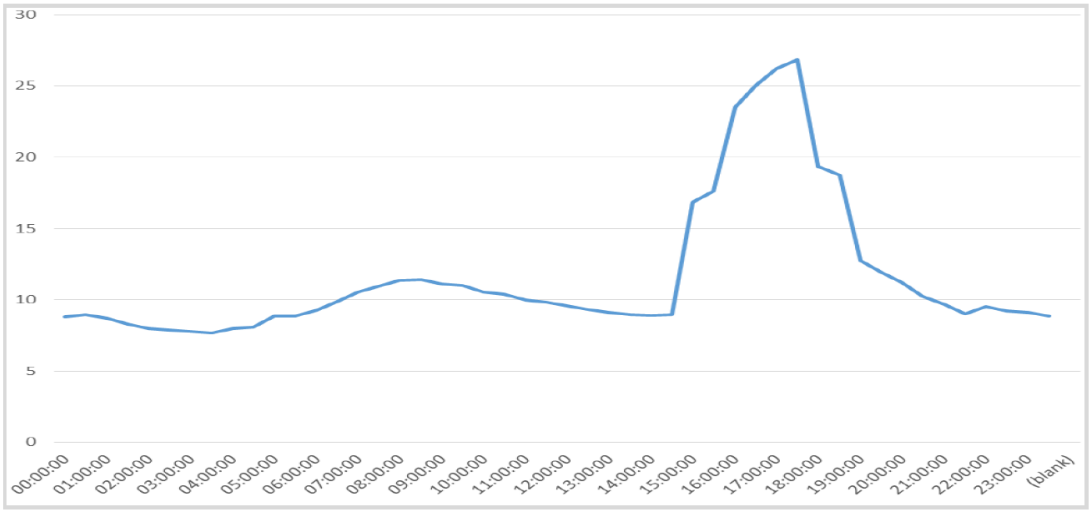
The following table illustrates the necessary generating capacity if there are 20 million heat pump installations each with an average 8 kW peak load. It shows peak capacity given varying shares between GSHP and ASHP variants. The table uses the coldest day efficiency when the grid will be most challenged but ignores the additional risk of any mass use of back-up immersion heaters.

Installed Quantity of Heat Pumps				20000000
Average capacity (kW)				8
ASHP efficiency on coldest day				175%
GSHP efficiency on coldest day				300%
Split between variants		Capacity Requirement (GW)		
ASHP	GSHP	ASHP	GSHP	Total
90%	10%	82.3	5.3	87.6
80%	20%	73.1	10.7	83.8
70%	30%	64.0	16.0	80.0
60%	40%	54.9	21.3	76.2
50%	50%	45.7	26.7	72.4
40%	60%	36.6	32.0	68.6
30%	70%	27.4	37.3	64.8
20%	80%	18.3	42.7	61.0
10%	90%	9.1	48.0	57.1

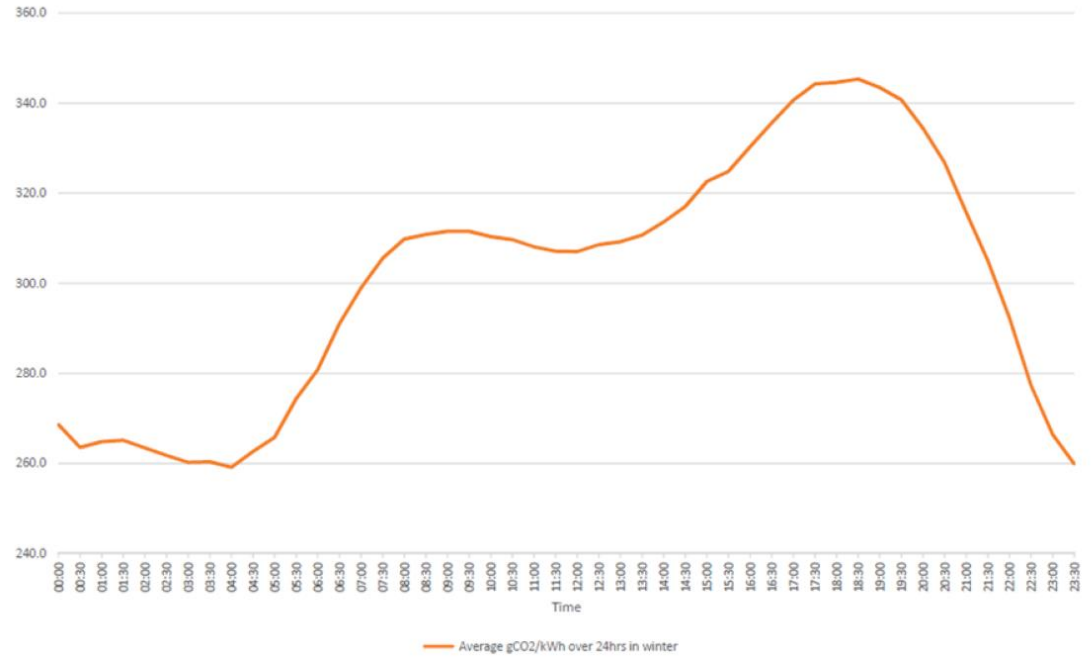
The difference between the two extreme scenarios is over 30 GW. To put this figure into context, the baseplate capacity for Hinckley C Nuclear Power Station is just over 3 GW. In other words, if the market deployment was 90% ASHP, there would be a need for 10 further Hinckley's.

Of course, this analysis is simplistic and the emergence of batteries, heat storage, smart controls and time-of-use tariffs will influence heat pump operating profiles so there won't be simultaneous operation of the entire installed estate even on the coldest day. That said, all of these emerging developments hugely favour the deployment of GSHPs.

