P_20.2

Report for Lancaster City Council

Climate Change Local Plan Review

Viability Assessment – Technical Appendices 1 – May 2021

Three Dragons
Enhabit
Ward Williams Associates

This report is not a formal land valuation or scheme appraisal. It has been prepared using the Three Dragons toolkit and is based on district level data supplied by Lancaster City Council, consultant team inputs and quoted published data sources. The toolkit provides a review of the development economics of illustrative schemes and the results depend on the data inputs provided. This analysis should not be used for individual scheme appraisal.

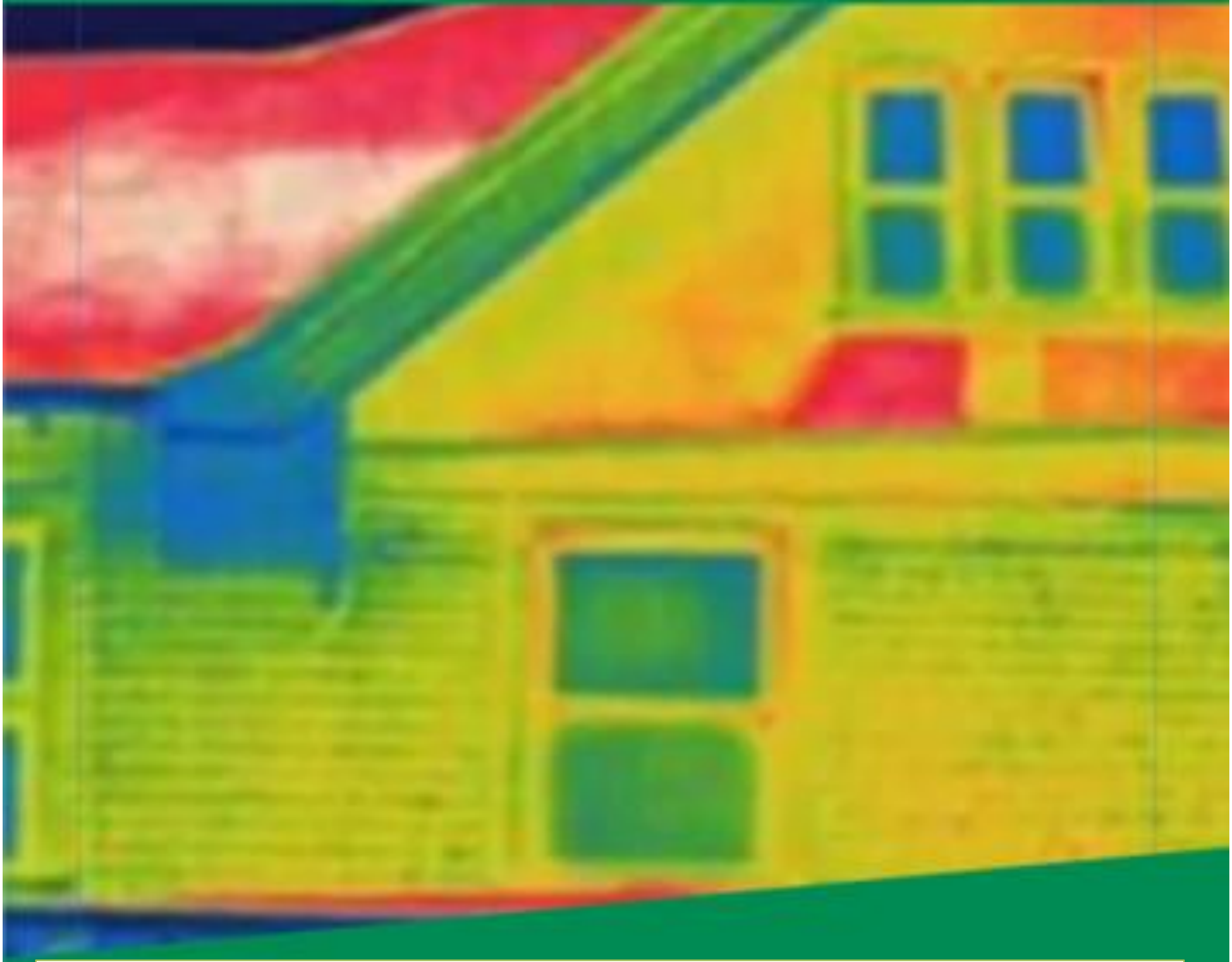
No responsibility whatsoever is accepted to any third party who may seek to rely on the content of the report unless previously agreed.

The assessment has been undertaken following national and professional standards, with objectivity, impartially, without interference and with reference to all appropriate available sources of information. No performance related or contingent fees have been sought.

May 2021

Three Dragons

Appendix A – Building standards



Lancaster City Council
Climate Change Local Plan Review

Policy response – Decarbonising standards and technology summary report

February 2021

CONTENTS

1 Optional standards

1.1 Overview

1.1.1 Lancaster City Council has set out a range of potential standards, aimed at decarbonising development, that it is considering bringing forward through a review of the local plan. This is set out in the brief for the viability work and repeated below in Table 1.1.

1.1.2 The council have asked the consultant team to review these standards and set out what they mean in terms of development in terms of how far they will take the council towards their aspirations towards addressing their declared climate emergency.

1.1.3 The initial list provided by the council is as follows. This includes the different standards considered by the government within its 2019 consultation on changes to the 2013 Building Regulations and the proposed Future Homes standard, as well as other higher environmental performance standards used for buildings.

Table 1.1 LCC optional standards November 2020 brief:

Ref	Optional standard
1.	Sustainable Homes Code Level 4 Equivalent (19% carbon reduction above 2013 Building Regulations)
2.	MHCLG Option 1 – Future Homes Fabric (20% reduction in CO2)
3.	MHCLG Option 2 – Fabric Plus Technology (31% reduction in CO2)
4.	Proposed Future Homes Standards 2025 (75-80% less carbon than 2013 Building Regulations),
5.	Passivhaus House or Net Zero Operational Carbon
6.	Net Zero Whole Life Carbon (operational and embodied carbon)

1.2 Government proposals

1.2.1 In its 2019 Consultation paper, the Ministry of Housing, Communities and Local Government (MHCLG) described its ambition to achieve a Future Homes Standard to address the Climate Emergency through changes to Building Regulations. The changes envisaged will be measured against the current 2013 Part L (Conservation of Fuel and Power) and Part F (Ventilation). Essentially, a two-step process is proposed:

- From 2025 if not sooner (see below), an interim measure that sees a planned reduction of building related CO2 emissions reduced by 31%.
- A full Future Homes Standard that proposes a 75-80% reduction in CO2 emissions compared to the 2013 Part L Building Regulations.

1.2.2 The government in January 2021 published '*The Future Homes Standard:2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings – Government response*'.[1] This sets out its aim to implement the interim uplift regulations Part L (Conservation of Fuel and Power) and Part F (Ventilation) in 2021/2. The Governments response clearly states:

- A preference to bring in 'Option 2' with an emphasis on the fabric first principle and improved energy efficiency (a 31% reduction in CO_2 on 2013 Building Regulation Standards) - to be in place in 2021/2.

> *A 2021 interim uplift will deliver high-quality homes that are in line with our broader housing commitments and encourage homes that are future-proofed for the longer-term. These homes will be expected to be more energy efficient and produce 31% less CO_2 emissions compared to current standards.*

- By 2025 seek greater energy efficiency with a corresponding 75%-80% reduction in carbon emissions (on 2013 Building Regulation Standards) – although there is less clarity as to how this higher standard can be achieved.
- To allow local authorities to set their own (planning) policies towards Energy Efficiency, ahead of any Government changes to building regulations.

1.2.3 On this last point the government has confirmed that Local Authorities retain the power under The Planning and Energy Act 2008 to set local energy efficiency standards for new homes.

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[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956094/Government_response_to_Future_Homes_Standard_consultation.pdf

1.2.4 As these steps (in relation to Option 2 31% CO_2 reduction), exceed the performance aspirations of the Sustainable Homes Code Level 4 equivalent (19% reduction in CO_2), and the Future Homes Fabric-only proposal (20% reduction in CO_2), the lower standards will become redundant. Therefore this summary report concentrates on achieving the higher standards that will be necessary for Lancaster City Council to adopt in their Local Plan for greater energy efficiency, lower energy consumption and considerably reduced CO_2 emissions in line with their own and national planned changes.

1.3 Fabric first approach

1.3.1 It is accepted building physics that to effectively achieve zero carbon emissions in buildings (with greater certainty as to performance), we must start with reducing the energy required as shown in the energy hierarchy below[2]. Once we have minimised energy demand, then we can design efficient heating and hot water systems, install onsite renewable technologies and finally, invest in national renewable technologies to offset any remaining onsite impacts. The latter may not be required if the energy demand can be sufficiently reduced onsite by designing well insulated, thermal bridge free and airtight homes. This is known as the fabric first approach.

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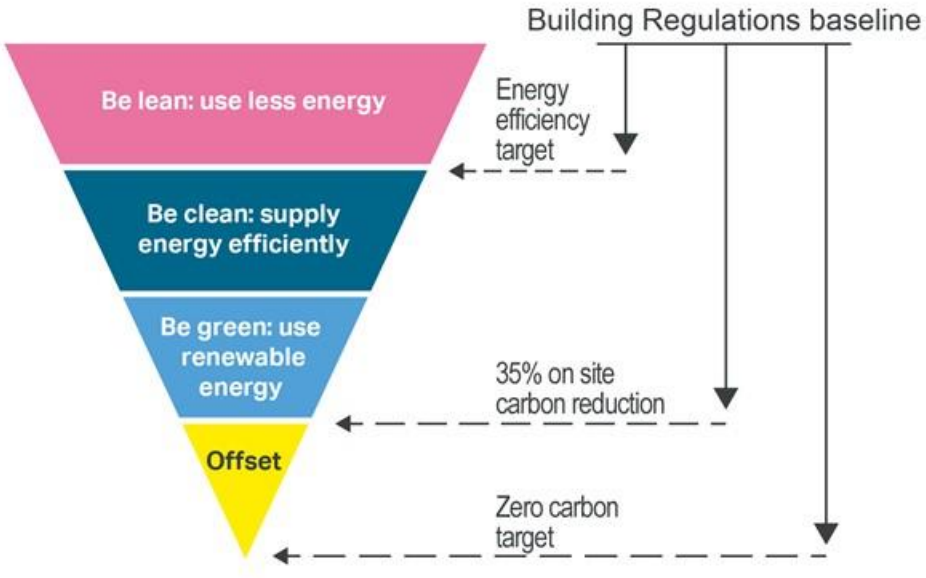
[2] Policy S12 https://www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan/draft-new-london-plan/chapter-9-sustainable-infrastructure/policy-si2-minimising



Source: Greater London Authority

1.3.2 However, the proposed Part L 2021 standards show only a modest improvement in the insulation levels in the roof compared to the current Part L 2013 and propose no changes to the wall and floor u-values. There is also only a modest requirement for improved performance in the double-glazed windows: the heat loss factor (otherwise known as a u-value) for current Building Regulations is 1.4 whereas the proposed for Part L 2021 is only 1.2. The 0.2 reduction in heat loss uplift provides marginal comfort gains and does little to reduce CO_2 emissions compared with future standards that aims to have windows that reduce their heat loss by almost 50% with a considerably better u-value of 0.8.

1.3.3 The Government has proposed a target standard for 2025 (originally 2050) that aims to achieve a reduction in Carbon emissions in the order of 75- 80% compared with a comparable building constructed to the current 2013 Building Regulations. The standard is based on building regulations and technical compliance, calculated using the Standard Assessment Procedure (SAP) model.

1.3.4 While the Government is proposing a stepped implementation of the 2050 'zero carbon' target by way of interim measures starting in 2022, Lancaster City Council are looking to achieve this step change to 'zero carbon' by 2030 having declared a Climate Emergency., and therefore will need to go beyond the current and proposed 2021 standards.

1.3.5 A detailed review of the fabric first approach and its importance in meeting the climate challenge is set out in the main Enhabit report in Appendix C.

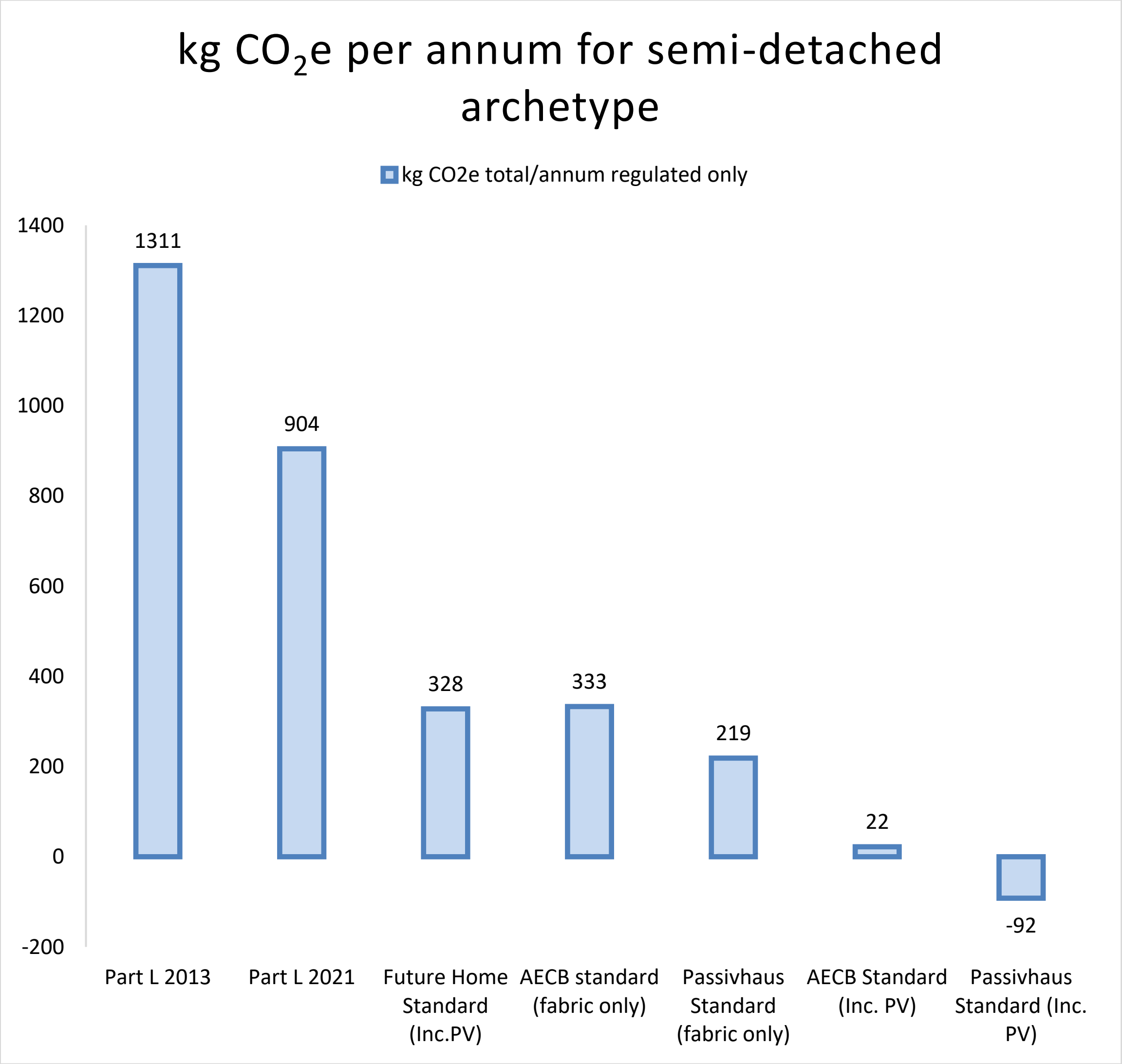
1.4 Comparison of standards

1.4.1 There are a range of standards that the council could consider when setting out their policy, some of which were referenced in the brief and repeated in Table 1.1. The following list sets out each of these, with more detail provided in the full Enhabit report in the appendices. Note - as previously discussed the first two approaches in Table 1.1 (CfSH4 and Option 1 FHS) are not considered as they are now made redundant by the planned 2021 Building Regulation changes:

- Current 2013 Part L (base position)
- 2021 Part L Standard
- Indicative Future Homes Standard
- PHI Low Energy Building
- AECB Building Standard
- Passivhaus Classic
- Passivhaus Plus/Premium (with Renewable Energy)

1.4.2 A detailed description and comparison of each of these standards in terms of their performance is set out in Appendix A. The council is also interested in understanding the potential around net zero whole life carbon (operational and embodied). This along with the standards outlined above are considered in more detail within the full Enhabit report in Appendix C.

1.4.3 These standards have a mix of requirements which are not always necessarily aimed at directly reducing CO_2 as part of their 'success' measurement but they do result in potential reductions as part of their low energy demands. It is also of note that to achieve net zero carbon, regardless of meeting the listed standards the energy source (e.g. the electricity supply) will also need to be decarbonised in order to meet net zero. However, to help illustrate the relative merits of each standard in meeting a reduced $C0_2$ the following diagram compares each approach, using regulated energy only (as required by the SAP protocol) and includes consideration of renewable energy supply[3]:



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[3] Note that this diagram is based upon the current CO2 performance of the energy supply. As the proportion of renewable and low carbon energy supply changes, the carbon performance of the different standards may vary. The figures are indicative and based on a standard model analysed by Enhabit Ltd for a recent development in Warwick in June 2020. N.B.The Future Homes Standard assumes provision of PV.

2 Review of technology and approaches to deliver improved standards and reduce environmental impact

2.1 Overview

2.1.1 Lancaster City Council have set out a range of technologies and approaches that could be used to help meet future building standards aimed at decarbonising new development and reducing environmental impacts. These are set out in the brief for the viability work and repeated below in Table 2.1.

