Consultation Response
17th June 2019

The future of low carbon heat for off gas buildings
A call for evidence

The Energy and Utilities Alliance (EUA) provides a leading industry voice helping shape the future policy direction within the sector. Using its wealth of expertise and over 100 years of experience, it acts to further the best interests of its members and the wider community in working towards a sustainable, energy secure and efficient future. EUA has six organisational divisions - Utility Networks, the Heating and Hotwater Industry Council (HHIC), the Industrial & Commercial Energy Association (ICOM), the Hot Water Association (HWA), the Manufacturers' Association of Radiators and Convectors (MARC) and the Natural Gas Vehicles Network (NGV Network).

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1. What evidence can you provide of low carbon heat technologies being taken up without government support?

According to statistics produced by Bsria there were 16,500 heat pumps (ground and air) sold in the UK in 2017. Of these 7,000 were installed through the RHI scheme. In the first quarter of 2018 9,500 heat pumps were installed and 3,000 of those were through the RHI. This would indicate that the proportion installed without government support is growing.

For Solar Thermal approximately 3,500 panels were sold in 2018, 450 through the RHI. This indicates that the majority are sold without government subsidy. However, we believe this is because some of the larger growth sectors for renewables are not supported by the RHI. Therefore we would suggest that greater government support would lead to much higher sales. It is also important to note that these sales numbers are significantly below the original targets for the RHI or the required numbers for meeting our carbon budgets.

2. What other barriers may impede the uptake of low carbon heat in buildings not currently using mains gas?

OFTEC have said, industry figures reveal that, unless wholesale and very expensive improvements are made to the energy efficiency of the home, heat pumps can cost up to 88% more to run than high efficiency oil boilers. This could leave rural consumers facing a rise in their heating bills of up to £750 per year. In addition to much higher running costs, even with the incentive payments currently available through the domestic Renewable Heat Incentive (RHI) scheme, heat pumps still cost at least £6,000 to install, making them prohibitively expensive for most households to take up. This excludes the cost of fitting the larger radiators and additional insulation often required for heat pumps to work effectively in rural properties, which tend to be older and less well insulated.

Similarly, the NIC found that, the cumulative discounted additional system cost to 2050 in a high heat pump scenario is substantial, at £214 bn in the Central case, targeting buildings requiring only Low, or Medium cost efficiency measures. The dominant contribution to the additional cost is that of the heat pump itself and the cost of replacing the heat distribution system, where required, which amounts to £192 bn (discounted) in the same scenario.[1]

Further, the NIC say that Heat pumps are suitable only in buildings with a sufficient level of thermal efficiency, while other buildings will require some level of energy efficiency retrofit alongside installation of a heat pump. This analysis estimates that more than 10 million buildings would require an energy efficiency intervention before a heat pump would be suitable.[2]

Other options may require boiler upgrades, but industry will continue its work to bring to market a low carbon bio liquid fuel to start replacing heating oil from 2022. The new fuel would work on existing high efficiency oil boilers following a relatively simple and low cost modification.[3]

With regard to other options for off grid, EUA believes that rural heat networks would be complicated and expensive. Whilst it can be argued that a rural heat network has fewer constraints with regards to installation, there are still significant barrier to implementation. Firstly, there has to be a sufficient energy source. It has been discussed that water source heat pumps could be used in local rivers and lakes. However these require significant upfront costs. They would then have to be connected to homes which would necessitate the digging up of all the roads in a small conurbation. Given smaller locations do not have access to alternative routes and access, this could be worse than similar works in more built up areas. Then the economics of a rural heat network would be complicated.

To offset the high upfront cost of the heat source the provider would have to assume that all people in the town/village, or at least a significant number would have to sign up to the scheme. Additionally, there needs to be a fairly high density of housing (+50 per hectare) in order for the heat network to economic – most rural locations do not meet this threshold. There are a number of competition issues here. What happens is a new home owner doesn't want to be part of the network. Will people be required to sign up in advance? Who will pay for the new heating system? We are aware that the CMA are looking into this area and will present options for new heat networks. However, we think given the limited number of customers on a rural heat network and the relatively high cost of heat, it is unlikely to be a viable option. Other options to be considered will be tough local planning restrictions, areas of natural beauty and other listed restrictions. We believe that prior to Scotland making any recommendations on rural heat networks, a full independent review should be undertaken in order to assess any potential barriers and costs.

Some have suggested heat as a service models to encourage the uptake of low carbon technologies, like heat pumps. The barrier to these models is not the models themselves, but consumer apathy to innovation in this space. People want heat, they are comfortable with the current model and effectively buy it as a package already when using comparison websites. When the appliance breaks they will choose the model appropriate to them at the time. However we

[1] https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf
[2] https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf
[3] https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf

believe that consumers are wary of products that are new to them and models that add complications like the non-ownership of the appliance. Unlike with cars where a consumer has a new car every few years, heating appliances have far less social value.

3. What could we do to remove these barriers and support the uptake of low carbon heat? Can you give examples of successful low carbon heat implementation?

The question for Scotland is what approach are they looking for? If the goal is to install more efficient boilers then the current approach could be improved by encouraging private landlords to change their heating, and this could be regulated. The current ECO scheme then offers assistance for vulnerable households, even if the evidence suggests there is still not enough funding to help all those in need.

If Scotland are looking for a way to mitigate the upfront cost of a heat pump then they are going to need to first reduce the heat demand from Scottish homes. The Danish model cited in the call for evidence works presumably because the low heat demand of the homes allows for cheap and small appliances to be installed. This is not the case in the UK where the most popular sizes of heat pumps are still extremely large. Therefore, the only alternative approach would be for government to fund new heat pumps, which would not be cost effective.

Whilst it is tempting to offer incentives for insulation when a boiler is installed, or to attempt to enforce it, in practice the consumer is not motivated to do multiple measures. One comment from installers is that insulation is not an attractive business proposition. The additional income is not substantial and the work is messy and cumbersome. If they have been asked to replace a boiler that is the work they will undertake. Scotland could look to try and incentivise multiple installations, or attempt regulation again, however the evidence is that consumers are not demanding this approach.

We are also concerned that attempts to regulate for this could lead to a backlash against the policy as has been seen with other attempts at consequential improvement legislation. EUA does believe that a whole house approach would be beneficial and we will work with our members and installers to see if there are any further ideas or innovations that emerge which could assist with this concept.

A number of partners have been attempting to create awareness in alternative heating for decades and the empirical evidence shows that consumers still just want to replace their existing appliance for the same one. The evidence points out that consumers are happy enough with the service from most existing appliances. They are cost effective to run, relatively cost effective to purchase, and they understand how to use them. Our members tell us that consumers are increasingly interested in smart heating controls and the ability to control these with their phone. However, this level of interest does not extend to their heating appliance. In order for consumers to become interested then the alternative has to offer a radically different set of outcomes. Electric cars are becoming more popular because they are cheaper to run, have better performance in some cases and technically can be charged anywhere there is a power socket. Heating options are not currently in that space.

A heat pump will offer no additional benefits to a consumer over a gas boiler. It will heat the house to a comfortable temperature and provide hot water, however it will be more expensive to run and more expensive to buy. Heating remains a deeply functional service and so consumer awareness will remain low. Scotland could spend a lot of money promoting new heating systems but there is little evidence this will make any difference to consumer purchasing behaviour. This is also supported by consumer research in this area.[4]

This is one reason why EUA supports the move to decarbonise the fuel rather than the appliance. Decarbonising gas would mean that consumers would not have demand a new product, they can continue to make the same purchasing decisions and yet their heating would become decarbonised. This seems simpler and more achievable than changing consumer behaviour and trying to raise awareness of new products that offer the same service just at a much higher cost. Gas grid extension requires capital investment for a pipe network, but provides an immediate carbon reduction compared to thermal electric heating, coal, oil or LPG. Combined with smart hybrid heating and green gas, decarbonised heat is a possibility with a gas mains extension. This would probably be limited to urban and semi urban areas. Rural areas would require use of either BioLPG or a bio oil.

BioLPG and Biopropane are terms used to describe LPG which is derived from production processes that use a variety of biological materials as feedstocks, including waste streams. Importantly, biopropane or BioLPG is chemically indistinct from LPG and so can be used as it is, just like conventional LPG. This also means that it can be 'dropped-in' to existing supply chains and appliances without the need to modify existing infrastructure or the technical specifications of LPG gas appliances. This sets it apart from bio liquids that cannot be blended with their conventional counterparts and thus require new infrastructure to transport and appliances to be fully compatible.