As one example, time-of-use tariffs and heat storage, principally in the form of vessels utilising phase change salts, will encourage households to operate the heat pump when electricity is low cost in order to minimise running costs. There is a fortunate correlation between low cost and low carbon electricity (see graphs below) so the Government should certainly favour this operating approach too.



Average electricity price by half-hour segment over 24hrs in London (Source: Octopus Energy).



Average carbon intensity of electricity by half-hour segment over 24hrs (Source: http://carbonintensity.org.uk)

During the heating season, low cost and low carbon electricity is typically available through the night (when system-wide demand is reduced) or whenever the wind is blowing. It is clearly sensible for most households to re-charge the hot water cylinder and/or heat battery mostly at night yet operating an ASHP at such a time is foolish for two reasons.

Firstly, the air temperature is typically cooler at night than during the day so the efficiency is further reduced: you are asking a less efficient appliance to operate when it will be least efficient.

Secondly, the noise nuisance from an ASHP will impact the household's ability to sleep and may impact neighbours too. The installation of ASHPs is already governed by strict planning regulations which, sadly, are routinely ignored. If these regulations were applied, ASHPs would not be a viable solution in areas of high density housing. The noise from ASHPs can be particularly disturbing on still nights when there is no wind noise: these are typical conditions when low pressure weather systems bring very cold temperatures to the UK.

Government policies have seemingly favoured ASHPs. As one example, the domestic RHI ASHP tariff was increased in October 2017 without any justification. Even so, the number of ASHP installations remains tiny - the 2019 figure was around 25,000 - even though global corporations such as Mitsubishi, Hitachi, LG, Panasonic, Samsung, LG and others have all been trying to build a market in the UK for some time. Very simply, the technology is not efficient enough, reliable enough or durable enough to appeal in the UK.

Looking overseas for precedents is a poor approach and provides unsuitable evidence upon which to base UK policies. The damper, milder, high humidity conditions characteristic to the UK climate present the worse combination of conditions for an ASHP. Indeed, there are some conditions, notably those which trigger freezing fog, which mitigate against their useful operation at all.

The public will not happily support a transition from a gas boiler to an ASHP. Something better is needed. They need something which looks like a gas boiler, acts like a gas boiler but delivers them far lower running costs and carbon emissions. That solution is available; it is a GSHP and can be priced at ASHP levels – see Annex Point 2.

2. In principle, a GSHP and an ASHP are similar appliances. The former incorporates a pump to circulate fluid around the ground array; the latter features a fan to move the air across the evaporator. The remaining components are very similar. As a consequence, the appliances are a similar price but a GSHP system has always been more expensive because it requires a ground array.

For reference, a ground array is typically either pipe buried in horizontal trenches or, more commonly, a probe installed within a vertical borehole. Shared ground arrays, available in the UK since Kensa's first installation in 2012, allow multiple properties to benefit from the same underground infrastructure and allow installation costs to reduce significantly. Shared ground arrays should be regarded as the 21st century equivalent to the gas network.

There is a common misconception that many properties won't have space for a ground array. This is nonsense. The densest low-rise housing in the UK is Victorian terraced properties but there would still be space for boreholes by utilising deeper holes running down the centre-line of the street. In reality, ASHPs are the questionable technology for these properties as the back-to-back gardens would mean a large number of appliances, each making a noise, would be in close proximity to each other. The existing regulations, if applied, would not allow such an outcome.

So, rather than being viewed as a cost burden, ground arrays are an asset which unlock all the advantages of GSHPs: accordingly, they should be regarded as vital national infrastructure. They last over 100 years and they should be installed by UK Plc. They are entirely unobtrusive so their installation would not upset anyone, a unique feature compared to other renewable technologies that often blight landscapes. Ground arrays are buried and, unlike many other technologies, such as ASHPs or solar PV panels, they cannot be stolen, a fate that inevitably awaits some solar panel and ASHP installations. A GSHP allow the householder to have a 'white box' inside the property that mimics a boiler. They also allow cooling in summer which will become increasingly attractive as temperatures continue to rise; that cooling is provided at zero cost and will reduce annual carbon emissions – see Annex Point 4.

Sadly, Government has not yet recognised the value of a ground array. Instead, officials have preferred to take the odd view that the higher costs will require more subsidy and so will automatically deliver less value. This thinking reached its nadir with the hapless 2020 Clean Heat Grant (CHG) consultation which suggested a flat £4000 grant for any and every heat pump installation regardless of variant, efficiency, capacity or any other criteria.

These embedded views of officials, both at BEIS and Treasury, should be either explained, with suitable justification, or changed. Efforts to meet with officials have been thwarted. There is a growing suspicion that the gas lobby has effectively encouraged Government to deploy ASHPs in the certain knowledge that their performance will be underwhelming.

In any event, the CHG consultation highlighted the crassness of current thinking. The documents mentioned the need to secure 'value for money' on over 40 occasions yet BEIS officials have never been able to articulate what they mean by 'value'. It would appear logical that they are seeking to support the lowest cost pathway to zero carbon heating yet BEIS has never published any evidence which reveals the differing costs between mass ASHP or mass GSHP deployment on the wider electricity system. It is a huge oversight. They simply focus on the appliance under the false apprehension that both variants deliver similar outcomes. Many responses to the CHG consultation pointed out the value of subsidising the ground array with a 100-year life rather than an ASHP with a 10-year life.