Table 2.1 LCC Technology and approaches November 2020 brief:

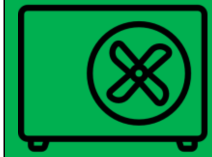
Ref	Optional technology/approach
1.	Air source heat pump for each new home
2.	Ground source heat pump for each new home
3.	District heating systems (typologies of 15 units and over)
4.	4 square metres/300 litre solar hot water panels/system
5.	4kW solar panel system
6.	Domestic wind turbines 5-6kW
7.	Rainwater harvesting system
8.	Grey water recycling system

2.2 Review of technology and approaches

2.2.1 Our review of these options is set out in the following table, which provides a summary of each of the technologies and their relative advantages and disadvantages. We have also added to the list to include (a) low energy light and appliances, (b) waste-water heat recovery and (c) mechanical ventilation with heat recovery.

2.2.2 It is important to note that the efficiency of any of these technologies in a residential building context is directly dependent on the robust efficiency of the fabric of the building in the first place. A poorly insulated building for example will require more power from the technology causing it to be inefficient in operation, or more of the technology will be required to satisfy the energy demand, creating extra capital cost and in some cases making practical installation impossible. It is therefore essential to take a Fabric First approach, as discussed previously, before considering the suitability of any particular technology.

2.2.3 A detailed description of each of the following technologies is set out in Appendix A.

Technology	**Advantages**	**Disadvantages**
(a)Low energy lights and appliances 	Less energy usage saving power and heat. Simple consumer choice using ERP (Energy Related Products) ratings. About the energy label and ecodesign | European Commission (europa.eu)	Some higher efficiency appliances can be more expensive to buy (but this is offset by efficiency and usually more durable).
1. Air Source Heat Pump (ASHP)[4] 	Combined with renewable electricity supply, potentially very low carbon solution for space and water heating. Provided there is space, relatively simple to install. Very quiet models available. Substantial part of cost can be reclaimed under RHI (until March 2022).	Moderate capital cost Some models may be a little noisy (like air conditioning units) and need regular maintenance, but this is likely to improve as the technology develops.
2.Ground Source Heat Pump (GSHP)[5] 	Combined with renewable electricity supply, potentially very low carbon solution for space and water heating. In right location, highly energy efficient, low to zero carbon emissions. Almost no noise associated with GSHP in operation. Substantial part of cost can be reclaimed under RHI (until March 2022).	High capital cost Local geological conditions may make it unsuitable.

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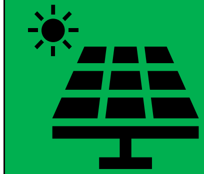
[4] Image - Flaticon.com

[5] Image - Smashicons

Technology	Advantages	Disadvantages
3.District Heating System (typologies of 15 units and over)[6] 	Local condition beyond scope of current report. Usually fossil fuel based energy generation in the UK with small pockets of geothermal heat that may help CO_2 reductions, although there is the opportunity for a centralised approach to decarbonisation. Efficiencies are possible when a balanced heat demand can be achieved (e.g. through a mix of uses needing heat at different times of the day). Can be logistically difficult to set up, partly through the normal need to include third parties, and there is an issue with monopoly supply for occupiers.	
4.Solar Thermal Panel 4m² panel system connected to 300 litre insulated hot water tank [7] 	Flat plate or evacuated tube collectors are useful for heating hot water and relatively cheap capital cost. Evacuated tube collectors are generally more efficient.	Evacuated tube collectors are more fragile than flat plate collectors and therefore need to be positioned high out of harm's way. Not suitable for partial or intermittent occupancy.
5.Solar – PhotoVoltaic Panels (PV) 4kWp solar panel system 	PV cells use light as a free source of energy. Can be attached to roofs or sited where no shading in a field for example. Can be installed retrospectively. Reducing in unit cost over time. Easily upgraded or replaceable if damaged.	Cannot be used at night so benefit from battery storage in addition with consequent losses of energy supply and additional capital and maintenance costs. Requires inverter box to transform the Direct Current (DC) supply at 12 Volts into 230 volt Alternating Current (AC) suitable for household use. Will not satisfy energy demand for houses with limited roofspace, or multi-residential blocks of flats as often insufficient roof area.

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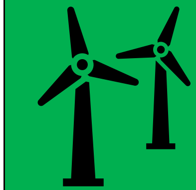
[6] Image - phatplus

[7] Image - Freepik

Technology	Advantages	Disadvantages
6.Domestic Wind turbines To generate 5-6kW 	NOT RECOMMENDED: Only medium and large-scale wind turbines in open areas, for example farmland, are viable.	Turbines in cities are rendered inefficient in cities or built-up areas due to turbulence. Maintenance and security of fixing points problematic over time for domestic installations. Can be viewed as ugly or noisy.
7.Rainwater Harvesting system[8] 	Useful for SUDS and reduction of flood risk. Irrigation applications. Water saving to achieve national targets. Resilience supply to reduce impact of summer drought. Possible application for under pavement cooling to counter Urban Heat Sink effects and overheating.	Additional design required for site drainage strategies.
8.Grey water recycling system 	NOT RECOMMENDED: May save on overall water utility bills and reduce pressures on central plant.	User-resistance perception of lack of hygiene. Local recycling (rather than centralised) may have higher maintenance requirements and hygiene controls. Centralised systems may be more efficient for water cleansing and energy usage.
(b)Waste Water Heat Recovery 	Zero carbon technology – useful energy saving device – simple to install – low maintenance and capital cost	Additional cost to install with added pipe runs.

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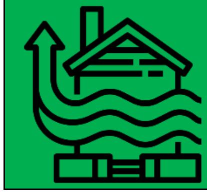
[8] Image - Icongeek26

Technology	Advantages	Disadvantages
(c)Mechanical Ventilation with Heat Recovery (MVHR) as upgrade to natural or mechanical extract ventilation (MEV)[9] 	Efficient controlled ventilation for clean, filtered, comfortable air. System recovers heat in the process of removing stale air. Low energy solution for high performance airtight buildings Easy regular maintenance	Ducting design can be complex and high capital cost. Ducting needs to be considered at early design stage. Space requirements Regular maintenance of filters required (typically every 3 months). Occupiers require education on use and maintenance of the whole system.

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[9] Image - ultimatearm

Appendix A - Comparison of standards

Standards and Fabric Comparisons – Practical Steps February 2021

Fabric Specifications - based on 'on-site' carbon targets for a typical semi-detached home.

	Current 2013 Part L (standard climate data)	2021 Part L Standard (standard climate data)	Practical steps to improve current performance to Part L 2021
Floor U-value (W/m2.K)	0.13	0.13	No change to current building regulation requirements.
External wall U-value (W/m2.K)	0.18	0.18	No change to current building regulation requirements.
Roof U-value (W/m2.K)	0.13	0.11	This requires an increase in thickness of insulation which will vary according to the characteristics of the material used. Typically this will involve adding insulation in the roof space either between and over the joists or between and over the rafters allowing always for appropriate ventilation. • To upgrade the roof insulation at ceiling level for example from current building regulations would require an additional **70mm of mineral wool** insulation.
Window U-value (W/m2.K)	1.4	1.2	The double glazing requires an improved performance with the following specifications included: • Frame factor = 0.7 • Solar Energy Transmittance= 0.63 • Light transmittance= 0.80 The installed U-value of the window must achieve 1.2 W/m2K by ensuring that the frame is 'thermal bridge free' i.e. it is placed in and behind the line of insulation to make sure there are no heat losses through the frame.
Door U-value (W/m2.K)	1.0 - opaque 1.2 – semi-glazed	1.0	Semi-glazed doors have up to 60% glass. If a door has more than 60% glass, it is then treated as a window. Solid or semi-glazed doors must have a certified u-value of 1.0 W/m2.K. The certification is normally supplied by the manufacturer via the wholesaler or retailer and is often indicated on a label attached to the window unit itself when first supplied to site. Sometimes the manufacturer and performance of the glazing can also be seen printed on the spacers in between the panes of glass.
Air permeability at 50 Pa	5.0 m3/(h.m2)	5.0 m3/(h.m2)	No change to current building regulation requirements. This is an air pressure test to check for air leakage or draughts. A trained and registered air tester conducts the test with regulated procedures and equipment.
Overheating	No explicit guidance	CIBSE guide >28^{0}C for 1%/year in bedrooms at night (22:00-07:00), OR 3% elsewhere (living rooms, kitchens, corridors etc and care homes) from May – September.	The detailed guidance is contained in the CIBSE Technical Manual TM59. In essence the guidance proposes a number of simple to achieve shading strategies to reduce the amount of solar heat gain through glazing. The first principle is to limit the amount of glass openings to South, West and East facades so it needs to be considered at the beginning of the design stage.. Additionally cross ventilation and window apertures are very important when combined with shading provided by balconies or brise soleil, shutters and external awnings or blinds. Shading by trees or large or climbing plants is seen as unreliable; curtains or internal blinds are insufficient for this level of heat reduction.

			Air conditioning is not recommended as it is an additional source of heat and energy use, and therefore CO2 emissions, contributing in particular to the Urban Heat Island Effect. Good Homes Alliance 'Overheating Tool' is designed to help planning decisions in this regard - Overheating in New Homes – Good Homes Alliance	
Heating appliance	Gas boiler (88% SEDBUK 2009)	Gas boiler (92% ErP)	Slight improvement on minimum efficiency standard compared to current building regulations. Specification requires an energy rating of at least 92%.	
Heat Emitter type	Regular radiators	Low temperature heating	Underfloor heating or large radiators are both suitable for water heated efficiently to a low level temperature (around 35^0C). The ability to operate at a low water temperature for space heating means that the boiler does not have to use so much energy and therefore helps reduce CO_2 emissions.	
Ventilation System type	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	No change to current building regulation requirements.	
PV	No	**For HOUSES** kWp = 40% ground floor area/ 6.5 **For FLATS** kWp = 40% ground floor area/ 6.5 x number of storeys in a block.	In the case of houses, the amount of power required to be produced by PV panels on a house is arrived at by the formula of 40% of the ground floor area divided by 6.5 to give a figure in kWp. This means that for a 70m^2 2-storey house, with ground floor area being 35m^2 (35 x 40/100)/6.5 = 2.154kWp would be the energy legislated for. The system must be connected to the house meter. In the case of flats, the amount of power required to be produced by PV panels on a block of flats is arrived at by the formula of 40% of the ground floor area divided by 6.5 times the number of storeys in the block, to give a figure in kWp. On the above example a 4-storey block of 35m^2 flats would require 2.154 x 4 = 8.616kWp of electricity generation from its PV array. The system must not be connected to the meter of the individual flat but metered as an overall system on its own. In both cases above, panels need to be mounted on a southerly facing roof (South East to South West) and have no overshading.	
Wastewater heat recovery (WWHR)	No	Yes	All showers must be connected to a WWHR unit, including showers over baths • The specification requires instantaneous WWHR with 36% recovery efficiency.	
Thermal Bridges Psi value (W/m.K)	0.05	0.05	No change to current building regulation requirements.	
CARBON EMISSIONS TARGET ($kgCO_2/m^2/yr$)	16.0	11.0	Overall improvements in the fabric specifications should achieve the target reduction. This will need to be demonstrated with an Energy Performance Certificate (EPC) calculated using the Standard Assessment Procedure (SAP) prepared by a Registered SAP Assessor under one of the nationally approved Quality Assurance schemes.	At least 31% less emissions compared with 2013 Part L.

	2021 Part L Standard (standard climate data)	Indicative Future Homes Standard Specification (includes measures already taken in 2021 Part L)	Practical steps to improve Part L 2021 to achieve indicative Future Homes Standard 2050
Floor U-value (W/m2.K)	0.13	0.11	This requires an increase in thickness of insulation which will vary according to the characteristics of the material used. Typically on a suspended timber floor an extra 70mm of insulation will be required and on a 70mm concrete screed floor only an additional 30mm of insulation can achieve the 0.11 u-value required. In both cases perimeter insulation of 50mm is assumed to reduce thermal bridges. With this level of additional insulation it makes economic and environmental sense to aim for the higher standard from the start rather than trying to retrospectively upgrade in the future. Adding an additional 30 – 70mm of insulation now is an easy win - trying to add this in the future will be very expensive.
External wall U-value (W/m2.K)	0.18	0.15	This requires an increase in thickness of insulation which will vary according to the characteristics of the material used. Typically with a full fill cavity wall current insulation levels would need to be increased by 65mm; with a Timber frame I-studs construction insulation increase would be 50mm; and with a Structural Insulated panel wall insulation requirement would be an additional 65mm to achieve the 0.15 u-value. With this level of additional insulation it makes economic and environmental sense to aim for the higher standard from the start rather than trying to retrospectively upgrade in the future. Adding an additional 50 – 65mm of insulation now is an easy win - trying to add this in the future will be very expensive.
Roof U-value (W/m2.K)	0.11	0.11	No change compared to Part L 2021 requirements.
Window U-value (W/m2.K)	1.2	0.8	Window performance upgrades from double to triple glazing. Given that triple glazed windows should pay for themselves in terms of energy saving over a five year period compared to the current cost of a double glazed unit, then the cost uplift to replace the windows between 2021 and 2050 is a false economy quite apart from the disruption involved, additional CO_2 in embedded energy and future labour costs.
Door U-value (W/m2.K)	1.0	1.0	No change compared to Part L 2021 requirements.
Air permeability at 50 Pa	5.0 m3/(h.m2)	5.0 m3/(h.m2)	No change compared to Part L 2021 requirements.
Overheating	CIBSE guide >28^{0}C for 1%/year in bedrooms at night (22:00-07:00), OR 3% elsewhere (living rooms,	The overheating strategy should be already in the original design stage work so no further requirements envisaged.	No change compared to Part L 2021 requirements.

	kitchens, corridors etc and care homes) from May – September.			
Heating appliance	Gas boiler	Low-carbon heating (e.g. Heat pump)	Fossil fuel boiler systems are to be phased out and replaced with low carbon technologies such as all electric heat pumps. Currently there is a Renewable Heat Incentive to help subsidise the cost and quarterly repayments of approximately 75% are spread out over 7 years.	
Heat Emitter type	Low temperature heating	Low temperature heating	No change compared to Part L 2021 requirements.	
Ventilation System type	Natural (with extract fans)	Natural (with extract fans)	No change compared to Part L 2021 requirements.	
PV	40% ground floor area	None	No change compared to Part L 2021 requirements.	
Wastewater heat recovery	Yes	No	No change compared to Part L 2021 requirements.	
Thermal Bridges Psi value (W/m.K)	0.05	0.05	No change compared to Part L 2021 requirements.	
CARBON EMISSIONS TARGET ($kgCO_2/m^2/yr$)	11.0 At least **31% less** emissions compared with 2013 Part L.	3.6 At least **75% less** emissions compared with 2013 Part L.	Overall improvements in the fabric specifications should achieve the target reduction. This will need to be demonstrated with an Energy Performance Certificate (EPC) calculated using the Standard Assessment Procedure (SAP) prepared by a Registered SAP Assessor under one of the nationally approved Quality Assurance schemes.	At least **75% less** emissions compared with 2013 Part L.
Floor U-value (W/m2.K)	0.11	≤ 0.11	No change compared to Part L 2050 requirements.	
External wall U-value (W/m2.K)	0.15	≤ 0.15	No change compared to Part L 2050 requirements.	
Roof U-value (W/m2.K)	0.11	≤ 0.11	No change compared to Part L 2050 requirements.	
Window U-value (W/m2.K)	0.8	≤ 0.80	No change compared to Part L 2050 requirements.	
Door U-value (W/m2.K)	1.0	≤ 0.80	Door performance upgrade mainly achieved with thicker insulated door panels. No penetrations allowed (e.g. letter box flaps) through door so post boxes are external as in most European countries. Good seals around door and frame ensure draught free doorways with minimal heat losses.	
Air permeability at 50 Pa	5.0 m3/(h.m2)	Passivhaus Standard ≤ 0.6 ach @50Pa AECB Standard ≤ 1.5 ach @50Pa	The air pressure testing regime required by the Passivhaus standard reflects more the reality of the fabric condition with windows closed as it does not allow uncontrolled air vents, air bricks or similar natural ventilation but chooses only controlled ventilation routes. The achievement of this air test to below 0.6 air changes per hour means in practice that an air tightness barrier needs to be established from the early design stage and good quality air tightness tapes must be used to secure junctions round windows, doors and other external penetrations from air infiltration.	

			Tests should be scheduled at regular intervals (at least 2 before final test) to ensure achievement of the standard and to check quality of seals. An on-site air tightness champion and 'tool box talks' for the construction team enable understanding and success.
Overheating	CIBSE guide >28^0C for 1%/year in bedrooms at night (22:00-07:00), OR 3% elsewhere (living rooms, kitchens, corridors etc and care homes) from May – September.	≤ 10% of hours in the year above 25^0C (5% recommended)	While the Passivhaus standard is not as stringent as the CIBSE guidance most Passivhaus developments are designed to at least a 5% risk factor. This is constantly under review and research and development of this aspect is currently ongoing at the Passivhaus Trust with initial findings to be published in late February 2021. As the fabric standard and build quality control is designed to emulate a constant comfortable temperature year round overheating should be only a small risk, however some councils (e.g. Exeter) have already specified using climate data sets that are predictive of climate conditions in 2050 to compensate. This is not yet an option included in the Future Homes Standard.
Heating appliance	Low-carbon heating (e.g. Heat pump)	Low-carbon heating (e.g. Heat pump)	No change compared to Part L 2050 requirements.
Heat Emitter type	Low temperature heating	Low temperature heating (usually underfloor works well with heat pump)	No change compared to Part L 2050 requirements.
Ventilation System type	Natural (with extract fans)	MVHR	Mechanical Ventilation with Heat Recovery is a key aspect of the Passivhaus standard as it provides comfort, filtered fresh air and good indoor air quality – this is beneficial for both health, mould prevention, odours and ventilation. The nature of the ducting required in MVHR means that this is best suited to new build projects and must be designed in at the outset. The filtration element of an MVHR system also makes this highly beneficial in polluted, noisy or inner city locations because it provides filtered fresh air at an optimum level without creating draughts nor having to open windows. Filter changes are a simple procedure.
PV	A modest array of PV panels already. No further requirement compared to Part L 2021	None	No change compared to Part L 2050 requirements. Renewables are not a required feature of Passivhaus but act as a further enhancement and CO_2 reduction measure. On difficult sites where for example the orientation of roofing does not comply with the FHS Specification the fact that PV panels are not needed may be advantageous.
Wastewater heat recovery	Already supplied under Part L 2021.	No	Wastewater heat recovery systems are not required in the Passivhaus standard but can be optionally added with beneficial effect as a further energy saving measure.
Thermal Bridges Psi value (W/m.K)	0.05	< 0.01	All junctions of external walls, floors and roofs, window and door frames, external corners and ridges must be designed from the outset to be thermal bridge free. The architect or building designer will need to ensure that where a fabric element is exposed to the outside air that this is in some way wrapped or protected by insulation so that heat loss is kept to a bare minimum. This is normally calculated using computerised calculation software to show that the standard required is achievable. The calculations are already being done for Part L so there are no additional calculation requirements for Passivhaus.

