Appendix 1 – Common Retrofit Technologies and Terminology

A1 Introduction

The following information goes into detail about the function and design of different retrofit low-carbon technologies that exist as well as the advantages and disadvantages of these. It also explains some of the common issues that occur within retrofitting that should be accounted for. It should be noted that these pieces of technology are what is currently available and being used, and with future design there may become more effective solutions. As well as this, as existing technology is improved, some of the disadvantages around efficiency, cost and installation may change.

A2 Low-Carbon Technologies

As of Feb 2021, the vast majority of properties are being heated by mains gas, with the figure being at around 188,769 dwellings. The most common heat type is boilers, and it is said to be under 1000 heat pumps. This needs to change in order to reach net-zero.

A2.1 Air Source Heat Pumps (ASHPs)

ASHPs work by absorbing the heat that is found in the air outside of a building and run in a similar way to how a fridge can create a cold environment through vapour compression, but for hot air. Some can also provide domestic hot water.

The issues around heat pumps are that with air source, a large external unit needs to be fitted to the dwelling, and therefore there needs to be adequate space for this outside of the property. Additionally, an internal hot water tank is required which will take up more floor space. Heat pumps are low temperature systems, which means that often they require longer running times as well as radiators with a larger surface area to distribute the heat. This change in operation compared with normal gas boilers which run hotter and so produce heat quicker means residents need to be informed about how to work them for them to be efficient heating systems. Without this adequate training, they run the risk of the system being inefficient, and using more electricity which causes an increase in bills.

The coefficient of performance (COP) for ASHPs ranges from 2 to 5, meaning for every unit of electricity inputted, 2 to 5 units of energy are outputted. However, the pricing of heat pump running costs are directly linked to the price of electricity, and currently with electricity being three to four times more expensive than gas, this can potentially be an issue for uninsulated dwellings as this will increase running prices. But these high costs can be combatted by increasing the energy efficiency of the property, ideally through a fabric first approach. This efficiency is what can save the consumer money on bills if they are being installed on draught-proof/ insulated dwellings. People can be quite resistant to heat pumps as they see them being high cost with little benefits, so it is essential to make sure that they know how to use them and are being installed correctly.

A2.2 Ground Source Heat Pumps (GSHPs)

GSHPs work by transferring heat from the ground outside the home to pump this directly into heating the building. Like ASHPs, they are also incredibly efficient, and are a great retrofit or new build instillation to adhere to zero carbon targets.

There are two types of GSHP's: vertical and horizontal systems. With vertical systems, bore holes are installed, which are deep holes into the ground to access the consistent hot temperatures beneath the ground. They require a full assessment to ensure their viability and can be more expensive than a horizontal system. However, they require less space than a horizontal system and are therefore more suited to urban areas. Like ASHPs, a fabric first approach should be considered when implementing these to avoid risk of fuel bills increasing.

A2.3 Exhaust Air Heat Pumps (EAHPs)

EAHPs extract heat from the exhaust air of the dwelling, and then distribute this heat to be used in water, air, or hydronic heating system (such as underfloor heating or radiators.) It is far less common than the other two heat pumps, and more research may need to be done to assess their effectiveness.

A2.4 Heat Networks

A heat network (also known as district heating) is a system whereby one central source delivers heat to several dwellings through insulated pipes. When talking about heat networks in the context of zero carbon, heat is usually generated by large ground or air source heat pumps.

The carbon performance of heat networks should be analysed to ensure that they provide a sustainable source of low carbon heat. In areas of high density such as the city centre, heat networks could be a great way to provide low carbon heating as it maximises the number of dwellings using one renewable system.

A2.5 Solar Photo-voltaic (Solar PV)

Solar PV is the system that uses solar power to generate electricity using photovoltaics. Typically, solar panels with solar cells are attached to a building's roof using an aluminium mounting system. The panels generate direct current (DC), and this flows to an invertor to create alternating current (AC), which powers appliances in the home.

Solar PV is a great zero carbon energy source and reduces the need for non-renewable energy in the home. However, there are issues when it comes to retrofit and their use. Until recently, the panels could only be placed on roofs at certain angles to the sun (e.g. south facing), and so an assessment would need to be undertaken to evaluate their effectiveness. Now, with an assessment to check viability, they can be placed at varying angles to the sun, such as east or west. They unfortunately cannot be connected to gas boiler systems to provide energy, and so this initial retrofit measure will need to be completed prior to its installation. However, connecting them to an electrified heating system together can lead to net-zero.

A2.6 Energy Storage (Batteries)

Battery storage or battery energy storage systems (BESSs) are devices that store renewable energy (such as from solar PV) and release that energy when it is needed. This is extremely useful when using renewables to power a dwelling given the sometimes-inconsistent nature of their supply of energy, e.g. the sun shining at different times of the day. An assessment of the cost effectiveness would need to be undertaken to ensure its financially viable. However, they may be essential in ensuring that a dwelling reaches net-zero.

A3 Insulation

A3.1 External Wall Insulation (EWI)

EWI involves applying a layer of insulation to the exterior of the dwelling and is commonly associated with solid brick buildings with no external wall insulation. As of Feb 2021, there were 43,601 solid brick homes, and the majority of these will need to be retrofitted/ The benefits of this being installed are that it avoids disruption to the internal space of the property for the tenant. It also greatly improves the thermal comfort and does this without reducing floor space. It often visually renews the appearance of walls, improves the weatherproofing, increases sound-resistance, and increases the lifespan of the walls by protecting the brickwork.