Unlike other forms of bioenergy, BioLPG is non-corrosive and so existing LPG storage and distribution infrastructure does not require any upgrade investment. Although not a wholly zero carbon fuel source, biopropane could offer an opportunity for LPG households to significantly reduce their carbon footprint by up to 90% compared to fossil LPG. The combustion of biopropane does result in carbon being emitted, but this is offset by the carbon that was removed from the atmosphere when the biomass feedstock was cultivated. However, the production of biopropane does produce carbon dioxide. Carbon emissions will result from the fertilisation of the feedstock, as well as from the transformation of the feedstock into a useable form of bioenergy. The exact carbon footprint of biopropane depends upon all of these factors, but also upon whether it is defined as a residue or a co-product under the European Union's Renewable Energy Directive (RED).

In the following analysis, we consider the use of biopropane that has been generated as a waste product of NESTÉ Oil's HVO biodiesel refining process. This has been classified as a residue under RED, with a carbon footprint of 0.036 kgCO2e/kWh. We consider the future emissions from three scenarios: Scenario 1 – All households currently using LPG as their primary heating fuel continue to do so. For simplicity, it is assumed that LPG use for residential heating maintains its current level of 0.93 million tonnes per annum (approximately 12.7 x 109 kWh). Using the DEFRA carbon

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/191541/More_efficient_heating_report_2204.pdf

9 factor of 0.21468 kgCO2e/kWh, this results in annual carbon emissions from residential use of LPG of 2.7 MtCo2e.

Scenario 2 - In this scenario, a tenth of the off-grid households that currently use LPG make the switch to biopropane each year. In this way, biopropane use is universal by 2025. Scenario 3 - All households that currently use LPG make an immediate switch to biopropane. This scenario would not be technically feasible at present, but is included for illustrative purposes. The annual carbon dioxide equivalent (CO2e) savings from each of the scenarios are presented in the table and graph below. Scenario 1 results in emissions of 2.7 million tonnes of CO2e (Mt CO2e) for each of the next ten years. The incremental switching approach in Scenario 2 reduces emissions by an additional 0.22 MtCO2e each year, resulting in annual emissions of 0.46 MtCO2e in 2025. The wholesale switching seen in Scenario 3 reduces annual emissions immediately to 0.46 MtCO2e and maintains this level until 2025.

The cumulative carbon savings are presented in the table and graph below. Scenario 1 results in cumulative carbon emissions of 27.2 MtCO2e by the end of 2025. Scenario 2 improves the situation, with cumulative emissions of 14.8 MtCO2e by 2025 – a saving of 12.5 MtCO2e in 10 comparison with Scenario 1. Scenario 3 results in cumulative carbon emissions of 4.6 MtCo2e – saving 22.7 MtCO2e in over Scenario 1.

Unlike other low-carbon heating alternatives, the use of biopropane does not face significant barriers to uptake. It requires no additional capital outlay, nor does it require the householders to change the way in which they use their heating system. Alternative technologies, such as heat pumps, may require new radiators and better levels of insulation in order to facilitate a lower temperature heating circuit.

Instead, householders will merely purchase a different fuel and their heating system will continue to function as before. Consequently, eliminating the price differential between LPG and biopropane would provide sufficient incentive to stimulate the uptake of biopropane. When discussing biofuels, it is often mentioned that their mass production can result in land use changes. These changes could exacerbate climate change, decrease biodiversity and have a negative impact on food security. However, as stated in DECC's 2014 Evidence Report: Biopropane for Grid Injection: "biopropane has an advantage in this respect, because it can be sourced to a large degree from non-food feedstocks, such as inedible fractions of palm oil, animal fats and wastes (such as used cooking oil)." As long as adequate sustainability 11 criteria are imposed – such as those imposed upon biomass under the RHI – the use of biopropane should have no negative ecological consequences.

As with any new energy source, it is necessary to evaluate the current capacity and potential scalability of the UK market. Initially, it is estimated that 40,000 tonnes of biopropane will be available within Europe annually. The vast majority of this would be destined for the British market and would be sufficient to heat 30,000 homes. Calor introduced BioLPG to the UK in March of this year demonstrating that this is not a future technology, but one available to homes today.
Over the coming years, global production of biopropane could be increased dramatically by taking advantage of worldwide HVO production and developing new pathways for production. For example, biopropane can be produced through the conversion of biomass feedstocks into syngas using gasification; followed by catalytic conversion of the syngas into methanol, di-methyl ether and finally biopropane.

Initial industry research shows that waste derived (using household waste) biopropane could cost slightly less than current prices for fossil LPG and significantly less that technologies such as heat pumps. A report published by GreenEA4 in September 2015 estimated that the production capacity of HVO within Europe will increase by 88.5% in the next three years. This rate of growth would be sufficient to sustain the deployment detailed in the second scenario in our analysis.

4. How can complementary systems, such as solar PV and heat pump systems be deployed to overcome such barriers?

EUA are aware of the Western Power Distribution/Wales & West Utilities Freedom project which is testing smart hybrid heating systems – i.e. use a heat pump powered by renewable electricity when available and the existing boiler (preferably using a bio fuel) the rest of the time. Tests indicate that renewable electricity may be available 75% of the time in the future 2050 scenarios. WWU report that there would not appear to be any reason why smart hybrid heating can't be retro-fitted to an oil fired system as the technology in Bridgend has developed with retrofitting in mind.[5] The majority of the 75 installations are actually two independent systems dovetailed and controlled by the smart software.

The Freedom Project, run by Wales and West Utilities and Passiv Systems, is a project assessing the use of hybrid heat pumps in and around Bridgend in Wales. Most of the installations are for on gas-grid properties, however three are off gas grid. A normal heat pump is installed in the property and the smart controls switch between using the heat pump and the gas boiler (running on either LPG or natural gas), dependent on the cost of the electricity, the demand in the network, or the carbon intensity. The project has been running for well over a year and the initial feedback from occupants is that they are paying less for their bills. For the off gas grid property, the householder has noticed not having to arrange as many gas deliveries, with LPG consumption down by about 70%. We would caution over the extremely limited sample size in this case.
Having said this, unless Scotland can make hybrids the same price as current appliances, whilst adding the required electricity production and reinforcement, this approach may not be cost effective. We are not sure what else can be done to target these barriers. The best way to eliminate barriers to low carbon heating is to decarbonise the fuel and allow households to keep their appliances. This is why we support biofuels as the primary way to decarbonise heat.

5. What do you consider to be the principal building-specific constraints on low carbon heat?

Scotland has significant areas of rural, hard to treat properties with low EPC ratings that would take significant amounts of spending to reach a decent EPC rating. Heat pumps require large investment in building fabric to insulate them, the heat pump themselves, rural electricity grid reinforcement and standby generation for when renewables are not generating at a high load factor, such as in the winter. Such investment is unlikely to pay back in financial terms, which may explain their limited take-up. Payback periods are very long, typically between 35-45 years, putting them beyond a consumer led route to decarbonisation. This makes heat pumps an extremely costly and unsuitable choice for rural Scotland, therefore Scotland should look to bio oil, or bio LPG instead, as they do not require significant changes to the home. Indeed, the recent CCC report stated that Scotland is the best placed region for BECCS plants to locate.[6]

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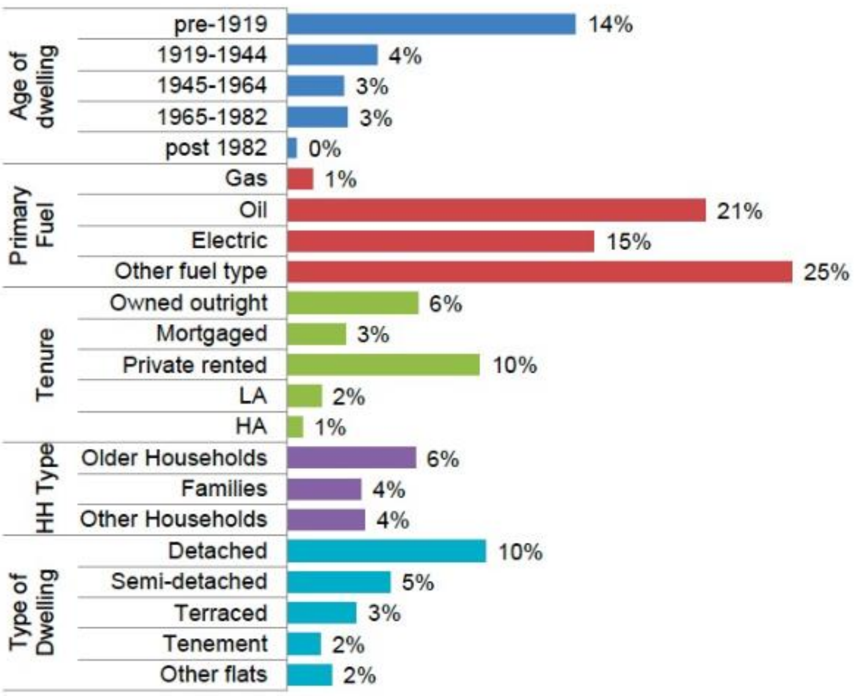
[5] https://www.theguardian.com/environment/2017/oct/08/pollutionwatch-log-fires-are-cosy-but-their-days-may-be-numbered 9
[6] https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

There are also major building related issues when replacing a boiler in an existing heating system with an Air or Ground Source Heat pump. Firstly the radiators are almost certainly too small as they would have been sized to run on an 80/60c flow and return regime. A Heat pump typically runs most efficiently at a flow and return regime of around 40/30c. Therefore, unless the radiators were originally oversized and also significant insulation upgrades have taken place within the house then they will need upgrading.