CARBON EMISSIONS TARGET ($kgCO_2/m^2/yr$)	3.6 At least **75% less** emissions compared with 2013 Part L.	N/A- Reduced CO_2 results from lower energy use. Better performance, lower carbon emissions.	Overall the Passivhaus fabric standard is equivalent to the proposed Future Homes Standard but with additional energy use, health and comfort benefits arising from a quality control process, improved thermal bridge free construction techniques, more robust air tightness, and better air quality and noise control from MVHR. Evidence from current Passivhaus projects indicates 80 -90% reductions in energy use and consequently a similar figure in terms of CO_2 emission reductions.	At least 75% less emissions compared with 2013 Part L.

	EnerPHit [a] (Passivhaus Institute Refurb Standard for comparison)	PHI Low Energy Building	AECB Building Standard	Passivhaus Classic	Passivhaus Classic /Plus/Premium (with Renewables)	Future Homes Standard proposed
HEATING Space Heating demand $Q_{H,PH}$	≤20/25 [b] kWh/m^2.year depends on climate zone	≤30 kWh/m^2.year	≤40 kWh/m^2.year	≤15 kWh/m^2.year	≤15 kWh/m^2.year	None indicated so not measurable
COOLING Space cooling demand $Q_{C,PH}$	≤15 kWh/m^2.year	≤30 kWh/m^2.year	≤40 kWh/m^2.year	≤15 kWh/m^2.year	≤15 kWh/m^2.year	None indicated
OVERHEATING Frequency of overheating (temp. $>25^{0}$C)	< 10% of hours in the year	< 10% of hours in the year	< 10% of hours in the year (5% recommended)	< 10% of hours in the year	< 10% of hours in the year	CIBSE guide >280C for 1%/year (See Fabric Specs Grid)
AIRTIGHTNESS Airtightness n50 Air Changes/hour	≤1.0 ach @50Pa (MVHR)	≤1.0 ach @50Pa (MVHR)	≤1.5 ach @50Pa (MVHR) ≤3.0 ach @50Pa (MEV)	≤0.6 ach @50Pa (MVHR)	≤0.6 ach @50Pa (MVHR)	≤5.0 m3/(h.m2) @50Pa (Natural ventilation with Extract fans)
PRIMARY ENERGY RENEWABLE (PER) [c]	< 60 kWh/m^2.year	< 75 kWh/m^2.year	< 75 kWh/m^2.year	N/A	< 60 / 45 / 30 kWh/m^2.year	None indicated but Primary Energy will be one of the principal metrics used for measuring energy efficiency.
RENEWABLE ENERGY GENERATION	≤ 60 + (QH - QH,PH)* fØPER,H + (QC - QC,PH) /2 kWh/m^2.year	N/A	N/A	N/A	N/A / 60 / 120 kWh/m^2.year	None indicated
CARBON EMISSIONS TARGET (kgCO$_2$/m^2/yr)	N/A- Reduced CO2 Results from lower energy use	N/A	N/A	N/A	N/A	(>75% reduction) 3.6

There are various low energy standards relevant to the UK which can be followed in order to obtain certification.
a: The EnerPHit standard can also be achieved by the 'building component method' where each building element mush achieve a minimum standard that varies with climate zone. This is the preferred route for historic buildings or those that are difficult to retrofit for legal, structural, economic or other reasons.
b: the space heating demand criteria depends upon the climatic zone.
c: primary energy renewable (PER) is the new Passivhaus criteria to replace Primary Energy. Either can be used at present, the building only has to meet one of these.

$\mathbf{Q_H}$: heating demand $\mathbf{Q_{H,PH}}$: Passive House criterion for the heating demand

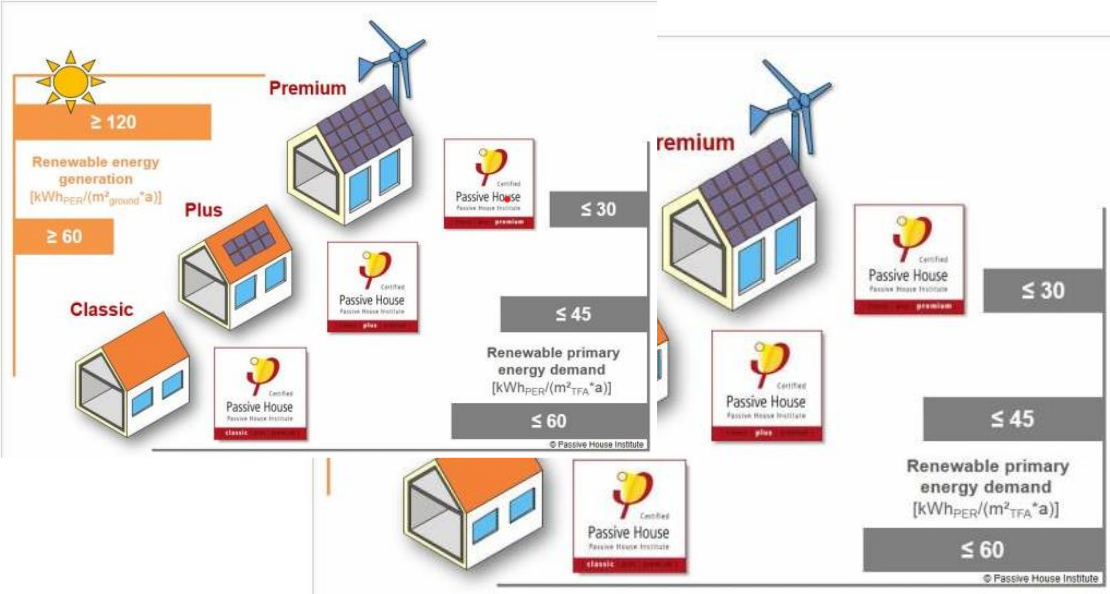
$\mathbf{f_{ØPER,\ H}}$**:** weighted mean of the PER factors of the heating system of the building

$\mathbf{Q_C}$: cooling demand (incl. dehumidification) $\mathbf{Q_{C,PH}}$: Passive House criterion for the cooling demand

Fabric Specifications Summary - based on 'on-site' carbon targets for a typical semi-detached home.

	Current 2013 Part L (standard climate data)	2021 Part L Standard (standard climate data)	Indicative Future Homes Standard Specification (includes measures already taken in 2021 Part L)	Passivhaus Classic (indicative, to achieve energy balance) & AECB Standard Climate location specified.
Floor U-value (W/m2.K)	0.13	0.13	0.11	< 0.11
External wall U-value (W/m2.K)	0.18	0.18	0.15	< 0.15
Roof U-value (W/m2.K)	0.13	0.11	0.11	< 0.11
Window U-value (W/m2.K)	1.4	1.2	0.8	< 0.80
Door U-value (W/m2.K)	1.0 - opaque 1.2 – semi-glazed	1.0	1.0	< 0.80
Air permeability at 50 Pa	5.0 m3/(h.m2)	5.0 m3/(h.m2)	5.0 m3/(h.m2)	< 0.6 ach @50Pa
Overheating	No explicit guidance	CIBSE guide >28^{0}C for 1%/year or 3% (see next cell to right)	CIBSE guide >28^{0}C for 1%/year in bedrooms at night (22:00-07:00), OR 3% elsewhere (living rooms, kitchens, corridors etc and care homes) from May – September.	< 10% of hours in the year above 25^{0}C (5% recommended)
Heating appliance	Gas boiler (89.5% SEDBUK 2009)	Gas boiler (92% ErP) - Low-carbon heating (e.g. Heat pump) is always an option.	Low-carbon heating (e.g. Heat pump)	Low-carbon heating (e.g. Heat pump)
Heat Emitter type	Regular radiators	Low temperature heating	Low temperature heating	Low temperature heating (usually underfloor works well with heat pump)
Ventilation System type	Natural (with extract fans)	Natural (with extract fans)	Natural (with extract fans)	MVHR The nature of the ducting required in MVHR means that this is best suited to new build projects and must be designed in at the outset.
PV	No	40% ground floor area as per formula. PV provision required unless target emission reached in other ways.	Assumed already installed under 2021 Regs, so no further PV required unless needed to achieve target CO2 reductions. (e.g. for reasons of orientation or exposed location)	None required. Future provision could be combined with battery storage options and help towards national grid resilience.
Wastewater heat recovery	No	Yes	Assumed already installed under 2021 Regs,	None required but encouraged as a 'Fabric First' issue.
Thermal Bridges Psi value (W/m.K)	0.05	0.05	0.05	< 0.01 Thermal bridge free design.

CARBON EMISSIONS TARGET ($kgCO_2/m^2/yr$)	16.0	11.0 At least **31% less** emissions compared with 2013 Part L.	3.6 At least **75% less** emissions compared with 2013 Part L.	N/A- Reduced CO_2 results from lower energy use. Better performance, lower carbon emissions.
Net Zero 'Carbon Ready' Compliant?	✗	✗	✗ Currently not, but possibly in the future with decarbonisation of the Grid	✓



[10]

What is Passivhaus[11]?

Passivhaus is an energy, comfort and quality standard. To achieve this, the building fabric (walls, roof, floor, windows and doors) and building systems (heating, hot water and ventilation) must be designed and built to a very high standard. The five basic principles of Passivhaus are shown in the diagram below. They are:

1. Ventilation that recovers heat
2. High levels of airtightness
3. Cold bridge free design
4. Passivhaus windows
5. High levels of thermal insulation

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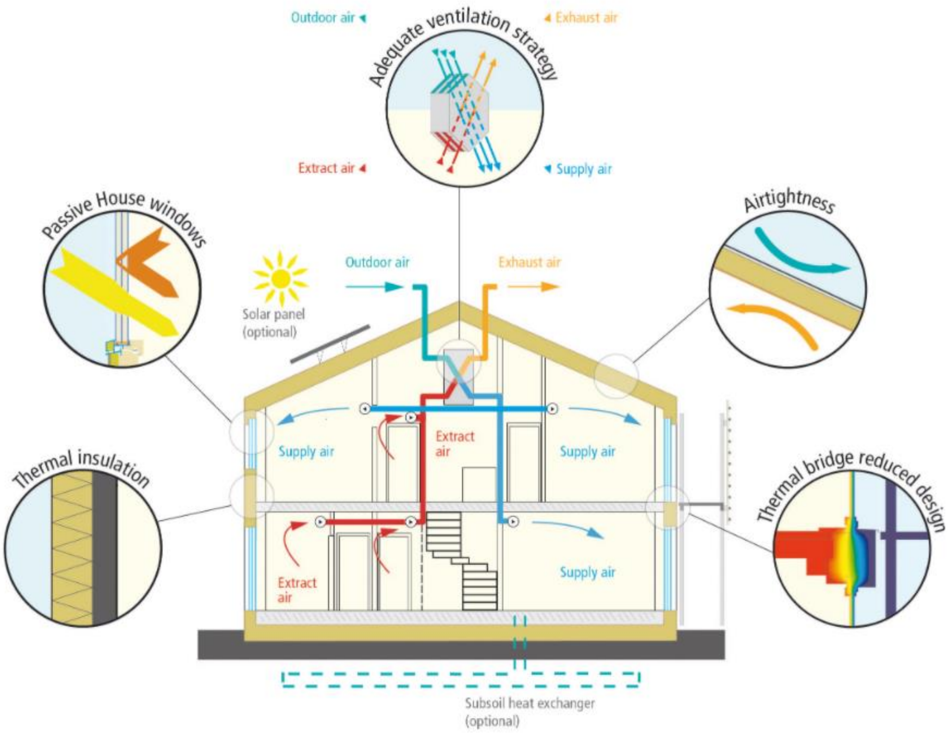
[10] Classic, Plus, Premium: The new Passive House classes and how they can be reached [ ] (passipedia.org)

[11] http://www.passivhaustrust.org.uk/what_is_passivhaus.php

The following five basic principles apply for the construction of Passive Houses:

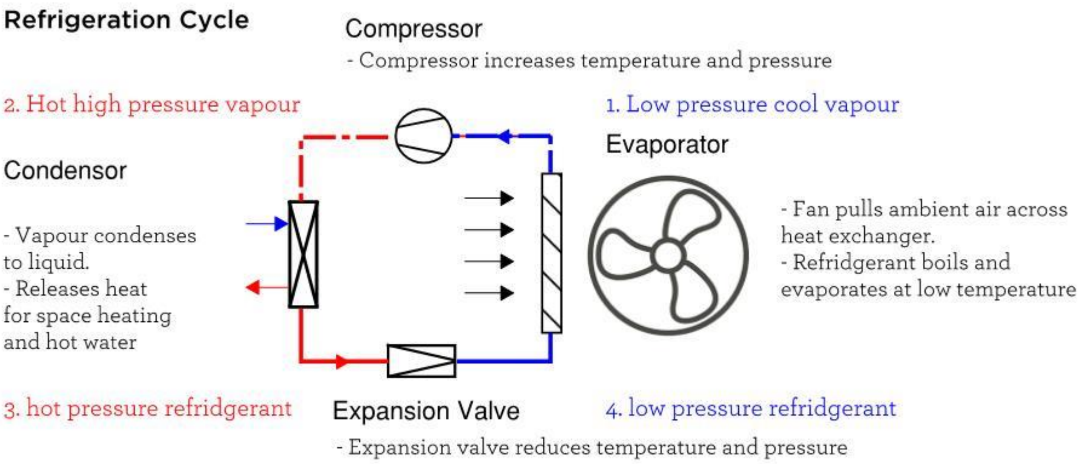


Appendix B – Detailed review of technology & approaches

1. Air Source Heat Pump (ASHP)

How does an ASHP work?

An air source heat pump system absorbs heat from the outside air and transfers this to a fluid. The fluid then passes through a compressor to increase the temperature so it can provide the heat for heating and hot water requirements within the home.
These systems can extract heat from outside temperatures as low as -15° C, however the efficiency of the system will decrease during particularly cold spells of weather. The electricity consumption of a heat pump is affected by the amount the heat pump needs to lift the temperature. If the heat pump only needs to lift the temperature from an outside air temperature of 10°C to 35°C it will work much more efficiently than having to lift from 0°C to 45°C. The SPF (Seasonal Performance Factor) or sometimes called the SCOP (Seasonal Coefficient of Performance) defines how efficiently the heat pump will run on average across all seasons.



ASHP's can either heat air to water or air to air systems. Air to water systems pass heat to any wet central heating system, and because the ASHP runs at a lower temperature than traditional boilers, these deliver energy saving efficiencies. These systems are great when heating underfloor systems and larger radiators which produce lower temperatures and work over a longer period of time.

Carbon Emission Reductions

Given a heat pump may have a little higher running costs compared to a gas boiler the biggest benefit of the heat pump is the **Carbon Emission Savings** they offer.

Using electricity to provide space heating has become a less carbon intensive option as renewables provide a larger contribution towards UK power generation. Since 2007 installed wind power capacity in the UK has grown from 2 GW to 21.7 GW in 2018[12]. Solar PV capacity has grown over the same period from 1.5 GWp to 13 GWp. This huge growth in renewable energy together with a steady reduction in coal power generation has dramatically changed the carbon intensity of grid electricity. According to Government statistics the carbon emission factor for UK grid electricity has decreased by almost a half from 0.467 kg CO_2e /kWh in 2007[13] to 0.255 kg CO_2e /kWh in 2019. This means that using electricity for space heating is now an increasingly low carbon option and technologies like heat pumps can offer huge carbon savings compared to a gas boiler.

Factors which affect efficiency of heat pump system

A well designed heat pump should have similar running costs to a gas boiler however in many cases the annual running cost may be a little higher. Due to the current low pricing of gas compared to electricity we wouldn't expect a heat pump to have lower running costs than a gas boiler despite its higher level of efficiency. Many factors can affect annual heating consumption such as internal target temperature, hot water demand and tank temperature, property insulation and level of heat loss and also the sizing and type of heat emitters.