EWI needs to be carefully planned to avoid moisture and condensation issues from thermal bridging. Details such as the roof, guttering and windowsills must be considered, and some may need to be replaced if the added layer outside of the property is too thick to allow for use/extension of the existing. EWI has previously had a bad reputation, particularly due to poor cladding installations in previous years, as well as potential fire safety risks. The Council’s Planning team will need to be engaged when designing EWI schemes, as they may pose aesthetic challenges for traditional heritage and listed buildings and on conservation areas, as the original brick layer of the properties would be covered up.

A3.2 Internal Wall Insulation (IWI)

IWI involves adding insulation to the inside of the wall. Although effective, IWI results in greater disruption for the resident, as well as a reduction of floor area if the cavity is too small to be filled and the wall thickness needs to increase. This may be an issue for already small dwellings.

As well as this, IWI poses increased fire and moisture risks. When the insulation is fitted, there is a danger of trapping moisture at the junctions. An increase in material insulation will always create an increased fire risk as almost all of these are to some degree combustible, except for mineral wool and some new plaster insulation products. Therefore, a degree of caution needs to be looked at around this, and if it is installed, it should be coated with non-combustible plasterboard or wet applied plaster coat. The cost of this is greater than cavity wall insulation, however the savings on the heating bills will be greater.

A3.3 Cavity Wall Insulation

Cavity wall insulation involves insulating the internal cavity walls and filling the air space, thereby inhibiting heat transfer. If possible, this has the advantage over IWI as it uses the existing wall structure, and so doesn't affect the floor space of the building. However, it is still invasive, and has similar problems of installation as IWI. In Manchester we are now having to redo some cavity wall insulation that has been incorrectly installed, which has come at a great cost.

A3.4 Floor Insulation

Internal insulation can also consist of insulating floors, particularly suspended-timber floors. Mineral wool insulation is typically fitted with netting between the joists, and this involves taking the floorboards up. Ground floors can also be insulated by replacing the concrete flooring or adding a rigid layer of insulation. Like IWI, this poses the same issues in terms of access, disruption to residents. If installed incorrectly, it can similarly result in trapping moisture and air, leading to condensation, as well as a fire risk. However, with proper planning, this is a great way to insulate a dwelling without reducing floor space or adding cladding. Additionally, new non-invasive robot technology which sprays foam insulation between the suspended-timber joists avoids the need to take up flooring.

A3.5 Roof Insulation

A great low cost, low regret retrofit installation is roof insulation. It is easy to install and can greatly reduce the heat loss of a dwelling. The main issue with this is that although it works well for houses, it is not possible for most individual flats and apartments. As of February 2021, it was estimated that nearly 34,000 dwellings in Manchester had no roof insulation at all, which is a surprisingly high number.

A3.6 Double/Triple Glazing

Double or triple-glazing is two or three glass windowpanes, separated by an air cavity. The increase in glazing results in a reduction of heat transfer, and therefore the building is more insulated. It is a relatively low-cost, effective measure at reducing heat loss in a building. An increase in glazing will make the building more airtight, but there is possibility of over-heating and a lack of ventilation, so this needs to be looked at when planning retrofit measures. Windows are also a key area for thermal bridging to occur, especially if the new windows have not been lined up with the existing or new insulation in the external walls. It is important to check on the viability of replacing windows in conservation areas or in a listed building to see if measures like this are possible.

A3.7 Doors

To increase the air tightness of the dwelling, doors can be insulated either around the frame or the material of the door itself. Alternatively, simply installing a new door with multiple material layers (e.g. composite doors with multiple layers for insulation) may be an easier and lower-cost measure. To insulate a door is a low cost, low regret measure, and can be done in line with all the other fabric first retrofitting.

A4 Retrofit Issues

A4.1 Thermal Bridges

A thermal bridge, also commonly known as a cold bridge, is a break or weak sport in the insulation of a building which results in a higher heat transfer. When the insulation is weaker, interrupted or broken at a point, it can cause major issues for air tightness and insulation. They are commonly found at junctions in the building, such as window details, and connections between walls.

Thermal bridges can result in condensation, damp, and mould growth in the building. PAS2035 retrofit standards require detailing of junctions to avoid thermal bridging, which often occurs through retrofit installations of EWI and IWI. Often if a thermal bridge has occurred, you will be able to see this under thermal imaging of the building, as it will visualise the colder areas where heat is being lost. These areas will then need to be re-designed to address this break.

A4.2 Mechanical Ventilation Heat Recovery System (MVHR)

MVHR systems are an advanced technological tool for ventilation in a dwelling. When all the air tightness measures have been installed, a common issue in retrofitting is the lack of ventilation. Therefore, this system is essential to deliver fresh clean air. They are very efficient, as they extract warm damp air from the dwelling, as well as draw fresh air from outside. The warm air that gets extracted passes through a heat exchanger, and this residual heat warms the clean external air, without contamination of the two. The pre-warming of the air means there is far less heat loss, thereby lowering heating costs. The system is commonly made up of ducts in the ceiling, with the central unit being stored in a utility room.

MVHR are especially great when the building is particularly airtight so that ventilation can still occur. Heating costs are reduced, but the systems are currently relatively expensive. They are particularly difficult to implement in small retrofit dwellings due to the large ceiling space required as well as utility space for the unit.

A4.3 PAS 2035 Installation

PAS 2035:2019 is the set of standards that are required for retrofitting measures, which are particularly relevant when applying for grant funding, as it must be clearly shown that these are going to be adhered to. PAS 2035 came about through how common retrofitting measures were being incorrectly installed, leading to poor living conditions and damage to the dwellings. To rectify these measures, it becomes costly as not only do they have to be removed, but also the structure must be made safe and then the measures re-installed. Complying with PAS 2035 through having the correct certified people involved (such as retrofit assessors and retrofit coordinators), is vital to ensure the success of the projects.