To try and counteract the BEIS thinking that ground arrays are somehow expensive and unwelcome, the few remaining companies in a GSHP sector ravaged by ignorant previous policy have developed business models which divorce the cost of the ground array from the upfront capital cost. By doing so, a GSHP installation costs no more than an ASHP installation. At this point, the obvious choice is a more efficient, more reliable and more durable GSHP. To

reach this cost parity outcome, limited subsidy support is required to 'seed' the market but at levels which provide exceptional value.

Private finance is ready to support Government subsidy. Many entities want to fund and own the ground array in return for an Annual Connection Fee (imposed on each householder); this fee is effectively the equivalent to the gas standing charge. These asset owners appreciate the long life of the ground array as well as its modest and predictable ongoing maintenance cost, the obvious consequence from being buried out of harm's way. As a result, these owners can recover their investment over the longer-term in order to reduce the fee.

This is helpful. For mass appeal, the aim is to ensure the Annual Connection Fee is modest and will mean the total household running cost remains lower than a gas boiler and much lower than a less efficient (and less flexible) ASHP. This will require some subsidy until volume has driven down supply chain costs but Government would be wise to provide this support in lieu of all the costs associated with any strategy focussed on ASHPs.

Rebalancing the market split between AS and GS would benefit the environment too. The GSHP's superior efficiency means carbon savings are more pronounced but there are even greater savings when you consider the intensity of electricity generation at the time of operation. A GSHP can easily shift its operation to times when generation is low carbon and heat batteries will allow the subsequent release of this heat when required by the property.

Another UK company, Sunamp Ltd, is currently leading the world with heat battery technology featuring phase change salts, and joint collaboration with Kensa will result in some appealing products. This is a far more effective 'hybrid' than the presumed gas boiler/ASHP variant – see Annex Point 18.

Most importantly, householders will benefit as they will have a quieter, more reliable and more durable appliance that will require less servicing and will require replacement less frequently. On this last point, and to illustrate a wider issue which fuels frustration with officials, BEIS persists with the belief, based upon no evidence at all, that an ASHP will have the same lifetime as a GSHP. This is absurd. A reasonably bright three-year-old knows that his favourite toy should be stored in his bedroom cupboard and not the garden: the same argument applies to heat pumps! The Committee really should question the competence of BEIS officials who cannot accept this simple reality: it is characteristic of wider failings which will hugely increase the cost of heat decarbonisation. See Annex Point 7.

3. Previous subsidy support policy has been woeful. There are countless examples of policy failings, but it is helpful to focus on one matter in some detail as it will explain why the deployment of GSHPs has been hampered over the past decade and they have lost their status as the most popular renewable heating technology.

As background, the Renewable Heat Incentive (RHI) was intended to provide a financial return to encourage the additional spend on a renewable heat technology compared to a fossil fuel alternative. To do so, the RHI would pay a tariff to the system owner for each kilowatt hour of renewable heat generated by the installation. To set tariffs, BEIS economists created a Tariff Calculator that sadly contained two major flaws.

Firstly, it presumed that any RHI recipient would benefit from both the tariff income and any running cost and ownership cost savings. This is clearly not the case when the property is tenanted so it penalised social landlords who recognised the appeal of the technology but were not incentivised to install it.

Secondly, it perversely rewarded less efficient and less durable technologies, such as ASHPs, on the basis that their less favourable running/ownership cost savings compared to other renewable technology – GSHPs - would demand a more generous tariff in order to deliver the required return on investment.

The RHI penalised more efficient and more durable technologies, such as GSHPs. It was that mad. These flaws were pointed out by the Kensa Group CEO during oral evidence to an RHI Inquiry in 2013: BEIS did nothing. The scandal of the RHI is not the 'Cash for Ash' episode in Northern Ireland but the setting of tariffs in the remainder of the UK. Careless errors resulted in the over-compensation of biomass, too. Worse, officials then used the subsequent deployment volumes to reach a conclusion that the public did not like GSHPs and they were not a technology that could deploy at scale. The policy failures are the main reason why GSHPs have not deployed: it is not any lack of appetite from the public.

BEIS must learn from these errors and consider the design of more bespoke subsidy schemes that strike the right balance. Kensa has shared proposals with BEIS officials for schemes that would require less subsidy (per kilowatt hour of renewable heat generated) than anything conjured up by the department: no formal response has ever been received. There is currently no support available for shared ground loop systems following the cancellation of the non-domestic RHI.

The Kensa proposal for new build seeks a partial subsidy for the ground array so public funding only supports the underground infrastructure: there would be no direct contribution to the house builder. Given the durability of the ground array, and the efficiency of a GSHP, the subsidy would deliver renewable heat at just 1.55p per kWh. The Clean Heat Grant suggested a rate of almost 6.33p per kWh for a small ASHP installation despite the apparent focus on 'value'.

In general, there is clearly little sense in favouring the subsidy of ASHPs (typically manufactured overseas) which might last 10-15 years, compared to subsidising ground arrays (installed by UK Plc) which will last over 100 years and will permit the installation of GSHPs (often manufactured in the UK). Subsidy support for the ground array will leverage in private sector investment and unlocks all the advantages outlined in Annex Point 1. And support would be superior value too!

Shared ground arrays are effectively the 21st century equivalent of the gas network. It should be noted that the gas network was installed using public money: we are merely asking for a subsidy which is relatively small compared to that of the gas main so we can compete with fossil fuels.

It is also worth emphasizing that utilities in the United States, who typically have a monopoly in any given municipality, are asking regulators if they can replace outdated gas networks, lumbered with the burden of ever-increasing maintenance costs, with district-wide ground arrays; evidence can be provided, upon request.

