Appendix A

Technical Performance Summary

Thermal Insulation:
Homes built to Passive House standards require very high levels of thermal insulation, and must be free of thermal bridges. U values of walls, floors and roofs in Passive House homes will normally need to be between 0.1 to 0.15 W/m2K. This is a significant improvement on the U values allowed by current Building Regulations and will result in much thicker insulation being required as summarised below:

	Minimum standards permitted under current Building Regulations	Typical standards used in Passive House dwellings
U Value - Wall	0.3 W/m2K	0.11 W/m2K
Insulation Thickness - Wall	100mm Mineral Fibre	300mm Mineral Fibre
U Vaule - Roof	0.2 W/m2K	0.1 W/m2K
Insulation Thickness - Roof	250mm Mineral Fibre	450mm Mineral Fibre
U Value - Floor	0.25 W/m2K	0.12 W/m2K
Insulation Thickness - Floor	50mm PIR Insulation	150mm PIR Insulation

Windows and External Doors:
Homes built to Passive House standards need to have very high performance triple glazed windows. These need to be well sealed and have insulating frames to ensure that the internal surfaces of the windows do not get colder than 16 degrees C, thus preventing condensation and cold down draughts even during the coldest weather. The size and location of windows has a significant impact on the overall performance of a Passive House since windows are key to the balance of maximising heat gains in the winter and minimising overheating in the summer. External doors used in Passive House homes typically have a U Value of 0.8W/m2 or lower. This is significantly better than the U values allowed under current building regulations as summarised below:

	Minimum standards permitted under current Building Regulations	Typical standards used in Passive House dwellings
U Value - Window	2 W/m2K	0.8 W/m2K
U Value - Door	2 W/m2K	0.8 W/m2K

Air Tightness:
Homes built to Passive House standards have excellent levels of air tightness. (Air tightness is a measure of how easily air can leak in or out through the building fabric.) As a result Passive House homes are draught free and very little heat is lost by warm air escaping through gaps in the building. Passive House buildings must have an air tightness of no more than $0.6h^{-1}$ @50Pa. This is much more onerous than the minimum standard of airtightness permitted under current building regulations, and is often seen to be one of the most difficult elements to achieve in a Passive House building. In order to achieve this standard any gaps must be completely sealed and special air-tightness tapes and membranes will need to be incorporated into the construction.

	Minimum standards permitted under current Building Regulations	Typical standards used in Passive House dwellings
Air Tightness	≤ $10m^3$/hr/m2 @ 50 Pa	≤ $0.6h^{-1}$ @ 50Pa
Note - the measurement and units used for Passive House air tightness standards are different to those used in UK Building Regulations, as they relate to the volume of the building not just the external surface area. As such they are difficult to compare, however for a typical house the Passive House standard is approximately 15 times more onerous than UK Building Regulations.		

Ventilation:
Passive House homes use a mechanical ventilation system with heat recovery (MVHR). MVHR runs continuously to remove air from the kitchen, bathroom, toilet and other rooms with high pollution and humidity. At the same time, the MVHR pumps fresh air from outdoors into the living rooms and bedrooms preheated with the heat from the outgoing air, without mixing airflows. This pre-heating of incoming air via the heat from outgoing air results in a system that saves approximately 10 times as much energy as it uses. Residential MVHR systems typically use about 22 watts, costing around 10p per day; this is comparable to having one low-energy light bulb on. In addition to the fresh air provided by the MVHR system, occupants of Passive House homes can open windows whenever additional ventilation is required.

	Minimum standards permitted under current Building Regulations	Typical standards used in Passive House dwellings
Ventilation	Intermittent extract fans in kitchens and bathrooms, with background ventilation via trickle vents.	$30m^3$/hr of fresh air per person provided via MVHR system

Heating:
Because a Passive House home is so well insulated, airtight, and windows have been optimised to balance solar heat gains against heat losses, the amount of energy required to heat the home will be very low. In theory a Passive House home can be heated entirely by the MVHR system, however it is usually better to provide a few small radiators, heated towel rails or other heat sources to ensure the comfort of residents. Passive House standards include very stringent requirements on the Space Heating Energy Demand which should not exceed 15kWh/m^2 per year, or a maximum peak load of 10W/m^2 although they do not place any restrictions on the fuel or energy source that can be used. However in light of the climate change emergency, it is recommended that all new homes use energy efficient electric heating via air-source or ground source heat pumps so not rely on fossil fuels.

	Minimum standards permitted under current Building Regulations	Typical standards used in Passive House dwellings
Heating Demand	≤ 96 kWh/m2. yr	≤ 15 kWh/m^2. yr
Cost of heating typical 110m2 house with gas	£445 per year [i]	£69 per year [ii]
Cost of heating typical 110m2 house with ASHP	£528 per year [iii]	£83 per year [iv]

i) 96 kWh/m2 x 110m2 x 3.8p / 90% boiler efficiency = £445
ii) 15 kWh/m2 x 110m2 x 3.8p / 90% boiler efficiency = £69
iii) 96 kWh/m2 x 110m2 x 15p / CoP 3 = £528
iv) 15 kWh/m2 x 110m2 x 15p / CoP 3 = £83

Photovoltaic Panels:

Whilst not a requirement of Passive House standards, it does make sense to include PV panels on new homes wherever possible. These convert the sun's energy into electricity that can be used on site or fed back into the grid. A typical PV array of 10 panels should generate approx. 3,400 kWh / year. This would equate to more than 25% of the primary energy demand of a typical 110m2 Passive House home over the course of a year.

Battery Storage Systems:

PV panels will only generate electricity during daylight, and will only achieve their best performance on bright sunny days. It is therefore helpful to use battery storage systems to ensure that the energy generated by a PV system can be used on site when needed and does not need to be exported to the grid. (The price of electricity

purchased from the grid is approximately 3 times as much as the price that electricity generated on site can be sold back to the grid). A typical battery system can store and deliver approximately 13.5 kWh.