It is quite rare for the heating system to be replaced and not unusual for the third or fourth boiler to be connected to the same heating system and radiators. With nearly 17m Combi's installed in UK properties then it is a real issue to replace one of these with a Heat pump. You cannot get Heat pump Combi's so now you will have to find a location within the already too small house to locate a hot water storage cylinder. Further, hot water cylinders are not as popular as they used to be and sales have declined steadily since 2001. If we also move to lower temperature heating devices, such as heat pumps, then the energy use needed to generate hot water will increase. Heat pumps need a hot water store, they cannot generate hot water on demand.
The below graph displays the proportion of homes in band F or G in Scotland by dwelling age, primary heating fuel, tenure and dwelling type in 2017.[7]

Figure 13: Proportion of Homes in Band F or G by Dwelling Age, Primary Heating Fuel, Tenure and Household and Dwelling Type in 2017 (SAP 2012)



Primary heating fuel is a key determinant of the energy efficiency of the dwelling. Properties heated by mains gas have an average rating of 66.8 and 47% are in band C or better.[8] Dwellings heated by other fuels (including electric and oil) have considerably lower ratings. The average energy efficiency rating for oil heated properties is 50.2 (making the average dwelling in this group E rated) and only 9% are in band C or better. Proximity to the gas grid has a similar effect on the

[7] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/5/
[8] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/5/

energy efficiency rating (average SAP rating 65.6 for dwellings near the gas grid, higher than the 57.5 for other dwellings).[9]

As dwelling characteristics associated with lower energy efficiency are disproportionately represented in rural areas, the average energy efficiency profile of rural properties is lower than that for urban; table 21 shows that mean SAP 2012 rating is 66.1 for dwellings in urban areas, higher than the 54.9 for dwellings in rural areas. This shows that there are still many homes that are unsuitable for heat pumps and are unlikely to ever be suitable, unless tens of thousands are spent retrofitting them. Of the oldest, pre-1919, properties only 17% rated C or better.[10]

6. What can be done to overcome these constraints?

Not much can be done to overcome the constraints- retrofitting homes requires significant investment, and heat pumps are unlikely to become any smaller, so space will always be an issue. A recent Dutch inspired retrofit project in Nottingham cost £85,000 per house, so clearly it is not an answer for most properties.[11]

Instead, it would be more cost effective to connect homes 25m from the gas grid to the grid, whilst simultaneously decarbonising the supply. For those homes on oil, it would be better to switch to bio oil, or bio LPG as it would not require a technology change, or spending more money on the house trying to overcome issues with insulation.

There is also a reluctance from consumers to spend time and money upgrading the EPC of their home, which is a requirement for heat pumps. To support this assertion, we cite the BEIS consumer attitudes tracker.[12] The October 2018 edition showed that only 2% of respondents had ever acted on the advice in an EPC.[13] This is further supported by data on the number of energy efficiency measures installed every year. For fabric measures, the number of installations drops in line with reductions in financial support. This clearly indicates that if they are provided free of charge some people may take them up, but consumers are unwilling to pay for them, especially if the market does not reward high usage reduction.

7. What evidence can you provide on the limitations of low carbon heat technologies (e.g. heat pumps) in buildings with poor energy efficiency?

Heat pumps operate more efficiently at lower output temperatures, and are therefore less suitable in thermally-inefficient buildings where high temperature heating may be required during cold periods.[14] These factors mean that heat pumps are effectively suitable only in buildings of a sufficiently high thermal efficiency.[15]
According to the NIC, heat pump heating is found to be the most costly of the main pathway options under most scenarios. Despite the substantial electricity network upgrade costs (in the

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9 https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/5/
10 https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/5/
11 https://www.theguardian.com/society/2019/jan/07/dutch-eco-homes-idea-arrives-in-uk-and-cuts-energy-bills-in-half-nottingham-energiesprong
12 https://www.gov.uk/government/statistics/beis-public-attitudes-tracker-wave-28
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15 https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf

region of £20 bn), the largest share of the cumulative discounted system cost (exceeding £200 bn) is associated with investment at the building level, in the heat pump unit itself and the accompanying energy efficiency and building renovation work required in many cases.[16] Heat pumps are likely to be suitable only in buildings with a minimum level of thermal efficiency, and hence the cost of this option is dependent on the depth of energy efficiency retrofit required to render the building suitable.[17] Such investment is unlikely to pay back in financial terms, which may explain their limited take-up.

The threshold for heat pump suitability is not clear-cut, and depends on the heat distribution system within the building, how appropriately the system is designed and installed, and the way in which the heat pump is subsequently operated by the user.[18] However, the requirement for sufficient building thermal efficiency is a key factor which will influence the cost and practicality of a heat electrification pathway, as widespread deployment of heat pumps is likely to require the renovation of millions of buildings with energy efficiency measures and, in many cases, new heat distribution systems.[19] Such a scenario would also require a behavioural change in the millions of consumers switching to heat pumps, to ensure appropriate system operation. As previously mentioned, the BEIS public attitude tracker survey reports most are unwilling to take up EPC measures, and very few are interested in switching to heat pumps.

The UK Government's analysis estimates that more than 10 million buildings would require an energy efficiency intervention before a heat pump would be suitable.[20] Whereas, for biopropane, gas and LPG no energy efficiency measures are required. This evidence leads us to the conclusion that electric heating is unaffordable for consumers and also unwanted, therefore Scotland should focus on decarbonising existing appliances. We believe that the consumer must be at the heart of the decarbonisation drive, and not be forced to implement measures they disagree with.

8. What low carbon heat solutions are appropriate for hard-to-treat properties where there are limited opportunities to improve energy efficiency of the building fabric?

EUA supports the move to decarbonise the fuel rather than the appliance. Decarbonising gas would mean that consumers would not have to purchase a new product, they can continue to make the same purchasing decisions and yet their heating would become decarbonised. This seems simpler and more achievable than changing consumer behaviour and trying to raise awareness of new products that offer the same service just at a much higher cost.

Gas grid extension requires capital investment for a pipe network, but provides an immediate carbon reduction compared to thermal electric heating, coal, oil or LPG. Combined with smart hybrid heating and green gas, decarbonised heat is a possibility with a gas mains extension. This would probably be limited to urban and semi urban areas.
Rural areas far away from the gas grid would require use of either BioLPG or a bio oil. BioLPG and Biopropane are terms used to describe LPG which is derived from production processes that use a variety of biological materials as feedstocks, including waste streams. Importantly, biopropane or BioLPG is chemically indistinct from LPG and so can be used as it is, just like conventional LPG.

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[16] https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf
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[20] https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf

This also means that it can be 'dropped-in' to existing supply chains and appliances without the need to modify existing infrastructure or the technical specifications of LPG gas appliances. This sets it apart from bio liquids that cannot be blended with their conventional counterparts and thus require new infrastructure to transport and appliances to be fully compatible. Unlike other forms of bioenergy, BioLPG is non-corrosive and so existing LPG storage and distribution infrastructure does not require any upgrade investment.