4. Shared ground loops are the optimum ground array solution. Rather than installing a shallow, individual borehole for each dwelling, it is more cost effective to drill a smaller quantity of deeper boreholes because productivity is always lost when the drilling rig is being re-positioned. There are also many technical reasons to support their deployment, not least the removal of any risk that a high heat use house will exhaust the capacity of the array.

Clearly, the business case for ground array ownership is more appealing if every property in a street is connected. For this reason, initial subsidy schemes (and deployment) should be focussed on new build and social housing retrofit. In both cases, a single decision-maker can require all properties to connect which massively reduces the cost of sale and allows lower prices to be charged.

For new build, BEIS officials seem to think that emerging legislation will act as a sufficient driver to support heat pump deployment, but nothing will happen quickly enough and developments approved under prior generations of the building regulations will continue to 'build-out' long after the new regulations are introduced. It is crass to install fossil fuel boilers that will need to be replaced in order to meet the carbon targets but the continuing delays in delivering suitable incentives and legislation simply highlight the strength of the housebuilding lobby.

For the retrofit schemes, there would need to be some refinements to current policy to ensure any homes purchased under Right-to-Buy legislation can be upgraded at the same time as the social properties since it would be foolish having to return to drill further holes.

These two applications will provide much-needed volume which will help drive down costs and allow appealing offers to be made to private households in due course. Drilling costs would reduce by up to 40% if there was increased volume for several reasons. Rather than operating on a national basis, with the associated cost of owning drilling equipment to deal with the vast range of geological conditions found across the UK, drilling contractors could have a regional focus which would also reduce some of the present mobilisation/accommodation/subsistence costs.

Further cost savings would be available if there was a more integrated approach, encouraged by Government, to utilise waste heat. Any heat rejected into the ground would increase the GSHP's source temperature, which would either increase the efficiency of the heat pump or reduce the cost of the ground array. A simple example would be the use of the waste heat generated by the cooling requirement in the neighbourhood supermarket. More significant outcomes would be possible if facilities like data centres were present. Only GSHPs can utilise this waste heat in integrated ways that reduce capital costs, reduce running costs and reduce carbon emissions.

Ground array costs would also reduce if passive cooling was provided. Passive cooling is a huge advantage of a GSHP/shared ground loop system and can reduce room temperatures by several degrees in the summer without the use of any air conditioner. Better still, its provision would actually reduce annual running costs and carbon emissions so householders would receive benefits not available from their existing gas boiler. Additional utility is important to support the transition and consumer buy-in to low carbon heating, as householders must *want* a heat pump, so it should do things that they *need*. Clearly, the prospect of rising summer temperatures is generating an increased interest in cooling.

Passive cooling with GSHP is simple. Over the winter, the ground temperature falls as its heat is taken by the GSHP to warm the home. As a result, by spring/summer, the ground is much colder than the prevailing air temperature so there is an opportunity to use this coolth. By circulating the fluid around the ground array, it is possible to transfer the coolth into the home and distribute it as cooled air in order to reduce room temperatures. Simultaneously excess heat from the home can be absorbed by the ground array fluid returning to the ground, helping to re-charge the ground's temperature and improving winter heating efficiency. As a consequence, the small amount of energy consumed by the passive cooling circulation pump in summer is more than offset by the reduced electricity consumption in winter, hence there is a net annual reduction in running costs and carbon emissions.

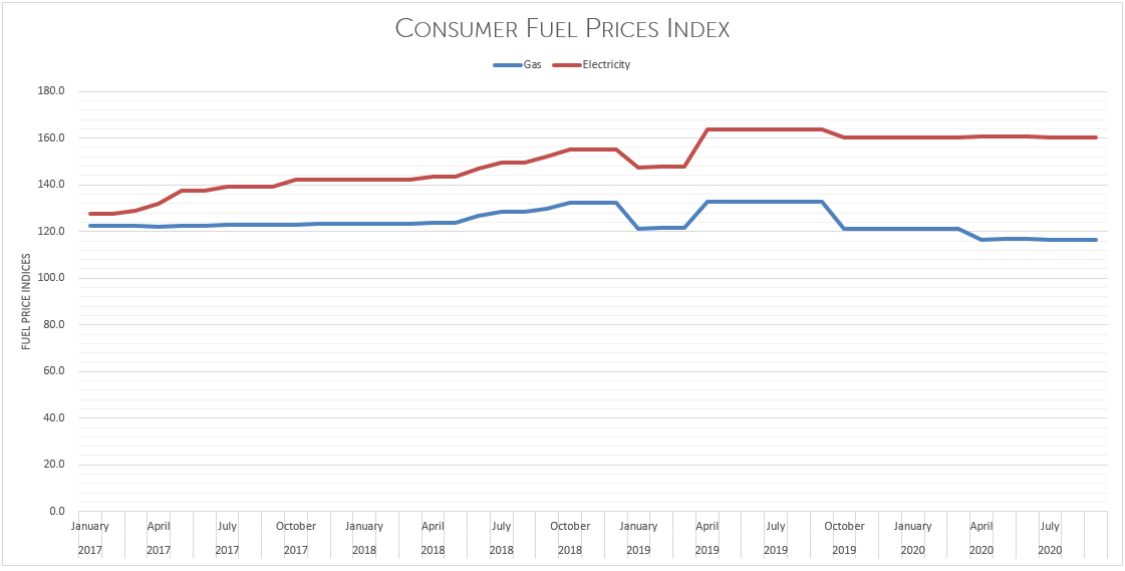
It is also possible to reduce ground array costs by installing a solar PV-T panel on the roof. These panels are designed to generate both electricity and hot water. They are obviously most effective in summer and their performance is enhanced if they are cooled. Again, the coolth in the ground can be used both to bolster the panel's output and efficiency, and also to transfer the rejected heat back into the ground.