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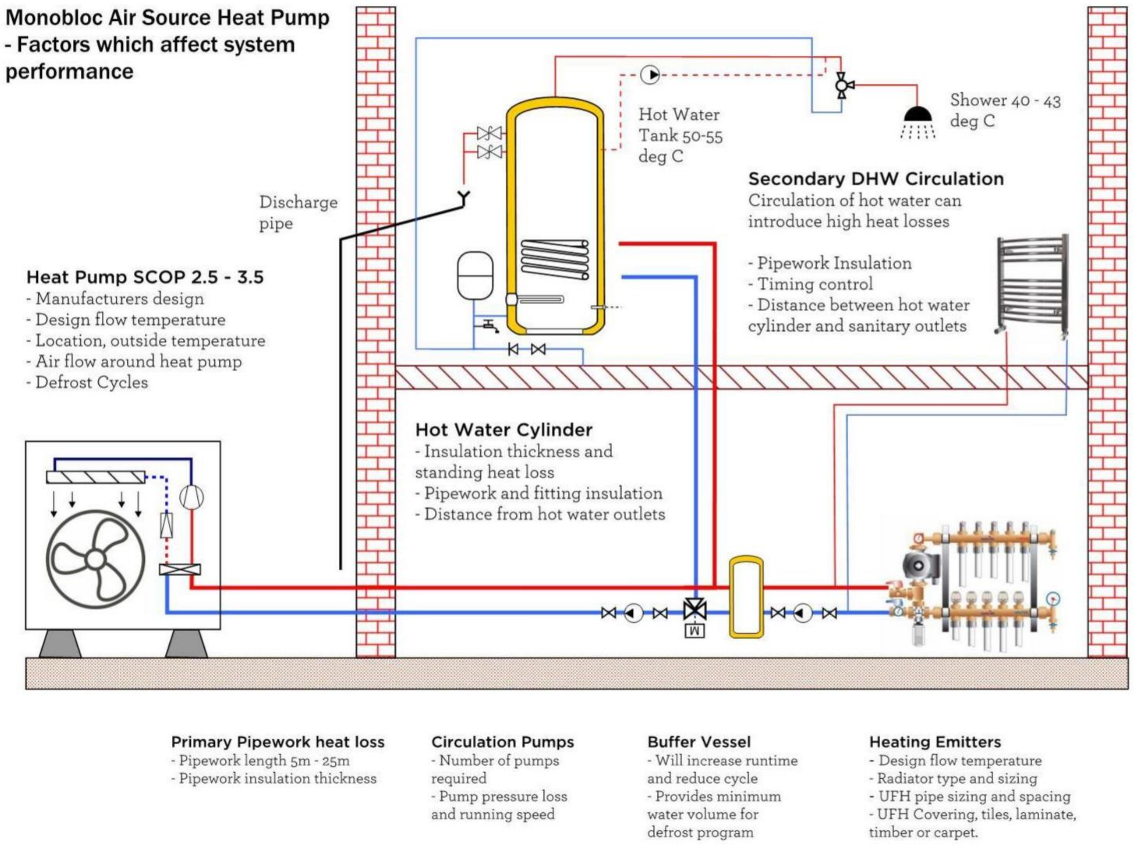
[12] https://www.gov.uk/government/statistics/regional-renewable-statistics**.** Regional Statistics 2003-2018: Installed Capacity

[13] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2007. Conversion factors 2007 - Condensed set (for most users)

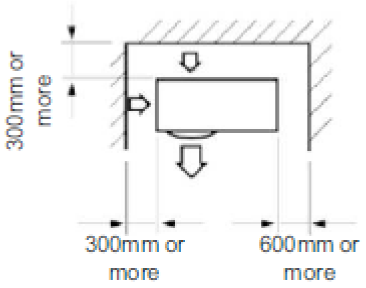


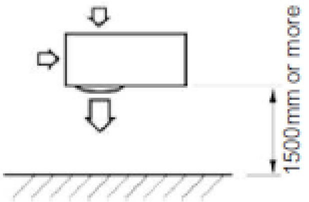
Spatial Considerations

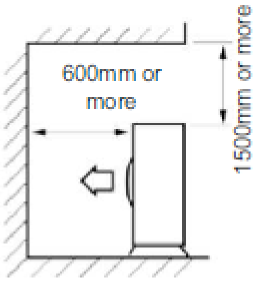
If the heat pump is too constricted and enclosed it's more difficult for the air to go through the fan. One of the dangers is when the cool air blown out is recirculated back into the heat pump, the coefficient of performance drops and the heat pump eventually cuts out due to freezing over.

For optimal efficiency it's best to allow a minimum of 30cm around the sides and rear of the heat pump and 1.5m of unobstructed space in front. There are some other restrictions due to planning requirements which also need to be taken into consideration, for example the heat pump needs to be 1m away from a neighbouring property. The simplest locations are at ground level in a rear garden, or at the side of the house

If the heat pump is to be at a distance from the property this can affect the efficiency of the heating system. We would recommend keeping below 15-20m between the hot water tank and heat pump. Some pipework could be run under the ground in insulated conduit. For greater distances split systems can be more efficient which use refrigerant pipework under the ground rather than heating fluid. The heat pump final location would need to be reviewed with detailed architectural drawings.

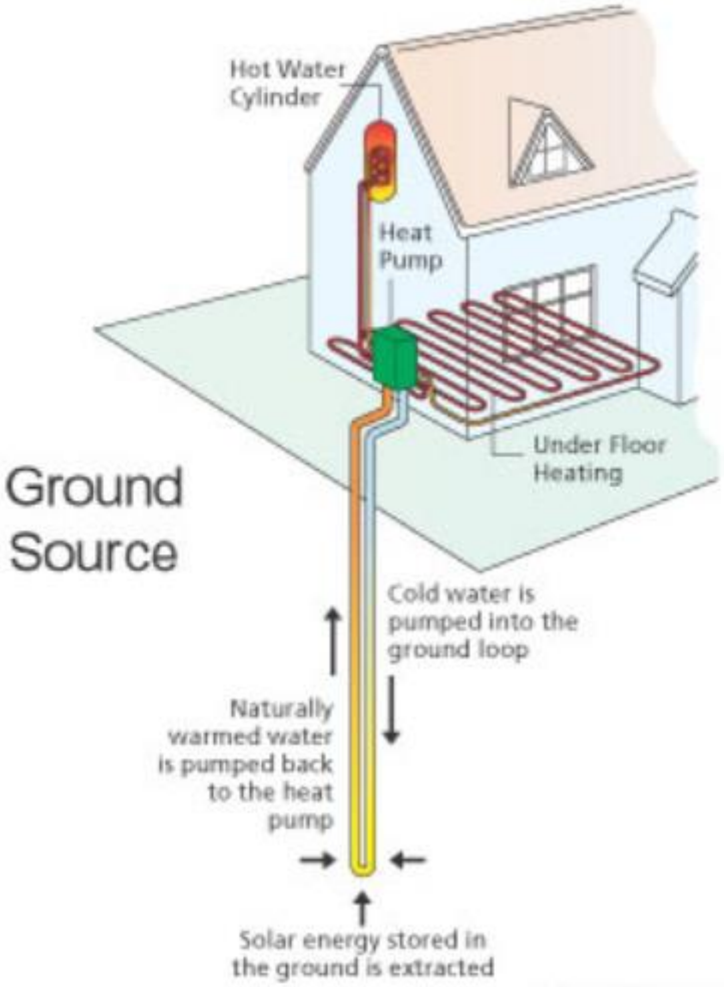






Depending on the size and power of the air source heat pump, the capital cost is around £11,000 to £14,000 + 5% Vat for supply and installation of the heat pump and hot water cylinder. The installation has a reduced VAT rate and should be eligible for staged repayments up to between £6,000 to £10,000 under the Renewable Heat Incentive (RHI – only available until March 2022) scheme or Green Homes Grant.

2. Ground Source Heat Pump (GSHP)



Like the ASHP described above, a Ground Source Heat Pump is highly energy efficient for providing hot water. However, there are some specific differences:

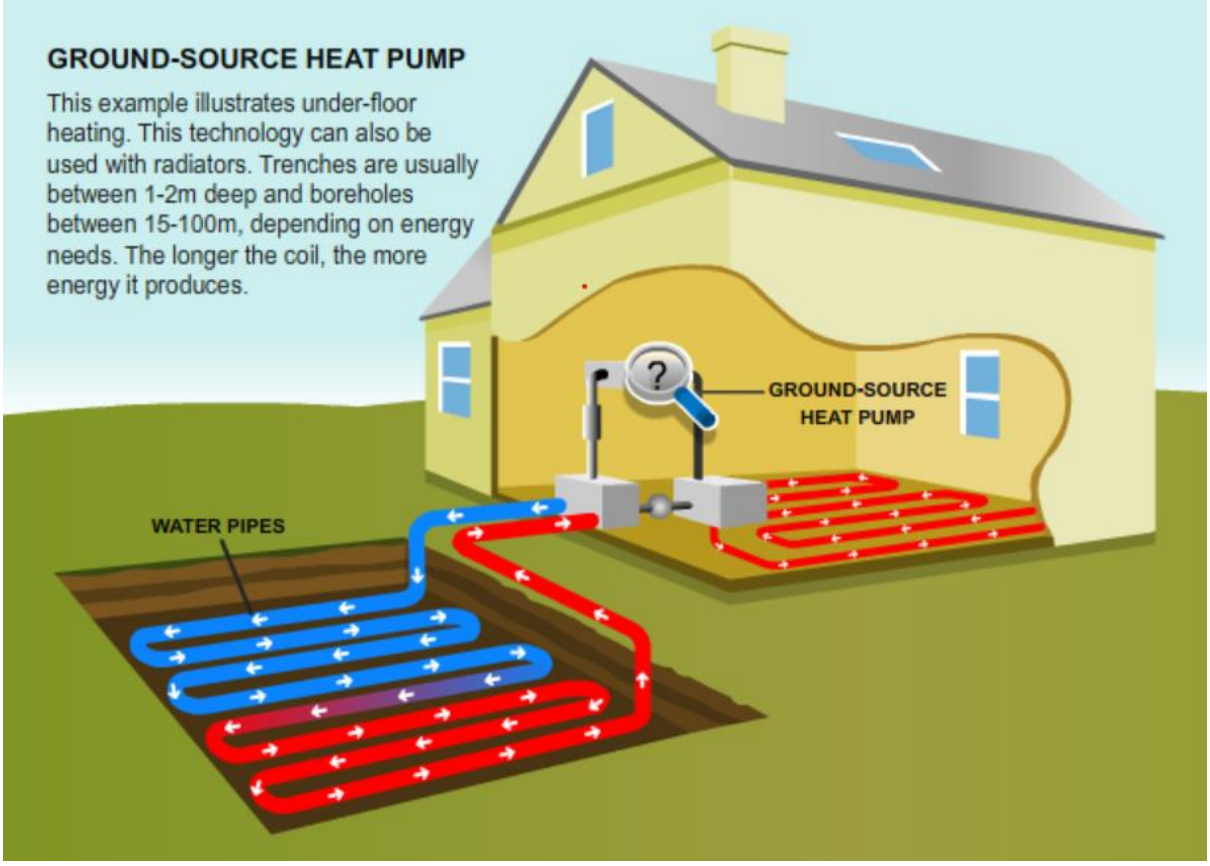
Advantages

- Low maintenance and running costs
- Less noise than gas boiler and air source heat pumps
- No carbon emissions if a renewable source of electricity is used to power the unit
- Up to 25 year lifespan of components – longer than air source pump
- Long term more efficient than an air source heat pump

Disadvantages

- High set up costs to drill down or excavate.

- The type of bedrock can affect the amount of energy that can be produced when using a vertical GSHP
- A horizontal GSHP requires a lot of space since the pipes are spread out over a large surface
- Some liquids used in the heat transfer can be environmentally undesirable so certified installations with appropriate materials must be specified



Costs for ground source heat pumps vary considerably depending on ground conditions but commonly quoted prices range from £14,000 to £20,000. If borehole drilling is required, costs can rise sharply. To give a rough idea, the cost of drilling a typical water well borehole to about 45m deep will be about £8,600; whereas, a hole of 75m will cost about £11,600, and 120m will cost about £15,000.[14]

3. District Heating

District heating (also known as heat networks or teleheating) is a system for distributing heat generated in a centralized location through a system of insulated pipes for residential

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[14] Ground Source Heat Pump Cost: 2020 UK Installation Prices (tradesmencosts.co.uk)

and commercial heating requirements such as space heating and water heating.[15] There are few district heating networks in the UK compared to mainland Europe. They have potential for reducing carbon emissions if they are powered by renewables or have local geothermal energy properties. Their discussion is currently beyond the remit of this report.

District heating or local heat networks are seen by many as a significant part of the future low energy infrastructure in the UK. These systems are common in many parts of Europe, where high density developments link to central sources of heat generation. There are a number of successful schemes in the UK, ranging from a small number of homes to city wide schemes such as those in Sheffield and Southampton. However, there are many schemes that have resulted in high operating costs, high heat loss through underground pipes, and ultimately high heating costs for residents. Careful design and operation is key, as is making sure that a district heating scheme is right for the location.

CIBSE (Chartered Institute of Building Services Engineers) recently updated the 'Code of Practice for Heat Networks in the UK (CP1)'. This document provides detailed advice to help decide if a district scheme is a good solution for a particular development and then to design the right system that will give long term benefits.

Key considerations when deciding if a district heating system is appropriate for a development include:

a. Is there a local source of low cost heat, for example a power station, waste incinerator, or existing local district heating scheme? Building a new energy centre or installing underground heat networks over long distances will significantly add to the capital cost of the development.
b. Does the development provide opportunity to take heat from one building and put it into another? This can be the case in summer where there is cooling demand, with heat removed by the cooling system able to be used to heat hot water.
c. Is there space to build an energy centre? Depending on the development size this space could be considerable.
d. Would a district heating system allow heat to be generated more efficiently than individual property heat generation? In most cases modern boilers and heat pumps modulate their output to deliver high efficiency at part load, so the efficiency benefits of a centralised system are quite low.
e. What is the carbon emissions of the central plant? Gas CHP is commonly used in energy centres, backed up by gas boilers. While the gas CHP is more carbon efficient than burning gas in a boiler, the carbon intensity of the national grid is falling rapidly and gas CHP can result in higher overall carbon emissions than gas boilers with grid electricity. If biomass heat is an option that can produce close to zero emissions with fuel from the right source, but there are air quality implications.
f. What is the long term opportunity? Does connecting the development to a central energy centre make transition to low carbon fuel simpler in future?
g. How will the development and the district heating system be managed? Who will take on responsibility for operating costs, maintenance, and end of life

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[15] District heating - Wikipedia

replacement? If there will be a managing agent or housing association taking on responsibility for management of the overall development it should be easier to add on additional duties. These operating costs should be offset against the alternative of annual boiler maintenance and boiler replacements that would typically be required with a property not on a district network.

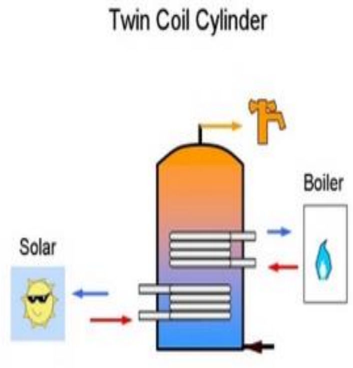
h. Who will manage metering and billing and what will be the cost to residents? There are several organisations who are able to provide this service. The Heat Trust scheme (https://www.heattrust.org/) helps to ensure fair practices so the consumers get fair pricing.
i. What are the alternatives for the development? It may not be feasible to install heat pumps in individual apartments or small terraced houses due to restrictions and space needed for external units. In these high density areas a communal system could be the most practical. For these units it is also often possible to utilise ‘exhaust air heat pumps’ which don’t require external units.
j. What is the predicted heat demand of the development? Homes built to high standards of energy efficiency, taking a ‘fabric first’ approach, will have very low heating demand and as a result take very little from the district scheme, making the financial business case challenging.

District heating should be considered as an option for all developments, but is challenging to design and operate cost effectively and with low carbon emissions. Experts should be consulted early in the process, with the cost, carbon and complexity fully tested against feasible alternatives. This will enable a decision to be made early and as a result the development to be designed to best suit district heat.

4. Solar Thermal

Solar thermal - or solar hot water - is the most efficient form of solar technology, delivering “free” hot water thanks to the sun’s energy. It is different from solar PV, which refers to generating electricity from the sun’s energy.

Solar thermal systems work alongside your conventional water heating system (e.g. gas boiler) and normally consist of solar panels (to capture the energy), pipes and a hot water cylinder (to store the hot water). The panels can be fitted on your roof or placed in any other unshaded area.



The hot water can be used for anything – baths, showers, doing the washing - it can even be used to heat swimming pools and, in some cases, whole buildings.

- Provides up to 70% of your hot water needs
- Saves 15-20% on your energy bills

You are paid for every unit of heat your panels produce, through the Renewable Heat Incentive (available until March 2022). This is payable for seven years after installation.

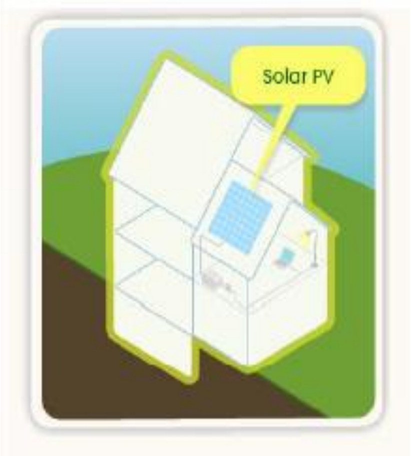
- Lowers your carbon footprint
- Protects against rising energy costs
- Provides greater energy independence
- Requires little maintenance

5. Solar PV

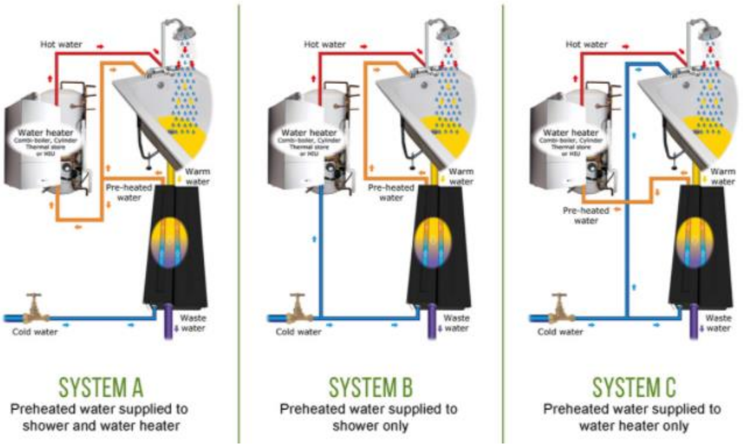
Solar PV (or photovoltaic) panels are used to generate electricity. They are best sited on a south facing pitched roof or a flat roof with minimal shading. The panels work by converting solar energy into electricity for consumption in the home or, where not needed, for export back into the electricity grid.