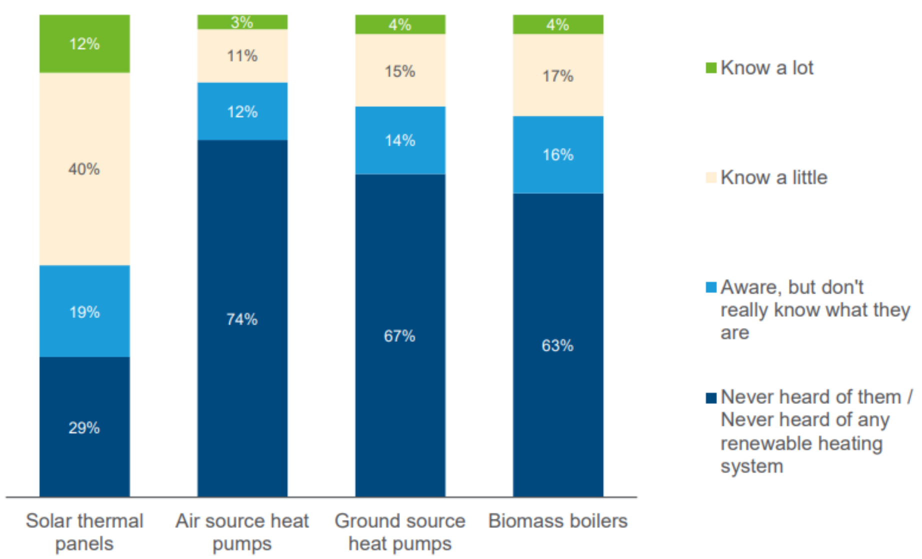
Although not a wholly zero carbon fuel source, biopropane could offer an opportunity for LPG households to significantly reduce their carbon footprint by up to 90% compared to fossil LPG. The combustion of biopropane does result in carbon being emitted, but this is offset by the carbon that was removed from the atmosphere when the biomass feedstock was cultivated.

10. What factors might inhibit uptake of heat pumps?

Heat pumps require large investment in building fabric to insulate them, huge upfront costs for the heat pump themselves, rural electricity grid reinforcement and standby generation for when renewables are not generating at a high load factor, such as in the winter. Such investment is unlikely to pay back in financial terms, which may explain their limited take-up.

Consumer awareness about heat pumps is also a factor, as the BEIS public attitude tracker shows, in December 2018, people were more aware of solar thermal panels (71%), than other renewable heating systems (38% were aware of biomass boilers, 33% were 7 aware of ground source heat pumps, and 27% were aware of air source heat pumps). The most common reasons given for being unlikely to install renewable heating systems were that it would cost too much to install (30%) and not being able to install them as they did not own the property (24%). In December 2018, two thirds (66%) of the public said they would only replace their heating system when their current one breaks down or starts to deteriorate, with 12% saying they would consider replacing their heating system while it was still working.[21]

Figure 14: Awareness of specific renewable heat systems, December 2018



[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776657/BEIS_Public_Attitudes_Tracker_-_Wave_28_-_key_findings.pdf

11. What do you propose as solutions to overcome any barriers to uptake?

There is no way to overcome the barriers to uptake. Heat pumps are already a developed technology, so further innovation is unlikely to bring down costs, size, or operation. Instead, the Government should be looking into low carbon gas and oil. Hybrid heat pumps would come closer to solving the energy efficiency requirement of buildings, however given the prohibitive costs, for widespread use, bio gas or bio oil will be a much more cost effective method.

12. What innovations could reduce the operational cost of heat pumps, i.e. higher performing heat pumps, new refrigerants, 'time-of-use' tariffs coupled with thermal storage, and 'heat-as-a-service' business models?

Unless Scotland can make heat pumps the same price as gas boilers, require less remedial work to the home, and work effectively in cold temperatures, whilst adding the required electricity production and reinforcement, these approaches will not work. We are not sure what else can be done to target these barriers.

There is little evidence to support the statement that novel business models work for heating appliances. A lot of faith is being placed on selling heating in a different way without the empirical evidence to support it. The two models that exist are buying in full from an installer or buying on credit. The latter is growing popularity but the report EUA has seen shows that it is still a fraction of the market. We suggest Scotland ask companies such as British Gas what information they can provide on this point.

Further to that, it is hard to envisage another model entering this market. This is because it would require the existing supply chain to embrace it, or develop a new supply chain. New entrants to the market are using internet selling as the key innovation. Boxt for example are selling boilers through a simple form on their website, offering a fixed price for installation and a guaranteed installation date. The push from Boxt is also for monthly payments. Our understanding is that they remain an outlier at the moment, but with a lot of potential for growth. It is hard to see other models for providing heating systems that could be compatible with this market, or other models that have been proven in other markets. For other big purchase items, credit is the main driver. This is something that is already available in the heating industry.

The other model that has been proposed is one where consumers don't own the appliance but pay a heating charge to a supplier. For clean heating the supplier would take the renewable heat incentive if one were available. The charge to the consumer may be smaller therefore that the total repayment cost of the appliance. Whilst there is an appeal to this model it is still effectively a credit arrangement just repackaged. The barrier to these models is not the models themselves, but consumer apathy to innovation in this space. People want heat, they are comfortable with the current model and effectively buy it as a package already when using comparison websites. When the appliance breaks they will choose the model appropriate to them at the time.

However, we believe that consumers are wary of products that are new to them and models that add complications like the non-ownership of the appliance. Unlike with cars where a consumer has a new car every few years, heating appliances have far less social value. Scotland don't need to stimulate this market. They tried with the Green Deal and it failed. If the market demands alternative payment models, they will emerge and the ones that work best will succeed. The role of Government is to ensure novel models do not exploit vulnerable consumers or lead to inappropriate selling.

EUA believe that from an economic stand point the encouragement of capital markets to provide green investments comes as a result of a harmonisation between both supply and demand side stimuli. Initial analysis of the supply side shows that capital markets and the companies within them, inherently operate under the main objective of profit maximisation. Therefore, in order to foster private investment on financial products that promote energy efficiency measures, such initiatives should also be seen to deliver low risk capital gains for the company that is offering them. Only then will the private sector be willing to engage in such operations.

Evidence from green mortgage initiatives suggest that leading mortgage lenders perceive green mortgages as carrying a lower financial risk. The reasoning behind this is twofold. Firstly, increasing the energy efficiency measure of a property means home owners demand 25 less energy and benefit from lower energy costs, in turn increasing their disposable income levels. Home owners in this position pose a lower lending risk as they are less likely to default on mortgage repayments due to the windfall of extra money.

Additionally, there have been studies to show that improvements in the EPC ratings of houses have a positive correlation with property value, further improving their risk profile. As mortgages are the heart of the EU economy accounting for approximately a third of EU banking assets, involvement in green mortgages appears to be a lucrative business opportunity from a supply side perspective. From the viewpoint of demand, sufficient consumer interest in green finance needs to be in place for the private sector to engage in offering it. Social behaviour plays a pivotal role in what is offered by the capital markets. Therefore, it is important to educate people on the importance of energy efficiency and the long term future of finite resources.

A consumer insight study was carried out by the UK Green Building Council across United Kingdom Italy and Sweden. Upon which consumers were asked to rank a number of factors they consider to be important when buying a property. The outcome showed that 'how energy efficient a property is' was ranked least important out of 8 factors within the United Kingdom. This suggests that changes in social behaviours can only come as a result of improvements in education and the national curriculum putting a higher emphasis on the importance of energy efficiency and its impact on the climate change.

EUA remain ambivalent on the use of private finance as a means of fostering the uptake of energy efficiency measures by consumers. Previous green finance initiatives such as the green deal scheme failed to deliver the expected energy savings. Whilst government subsidy has a proven track record in delivering energy and carbon savings, we believe government should err on the side of caution when intrusting in private finance to promote energy efficiency savings. Our belief is that financing energy efficiency measures through consumer credit is a sub optimal strategy when attempting to increase consumer demand.

We believe there is very little evidence to support a relationship between financial measures which incorporate the use of consumer credit and the demand for energy efficiency measures. Focusing on domestic gas boilers, a recent market survey on how boilers are financed showed that a very small percentage of consumers used private finance for their purchase. The Green Deal also failed to create a finance market for boiler installation. Private finance for boilers is also widely available and at a competitive interest rate so Government intervention in this market is not necessary.

Air conditioning and heat pump technology is not new, nor is it in niche production. Therefore most of the costs are already at a low point through mass production. There may be technological developments that bring down the costs for certain components, but this will be limited. This technology is extremely mature and in production across the world, any innovations to bring down costs are probably already factored in. Industry will always look to produce product at the lowest possible cost as long as the product remain safe and efficient. The aim of the heat pump manufacturers is to maximise sales, therefore they will already be acting to ensure lowest cost. EUA believes that Scotland should be cautious about pursuing too much cost reduction in mature markets. Often this can lead to promotion of products that may not meet certain safety or efficiency criteria and may be inferior products.