None of these embellishments are possible with an ASHP. They all require a ground array. Subsidy support for ground arrays is the obvious way to unlock the market.

Of course, explaining all of these opportunities, and engaging with an ever-increasing number of parties (architects, energy strategists, M+E consultants, developers, landlords) who can contribute towards the optimum site solution is time-consuming, and is one of the reasons that heat pump appliance prices appear high. It typically takes over two years and 200 man-hours to graduate from enquiry to order on a typical 100-unit new build scheme with a developer. In part, this is due to the complicated and ever-changing subsidy scheme rules.

Government needs to create a longer-term support scheme where the grants are tapered to a) encourage early adopters and b) reflect falling supply chain costs. Securing a repeat order will be relatively straightforward if nothing has changed!

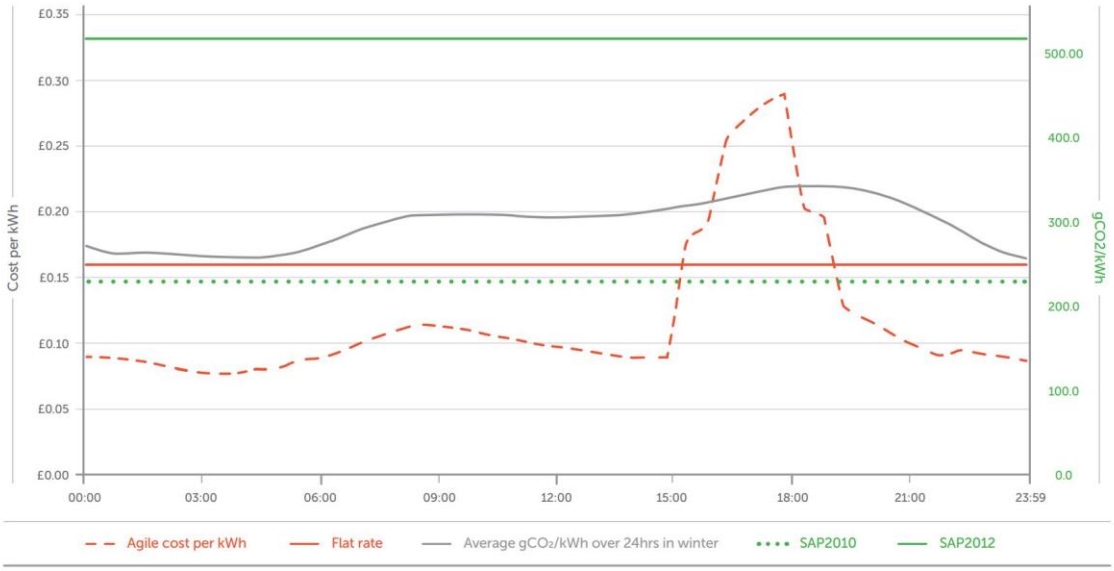
5. It is clearly unhelpful to heat pump deployment that BEIS statistics demonstrate that electricity prices are rising at a far faster rate than gas, as detailed below.



Gas is currently around 2.7p per kWh: electricity is around 16p per kWh. In part, the growing disparity is because there is a heavy burden (around 22% according to Ofgem) on electricity bills to pay for social/green policies. For householders to embrace heat pumps, it is necessary to lower the cost of electricity and increase the price of gas.

Industry is doing its part. The emergence of time-of-use tariffs are helpful at cutting running costs and carbon, demonstrable in the UKRI-backed Energy Superhub Oxford scheme, which features ground source heat pumps integrating with smart controls, load-shifting and agile tariffs; view the project video here https://youtu.be/w9l3lBxwoHk

The following table shows the average price of electricity on the Octopus Agile tariff over a 24-hour period.



If the GSHP is generally operated when electricity costs are lower, with the heat being stored, the average electricity cost per kilowatt hour is around 8p. Once the typical retrofit efficiency of 300% is applied, the cost for each kilowatt hour of heat is consistent with gas.

Government needs to do its part. Government has signalled an intent to tax mains gas using the proposed Green Gas Levy which, if the policy is designed effectively, should widen the running cost saving of a GSHP against a gas boiler. This differential needs to be increased so there is a clear and certain saving which will underpin the public's enthusiasm for low carbon heating, and there needs to be a published pathway to reach quite different prices in the future. It is important that the public can see that a graduation to a GSHP will result in more pronounced savings over time.

6. Lower running costs will also underpin emerging business models to support roll-out to private houses currently heated by gas. In order to support a street-by-street approach, regulations would be required to prevent new gas boiler connections once a neighbourhood shared ground array has been installed. Of course, it would be foolish to expect a householder to happily transition to a heat pump at the point that the gas boiler fails: at that time, there is an urgent need for heat so the temptation would be to repair the gas boiler to prolong its life.

To ensure rapid transition to GSHPs, it would be necessary to encourage an upgrade before the gas boiler fails. For this to be appealing, there should be no cost, or minimal cost, to the householder so they can all act simultaneously in order to strengthen the economics for the ground array owner. This outcome should be possible. Asset owners can fund the heat pump installation. They will likely offer the householder heat for a slightly lower price than gas and take the wider running saving as margin to support the upfront installation cost. This outcome would be a politically attractive way to transition whole communities from gas without any negative reaction that heating bills have increased: it would also lower carbon emissions by around 80%.