A solar PV array should generally be installed on a South facing roof. The size of the array should be as large as possible within budgetary limitations and usually staying below a peak size of 4kW, in order not to exceed certain restrictions put in place by your District Network Operators. 4kW residential scale solar PV systems cost in the range of £4,000 - £8,000, depending upon the size of the system and brand of system.

For a PV installation, it is also of high importance that no shading is present on the PV arrays, as this heavily reduces the electricity production.



Waste Water Heat Recovery



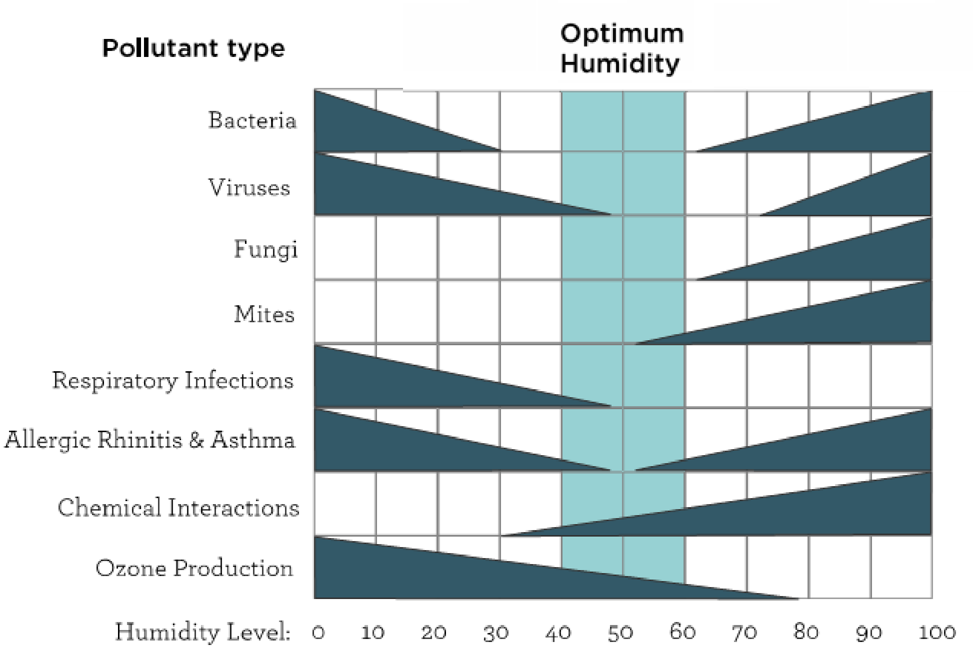
Waste water heat recovery is an energy saving device that absorbs the heat from hot baths or showers for example and transfers the heat to the cold water that supplies the hot water tank. The uplift in temperature provided by the hot waste water helps to reduce the amount of energy required to maintain the central hot water cylinder. Simple to install and maintain, it is also a relatively low cost item.

Mechanical Ventilation with Heat Recovery

As a building gets more airtight, the need for mechanical ventilation increases. A mechanical ventilation system can greatly improve comfort and indoor air quality, leading to health benefits.

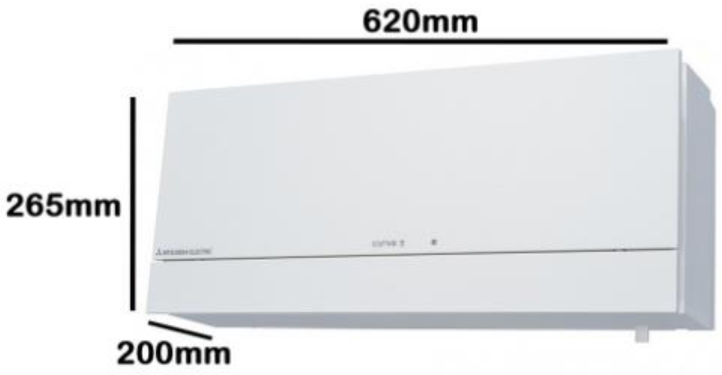
A mechanical ventilation with heat recovery (MVHR) system consists of a central unit, ducts with supply or extract valves in each room, and an intake and exhaust duct to outside. This system means that warm air extracted from kitchens and bathrooms can be passed through a heat exchanger in the central unit to pre-warm the air coming in from outside. Incoming air is also filtered to remove pollution and particulates. Installing an MVHR system typically costs £5,000 to £8,000, but this doesn't include the cost of the disruption to the property and making good, which is why MVHR is usually only installed during construction or when undertaking a major retrofit.

Improved air quality will help regulate humidity levels, increase oxygen / CO2 ratios and help to remove smells and volatile organic compounds (VOCs) given off by chemicals and everyday household items. Periodic changes of filters are required to ensure clean air and system efficiency. See graph below showing how bacteria and viruses are reduced within the ideal humidity range.



Optimum relative Humidity Levels (%)
for the Reduction of Harmful Contaminants

Localised heat recovery can be achieved where MVHR is impractical.
For bathrooms and toilets, heat loss can be controlled and draughts reduced by installing a single room heat recovery unit, such as this through the wall ventilation unit with heat recovery.[16]



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[16] Mitsubishi VL100EU5-E Lossnay Wall Mounted Single Room MVHR Unit (wall switch model) (bpcventilation.com)

Appendix C – Enhabit report

Please note that Appendix A and B of the Enhabit report are the same as Appendix A and B of this ‘Decarbonising standards and technology summary’ report and are therefore not repeated.

LANCASTER CITY COUNCIL CLIMATE CHANGE REVIEW OF LOCAL PLAN

Carbon standard and renewables evidence

FEBRUARY 12, 2021

ENHABIT

Document Control

Version	Date	Description	Author	Approver
1	12/2/2021	DRAFT Rev 1	TW	SP
2	04/05/2021	DRAFT Rev 2	TW	SP

Contents

Introduction

In its 2019 Consultation paper, the Ministry of Housing, Communities and Local Government describes its ambition to achieve a Future Homes Standard to address the Climate Emergency through changes to Building Regulations. The changes envisaged will be measured against the current 2013 Part L (Conservation of Fuel and Power) and Part F (Ventilation). Essentially, a two step process is proposed:

1. From 2025 if not sooner (see below), an interim measure that sees a planned reduction of building related CO_2 emissions reduced by 31%.
2. A full Future Homes Standard for 2050 that proposes a 75-80% reduction in CO_2 emissions compared to the 2013 Part L Building Regulations.

As both these steps exceed the performance aspirations of the Sustainable Homes Code Level 4 equivalent (19% reduction in CO_2), and the Future Homes Fabric-only proposal (20% reduction in CO_2), this report concentrates on the viability of a number of the higher achieving Standards that will be necessary for Lancaster City Council to adopt in their Local Plan for lower energy consumption in use and considerably reduced CO_2 emissions in line with their own and national planned changes.

The Government Response to Future Homes Standard Consultation[1] document, published in January 2021, confirms that Local Authorities retain the power under The Planning and Energy Act 2008 to set local energy efficiency standards for new homes, and at the same time commits to an interim uplift in Part L standards.

The Government paper states:

A 2021 interim uplift will deliver high-quality homes that are in line with our broader housing commitments and encourage homes that are future-proofed for the longer-term.
These homes will be expected to produce 31% less* CO_2 *emissions compared to current standards.

The aim of the Government is to implement the interim uplift regulations Part L (Conservation of Fuel and Power) and Part F (Ventilation) **in 2022**.

The driver behind this initiative is the declared Climate Emergency and it seeks to position the performance of the housing market to being 'zero carbon ready'. To do this requires a Fabric First approach. Renewables and other low emissions technologies can then be added at the same time for further improvements in performance, or fitted retrospectively as technology improves and unit costs for the technology come down (as is well documented with Solar PV panels which halved in cost over a 5-year period).

Standards based on building regulations & SAP (Part L 2013, 2021 and Future Homes Standard)

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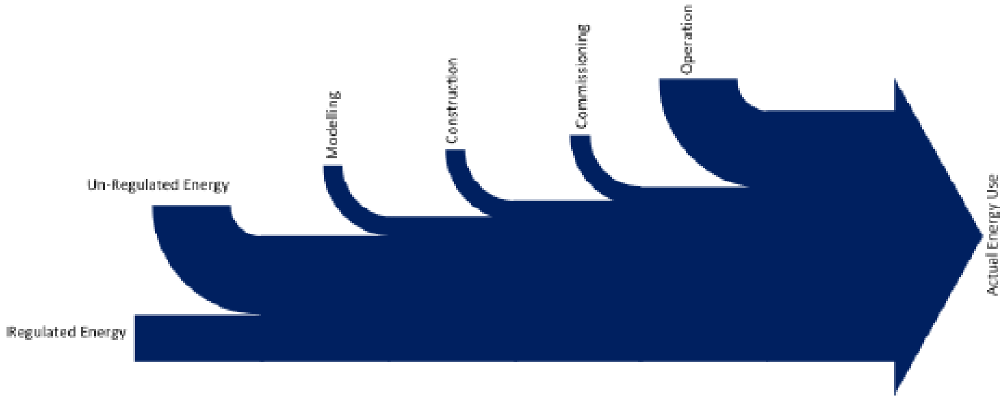
[1] **The Future Homes Standard**: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings. Summary of responses received and Government response. January 2021 Ministry of Housing, Communities and Local Government (see pages 4 & 5).

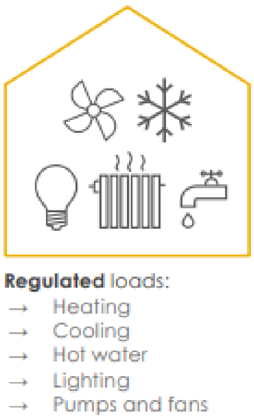
The Building Regulations use a Standard Assessment Procedure (SAP) or a Simplified Building Energy Model (SBEM) for calculating the heat gains and losses in a building. SAP and SBEM take in to account many of the heat losses and gains in the normal operation of a building but perhaps surprisingly to many there is often a large performance gap between the predicted, designed energy use of a building and the actual energy used once occupied.

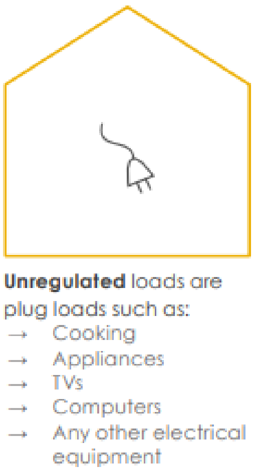


The Performance Gap growth from Design to Operation (Green Construction Board, 2013, p.4) as quoted by B. Bowden[2]

Human behaviour can account for some of this but often there is a variance in predicted and actual operational performance of the fabric of the building which is why an understanding and focus on this aspect is most important.

Regulated energy (regulated by Part L of the Building Regulations) covers areas such as space heating, lighting and hot water. Cooking and appliances are <u>not</u> regulated by Part L and fall within the category of 'un-regulated energy use'.





The Building Regulations approach emphasises CO_2 reduction as a primary target. However, if we are aiming to achieve the Future Homes Standards and beyond for 2050 using the **SAP** way of calculating emissions, even 100% carbon reduction **will not achieve zero carbon** as it does not include unregulated energy. According to the LETI Climate Emergency Design Guide 'unregulated energy can form up to 50% of total operational energy.'[3]

The Fabric First Approach

It is accepted building physics that to effectively achieve zero carbon emissions in buildings (with greater certainty as to performance), we must start with reducing the energy required as shown in

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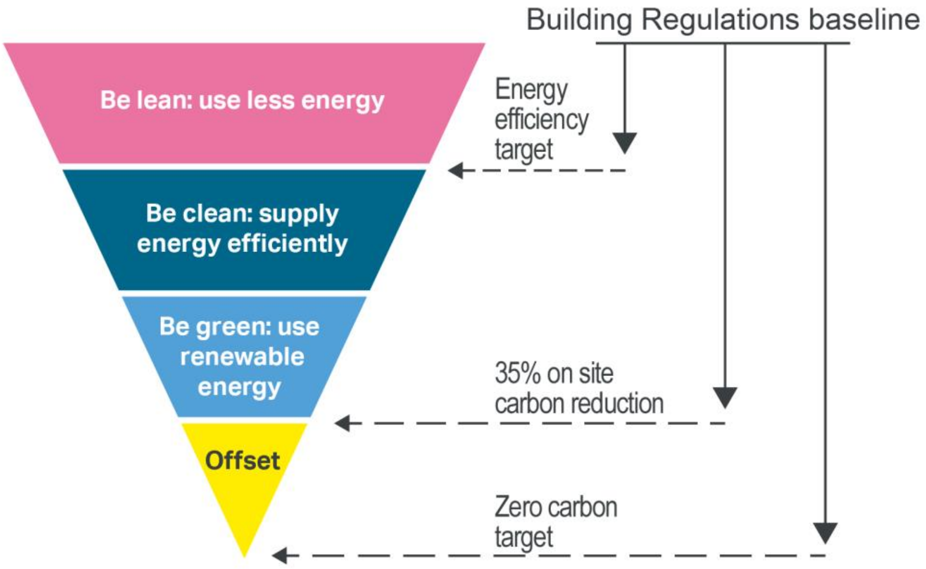
[2] Bernadette Bowden: Building Standards Scholarship 2015/16 Building Control influence on the energy performance gap of buildings. Southend-on-Sea Borough Council, January 2016.

[3] LETI Climate Emergency Design Guide p.40. Illustrations from LETI.

the energy hierarchy below[4]. Once we have minimised energy demand, then we can design efficient heating and hot water systems, install onsite renewable technologies and finally, invest in national renewable technologies to offset any used on site. The latter may not be required if the energy demand can be sufficiently reduced onsite by designing well insulated, thermal bridge free and airtight homes. This is known as the fabric first approach.

In current building regulations for new domestic properties (Part L1A)[5], this has been recognised by introducing a fabric energy efficiency target known as the TFEE (Target Fabric Energy Efficiency) as well as the overall target CO_2 emissions rate known as the TER (Target Emissions Rate). However, the TFEE has not been introduced for new non-domestic buildings which must only achieve a TER (Part L2A)[6].



Source: Greater London Authority

Fabric plus technology (31% reduction in CO_2) – interim standard

This is the proposed Future Homes Interim Standard for 2022 (but encouraged by the government to be implemented from 2021 under the interim uplift to Part L 2021) based on the current Building Regulations approach.

The following building fabric specification provided in the Government response to the Future Homes Standard consultation document with renewable technologies will typically allow a building to operate at or near to the 31% reduction in carbon emissions.

	2021 Part L Standard (standard climate data)
Floor U-value	0.13

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[4] Policy S12 https://www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan/draft-new-london-plan/chapter-9-sustainable-infrastructure/policy-si2-minimising

[5] Approved Document L1A – conservation of fuel and power in new dwellings https://www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power

[6] Approved Document L2A – Conservation of fuel and power in new buildings other than dwellings https://www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power/3

(W/m2.K)	
External wall U-value (W/m2.K)	0.18
Roof U-value (W/m2.K)	0.11
Window U-value (W/m2.K)	1.2
Door U-value (W/m2.K)	1.0
Air permeability at 50 Pa	5.0 m3/(h.m2)
Overheating	CIBSE guide >28^0C for 1%/year or 3%
Heating appliance	Gas boiler
Heat Emitter type	Low temperature heating
Ventilation System type	Natural (with extract fans)
PV	40% ground floor area (formula)
Wastewater heat recovery	Yes
Thermal Bridges Psi value (W/m.K)	0.05

a. ‘Fabric First’ considerations

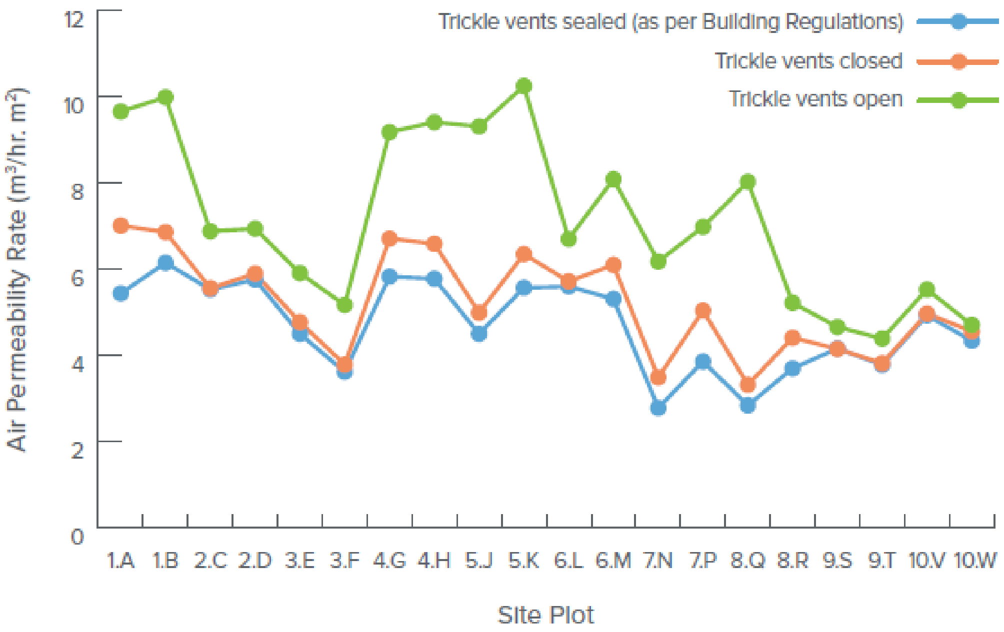
The first step in reducing CO_2 emissions focuses on fabric to achieve an energy balance that delivers a comfortable temperature for its human occupants with an efficient level of heating energy. Achieving high efficiency and low CO_2 emissions means initially a substantial improvement in the insulating performance of walls, floors, roofs, windows and doors: the external envelope of a dwelling. It also means that how these elements are put together needs to be considered as a whole to limit heat loss.