14. What factors might inhibit uptake of hybrid heat pumps?

Low consumer awareness, space issues and cost might inhibit the uptake of hybrid heat pumps. To operate a heat pump, a new gas boiler is required alongside the current boiler, and of course the heat pump itself. In smaller houses there may be space issues, as heat pumps require a lot of room. The BEIS public attitude surveys reports that awareness of such low carbon heating is low, and people tend to prefer a like for like replacement when choosing a heating system, not one that is relatively unheard of, or more expensive. The total cost of a hybrid domestic heating boiler with its associated Air Source Heat Pump can be between £5,000 to £10,000, including installation. Ground Source Heat Pumps cost between £13,000 to £20,000 for installation and integration with the hybrid system.[22]

15. What do you propose as solutions to overcome any barriers to uptake?

Given the low uptake of hybrids because of their cost, and space requirements, government should consider subsidy or incentives for such technology.

16. Can you share any evidence on the types of buildings where hybrid heat pumps may best be deployed?

The UK Government's report on hybrid heat pumps found that, in general, heat pumps work most efficiently with smooth heating profiles (i.e. those where the peak heat demand is relatively close to the average heat demand), as this allows them to operate at low flow temperatures.[23] Buildings which are either small or highly thermally efficient require less heat to raise the internal temperature, and therefore are likely to have 'smoother' daily profiles, compared to larger, less efficient buildings.[24] These factors mean that in terms of overall efficiency and emissions, the

[22] https://smartrenewableheat.com/blog/what-is-hybrid-heat-pump-system-dual-fuel/

[23] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf

[24] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf

performance of HHP systems is likely to be best for small, efficient buildings.[25] However, for extremely efficient buildings with very low peak levels of heat demand, hybrid systems may not offer significant advantages over standalone heat pump systems. In such cases, the ratio between hot water and space heating demand and the selected strategies for meeting each of these are likely to be influencing factors in determining the pros and cons of hybrids versus standalone heat pumps.[26]

Table 3-11 Impacts of building type on cost and performance

Parameter	Options	Impact on product cost	Impact on performance
Building type	Examples: • Semi-detached house with no insulation • Flat with no insulation • Detached house with cavity wall insulation & roof insulation	• HIGH • Building energy demand determines sizing of heat pump and emitters • Building specifics affect installation costs	• HIGH • More efficient buildings will have lower and less variable energy demand, leading to higher heat pump efficiency and lower emissions

18. What factors might inhibit uptake of electric storage heating?

EUA's position on storage heaters is as a product they have a number of significant drawbacks which in our opinion render the use of electric heating in this form sub-optimal with regards to off grid homes. Through conducting in house cost analysis of storage heaters, particularly investigating replacement costs of an old storage heater with a newer more efficient one. We found that storage heaters are not a cost effective measure when attempting to meet the government's decarbonisation targets. They require two electric supply cables which will incur additional installation costs which is unavoidable if the fan is installed as supplementary heat.

Typically Storage Heating properties will be solid walls/floors which makes it difficult to add the additional cable required to power the fan. Controls can be difficult to understand and as such better/more education for the end user is required. More complex internal components potentially increase future repair costs. Due to the Load required for Storage Heaters they require double the load of Direct Acting Radiators these can use approximately 50% less energy compared to Night Storage heaters Ofgem (2018) suggest there to be 1.7 million storage heaters in situ off grid, for modelling purposes we take the assumption of a 50/50 split of the storage heating population in terms of new vs old and also further assume the cost of installing a new storage heater to be approximately £4,500.

Given this we calculate the cost of replacing 850,000 traditional storage heaters (half the population of storage heater in situ) to be £3,825,000,000. In terms of carbon savings, Ofgem

[25] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf
[26] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf

2018 suggest that old storage heaters require 7453kWh/yr on average, with this and the carbon factor of electricity being (0.4 kgCo2/kWh) as suggest by the Energy Savings Trust. We find the average carbon emissions of a single traditional storage heater is calculated to be approximately 2.981 tonnes. Further multiplication by 850,000 suggests that the aggregate carbon emissions of all traditional storage heaters to be 2,534,020 tonnes.

In a similar vein, we calculate the carbon emissions of new storage heaters. Ofgem 2018 suggest that new storage heaters require 6682kWh on average, therefore putting the average carbon emissions of a single new storage heater at 2.672 tonnes and the aggregate carbon emissions of all new storage heaters at 2,271,880 tonnes. Differencing the aggregate carbon emissions of all traditional storage heaters with new storage heaters gives us the level of carbon savings if replacement were to take place.

In order to monetise the aggregate carbon savings, a simple division of the carbon savings with the cost of replacement puts the cost per tonnes of carbon saved at approximately £14,591 per year. Further, discounting the cost of carbon saved across the lifetime of a new storage heater which we assume to be 25 years. We determine the cost of carbon saved of a full off grid replacement at approximately £583.66 per tonne. From the above deductions, our view is that despite the benefit of newer storage heaters being more energy efficient our belief is that the total cost on government in order to benefit from the carbon saving far outweigh the carbon savings.

Our view is that in order to viably and effectively reach the government's decarbonisation targets, those primarily utilising electricity as means of heating should be converted to mains gas where possible as a more cost effective fuel option. However, we understand that where this not feasible and if electricity is the only option governments should utilise Direct Acting Electric Products which are cheaper to install and have lower running costs based on evidence provided to us by the Electric Heating Company who have conducted detailed analysis in this area within 289 Flatted Properties/Sheltered Housing Dwellings. The Electric Heating Company are happy to share this information if required. They also would not need conversion to a wet central heating system as would be the case with conversion to a heat pump.

19. What do you propose as solutions to overcome any barriers to uptake?

None - instead the Government should consider decarbonising current appliances, or hybrid heat pumps in some circumstances.

20. Can you provide any evidence of electric heating technologies not already described that should be considered as potential future heating solution?

No, even after an major energy efficiency retro-fit in 26 million homes and businesses, it is estimated that to meet peak heat demand would require the equivalent of 30 new nuclear power stations, or 100 additional inter-connectors, 60,000 additional wind turbines (with back up) or every UK home to have solar PV (again with back up). On top of that, the UK's current distribution networks could not cope with such extra demands on them.

A recent study of Bridgend, produced by Wales and West Utilities, suggest that 81 per cent of households simply do not have the cash at their disposal to make that investment, without massive subsidies. The UK would also need to be entirely re-wired, from power station to the home to keep people warm and meet the UK's climate change obligation. That cost would also be borne by the consumer (voter). E&Y estimate the current additional cost per household, to increase sub-station capacity is £290 (urban) and £390 (rural).

24. Regarding Bioenergy technologies, what evidence can you provide on: a) the cost of the technology, including installation, maintenance, fuel and other running costs, and the extent to which costs of biomass boilers are in line with those in tables 2 and 3 above b) customer satisfaction with the system c) lifecycle and overall efficiency of the technology d) type of feedstock used, and whether this is grown in Scotland or imported?

Our understanding from conversations with manufacturers is that all current appliances are compatible with biofuels. So exiting oil and lpg boilers are able to run on bio fuel without additional cost. The installation would also be the same, therefore there would be no additional costs.

31. What factors might inhibit uptake of the installation of heat networks?

Heat networks require significant capital investment in household heat exchangers, a flow and return pipe network and a low carbon fuel source. Payback periods are very long, typically between 35-45 years, putting them beyond a consumer led route to decarbonisation.

Whilst it can be argued that a rural heat network has fewer constraints with regards to installation, there are still significant barrier to implementation. Firstly there has to be a sufficient energy source. It has been discussed that water source heat pumps could be used in local rivers and lakes. However these require significant upfront costs. They would then have to be connected to homes which would necessitate the digging up of all the roads in a small conurbation. Given smaller locations do not have access to alternative routes and access, this could be worse than similar works in more built up areas.

Then the economics of a rural heat network would be complicated. To offset the high upfront cost of the heat source the provider would have to assume that all people in the town of village, or at least a significant number would have to sign up to the scheme. Additionally, there needs to be a fairly high density of housing (+50 per hectare) in order for the heat network to economic – most rural locations do not meet this threshold.

There are a number of competition issues here. What happens is a new home owner doesn't want to be part of the network. Will people be required to sign up in advance? Who will pay for the new heating system? We are aware that the CMA are looking into this area and will present options for new heat networks. However we think given the limited number of customers on a rural heat network and the relatively high cost of heat it is unlikely to be a viable option. Other options to be considered will be tough local planning restrictions, areas of natural beauty and other listed restrictions. We believe that prior to Scotland making any recommendations on rural heat networks, a full independent review should be undertaken in order to assess any potential barriers and costs.