7. Many of the issues over the past decade could have been avoided if BEIS officials had a greater understanding of the energy and heat sectors. An ever-changing team of officials, drafted in from Ministries across Whitehall, or elsewhere, take time to learn the basics and typically transfer before they can do anything useful. The consequence is that industry has a far more thorough recollection of the history than anyone within BEIS and a far greater understanding of what needs to be done. Sadly, officials ignore industry. Instead, they rely on reports from the same small group of consultants who merely regurgitate prior work or present the views of the major incumbents who reward them via other lucrative contracts. The lack of top-level critical analysis within BEIS must be corrected or mistakes will continue to be made.

It is obviously outside the scope of this enquiry but energy policy is not especially party political and long-term plans cannot fit into the five-year parliamentary timetable, it should become the responsibility of a separate Commission staffed by the very brightest scientists and engineers who have considerable experience of the sector. They should replace civil servants who often merely understand the process but have no ability to evaluate the outcomes.

8. Government announcements have dampened interest in heat pump technology by persisting with the wholly inaccurate myth that heat pumps are only suitable for well-insulated homes. This is nonsense. Homes with inferior insulation specifications will simply need larger radiators in order to achieve the required room temperatures.

There is a more important point too, conveniently ignored by the incumbent fossil fuel boiler manufacturers. Very simply, the size of the radiators required to heat a home with less-than-ideal insulation should not vary between a heat pump and a fossil fuel condensing boiler, provided the latter is designed, as required, to operate in condensing mode. The efficiency advantage of a condensing boiler is only delivered if the return temperature is around 50^{o}C. That is the same temperature that can be achieved with a heat pump.

Annoyingly, most condensing boiler systems are not set up this way. Instead, installers routinely set the flow at 80^{o}C so the return temperature is well above the temperature to permit condensing. The advantage is smaller and less expensive radiators: the disadvantage is a loss of efficiency. There has been no enforcement at all to ensure condensing boilers are set up to achieve the outcomes expected by the legislation that mandated their use. It is a shocking failure. If the radiators had been sized correctly, millions of houses would be prepared for a simple graduation to a heat pump.

On many occasions, Kensa has asked BEIS officials to explain why they believe a heat pump delivering water at 55^{o}C cannot heat a poorly insulated home whereas an oil boiler delivering water at the same temperature seemingly can. No response has ever been received.

Also, Government seemingly has no understanding of where a GHSP can be deployed. The recent Green Homes Grant scheme recommended that householders visit the Simple Energy Advice website which is managed by BEIS. Having entered details of their property, the website would recommend upgrades but the outcomes were perverse. Often, it was suggested that households with no access to mains gas should seek a gas network extension even if the nearest connection was miles away! GSHP's were only recommended if there was a huge garden (ignoring the limited space required by a borehole) and the property was very well insulated. A Kensa employee living in a home with a GSHP was advised to replace it with night storage heaters (which would have quadrupled his running costs). These issues are frustrating beyond belief but characteristic of the outcomes tolerated by officials with little expertise in such matters.

9. Please refer to Annex Points 1 and 2.

10. Government has a shocking record at delivering heat pump demonstrator projects.

- The 2008 Field Trial, part-funded by the DECC, and managed by the Energy Savings Trust, produced a report that had to be withdrawn since it lacked any robustness and failed to survive peer review. It significantly damaged the market it was trying to serve.
- The subsequent 2017 Renewable Heat Premium Payment Heat Pump Monitoring Project, fully-funded by DECC and managed by its officials, produced questionable performance data for just a fraction of the 800 properties. It could only be published after the acceptance of an industry demand that it contained a caveat emphasizing the results could not be taken as representative of any wider sample.

There is real risk that the 2020-2022 £16.5m Heat Pump Demonstrator Project will be a further waste of public funds because the wrong technologies (especially ASHP/gas boiler hybrids – see Annex Point 10) are required to feature prominently (even though there is no market demand for them) and, more particularly, because the installations need to take place at properties previously heated by a gas boiler.

Very simply, no ASHP installation will deliver a lower running cost than gas and any ASHP installed as part of a hybrid/gas installation will hardly operate in winter if the intent is to minimise running costs. As a result, there is risk that householders will be underwhelmed with outcomes which is exactly what the incumbent gas sector expects. They will use the disappointing results to support their argument for hydrogen.

It would have been wiser to focus the Demonstrator Project on properties currently heated by night storage heaters or direct electric heating. These properties would have exactly the same characteristics as homes equipped with a gas boiler and would have been occupied by similar residents so the performance of heat pumps would have been equally applicable to a wider property base. The critical difference is that the occupants would have welcomed the reduced running costs, and greater utility of a wet heating system so the reaction to heat pumps would have been far more positive. This is not what the gas sector wants at all!

11. Once supply chain costs have reduced significantly via exposure to the new build and social housing retrofit markets, and once Government has altered the relative pricing of gas and electricity, it will be possible to consider the

displacement of gas boilers at private houses. As explained in Annex Point 6, regulation will be required to prevent new gas boiler installations once a communal ground array has been provided for the neighbourhood. Private sector entities can fund this underground infrastructure and will likely also provide the GSHP at zero cost in order to accelerate uptake. These asset owners will have no interest in ASHPs as the reduced efficiency, reliability and durability will negatively impact the offers they can make to the householders.

Again, it will be crucially important that Government targets opportunities in the right order. Early installations should focus on areas with higher density housing, with higher heat demand, that is located about favourable geology or adjacent to helpful surface features (water and/or sources of waste heat) as the ground array installation costs would be lower and would permit more attractive offers to the householders. As supply chain costs continue to fall, it would be possible to migrate to areas which are less conducive (and therefore more expensive) whilst maintaining the same appealing offers to householders.