The rate of heat loss is described numerically as a u-value in watts per meter squared of the material or set of components in degrees Kelvin ($W/m^2.K$), similar to degrees Centigrade. The lower the number, the lower the rate of heat loss. In human terms this means that if you have a well insulated home it will take longer for heat to escape through the fabric so you can maintain a level of comfort without having to top up with more heat energy – lower bills; conversely the theory goes that if you can stop the heat travelling inwards to the dwelling on a hot summer’s day, you can remain cooler. Achieving the theoretical state can only be done by ensuring the fabric considerations are understood and implemented at all levels from initial design to final construction.

Achieving the CO_2 reductions can be a matter of modifying the u-values of the fabric to suit: but the design modelling in SAP or SBEM may be unrealistic as there are a number of unregulated heat losses such as use of fridges, washing machines, TVs, computers, lifts, cooking and kettles (appliances) and increasingly the charging of electric vehicles, that are not accounted for, nor do these models reflect local weather patterns, leading to inaccurate estimates of both energy use and carbon emissions.

Further weaknesses in the Building Regulations methodology were shown by the Zero Carbon Hub who produced an in-depth final report in July 2014 entitled ‘Closing the Gap Between Design and As Built Performance End of Term Report’. One striking example (below) is the difference between ventilation through trickle vents (uncontrolled draughts) as measured by Building Regulation requirements which seal up the vents for testing contrasted with the actual ventilation losses with the trickle vents open or closed in normal operation. In almost every case the SAP produced for Building Regulations calculations will exaggerate the performance of air tightness as indicated by the Air Permeability Rate.

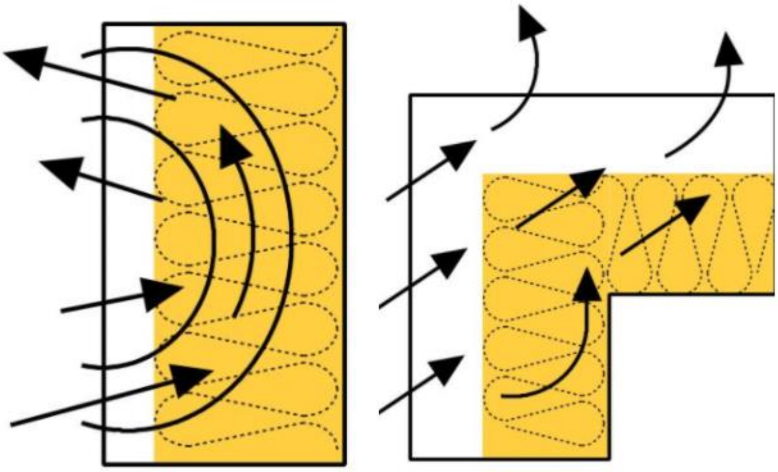
Figure 1. Air permeability rates for Trickle vents open, closed and sealed



b. Weather and air tightness, thermal bypass and thermal bridges

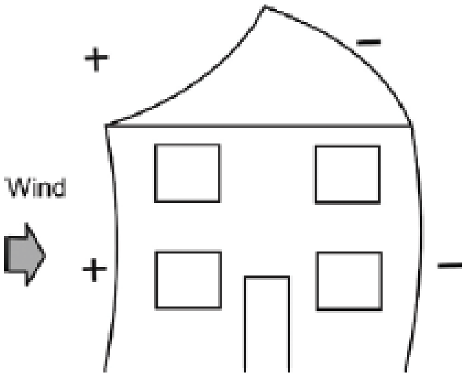
Part of the fabric makeup will naturally be the structure itself and the thickness of insulation, but weathertightness and airtightness are also significant factors in ensuring that heat loss is kept to a minimum. The key effect of wind pushing air into or across a building and heat flows causing air to percolate through and out of a building can combine to create the heat loss that is described as 'thermal bypass'.

- Thermal Bypass is where air travels either
  a. across a surface 'wind washing or wicking away heat' or
  b. through a structure, looping its way up perhaps from a cool basement level, warming as it goes up the insides of a wall and emerging into a cold roof space and in the process turning in to condensation.



If the outside of a building is not windtight cold air can move through or past the insulation and "steal" the heat, even when none actually infiltrates into the inside of the building. Corners and eaves are particularly vulnerable. Graphic: Mark Siddall

Even in an airtight building you can have air movement through or around the insulation, in effect bypassing its effect and making it perform less well. Thermal bypass can dramatically reduce the performance of insulation. Consider too that "just a small crack 1mm wide and 1mm long (..can..) allow an extra 360g of water i.e. a good glassful, into the roof space, every 24 hours." (Mark Siddall principal at LEAP, Low Energy Architectural Practice, quoted by Kate de Selincourt, 4th January 2021[7]). Building regulations generally do not address the air moisture issue even though the stack effect is well known and moisture is a common cause of building fabric failure but the conclusion is that "we need to treat the outside of the building – membrane, boards, render, or masonry, like the air barrier it is" – particularly in cavity wall construction which is commonplace in the UK, it is imperative to minimise air movement through the cavity by ensuring full fill insulation.



Bankvall [1978] reports that for a wall with a 20pa (Pascal) pressure difference between inside and out (equivalent to a velocity of 2.5m/s) the air flow through 300mm of insulation would result in a 35% reduction in thermal performance. [8]

From the above discussion airtight construction is a prerequisite for a low energy home and all joints, cracks and services penetrations through the air barrier should be sealed accordingly. Service penetrations would need robust sealing systems such as those produced by www.doyma.com

Due to the exacting airtightness requirement of 0.6 air changes per hour at 50 Pascals (ach/hr@50pa), residential construction achieving the PassivHaus standard can be considered to address several potential bypass mechanisms, although it does not confront directly the question of wind tightness. Consequently, it is an issue that relates to the 'Performance Gap' that is often reported on when a

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[7] Beware thermal bypass – it's air behaving badly! By Kate de Selincourt in Siga Blog 04/01/2021

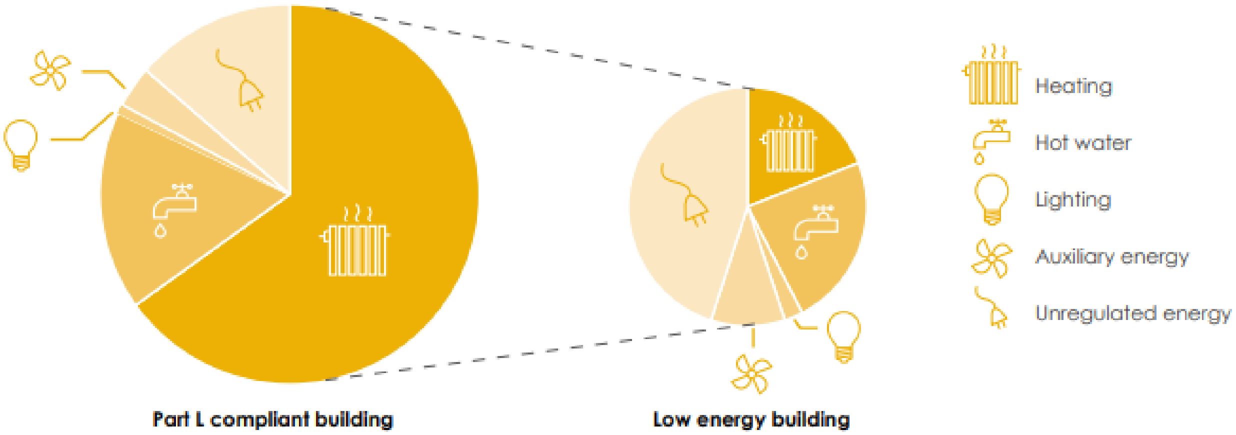
[8] From an illustration in The Impact of Thermal Bypass by Mark Siddall. Green Building Press 2009.

building in its daily operation fails to match the designed or predicted performance, often by a serious margin.

The Passive House Trust has reported that the heat loss performance gap is commonly underestimated, and calculates that an average building consumes 'over 40% more energy than its EPC modelling would indicate.'[9]

As part of this overall picture of a building in operation it is important to eliminate the paths or bridges for heat transfer (thermal bridges) as far as possible as these weak points create cold spots, compromise the efficiency of the material performance and in the worst case can cause condensation or excess moisture issues. These thermal bridges are typically created at junctions between walls and ground floors, walls and roof ridges, eaves and gables, at corners of buildings and around the frames of doors and windows. As the insulation of the fabric significantly improves the importance of thermal bridges increases because they will contribute a relatively higher percentage towards heat losses.

In short, thermal performance is not simply a consequence of increasing the thickness of insulation but also that of the protection and encapsulation of the insulation through good design and workmanship. Perhaps one answer is to have an 'Energy Champion' on site much as there is an Airtightness champion already, as proposed by the Zero Carbon Hub in 2014.[10]



Residential Energy breakdown[11]

c. Other factors influencing performance – Orientation and Overheating

Site factors can have a profound influence on the performance of a building and the state of heat loss or overheating can depend on the orientation in relation to solar gain. Overheating is of increasing concern and is usually a result of using too much glass and not enough shading. A new consultation document Part X has been issued in draft form under the Future Homes Standard to gather responses on the reduction of overheating risk.[12]

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[9] Passivhaus: the route to zero carbon? Passivhaus Trust, March 2019

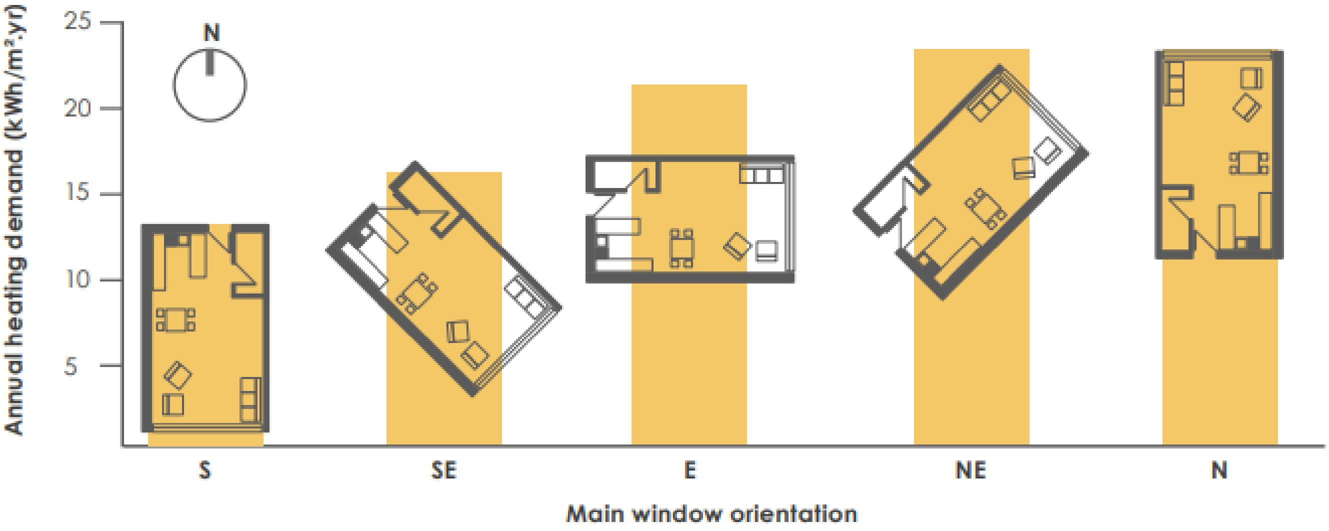
[10] Closing the Gap between Design & As-Built Performance End of Term Report, published by the Zero Carbon Hub, July 2014.

[11] Illustration from the LETI Climate Emergency Design Guide

[12] Approved Document [X] - Overheating - consultation version - January 2021 (publishing.service.gov.uk)

The LETI Climate Emergency Design Guide illustrates the effect of orientation around the compass in terms of changes in energy demand on a specified building. The window elevations and fabric when facing South in this example are shown to consume about 12 kWh/m^2 per year. Orienting the same building through 180 degrees so that the primary windows elevation faces North means that the building now consumes double the energy to about 24 kWh/m^2 per year and therefore increases its production of carbon emissions. A building can still be made to achieve the lower rate of energy consumption in this north orientation but compensating fabric measures need to be adopted making it more expensive in materials and may possibly reduce available living space.

Why Orientation is important[13]



When it comes to overheating the Future Homes Standard relies heavily on the detailed guidance contained in the CIBSE Technical Manual TM59[14]. In essence the guidance proposes a number of simple to achieve shading strategies to reduce the amount of solar heat gain through glazing.

The first principle is to limit the amount of glass openings to South, West and East facades so it needs to be considered at the beginning of the design stage. Additionally cross ventilation and window apertures are very important when combined with shading provided by balconies or brise soleil, shutters and external awnings or blinds.

Shading by trees or large or climbing plants is seen as unreliable; curtains or internal blinds are insufficient for this level of heat reduction. So external shading is essential for any highly insulated building.

Air conditioning is not recommended as it is an additional source of heat and energy use, and therefore CO2 emissions, contributing in particular to the Urban Heat Island Effect.[15]

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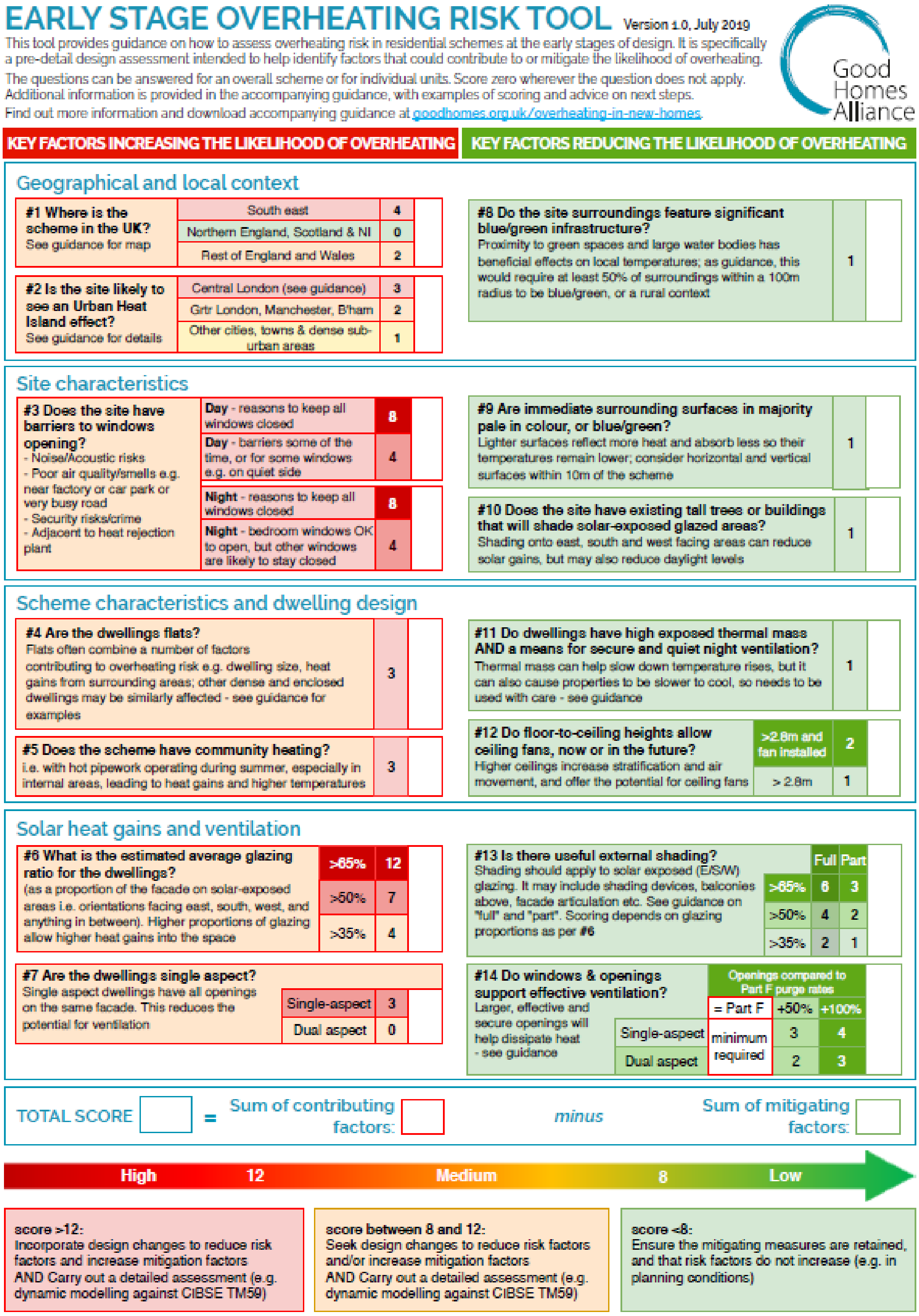
[13] LETI Climate Emergency Design Guide

[14] www.cibse.org

[15] Reducing Urban Heat Islands: Compendium of Strategies published by US Environmenatl Protection Agency

The Good Homes Alliance ‘Overheating Tool’ is designed to help planning decisions in this regard and used in conjunction with a guidance booklet.[16]



EARLY STAGE OVERHEATING RISK TOOL Version 1.0, July 2019

This tool provides guidance on how to assess overheating risk in residential schemes at the early stages of design. It is specifically a pre-detail design assessment intended to help identify factors that could contribute to or mitigate the likelihood of overheating.