32. What could be done to further encourage the development of heat networks?

Creating a greater market for heat networks in heavily urbanised areas is key to encouraging the growth of heat networks in Scotland. In areas where the installation of heat networks would be cost-effective and where they could deliver low cost heating to a large number of high density properties, they should be incentivised either through subsidy or building regulations. A particular focus on delivering heat that is affordable and able to be decarbonised in the future could benefit households in urban areas who do not have access to the gas grid and therefore have to rely on costly direct electric heating, something which is common in Edinburgh as well as many rural towns and villages in the Highlands and North East.

33. Where and in which circumstances are heat networks the most appropriate low carbon solution in areas not using mains gas?

According to the Department for Business, Energy and Industrial Strategy website, heat networks "have the potential to reduce heating costs, in some cases by more than 30%".[27] Blocks of flats in city centres are the most suitable for heat networks, given they are most likely to be close to a factory that can provide waste heat. Rural areas are unlikely to be suitable for heat networks because they are often scarcely positioned, and not usually near a facility for waste heat. We believe that the non-domestic arena is best placed for heat networks, as individuals would not be tied into long contracts.

34. What examples can be provided to show how readily heat networks can be moved to renewables – especially in those buildings with a high peak heat load?

Where technologies such as CHP, biomass, solar thermal and heat pumps are part of the central plant, it may be beneficial to install a thermal store to deal with the intermittency of their operation. In which case the thermal store has to be sized to integrate the technology with the hot water stores in the network. A thermal buffer provides an additional volume of water to dampen down the effects of heat sources / systems that are slow to respond (i.e. to turn on / off and ramp up / down), such as biomass.[28]

Most heat networks being installed in the UK use a central plant room serving multi-occupancy buildings or small groups of buildings. Many of these are using combined heat and power (CHP) to generate heat and electricity – the latter either being used in the building, sold back to the grid, or both. Very often, the CHP will be combined with other heat sources including gas, oil or biomass boilers, heat pumps and solar thermal.

Where a mix of heat sources are in use the design should account for the differing performance characteristics of each type of plant and seek to optimise each. Care must also be taken to ensure that none of the plant is oversized – a common problem in the past – as this introduces inherent inefficiencies to the system.

[27] https://www.gov.uk/government/news/new-central-heating-for-cities-to-help-reduce-energy-bills
[28] https://hotwater.org.uk/uploads/5B053A7597A5F.pdf

A typical example would be sizing the CHP to meet base heat loads throughout the year. Ideally, if the CHP is used to generate electrical power through the summer, then any surplus heat produced by the CHP could be stored in a thermal storage vessel to supply domestic hot water, or to drive an absorption chiller for comfort cooling.

In the winter, when the base load is higher, a biomass boiler might be used to back the CHP up, with responsive heat sources such as modulating gas boilers 'kicking in' to meet peak loads whilst maintaining constant flow temperatures.

Where the energy centre is providing domestic hot water as well as space heating, there may also be benefits to including calorifiers or heat exchangers feeding into buffer vessels. Such an arrangement allows solar heating or heat pumps to be used to pre-heat the cold mains water, with one of the other heat sources bringing it up the required temperature.

A key benefit of using central energy centres in this way is that new, low carbon heat sources can be introduced relatively easily in the future without disruption to the spaces being heated. It is likely that with the growth of renewable energy in the UK, particularly from wind (the UK now has the largest installed offshore wind capacity in the world), future energy centres will need to include ways to make use of surplus electricity, such as heat pumps.

In some locations, energy centres may also be able to take advantage of nearby waste energy sources from industry or waste incineration. All of which means that energy centres will require a high level flexibility and this needs to be addressed in the initial design. Centralisation of heat sources also simplifies routine maintenance, compared to accessing individual boilers in each space/apartment.

38. What evidence can you provide on the further developments needed for future market readiness and deployment of the low carbon technologies covered above?

In terms of establishing the practical and commercial viability of hydrogen, joint work between the UK Government and companies operating in the gas industry, for example through the Hy4Heat project, will need to continue. Projects like this will be vital to establishing the technical foundation and Government support necessary to unlock investment in production and infrastructure. It is the case for every low carbon heating technology that uncertainty over the UK Government's position is restricting investment and consumer confidence.

Scotland is uniquely well placed to lead the UK, and potentially Europe, in hydrogen for heating and transport. With its historically large oil and gas sector and potential to develop renewable energy, Scotland's energy industry has the expertise and infrastructure to take the lead on hydrogen. Much of Scotland's existing gas infrastructure, including the gas grid as iron mains are replaced by plastic pipes, can be repurposed for pure hydrogen.

Carbon capture, usage and storage is a development which has stalled due to the UK Government's indecision over investment in its development. A previous competition to stimulate work on advancements in CCUS was cancelled, depriving the private sector of the necessary certainty needed to invest in this technology which will be vital, not only for producing low carbon hydrogen, but for many other sectors in the economy.

39. What evidence can you provide to show potential economies of scale and unit cost reductions that could be achieved through increases in annual levels of deployment of the low carbon heat technologies covered in this call for evidence?

It is difficult to predetermine potential economies of scale and unit cost reductions for new low carbon technologies, but inevitably a bigger scale, with more scale will bring prices down. However, as previously mentioned already established technologies like heat pumps are unlikely to come down hugely in price as they are already sold across the world at a big scale, and are not new anymore. The implication is that innovations in cost reduction will already be established and mature, so there will be very little room for further reductions.

40. What examples can you provide of instances where installing a modern low carbon heating systems has also lifted households out of fuel poverty?

In 2017, 24.9% of households (613,000) were estimated to be in fuel poverty, a similar level to 2016 (26.5% or 649,000 households).[29] Between 2016 and 2017 rates of fuel poverty decreased in urban areas (from 24% to 21%), widening the gap when compared to rural areas (43%).[30] This is likely to be driven by gas prices continuing to fall in 2017, while oil prices increased by 24% between 2016 and 2017.[31] Given this disparity between rural and urban, it is essential that the gap is not further increased by more expensive heating methods, like storage heaters or heat pumps for rural properties.

Currently the lowest cost option would be limited to moving existing oil boiler installations to bio oil, or bio-LPG systems which would require changing the fuel tank, connections and boiler. This could cost an additional £2000 in comparison to an existing oil boiler replacement. (This is still significantly lower than the cost of moving to a heat pump). Therefore, Scotland would have to calculate if they are willing to ask consumers to pay this additional fee and if there will be support for those in fuel poverty to change. A factor tied to this is that if the volume of oil boiler systems decreases then the fuel may increase in price quite significantly. Those that are able to pay for a new appliance will. Those in fuel poverty, of which there are approximately 14% in rural areas, will then not only have an appliance that needs changing but will be paying significantly more for their fuel.[32]

A simpler method would be to work with the industry to develop a biofuel that would not require an appliance change. The LPG industry have done this with Bio-LPG. Therefore we do not believe that a firm date for ending high fossil fuels is necessarily functional unless the surrounding mitigating factors were considered. We understand that having a long term requirement should drive industry to reform, however the concern is that in reality it will lead to political pressure to water down or amend them which could undermine initiatives.

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[29] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[30] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[31] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[32] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/639118/Fuel_Poverty_Statistics_Report_2017_revised_August.pdf

Electric heating is typically 100% efficient, but a unit of electricity is considerably more expensive than a unit of gas. According to the Energy Saving Trust, standard rate electricity costs 13.86 p/kWh while off-peak economy 7 electricity costs 7.21 p/kWh. By comparison, a unit of gas costs 4.18 p/kWh. A new condensing boiler delivers heat at efficiencies of 90% and over. Consequently, the use of gas heating costs 4.6 p/kWh of delivered heat, compared with 13.86 p/kWh of heat for a system using electric storage heaters. The cost of electric heating could be reduced if the homeowner is able to take advantage of an Economy 7 tariff.

Connection type	Cost per property
Single property to an existing gas grid (outside London)	£346
Single property to an existing gas grid (London)	£743
Small development of 10 properties	£988
New development of 100 properties	£1,076
Commercial/industrial estate (20 medium sized units)	£1,681

Source: CCC

NB. The single property cost estimates assume the property is located within 23 metres of the existing gas distribution system. For the purposes of this report we have used the higher average connection cost figure of £630, supplied by the GDNs rather than the <23m connection costs

The next step is the installation of a new gas boiler - this is estimated to cost approximately £2,000 including installation. For first time central heating, new radiators and associated pipe work need to be fitted alongside the boiler. Discussions with external stakeholders suggest that this is likely to cost in the region of £2000. **Overall, this brings the total cost of a gas connection and first time central heating system to £4,600 for properties outside London within 23m of the existing grid. (based on Baxi figures)**

The cost of solid wall insulation varies considerably, depending on the size and type of property that is to be insulated. Solid wall insulation is installed by fixing a layer of insulation to the outside of a property and covering it with render or cladding. The Energy Saving Trust (EST) estimates that the cost of external solid wall insulation ranges between £8,000 for a small flat to £22,000 for a large detached house.

