Written evidence submitted by Dr Alex Alliston (DHH0013)

My evidence is drawn from the journey I took as a homeowner to understand the options available to retrofit low carbon heating to my Victorian terrace house.

Recommendations

- Provide grant funding for homeowners to have a retrofit assessment from an accredited Retrofit Assessor so that the homeowner (including private landlords) can properly understand the options, costs and benefits of making low-carbon heating retrofits. Such grant support could be limited to homes with a current EPC of D or below.
- Launch a training programme for Retrofit Assessors to meet this demand.
- For hard to treat homes, especially the ~5 million terraced houses in the UK, recognise that ASHPs are not an optimal or indeed viable solution. Be honest about this in the government energy advice. ASHPs are only really effective in homes designed to have a low heat demand.
- Recognise that the hard to treat homes require significant capital spend to improve their energy efficiency. Fabric First is a good policy. Provide either a higher level of grant support or mechanisms to spread the costs, like the Green Deal (costs being recovered from savings on the energy bills).
- Consider support for the development of street-wide/district-wide mandatory schemes for fabric retrofits to terraced housing. Such schemes would require a high level of grant support and/or mechanisms to spread the costs, but would provide the best economies of scale.
- Remove heritage and council restrictions that prevent people from improving their home's heat efficiency (accept that our old housing stock must change appearance to meet this goal – do we want un-altered Victorian streets or better insulated homes?)
- Investigate the potential for street-wide/district wide district heating or ground source heat pump schemes as a way to provide best economies of scale and a heat pump solution more appropriate to terraced housing.
- Mandate and enforce a "fabric first" approach to new build homes such that they are very low energy demand buildings (do not allow developers to trade-off thermal efficiency for e.g. solar water heating or solar PV to achieve EPC level/net carbon zero targets).
- Whilst investigating the potential for H_2 as an alternative to or supplement for natural gas, revisit the potential role that "green" (bio-gas from grass) could play in decarbonising the gas network. Be realistic about the potential cost of H_2 and the timelines for introducing either blue hydrogen or green hydrogen at any significant scale.
- Consider how to encourage the development and deployment of smart low carbon heating solutions that can utilise electricity at time of low demand and/or low carbon intensity. The main focus here is on ensuring that the price signals from the market reward those that can load-shift.
- Support the financially vulnerable during the transition.
- Complete the rollout of smart meters.
- Support the development of "heat as a service" pilot projects.

My background

I am a professional engineer with a background in tidal and wind energy and now a self-employed consultant in sustainable energy. I am an early adopter of green technologies, having installed at my home solar PV 8 years ago, a Sunamp heat battery 4 years ago (first in England), an LG Chem battery (linked to the solar PV) 3 years ago and now use the Octopus Agile time of use tariff. I have driven an EV for 5 years.

I am also a private landlord with a Victorian mid-terrace property in Reading. During my period of residence in that property I upgraded to double-glazed windows and increased loft insulation to 250mm. The property has an EPC D.

Options for the terraced house

The wall-hung gas boiler is over 30 years old and is ripe for replacement. The message we are hearing from government is that the future of low carbon domestic heating is with heat pumps or heat networks. With this in mind, I researched the options for ASHPs (air source heat pump) as a potential retrofit solution.

The Energy Saving Trust suggests a guide price of £9-11,000 (https://energysavingtrust.org.uk/advice/air-source-heat-pumps/).

The prices I was quoted were i.r.o. £12,500 plus a further £2,000 for upgrading radiators, with £6,440 available through the RHI (or £5,000 from the Green Homes Grant scheme + RHI balance). So I was looking at a net cost of £8,000 to install the ASHP. A new condensing boiler would cost around £2,000 installed with no requirement to replace radiators. Furthermore the ASHP requires the replacement of the existing vented hot water cylinder and also the placement of additional hardware in the house (expansion tank) with no space available.

Consultation with the local authority confirmed that I would also require planning permission as the heat pump would be too close to the neighbour for permitted development and poses a potential noise nuisance. Note that ASHP noise levels are typically 50dBA@1m, whereas background noise levels at night are typically 35dBA. Furthermore the need for ASHP to regularly run defrost cycles (at night) means that there is a significant potential for noise nuisance.