The questions can be answered for an overall scheme or for individual units. Score zero wherever the question does not apply. Additional information is provided in the accompanying guidance, with examples of scoring and advice on next steps.

Find out more information and download accompanying guidance at goodhomes.org.uk/overheating-in-new-homes.

Good Homes Alliance

KEY FACTORS INCREASING THE LIKELIHOOD OF OVERHEATING | **KEY FACTORS REDUCING THE LIKELIHOOD OF OVERHEATING**

Geographical and local context

#1 Where is the scheme in the UK? See guidance for map	South east	4
	Northern England, Scotland & NI	0
	Rest of England and Wales	2
#2 Is the site likely to see an Urban Heat Island effect? See guidance for details	Central London (see guidance)	3
	Grtr London, Manchester, B'ham	2
	Other cities, towns & dense sub-urban areas	1

#8 Do the site surroundings feature significant blue/green infrastructure? Proximity to green spaces and large water bodies has beneficial effects on local temperatures; as guidance, this would require at least 50% of surroundings within a 100m radius to be blue/green, or a rural context	1

Site characteristics

#3 Does the site have barriers to windows opening? - Noise/Acoustic risks - Poor air quality/smells e.g. near factory or car park or very busy road - Security risks/crime - Adjacent to heat rejection plant	**Day** - reasons to keep all windows closed	8
	Day - barriers some of the time, or for some windows e.g. on quiet side	4
	Night - reasons to keep all windows closed	8
	Night - bedroom windows OK to open, but other windows are likely to stay closed	4

#9 Are immediate surrounding surfaces in majority pale in colour, or blue/green? Lighter surfaces reflect more heat and absorb less so their temperatures remain lower; consider horizontal and vertical surfaces within 10m of the scheme	1
#10 Does the site have existing tall trees or buildings that will shade solar-exposed glazed areas? Shading onto east, south and west facing areas can reduce solar gains, but may also reduce daylight levels	1

Scheme characteristics and dwelling design

#4 Are the dwellings flats? Flats often combine a number of factors contributing to overheating risk e.g. dwelling size, heat gains from surrounding areas; other dense and enclosed dwellings may be similarly affected - see guidance for examples	3
#5 Does the scheme have community heating? i.e. with hot pipework operating during summer, especially in internal areas, leading to heat gains and higher temperatures	3

#11 Do dwellings have high exposed thermal mass AND a means for secure and quiet night ventilation? Thermal mass can help slow down temperature rises, but it can also cause properties to be slower to cool, so needs to be used with care - see guidance		1
#12 Do floor-to-ceiling heights allow ceiling fans, now or in the future? Higher ceilings increase stratification and air movement, and offer the potential for ceiling fans	>2.8m and fan installed	2
	> 2.8m	1

Solar heat gains and ventilation

#6 What is the estimated average glazing ratio for the dwellings? (as a proportion of the facade on solar-exposed areas i.e. orientations facing east, south, west, and anything in between). Higher proportions of glazing allow higher heat gains into the space	>65%	12
	>50%	7
	>35%	4
#7 Are the dwellings single aspect? Single aspect dwellings have all openings on the same facade. This reduces the potential for ventilation	Single-aspect	3
	Dual aspect	0

		Full	Part
#13 Is there useful external shading? Shading should apply to solar exposed (E/S/W) glazing. It may include shading devices, balconies above, facade articulation etc. See guidance on "full" and "part". Scoring depends on glazing proportions as per **#6**	>65%	6	3
	>50%	4	2
	>35%	2	1

		Openings compared to Part F purge rates		
		= Part F	+50%	+100%
#14 Do windows & openings support effective ventilation? Larger, effective and secure openings will help dissipate heat - see guidance	Single-aspect	minimum required	3	4
	Dual aspect		2	3

TOTAL SCORE = Sum of contributing factors: *minus* Sum of mitigating factors:

High 12 Medium 8 Low

score >12: Incorporate design changes to reduce risk factors and increase mitigation factors AND Carry out a detailed assessment (e.g. dynamic modelling against CIBSE TM59)	score between 8 and 12: Seek design changes to reduce risk factors and/or increase mitigation factors AND Carry out a detailed assessment (e.g. dynamic modelling against CIBSE TM59)	score <8: Ensure the mitigating measures are retained, and that risk factors do not increase (e.g. in planning conditions)

d. Fabric Proposals for Part L 2021 and context of Future Homes Standard 2025

The proposed Part L 2021 standards outlined at the start of this section show a modest improvement in the insulation levels in the roof compared to the current Part L 2013 but propose no changes to the

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[16] Overheating in New Homes – Good Homes Alliance

wall and floor u-values. There is also a modest requirement for improved performance in the double-glazed windows: the heat loss factor (otherwise known as a u-value) for current Building Regulations is 1.4 whereas the proposed for Part L 2021 is only 1.2 which is also achievable with double glazing. The 0.2 reduction in heat loss uplift provides marginal comfort gains and does little to reduce CO_2 emissions compared with the 2025 standard that aims to have windows that reduce their heat loss by almost 50% with a considerably better u-value of 0.8.

These fabric changes are envisaged within a 5 year period but the initial fabric and good quality windows will last a lot longer than that. It seems short sighted and more importantly uneconomic and even impractical to require improvements retrospectively in such a short time frame. It would make more practical sense to put in the modest amounts of insulation into the walls, floors and roofs right at the beginning. The insulation itself is much less expensive than labour or retrofitting later. Installing insulation once the walls or floor are finished may not even be possible, rendering the building inadequate after just 25 years.

Therefore, when assessing the viability of a fabric measure it is essential to weigh up what is practical for the long term. Insulation and airtightness, thermal bridge and bypass reductions, ventilation and indoor air quality are all essential qualities of a Fabric First approach and should not be compromised without very good reasons as they form the foundations of what is to follow.

Fortunately, there are some measures that can wait for later installation and these are broadly the applied technologies such as heat pumps, radiators and solar energy appliances which are aimed at low or zero carbon emissions. The one exception to retro-fitting is perhaps MVHR, Mechanical Ventilation with Heat Recovery (See Appendix for low energy technologies) where the ducting requirements of a centralised system need careful consideration and will need designing in to a new building at the earliest stage. Passing rigid ducts through a house can be a complex problem that becomes easier and even simple if it is incorporated at the beginning of the design process.

One easy win re-introduced for Part L 2021 is the provision of Waste Water Heat Recovery (WWHR) units for all showers in dwellings (including over a bath). As it is part of the hidden plumbing in a bathroom it makes sense to build it in from the beginning as part of the fabric to minimise disruptive re-decorating at a later stage.

WWHR was temporarily dropped as a requirement in building regulations but the benefit of this low cost energy saving device is a sensible carbon reducing measure.

There is another discrepancy in the Part L 2021 Standard which proposes keeping to existing fossil fuel supplies, and consequently maintaining the status quo of carbon emissions, by providing gas networks for new homes to enable the continued installation and use of gas boilers. There is a small possibility that gas networks could be used for distribution of biofuels or other lower carbon fuels. What we do know is that the electricity grid is decarbonising and heat pumps are seen as the main solution to heat and hot water in new homes.

It makes more sense economically and environmentally to install the appropriate utilities which necessarily excludes heavy carbon emitters like household gas. As Primary Energy factors take a more central stage in the reported calculations for SAP and SBEM, so it will be disadvantageous to householders wanting to get a good EPC when they come to sell or buy new homes to be saddled with gas. The new proposed CO_2 emissions factors for gas will be 0.210 (mains gas) to 0.241 (bottled LPG) expressed as kilograms of carbon emissions per unit of power used per hour. The only exception to this approach is if there is the local possibility of biogas which will have a more favourable emissions factor of 0.024 $kgCO_2e/kWh$ but it has a limited application. Electricity generation will by contrast attract a factor of 0.136 kgCO_2e/kWh which is nearly 50% less than mains gas or LPG. The lower the factor the greater the reduction in carbon emissions.

Proposed Future Homes Standard 2025 (75-80% less carbon than 2013 Building Regulations)

The Government has proposed a target standard for 2025 that aims to achieve a reduction in Carbon emissions in the order of 75- 80% compared with a comparable building constructed to the current 2013 Building Regulations. The standard is based on building regulations, and technical compliance is calculated using the Standard Assessment Procedure (SAP) model as previously described. The Future Homes Standard aims to be 'zero carbon ready' for new homes built from 2025 onwards. It then relies on the decarbonisation of the Grid to achieve 'zero carbon' 25 years later in 2050.

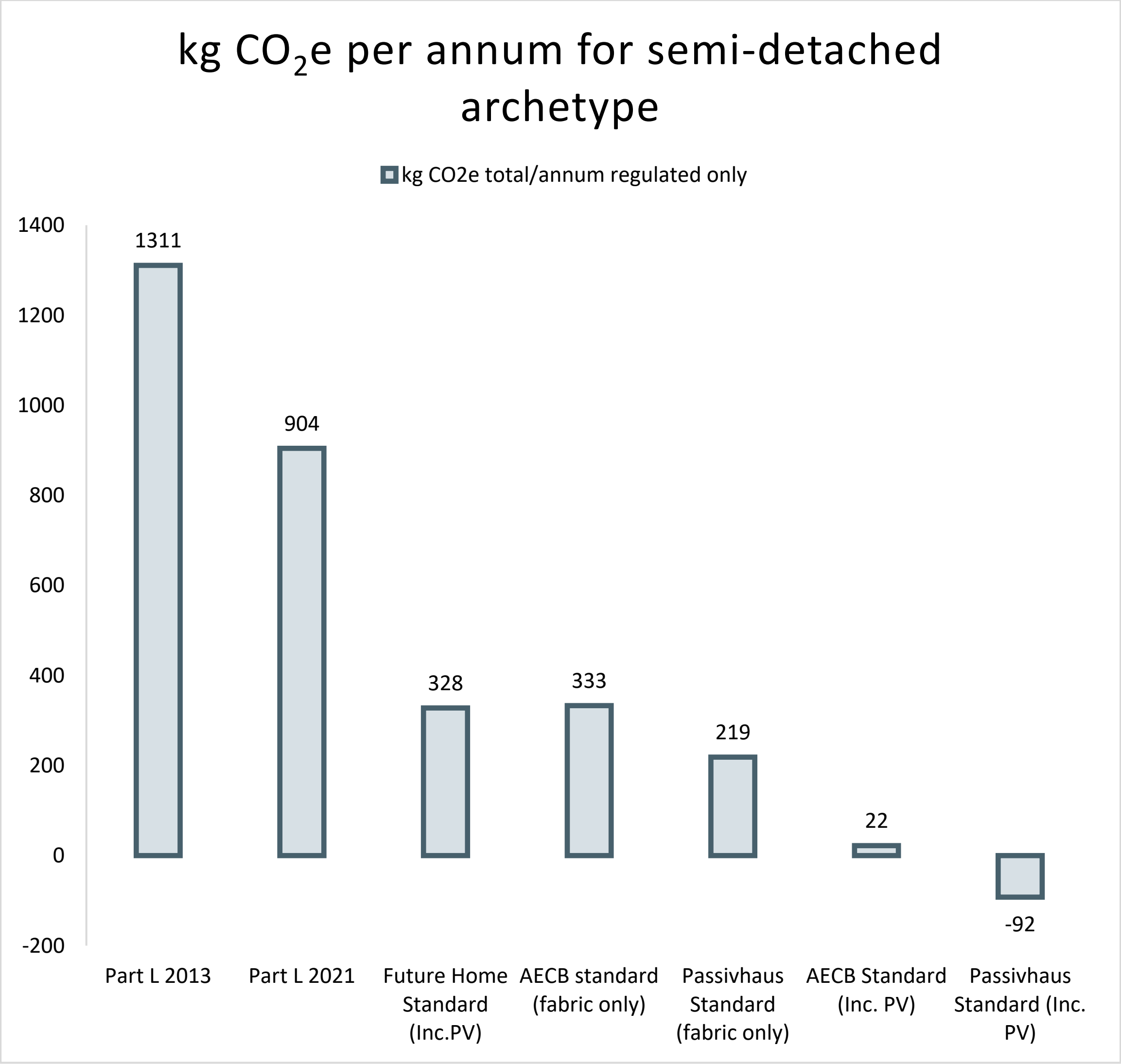
While the Government is proposing a stepped implementation of the 2050 'zero carbon' target by way of interim measures starting in 2022, **Lancaster City Council are looking to achieve this step change to 'zero carbon' by 2030** having declared a Climate Emergency.

The following building fabric specification provided in the Government response to Future Homes Standard consultation document with renewable technologies will typically allow a building to operate at or near to the 75% reduction in carbon emissions.

	Indicative Future Homes Standard Specification (includes measures already taken in 2021 Part L)
Floor U-value (W/m2.K)	0.11
External wall U-value (W/m2.K)	0.15
Roof U-value (W/m2.K)	0.11
Window U-value (W/m2.K)	0.8
Door U-value (W/m2.K)	1.0
Air permeability at 50 Pa	5.0 m3/(h.m2)
Overheating	CIBSE guide >28^0C for 1%/year in bedrooms at night (22:00-07:00), OR 3% elsewhere (living rooms, kitchens, corridors etc and care homes) from May – September.
Heating appliance	Low-carbon heating (e.g. Heat pump)
Heat Emitter type	Low temperature heating
Ventilation System type	Natural (with extract fans)
PV	No further requirement (assumed already installed under 2021 Part L)
Wastewater heat recovery	No
Thermal Bridges Psi value (W/m.K)	0.05

In August 2020, Enhabit carried out a study to look at Zero Operational Carbon for Warwick District Council. Comparing the standards in this semi-detached archetype using regulated energy only (as required by the SAP protocol) we can see in the table and in the graph below that the Future Homes Standard is very similar to the AECB Building Standard in terms of Carbon emissions.

The fabric demand is significantly reduced in the AECB and Passivhaus standards when compared with the Part L and Future Homes standards. When solar photovoltaic panels are applied to a house built to the AECB or Passivhaus standard this reduces CO_2 emissions further. The Passivhaus standard actually achieves zero carbon, although as discussed earlier this is not true zero carbon as it does not include un-regulated energy.



Comparison of different fabric standards used in the UK and their relative Carbon emissions when applied to a typical semi-detached two storey house.

Passivhaus based standards

From the Passivhaus Trust website, it can be seen that the examples of certified PH buildings are widespread across the UK.

As of the 29 January 2021 Passivhaus Trust Newsletter there are now over 5000 Passivhaus units under development in the UK at present with over 1,375 units completed and fully certified to date.

1375+ CERTIFIED UNITS

302+ CERTIFIED PROJECTS

MORE THAN 5000 UNITS UNDER DEVELOPMENT

200+ PROJECTS UNDER DEVELOPMENT

In a paper sponsored by Atkins and by the Hastoe Group of construction companies The Passivhaus Trust reports that while current uplifts on costs above Building Regulations compliant construction is in the order of 8% more, that the benefits of scale will bring costs down further to a small 4% uplift which is more than offset by wider benefits to health, wellbeing and comfort.[17]

Passivhaus is an energy, comfort and quality standard that goes beyond Building Regulations. To date over 1,375 Passivhaus homes have been completed in the UK, mostly as affordable housing but with some Passivhaus housing for sale. A true Passivhaus must be certified by a Passivhaus Certifier and verified by the Passivhaus Institute[18] in Germany, who own and developed the standard. It uses a fabric first approach and reduced technologies are required.

There are three levels of Passivhaus standards depending on renewable energy generation

Passivhaus Classic – which does not use renewables to achieve its standard and is broadly described in the table below

Passivhaus Plus – On site Renewable Energy Generation that produces more than 60 Kwh of Primary Renewable Energy per square meter (of the built ground) per year

Passivhaus Premium - On site Renewable Energy Generation that produces more than 120 Kwh of Primary Renewable Energy per square meter (of the built ground) per year

The Renewable Energy Standards also require that the Primary Renewable Energy demand used in the operation of the building must be less than or equal to:

60 kWh of renewable energy per square meter of the internal usable floor area per year for the achievement of the Classic Standard

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[17] Passivhaus Construction Costs (passivhaustrust.org.uk)

[18] http://www.passivehouse.com/

45 kWh of renewable energy per square meter of the internal usable floor area per year for the achievement of the Plus Standard

30 kWh of renewable energy per square meter of the internal usable floor area per year for the achievement of the Premium Standard

	Passivhaus Classic (indicative, to achieve energy balance) & AECB Standard **Climate location specified.**
Floor U-value (W/m2.K)	≤ 0.15
External wall U-value (W/m2.K)	≤ 0.15
Roof U-value (W/m2.K)	≤ 0.15
Window U-value (W/m2.K)	≤ 0.80
Door U-value (W/m2.K)	≤ 0.80
Air permeability at 50 Pa	Passivhaus Standard ≤ 0.6 ach @50Pa AECB Standard ≤ 1.5 ach @50Pa
Overheating	≤ 10% of hours in the year above 25^{0}C (5% recommended)
Heating appliance	Low-carbon heating (e.g. Heat pump)
Heat Emitter type	Low temperature heating (usually underfloor works well with heat pump)
Ventilation System type	MVHR
PV	None
Wastewater heat recovery	No
Thermal Bridges Psi value (W/m.K)	< 0.01

Passivhaus is a voluntary standard that is said to achieve a 75% reduction in space heating requirements, compared to standard UK new build[19] and to achieve significant reductions in carbon emissions. As such it can be defined as truly "Zero Carbon Ready" under the terms of the new Future Homes Standard 2025. Developments must meet a number of performance targets to be certified as Passivhaus which ensure that it does not suffer the pitfalls of the Performance Gap associated with EPC's. Certification is by a qualified assessor and follows a set procedure.