Cavity wall insulation can often be installed quickly and with minimal disruption. However, many cavities are deemed to be "hard to treat" and can only be insulated at greater expense and disruption. The EST estimates that the cost of cavity wall insulation ranges between £330 for a small flat and £720 for a detached property. Many loft spaces can be easily insulated by the homeowner themselves, although factors such as inaccessibility, flat roofs, loft conversions and damp mean that it is often advisable for a professional to undertake the work. Many homes already have some level of loft insulation, in which case this can be topped up to a recommended depth of 270mm. The cost of loft insulation varies depending on the depth of the existing insulation and the surface area of the loft. The Energy Saving Trust estimate that loft insulation (going from 0 to 270mm) costs between £285 for a mid-terrace house to £395 for a detached property. Top up insulation (120 to 270mm) is estimated to cost between £240 and £310. Gas Grid Connection the installation of a new "wet" central heating system in a previously electrically heated, off grid home is a three stage process. Firstly, the household must be connected to the gas grid. Information provided by the Gas Distribution Networks indicate that the average cost of a connection to the gas grid is approximately £1,200. However, this average figure overstates the cost of connection for a significant proportion of UK homes. Homes that are closer to the existing grid can be connected at lower cost than those further away. The 2016 Committee on Climate Change "Next steps for UK heat policy" report estimated the following costs of connection.

The table below demonstrates the bill savings that would be experienced through the installation of each of the considered measures.

	Heat demand (kWh)		
	10,000	15,000	20,000
Initial bill	£1,386	£2,079	£2,772
		Savings	
Cavity wall insualtion	£116	£175	£233
Solid wall insulation	£215	£322	£430
Loft insulation	£29	£44	£58
Gas grid connection	£922	£1,382	£1,843

A connection to the gas grid leads to the most significant bill savings – providing a saving of £1,843 for a home with a heat demand of 20,000 kWh. By contrast, cavity wall insulation saves £233, solid wall insulation would save £430 and loft insulation would save just £58.

It is our view that low carbon is not the answer to fuel poverty, and low carbon technology, is more likely to increase fuel poverty rather than decrease it, because the costs are almost always higher than existing technology. Given this, EUA ultimately promotes the connection of urban off grid properties to mains gas where it is feasible to do so as the first port of call, when considering the most economically efficient and optimal means to improve energy efficiency and tackle fuel poverty. However, EUA understands that this may not always be the best option, particularly in rural off-grid properties. Given this, we believe that the fuel to these properties should be decarbonised utilising bio propane and bio-oil.

43. How should the deployment of low carbon heat be funded? i.e. what relative contribution should come from central public funding, energy consumer's bills and private recipient funding?

EUA believes that the deployment of low carbon heating will need to be facilitated using a mix of government grants, levies on bills and personal contributions.

It will be vital for the deployment of low carbon heating technologies to go hand-in-hand with continuing efforts to tackle fuel poverty. The transition to low carbon heat will inevitably carry additional costs, regardless of the technology chosen, both in terms of infrastructure and in-home changes. For fuel poor households it would be extremely regressive for this transition to cause their bills to rise. Where fuel poverty schemes in England have lacked the scope and focus to tackle this issue in an ambitious way, Scotland's Area Based Schemes have pioneered a more locally focused, whole system approach. We believe that this kind of approached should be maintained even after the end goal of schemes such as those under HEEPS gradually shift from largely delivering insulation upgrades to assisting the transition to low carbon heating. When Scotland has the highest rates of fuel poverty in the UK, 25% as of 2017, balancing the need to decarbonise heating with the risk of pushing more households into fuel poverty will be a key challenge for Scotland. Figures show that the average gas bill for UK households is £630 a year, its lowest level since 2011, whilst the average electricity bill has continued to rise and stands at £619.[33] Given this fact, the transition to low carbon heat should take fuel costs into account alongside the cost and disruption of appliance changes in the home.

A key challenge for deployment will be the treatment of the so-called 'able-to-pay sector' i.e. those households who can afford to make the transition themselves but may still need some level of government assistance and/or advice. Again, the Scottish Government's partnership with the Energy Saving Trust puts advice and information for consumers at the heart of energy policy. By providing interest free loans, and even accompanying cashback offers, the Scottish Government has incentivised uptake of energy efficiency measures, including new heating systems. Schemes like this can be adapted to the new challenges of decarbonising our heating systems which is vital when UK Government figures show consumer awareness of, and appetite for, many low carbon heating technologies currently on the market is very low.

44. What is needed to encourage private investment in low carbon heat?

EUA believe that from an economic stand point the encouragement of capital markets to provide green investments comes as a result of a harmonisation between both supply and demand side stimuli.

Initial analysis of the supply side shows that capital markets and the companies within them, inherently operate under the main objective of profit maximisation. Therefore, in order to foster private investment on financial products that promote energy efficiency measures, such initiatives should also be seen to deliver low risk capital gains for the company that is offering them. Only then will the private sector be willing to engage in such operations. Evidence from green mortgage initiatives suggest that leading mortgage lenders perceive green mortgages as carrying a lower financial risk.

The reasoning behind this is twofold. Firstly, increasing the energy efficiency measure of a property means home owners demand 25% less energy and benefit from lower energy costs, in turn increasing their disposable income levels. Home owners in this position pose a lower lending risk as they are less likely to default on mortgage repayments due to the windfall of extra money. Secondly, there have been studies to show that improvements in the EPC ratings of houses have a positive correlation with property value, further improving their risk profile.

As mortgages are the heart of the EU economy, accounting for approximately a third of EU banking assets, involvement in green mortgages appears to be a lucrative business opportunity from a supply side perspective. From the viewpoint of demand, sufficient consumer interest in

[33] https://www.eas.org.uk/en/fuel-poverty-overview_50439/

green finance needs to be in place for the private sector to engage in offering it. Social behaviour plays a pivotal role in what is offered by the capital markets. Therefore, it is important to educate people on the importance of energy efficiency and the long term future of finite resources. A consumer insight study was carried out by the UK Green Building Council across United Kingdom. Italy and Sweden. Upon which consumers were asked to rank a number of factors they consider to be important when buying a property. The outcome showed that 'how energy efficient a property is' was ranked least important out of 8 factors within the United Kingdom. This suggests that changes in social behaviours can only come as a result of improvements in education and the national curriculum putting a higher emphasis on the importance of energy efficiency and its impact on the climate change.

EUA remain ambivalent on the use of private finance as a means of fostering the uptake of energy efficiency measures by consumers. Previous green finance initiatives such as the green deal scheme failed to deliver the expected energy savings. Whilst government subsidy has a proven track record in delivering energy and carbon savings, we believe government should err on the side of caution when intrusting in private finance to promote energy efficiency savings. Our belief is that financing energy efficiency measures through consumer credit is a sub optimal strategy when attempting to increase consumer demand. We believe there is very little evidence to support a relationship between financial measures which incorporate the use of consumer credit and the demand for energy efficiency measures. Focusing on domestic gas boilers, a recent market survey on how boilers are financed showed that a very small percentage of consumers used private finance for their purchase. The Green Deal also failed to create a finance market for boiler installation. Private finance for boilers is also widely available and at a competitive interest rate so Government intervention in this market is not necessary.

45. Of the current sources of finance which are currently available for low carbon heat, which are working well and which are not? Are there successful examples of attracting private sector finance to support low carbon heat deployment that should be explored?

Successful finance schemes in the domestic energy sector are government backed and guaranteed. The failure of private financed based schemes, such as the Green Deal, has been the large amount of bureaucracy and financial risk that they carry.

The success of the Renewable Heat Incentive has been mixed. In the domestic sphere, take up of biomass boilers has been large and the scheme has facilitated rapid growth in investment in that particular technology. The UK Government intended for the RHI to primarily drive uptake of heat pumps but even as the scheme approaches its end in 2021 it has not succeed in its key goal. A separate part of the RHI which incentivises injection of renewably produced green gas into the grid, however, has seen high levels of interest and has leveraged private sector investment in biomethane. This low carbon fuel is identical to natural gas once fed into the grid but is produced from organic wastes which enables them to act as a resource that is already reducing the carbon intensity of the gas grid.