The general advice for heat pumps it that they are suited to properties with high levels of insulation (an EPC C or above) – the rule being to reduce demand first in order to limit the size of the heat pump and how hard it has to work (hard work = lower efficiency). This is reflected in government-endorsed advice https://www.simpleenergyadvice.org.uk/measures/meta_air_source_heat_pump and the “fabric first” approach proposed in the latest consultation on privately rented properties (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932402/prs-consultation-october-2020.pdf)

The property was built in 1888 and has solid walls and small rooms, so the only viable options are external wall insulation and under-floor insulation. The prices I was quoted for external insulation were i.r.o. £15,000, including access scaffolding (difficult as there is no rear access to the property). With the GHG scheme this would be a net cost of £10,000. Furthermore consultation with the local authority confirmed that I would also require planning permission as the cladding would change the external appearance of the house (move from brick to a painted render).

I did not consider underfloor insulation as this would be too disruptive: however, I have subsequently found a new option in the Q-bot (www.q-bot.co) that uses an innovative remote controlled vehicle to spray insulation under the floorboards, costing around £2,500.

It is worth noting that according to the EPC report to move from the current D56 to C78 would require additional loft insulation (D58), wall insulation (D60), under floor insulation (D61), new condensing boiler (D68) AND solar water heating (C70) at a total estimated cost of £27,000. The EPC makes no mention of heat pumps. The impact on the EPC of the wall and floor insulation is small and hardly justifies the investment cost. The biggest single change would be to upgrade to a modern condensing boiler.

Adding solar PV alone at a cost of around £6,000 would take the EPC to C69 in one step.

The EPC alone is neither sufficient nor accurate enough for the homeowner to make informed decisions. Best practice before embarking on any retrofit programme is to carry out a full retrofit assessment – this includes a room-by-room energy assessment. The Retrofit Assessor then provides a detailed report on the options which enables to the homeowner to plan and budget for the retrofit actions (see for example https://carbon.coop/portfolio/home-energy-assessment/). A typical assessment costs i.r.o. £600 (compared to under £100 for an EPC). It is vital that homeowners understand how their home can be improved, so government should consider supporting through grants a retrofit assessment for hard to treat homes at as a minimum (e.g. EPC D or lower).

There is some considerable debate as to whether ASHP is an appropriate or optimum solution for all the 25 million homes currently connected to the gas grid. An ASHP is not a direct replacement for a boiler. ASHPs require a well-designed, thermally insulated home to provide their optimum performance, together with a behavioural change with respect to how the heating system is operated. ASHP don't work well with sub-zero outside temperatures (lowered coefficient of performance (COP), lower flow temperatures and increased defrost cycling) and as a result hybrid solutions (ASHP + boiler) have been proposed. However, this is effectively replacing a boiler with an ASHP + boiler in combination, significantly increasing both capital and maintenance costs and significantly increasing space requirements.

To make a home truly ready for ASHP requires not only consideration of the insulation, but treatment for draughts and then to understand the knock-on effect of these improvements on ventilation and air quality (so called "deep retrofit"). It is hazardous to treat these in isolation, risking air quality degradation (e.g. condensation and mould build-up), and failure to achieve projected thermal efficiency gains (e.g. fabric has too many thermal bridges or draughts are not dealt with) and as a result the home is colder or energy bills higher with the ASHP.

An ASHP is not a simple upgrade and should not be treated or promoted as such. However, for new-build it can be an ideal low carbon heating solution, so it is vital that all new builds from now on are appropriately designed with insulation, draught proofing and ventilation for minimum energy requirements. The building regulations need to reflect the priority of fabric over the installation of for instance solar water or solar PV to achieve target EPC levels.

So what are the options for low carbon heating for a Victorian terraced house?

An ASHP is not suitable due to noise levels, space requirements and the need for significant upgrade to building fabric. As stand-alone project the capital cost of £35,000 for heat pump and fabric upgrades is prohibitive. The fact is that the Victorian terrace house is not optimally designed to suit an ASHP is another barrier. If I took action today, I would restrict my investment to a modern condensing boiler.

There could be options for whole streets to connect to a district heating network or adopt ground source heat pumps (using shared boreholes, therefore shared costs). The heat pump unit in this case is much smaller and suited to small, space constrained properties. The ground source heat pumps have higher operating efficiencies (COP) than ASHP. The capital costs are much higher than ASHP and homes will still need to have significant upgrades to building fabric. However, there may be scope for grant-funded district heating schemes of this type (installing ground heating loops and fabric upgrades) and this should be investigated.

Are there simpler and easier to deploy options that are still low carbon?