12. MCS is burdensome but is delivering decent outcomes. It would be improved if manufacturers were made responsible for the performance of their installer networks. Some manufacturers merely wish to 'box shift' and have scant regard for any final installation. Instead, they merely sell product to distributors/merchants and have no further involvement with any installation. This approach is wrong and has led to some miserable outcomes.

The car industry is mature and sells a product at a similar price point. It can provide a useful example on the approach to be adopted by the heat pump sector. Car manufacturers impose very stringent quality standards on independent businesses which want to sell/service their product and this model should exist in the heat pump world. Only by penalising manufacturers for the antics of the 'hard-sell' installer brigade can you effectively safeguard the integrity of the technology.

Worryingly, the poorly conceived Green Homes Grant has spawned a legion of opportunists, often with no background in heating, who are looking to take advantage of a short-term grant programme. These businesses have no long-term interest in the sector and will migrate to other opportunities as they arise. This is no way to grow confidence in the sector.

13. A typical GSHP costs around £1500. Around £1350 is the material cost with the remainder being the labour cost. The List Price is around £6000 which allows for a maximum discount of around 45% to a plumbing merchant. These figures mean the manufacturer makes a gross margin of around £1800. This may appear excessive, and it is certainly much higher than the margins made on fossil fuel boilers, but it is necessary because the cost of sale is so high.

As evidence, no heat pump manufacturer/supplier is consistently making money in the UK because the volume opportunities are scarce and it is exceedingly difficult to build a business selling one heat pump at a time to private householders. These 'one-off' projects typically require engagement with an architect, a plumber, a SAP assessor and other stakeholders, and the process is not only lengthy but offers no guarantee of an order.

Whilst volume will allow some material costs to fall a little, say by around 10-20%, there is still risk that any adverse movement in the global price of stainless steel or copper will increase costs. The real opportunity to reduce selling prices is to cut the cost of sale. Heat pumps should be selling at £2000 and not £3300. This would still provide a gross margin of £500 per unit to allow the manufacturer to support the installer, as required.

14. For this reason, it is vital that Government policy supports sales into the new build and social housing retrofit markets, two sectors where repeat business is also possible. Belated support has been available via the non-domestic RHI since 2018 but the scheme is scheduled to close in March 2021, the inevitable consequence being many properties will be fitted with fossil fuel alternatives.

Many planned Kensa projects have been impacted by Covid-19 but BEIS officials have yet to offer any appropriate RHI application extensions to these smaller (sub 100kW) projects. As a result, staff recruited to deal with the last-minute rush ahead of the NDRHI closure will have no work to do from April 2021 onwards.

It is impossible to build a sector if the only support is available via 'competitions' such as the Social Housing Decarbonisation Demonstrator Programme. Clients looking to commit resource to major investment initiatives need certainty that support is available if they meet the scheme requirements.

Much work needs to be done quickly to ensure there is adequate support for the right projects.

15. Shared ground arrays are the best approach. Current costs could fall by around 40% if there is volume. Further savings would be possible if waste heat is utilised and/or there is a cooling load.

Kensa has provided BEIS officials and the CCC with detailed projections of future costs given various levels of market activity.

16. It is vital that Government understands that a GSHP can deliver heating and cooling and combined systems are more efficient. Bizarrely, the RHI actually penalised installations which did both! For the purpose of this response, it is sufficient to make clear that a GSHP makes use of warmer ground to heat and cooler ground to cool. ASHPs and air conditioners use cold air to heat and warm air to cool. Any engineer would quickly spot the opportunity.

17. No VAT should be levied on any GSHP installation.

18. BEIS officials have seemingly fallen for the appeal of ASHP/gas hybrids based upon one poor-quality report (the Freedom Project) which was presented by fossil fuel incumbents who want to see continued utility for the gas network. Why would any householder want two appliances, each with a relatively short design life, to take the place of their single gas appliance? The only possible answer is a reduction in running/ownership costs but that will not be the case.

Right now, if a householder wants lower running costs from any gas boiler/ASHP hybrid, the gas boiler will handle virtually all of the load if standard tariffs are used. The Freedom Project conceded this outcome and some of its scenarios reflected a possible future pricing position to justify the appeal of its hybrid but reality is more compelling. Many of the households who received a free ASHP have asked for it to be removed as they realised it was increasing their bills.

19. Of course, some observers argue there are two other benefits to justify a gas boiler/ASHP hybrid:

Firstly, the CCC suggest that many properties will not have sufficient internal space to house a hot water cylinder so the gas combi boiler would need to remain to provide hot water.

Secondly, the gas lobby suggest that there won't be sufficient capacity to run the ASHPs at times of peak demand so the gas boilers would provide essential backup.

20. Both arguments survive little scrutiny and both issues disappear with the use of a superior 'hybrid', namely a GSHP and heat battery. This set-up requires no space inside the house and can be installed exactly where the ASHP would have been positioned. Whereas an ASHP will disfigure the property and make a noise, a GSHP/heat battery can be installed within a shelter that has been designed to blend with the property's appearance. And this hybrid would easily overcome the peak demand issue as the heat pumps could switch off and utilise the stored heat in the battery. A GSHP is more reliable and durable than an ASHP: a heat battery is more reliable and durable than a gas combi boiler. The combination would result in the lowest running costs, lowest ownership costs (as replacement would be required less frequently) and lowest carbon emissions and air pollution (as there is no gas combustion at all).

This novel hybrid arrangement of a GSHP and heat storage does not suit the fossil fuel incumbents: it does suit a householder and the environment, and these are the outcomes which should most interest Government.

21. Industry will cover all the shortfalls in the supply chain as soon as there is confidence that there is a significant and sustained market opportunity. This will include the provision of training and project support. Manufacturers who adopt a 'partnership' approach with their installer networks will deliver the best outcomes and this approach should be encouraged by policy.