46. How should off gas buildings be assessed for their suitability for low carbon heat technologies?

Almost all off gas buildings will be suitable for green gas, or gas powered heating, as well as oil heating. Some may require the installation of new radiators, or indeed a first time central heating, but given the fact even F rated properties are suitable for central heating, this will not be an issue. The issues arise when trying to install heat pumps, as they require significant levels of insulation and retro fitting. More regulation is not needed, given installers already face regulations, and are extremely qualified.

48. What wider information and advice should be supplied to inform consumers seeking to install low carbon heat supply in buildings that are off gas?

The BEIS public attitudes tracker shows that in December 2018, two thirds (66%) of the public said they would only replace their heating system when their current one breaks down or starts to deteriorate, with 12% saying they would consider replacing their heating system while it was still working.[34] This shows people are generally not interested in low carbon heating, rather than being particularly ill informed. The majority of people who were involved in the decision-making process about a new boiler or heating system found it very easy to get the information they wanted (60%) and felt they had the right information to help them make a good decision (91%). The public were most likely to trust a tradesperson or their friends and family to provide advice about which heating system install in their home. It has been suggested that installers should be mandated to offer to install a low carbon heat product, like a heat pump, however this is likely to decrease their uptake, as people will be made aware of the huge price difference.

49. What evidence can you provide on the role that regulation could play in helping to support uptake of low carbon heat in existing buildings (domestic and non-domestic)? What form should this regulation take?

Regulation has played an important role in key advancements in the heating industry such as the mandating of condensing boilers in 2005. Regulation will be needed to encourage, and eventually, mandate the uptake of low carbon heating sources. EUA believes that, given the range of technologies likely to be available to consumers in the coming decades, regulations will need to emphasise consumer choice rather than picking winners. Government regulation can be particularly useful in setting technical standards which we believe would be appropriate in the development of hydrogen for use in heating.

51. How should the Scottish Government respond to the CCC's advice and the UK Government announcement in the Spring Statement that new buildings constructed now should "accommodate low carbon heating from the start"?

The need to reduce our carbon emissions is a given, but we must remember that ultimately the consumer is at the centre of that journey. Being selective in our approach to low carbon heating, will cost the consumer and the planet. The UK Government have recognised this via their commitment to seek to increase the proportion of Green Gas in the grid over the coming years.
The gas grid can deliver low carbon heating, so gas grid connections, using biomethane or hydrogen will still be part of the mix for new build homes under the chancellor's new plans. The future plans for low carbon heating must reflect how people actually live in their homes. Gas boilers are affordable, convenient and able to deliver on our carbon targets. Changing the type

[34] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776657/BEIS_Public_Attitudes_Tracker_-_Wave_28_-_key_findings.pdf

of gas in the grid to a low carbon version, such as biomethane or hydrogen, will deliver low carbon heating at a price consumers can afford.

The UK needs to preserve the environment for future generations and that means being creative and innovative in how we tackle climate change. EUA are delighted that the Government have listened to the evidence and committed to invest in green gas.

EUA agree with the spring statement so long as the criteria is 'renewable ready', and not banning certain technologies. So, this would mean that bio LPG and bio oil should be eligible for installation, alongside other energy efficiency measures, like bigger radiators and hot water cylinders.

According to the Scottish Government, levels of fuel poverty among households using electricity as primary heating fuel have remained among the highest, at 52%.[35] Whereas, households using gas as primary heating fuel have continued to see improving fuel poverty levels in 2017: 19% of these households are fuel poor, down from 23% in 2016, a decrease of 3 percentage points.[36] Consequently, the rates of fuel poverty for households within coverage of the gas network and for urban households have both decreased in 2017 by 3 percentage points, to 22% and 21% respectively.[37] Scotland should bare this in mind when choosing between gas solutions for decarbonisation and electrification, given the potential for electric heating to exacerbate fuel poverty.

52. Have you encountered any specific examples of barriers to the installation of low carbon heating systems in new buildings?

When considering alternative heating technologies for domestic properties, it is important to consider how they could affect the ways in which households generate hot water given that this inevitably goes hand-in-hand with heating. The fact that the current generation of heat pumps do not heat water to temperatures that consumers are used to (typically only a maximum of 50°c) would necessitate an alternative method of hot water generation, such as a cylinder with an immersion heater and an electric shower. This could significantly increase the overall electricity usage of the whole system and therefore upfront and ongoing costs for consumers as well as considerations around grid infrastructure. New build homes are smaller than older homes, so often do not have the space for heat pumps and hot water cylinders, so clearly this will be a barrier.

54. Can you provide evidence on the comparative cost of installing low carbon heat solutions in new buildings compared to retrofitting to install low carbon heat at a later date?

The Committee on Climate Change commissioned a study from Currie & Brown and Aecom entitled *The costs and benefits of tighter standards for new buildings* which found that installing an air source heat pump and ultra-high levels of insulation in a new home is £4,800 whereas retrofitting one into an existing home would be £26,300.[38]

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[35] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[36] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[37] https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/pages/6/
[38] https://www.theccc.org.uk/wp-content/uploads/2019/02/UK-housing-Fit-for-the-future-CCC-2019.pdf#page=42

55. Are there particular actions that you would identify for consideration as part of any action to 'future proof' new buildings for low carbon heat retrofit?

The UK needs more housing but there is no justification for building homes with a permanent legacy of high energy bills. New buildings need to be 'future proofed' to break the vicious cycle of expensive retrofitting programmes – one way of achieving this is by making new build properties that are hot water ready. Hot water storage also offers the only inexpensive practical solution for turning the energy produced by renewable technologies into something useful and banking it for when it needs to be used.

With fast approaching carbon budgets, and increasing pressure being placed on the Government to improve the nation's air quality, decarbonisation of heat and making the UK's housing stock more energy efficient is high on the political agenda. Whilst retrofitting the existing housing stock will prove complex (80% of the current housing stock will still be in place in 2050), ensuring new build properties are efficient, low carbon and future proof serves as a good way to start reducing domestic emissions.

Actions to achieve future proofed buildings would be ensuring all new buildings come with hot water cylinders, thermostats and large radiators.

Additionally, installing hydrogen ready boilers that can be easily converted to burn hydrogen in the future would save people from buying new appliances, when the gas is greened, as the chancellor committed to in his spring statement.

56. In light of the reservation of consumer protection powers, how else could the Scottish Government ensure consumer protection on a robust basis? For example, through commercial agreements.

All the industry asks from the Scottish Government is to not add additional red tape to training and skills requirements. Initiatives such as MCS and the upcoming Each Home Counts Quality Mark will add too much additional cost and bureaucracy meaning most installers will not engage, which could lead to fewer accredited installers and a growth in unqualified and possibly untrained engineers. It could also disincentivise people from joining the industry because of the high upfront costs and maintenance costs of operating in the sector. We know that there are more renewables installed than are registered through MCS, suggested an unregulated part of the market. Some estimates put it at more than 50% of installations. We would ask that Scotland learn from the Gas Safe Register approach which has been effective and not adding a layer of red tape installers can't engage with.
Consumer protection is important but there has to be awareness of the proportionality of anything brought in that can bring up cost, ultimately born by the consumer.

57. What actions should we undertake to ensure the Scottish supply chain has the skills and capacity to capitalise on the future increase in demand for the installation of low carbon heat?

The industry will ensure that installers have the skills necessary. When changes to the industry are made such as regulation for new products the market will and has provided the required upskilling. When condensing boilers were mandated and today with boiler plus, manufacturers will provide installers with the skills needed to safely and correctly install the measures. Currently manufacturers train over 30,000 installers a year. Even more are trained by private training companies. Heating engineers also have to be retrained every 5 years and so there is the option to add new modules to their existing courses.

Scotland has an unprecedented opportunity to take a lead on hydrogen, given its geographical features, being suitable for extensive off shore wind to power hydrogen generation, and the massive advances it has taken in cutting carbon emissions so far. Taking an early lead on hydrogen production could allow Scotland to become a net exporter of hydrogen to the rest of the UK and overseas. Scotland should be taking these decisions early on, so that they can put in place the infrastructure and funding required to connect more homes to the gas grid, under the proviso that in the long term they will be using hydrogen. A clear policy on hydrogen- or any low carbon heat is required to give business the confidence to invest. In any case, this should be the priority rather than skills alone, because installers can have all the skills in the world, but if there's no demand, there's no point.

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