The conceptually simplest is the H_2-ready boiler (installed now to burn methane, but upgraded in the future to burn H_2). The existing gas pipe network will be compatible with H_2 (the upgrade program to replace steel and cast iron with polypropylene pipes is due to complete in 2032). However, the production of H_2 either from methane (with CCS) or by direct hydrolysis using wind energy are very inefficient uses of valuable low carbon energy (100kWh wind energy gives 45kWh of heat http://www.csrf.ac.uk/2020/09/hydrogen-for-heating/). To convert the gas grid to H_2 would require a massive increase in renewables, well beyond the government's already ambitious targets. Furthermore an H_2 grid would not store as much energy in the pipes, so would be much less resilient in time of high demand. The cost/kWh for H_2 is unlikely to be lower than the current cost of electricity per kWh.

A further option would be to inject H_2 into the current gas grid – boilers can already cope with 20% hydrogen - and develop a grid based on bio-methane from marginal or under-grazed grass (see for instance https://www.ecotricity.co.uk/content/download/397/file/green-gas-report.pdf). This would require no change to existing boilers and a significant reduction in the carbon intensity of the gas grid. As with H_2 alone, the gas will be more expensive per kWh than current grid gas.

And gas at the moment is artificially cheap, as there are no carbon taxes or environmental charges on the bill (unlike electricity that has the social and environmental obligation levy supporting renewable generation and other programs).

Nevertheless there is a serious option to use of direct electricity to a thermal store. These could either be traditional night storage heaters or the more recent development of "block" thermal stores (so called heat batteries) that exchange stored heat to water and offer capacities and performance similar to gas boilers. Examples of heat batteries are Sunamp, tepeo ZEB and Pumped Heat (the latter two are at beta test stage, the former is commercially available). These are sized to directly replace a boiler with no requirement to re-design your radiator or hot water systems or change your behaviour with respect to how your home is heated/comfort expectations. They are larger than boilers, so need space, but can be mounted outside so the space issue is much less critical (and no noise nuisance).

Unlike ASHP, thermal energy stores are not in continuous on/off operation – they can be set to "charge" when energy costs are lowest (usually when the grid is greenest) and release heat energy to meet demand. Furthermore, they could be used to help with grid balancing, providing demand-side flexibility.

Such storage systems would also lend themselves to an alternative business model of "heat as a service" – where the hardware is owned and controlled by a utility and the heat is sold to the homeowner on a metered heat basis. This merits further investigation and pilot projects. Heat as a service is also a way to deliver heat to vulnerable customers, removing the need for them to make capital investments.

The ability to separate the heat demand from the electricity demand is a potential game-changer. However, there are issues to address therefore in how the electricity is charged at times of low demand to encourage development of these smart systems.

A typical electricity bill only 33.3% is the wholesale cost of the power. For a 15p/kWh tariff, say, 5p/kWh is the wholesale cost, 3.45p/kWh is social and environmental charges, 3.3p/kWh is network costs and 3.3p/kWh operating costs (https://www.ofgem.gov.uk/data-portal/breakdown-electricity-bill).

The government low carbon plan includes a very large increase in the amount of renewable generation (mainly offshore wind), which will only increase the mismatch between generation and demand. Cornwall Insight estimates that by 2033/34 wholesale electricity prices will be negative for 13% of the year and over 12p/kWh for 9% of the year (https://www.cornwall-insight.com/newsroom/all-news/imbalance-prices-turn-negative-for-six-straight-hours).

This mismatch should drive significant price variations between peak and off-peak electricity in a properly functioning market. Market pricing policies should drive economically beneficial behaviour in consumers. Right now if the wholesale price is zero and all other charges remain the same, the consumer would still pay in the region of 8p/kWh if this zero price was passed on to them by their supplier. Likewise if the wholesale electricity price is 12p/kWh the consumer would pay in the region of 22p/kWh. There is some incentive here to load-shift, however the price structure do not reflect the benefit to the system of customers being able to absorb energy at times of zero or negative wholesale prices.

Octopus Energy's Agile tariff is unusual in that the pricing structure is designed to pass on negative prices to the consumer (the grid and social/environment charges are a fixed multiplier of the wholesale price), thus encouraging load shifting (https://octopus.energy/static/consumer/documents/agile-report.pdf). Octopus admits that this tariff is still a trial, but the massive shifts in demand away from peak and towards night time consumption provides a clear message that consumers will engage with their energy if they are given the tools to do so.

Current market rules do not well incentivise consumer to load shift. However, load shifting at peak periods is a very good thing as it reduces the required size of the network and the amount of standby generation.

For TOU tariffs to become main-stream will require changes to system charges, the completion of the rollout of smart meters, the development of smart products and smart control systems (with in-build algorithms to predict demand and optimise consumption at times of minimum cost/minimum grid carbon intensity). All of which the government needs to encourage and support.

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