22. The most pragmatic GSHP rollout programme is via a street-by-street approach embracing shared ground arrays. As such, the heat pump installers will have no involvement in the design and delivery of most ground arrays: they will merely need to connect the heat pump in a similar fashion to the way they have traditionally attached a gas boiler to the gas network. This is an enormous advantage as it places the responsibility for the ground array with the long-term asset owner and separates the installer from the most challenging aspect of the design.

The design of heat pump systems is sensitive to the building's heat requirements so there either is a need for plumbers to understand how to perform heat loss calculations or partner with third parties who can handle this aspect. To be clear, this is a new requirement as the historical approach with fossil fuel boilers involves the installation of an appliance which is several times larger than the heat load simply because there was no cost penalty for adopting such a 'belt and braces' approach. Few calculations to size heat emitters correctly were ever performed.

The MCS design standards are comprehensive and provide plenty of useful information to support any installer. It is not difficult to design and install competently. Most do. In most cases, it is not a lack of training or knowledge which delivers poor outcomes: it is greed. If the heat pump market is to progress well, it is vital that steady and continuous

growth is available to reward companies that adopt a strategic and sensible long-term view. Current policies do not support this approach.

23. The market will benefit if this training is delivered by entities with a real stake in the sector, so that means Government should direct plumbers towards manufacturers' own training and support programmes. The best courses will include practical work and be delivered by engineers with real-life installation experience; some 'on-site' hand-holding might also take place as well as supervision of early installs.

Without some 'sign-posting' towards the manufacturers, the danger is that colleges will get involved again and conjure up a syllabus that will be delivered by a lecturer who has never installed a heat pump. This creates issues when questions which extend beyond the course content are posed. Colleges can usefully provide an overview but specific additional training, in order to secure any qualifications that should become necessary, must be delivered by manufacturers.

With this approach in mind, the car industry again provides an exemplar. A college can provide a course covering the basics of car mechanics but anybody servicing vehicles within a dealership network will receive additional training specific to that marque.

Manufacturers who do not engage in this process should not have access to the market.

24. MCS has generally been useful and the latest heat pump standards have helped eradicate many of the poor design practices that previously plagued the industry. That said, it is not well-suited for 'one man' bands where the focus is on plumbing rather than compliance with a quality standard. It is essential that these plumbers are embraced so there is huge value in supporting 'umbrella' schemes where manufacturers, and others, partner with the installer to work jointly on projects.

It would also be helpful if MCS could be refined in order to swiftly issue sanctions against installers who do not deliver compliant systems. Also, the industry would benefit from the manufacturers being jointly responsible for any failings to ensure that product is only sold to entities who can demonstrate the necessary knowledge.

25. Worryingly, some Government subsidy support schemes, such as the current Green Homes Grant, encourage businesses with a marketing focus to take advantage of short-term opportunities. Typically, these companies look to minimise the cost of the installation in order to maximise profits and most will shut down and move onto the next opportunity before the inevitable issues become apparent to the householder. For many reasons, the Green Homes Grant is an absurd scheme that has the potential to cause great damage to the heat pump sector: it is also a scheme that didn't benefit from any consultation or any contributions from the sensible and experienced market players.

26. The public's enthusiasm for heat pumps will increase if they are routinely specified for new homes as they will be regarded as a modern and aspirational feature. GSHPs will also be able to provide zero cost passive cooling which will be a new feature not available from any fossil fuel boiler. BEIS officials appear to believe that the long overdue update to the building regulations and the proposed Future Homes Standard will be sufficient to stimulate deployment in the new build sector.

This may be the case but the impact will not be felt for years as housebuilders will continue to build properties approved under prior generations of the building regulations for a considerable period. As a consequence, there is a need to subsidise the ground arrays for new build installations at a rate that provides exceptional value for money given the longevity of the infrastructure and its ability to mitigate against investment elsewhere in the electricity system.

27. Government should specify heat pumps for all housing where it has an influence on procurement. Local authorities should follow suit. Many local authorities have declared climate emergencies and some have set a net zero carbon target for 2030. Sadly, there is no long-term subsidy support programme which allows them to plan for the decarbonisation of their buildings and this must change quickly so examples can be set for the wider public.

28. Whilst the carbon intensity of electricity generation continues to fall, there is no sense in allowing any direct electric heating because the running costs and carbon emissions will be around three times higher than those achieved with a GSHP. There is a disproportionate amount of direct electric heating in social properties yet many of these properties somehow receive an EPC C rating thanks to some peculiar running cost data embedded in the SAP software. Government's own statistics reveal higher levels of fuel poverty in electrically heated Band C properties than Band D properties fitted with a fossil fuel boiler; these properties should be targeted especially as the local

electricity system architecture will easily be able to handle a fleet of heat pumps. Good outcomes from these installations will help spread the message that heat pumps are an attractive technology.

29. BEIS officials should immediately re-consider the focus of the Heat Pump Demonstrator Project and recognise that the likely outcomes (given the relative pricing of gas and electricity) will result in public money being used to deliver installations which increase running costs. This will be hugely unhelpful to the future rollout of heat pumps in the UK and is exactly what the gas lobby will use to strengthen their argument that green gas and hydrogen is the only decarbonisation strategy.

30. Government should make clear the scale and timing of future levies to the price of gas. At the same time, it should announce the removal of levies from the price of electricity or, at the very least, when used to provide heat via a heat pump. It will then be possible for the public to calculate the ever-increasing future running cost savings which will underpin their investment in a low carbon heat technology or allow them to take advantage of a fully-funded installation.