Benefits and criticisms of Passivhaus development

1. From the perspectives of residents, developers and managers, the key benefit of Passivhaus development is the reduced energy costs for occupiers and positive impact on fuel poverty. This largely explains why Passivhaus has been particularly strong in the affordable housing sector (but providing the same benefits for sale Passivhaus housing). Passivhaus is said also to provide healthier homes due to improved, filtered indoor air quality and consistent comfortable temperatures.

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[19] See the Passivhaus Trust website at http://www.passivhaustrust.org.uk/what_is_passivhaus.php#2

2. These benefits are set against criticisms that Passivhaus is a more expensive option to develop, it is more complex and time consuming and residents need guidance in making effective use of their home. On the latter point – this probably reflects some historic use of complex instruction manuals which could be effectively replaced with simpler and clearer resident guidance.

3. In terms of the additional construction cost, the research identified a range of views from those with experience of Passivhaus development. We concluded that an uplift in construction costs at 8 - 10% over Building Regulations is a reasonable assumption but that Passivhaus schemes can be delivered without any cost premium as reported from developments in Ireland and that larger/longer term developments are likely to have a lower cost uplift than small, one-off schemes. At the same time, the market value of sale housing can attract a price premium of about 5%-10% and possibly more in the right circumstances.

Alternative Energy Standards

4. The AECB (Association for Environment Conscious Building)[20] Building Standard and Passivhaus Institute Low Energy Building are both energy standards that follow the Passivhaus methodology but are not as stringent as the Passivhaus standard. The performance of the different standards can be compared through a whole life costing exercise that assesses the capital construction costs, the energy bills and the maintenance costs over a period of time (100 years in this study).[21] The analysis has revealed that Passivhaus dwellings are comparable with a Building Regulations house, despite the construction costs and lifetime maintenance costs being higher. If a Passivhaus-ready construction system is used (e.g. a timber frame system), the whole life costs are more favourable. By contrast, the AECB building standard does not produce sufficient savings on energy bills and has a higher whole life cost than the Building Regulation house.

	% difference in comparison with Building Regulations case			
	Construction costs	**NPV Maintenance Costs**	**NPV Energy Bills**	**NPV Whole life costs range**
CASE 2 Passivhaus - Timber frame, Electric space heating, AHSP hot water, MVHR	+7%	+28%	-31%	-4% to +2%
CASE 3 Passivhaus - Timber frame, Gas heating & hot water, MVHR	+8%	+52%	-40%	-4% to +1%
CASE 4 Passivhaus - Masonry cavity walls, Gas heating & hot water, MVHR	+13%	+52%	-42%	-1% to +4%
CASE 5 AECB Building standard - Masonry cavity wall, Gas heating & hot water, MVHR	+12%	+52%	-29%	2% to 6%

Summary of the Whole life costing analysis for a house designed to Building Regulations, AECB building standard or the Passivhaus standard

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[20] https://www.aecb.net/

[21] This report follows the BSRIA Guide on Whole Life Costing Analysis BG 5/2008

5. The closest standard to Passivhaus is the Passivhaus Institute Low Energy Building that allows a slight relaxation of the Passivhaus criteria and would result in heating bills approximately twice that of a Passivhaus. The AECB Building standard results in higher whole life costs, and significantly higher than a typical Building Regulations house.

The suite of Passivhaus standards informs the AECB Building standard which is based on the Passivhaus methodology, and is identical in every way apart from a more relaxed space heating demand and airtightness target; it is often seen as a stepping stone to Passivhaus because it shares its fundamental approach. To analyse the detailed aspects of a building, Passivhaus (and the AECB, under usage rights) uses its own building physics software called the PassivHaus Planning Package (PHPP) which is used under licence from the Passivhaus institute. Detailed and intensive training is required in its use as part of a quality control process.

Barriers to achieving the Passivhaus Standard and Reducing the Performance Gap

Despite the increased awareness of the Passivhaus approach to building it is still relatively unfamiliar on site with its extreme airtightness measures, well co-ordinated insulation, careful window installation procedures and generally high workmanship levels that are consistent with the performance standard. So measures to reduce the performance gap are essential.

On-site or construction stage policy measures could be used to reduce the impact of the performance gap. Key quality control procedures used in Passivhaus schemes that could be replicated in policy are:

- Airtightness testing of every building (as per the future homes standard and Passivhaus standards)
- Passivhaus training on thermal bridging, airtightness, thermal bypass and building services for both designers and contractors, and continued onsite support with this knowledge
- Knowledge of MVHR is essential for the Passivhaus standard although not for the AECB standard. In view of its many benefits it would be an advantage to understand the implications of this technology. See more on MVHR in Appendix B.
- Dedicated airtightness coordinators
- Improved on-site quality control procedures and management

All of these points should be covered in a report submitted at planning stage, on how the performance gap will be mitigated against at both the design stage and in-construction.

Training is available on these topics from specialist consultants, or by attending the Passivhaus Tradesperson course[22]. To reinforce the learning onsite, the Zero Carbon Hub has produced a freely available Builder's Book[23] that contains posters around fabric, ventilation, heating and hot water performance issues that can be displayed on site.

The extent of the improvement in the performance gap due to each of these policy measures is not quantifiable, however the potential for CO_2 emissions reduction could be significantly more than the

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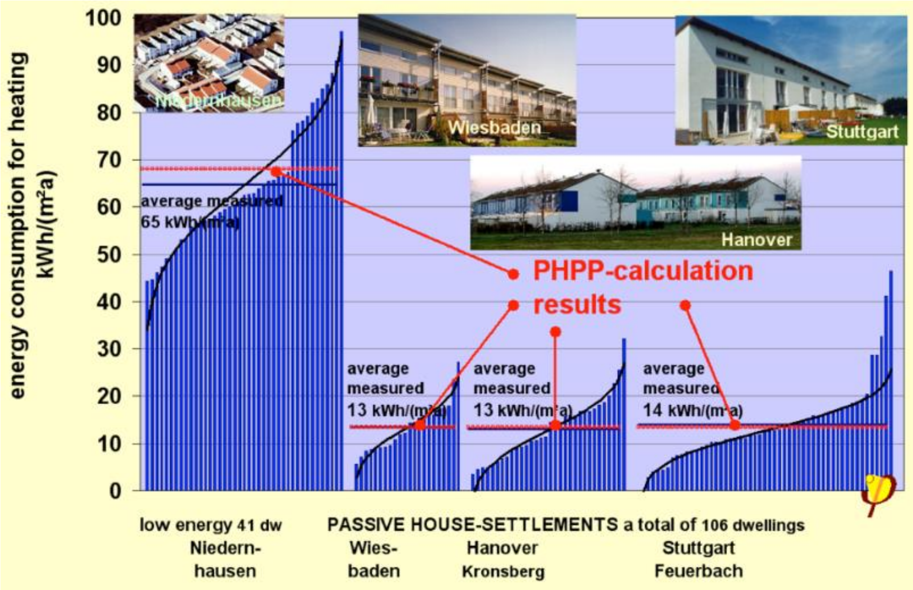
[22] http://www.passivhaustraining.co.uk/contractor/ and http://www.passivhaustrust.org.uk/event_detail.php?eId=373#.XVZ2XSNKiHs This is an official 2 day course certified by the Passivhaus Institute and can be taken with or without the exam & revision day. It covers all the major topics required to achieve fabric performance in construction. Costs are around £350 + VAT.

[23] Zero Carbon Hub Builder's Book http://www.zerocarbonhub.org/sites/default/files/resources/reports/Zero%20Carbon%20Hub%202015%20FINAL%20REV%202910_WEB.pdf

40% performance gap reduction in CO_2 emissions over building regulations that has been identified by the Passivhaus Trust[24]. It will ensure that any policy that requires a percentage reduction on current building regulations, is far more likely to achieve that percentage reduction when the building is in use. Evidence from the Passivhaus Institute suggests that the Passivhaus standard does not exhibit the performance gap.



The training and report should help to address the following issues as identified in the Zero Carbon Hub Report 'Closing the gap between design & as-built performance'[25]

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[24] Passivhaus: the route to zero carbon? Passivhaus Trust, March 2019

[25] Closing the gap between design and as-built performance, End of Term Report, July 2014, Zero Carbon Hub,

Construction responsibilities for energy performance unclear, lack of collaborative working.

Product substitution on site without due regard for impact on energy performance.

Lack of adequate quality assurance on site and responsibility for QA.

Poor installation or commissioning of services.

Short term fixes and improvisations on site without understanding of long-term impact.

Site management - inadequate consideration of sequence of trades and activities on site, later phase work undermining previous works

Lack of site team energy performance related knowledge and skills and / or care.

Poor installation of fabric, e.g. due to installation guidance or design drawings not followed.

Limited tests and agreed protocols available for in-situ fabric performance measurement.

Net zero carbon standard - Zero Carbon Homes and Allowable Solutions[26]

The first definition of a zero carbon home was a home achieving Level 6 of the Code for Sustainable Homes. This included emissions of both regulated energy (space heating, hot water, lighting and ventilation) as well as unregulated energy (such as appliances and cooking).

In the 2011 budget, the coalition government confirmed the commitment that from 2016 all new homes would be zero carbon, however it excluded unregulated energy use from the definition making it easier to achieve.

In England, the definition of a zero carbon home became one where CO2 emissions from regulated energy use were limited or mitigated by a combination of three factors (the first two of which are known as ‘carbon compliance’ standards):

1. Achieving minimum Fabric Energy Efficiency Standards (FEES) based on space heating and cooling:
2. Using low and zero carbon technologies and connected heat networks to limit on-site built emissions:
3. Where it is not possible to reduce the regulated CO_2 emissions to zero using these on-site measures, the remaining carbon emissions could be mitigated through allowable off-site solutions.

‘Allowable solutions’ included a system of off-setting and price capped payments to Local Authorities. Naturally a number of concerns were raised by this approach including:

- Typically, every year, new homes account for just 1% of the total housing stock, and at present it is considerably lower than this. This means that the proposed measures would take a long time to have a significant impact on total emissions from the UK building stock.

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[26] Zero carbon homes - Designing Buildings Wiki

- Developers might find it easier to adopt 'allowable solutions' rather than meet the carbon compliance standards.
- The standards might not really achieve 'zero carbon', focussing on operating emissions rather than capital emissions (ie they did not take account of carbon emissions resulting from actually constructing a new home) nor reflect the use of 'unregulated energy'.

In July 2015, the building industry , who had been steadily investing in supply lines, procedures and training to achieve the higher Codes (levels 5 & 6) for the previous 10 years were surprised by the government scrapping the zero carbon target requirements.

In the meantime a forward thinking architect had been quietly proving the viability of the Passivhaus approach with two significant projects, the first built in Wales in 2010 and the second more challenging but equally ground breaking in 2015.

A description of the UK's first zero carbon (Code 6) affordable certified Passivhaus launched in 2010 can be found here: Larch House | bere architects

The UK's first Passivhaus Plus built on a north facing site in the Chiltern Hills and completed in 2015 is an example of a "building as a power station" and shows the viability of an electrical grid powered by renewable energy - Case study: Lark Rise, the UK's first Passivhaus Plus – CIBSE Journal This house has undergone extensive monitoring and latest figures show that the house exports 10 times more energy to the grid than it imports annually. It imports 3.38kWh.m^2/year and exports 34.6 kWh.m^2/year.

The Passivhaus Trust have undertaken research into achieve a truly net zero homes, and concluded in their 2020[27] report that it would not be possible to achieve a true net zero home without building a fabric similar to the Passivhaus standard.

Net zero whole life carbon standard

The LETI Embodied Carbon Primer is perhaps the best document to explain this very difficult standard. It begins with this definition:

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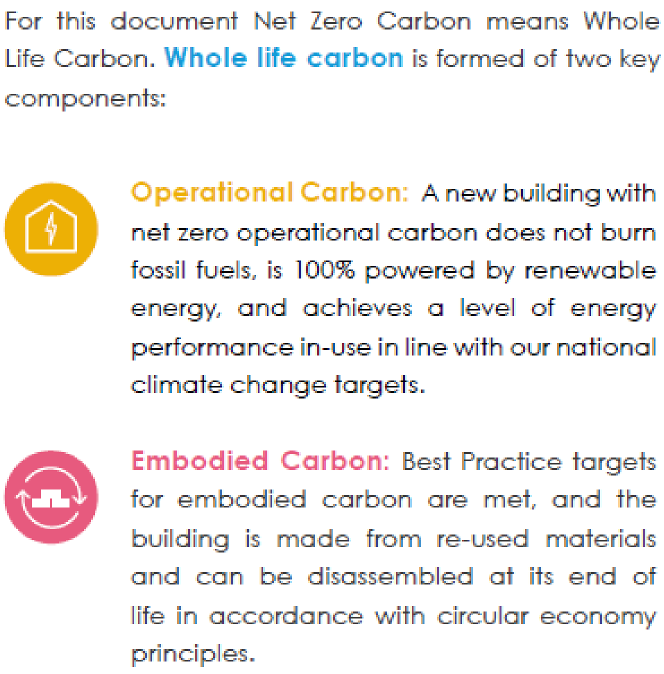
[27] Passivhaus: The route to zero carbon?
https://www.passivhaustrust.org.uk/guidance_detail.php?gId=40



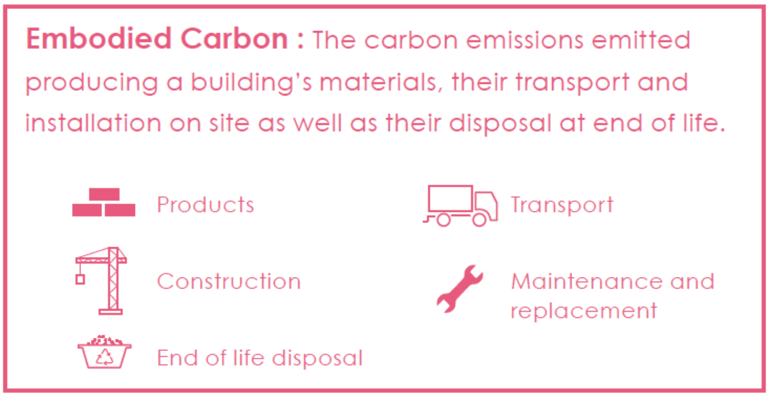
For this document Net Zero Carbon means Whole Life Carbon. **Whole life carbon** is formed of two key components:

Operational Carbon: A new building with net zero operational carbon does not burn fossil fuels, is 100% powered by renewable energy, and achieves a level of energy performance in-use in line with our national climate change targets.

Embodied Carbon: Best Practice targets for embodied carbon are met, and the building is made from re-used materials and can be disassembled at its end of life in accordance with circular economy principles.

One of the leading proponents of this approach is Tim Martell, a member of the AECB, who has developed a piece of software called PH Ribbon designed to assess embodied carbon components. His research leads us to believe that currently, on-site net zero carbon is not possible except in very extreme cases led by committed individuals. Renewables near a site are allowable under the Zero Carbon Hub definition and perhaps battery storage technology will have developed to use less problematic materials in their manufacture to have an impact by 2050. For the moment we are a long way off approaching this standard and so is not currently relevant to the more immediate requirement of finding answers to Future Homes standards.

Illustrations in this section are taken from the LETI Embodied Carbon Primer.[28]



Embodied Carbon : The carbon emissions emitted producing a building's materials, their transport and installation on site as well as their disposal at end of life.

- Products
- Transport
- Construction
- Maintenance and replacement
- End of life disposal

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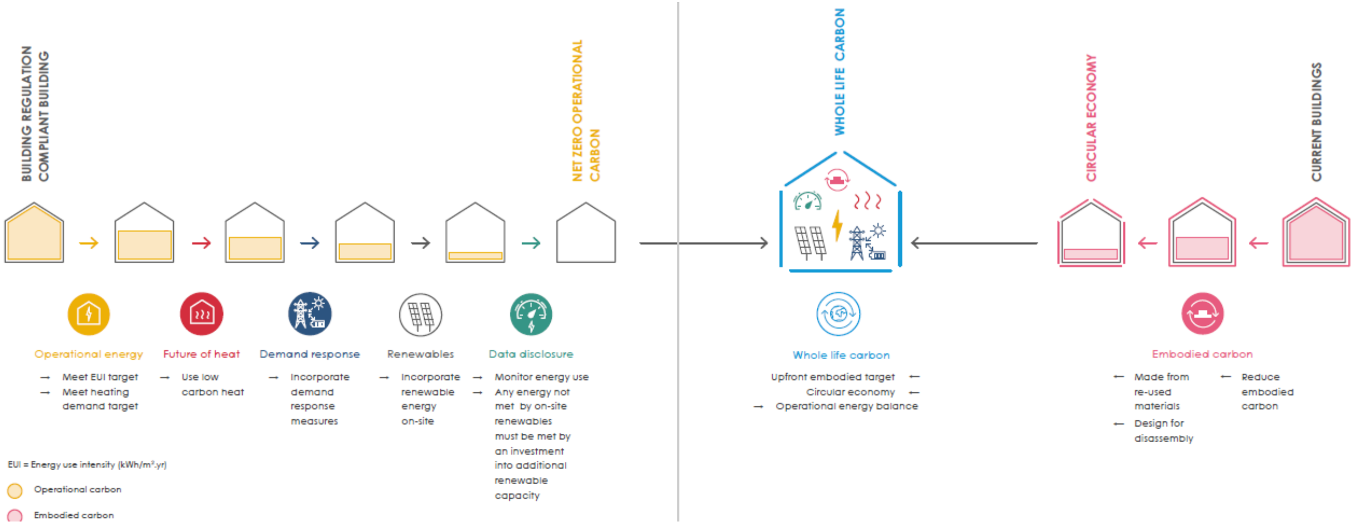
[28] Embodied Carbon Primer | LETI

The scale of the task is well represented in this illustration:

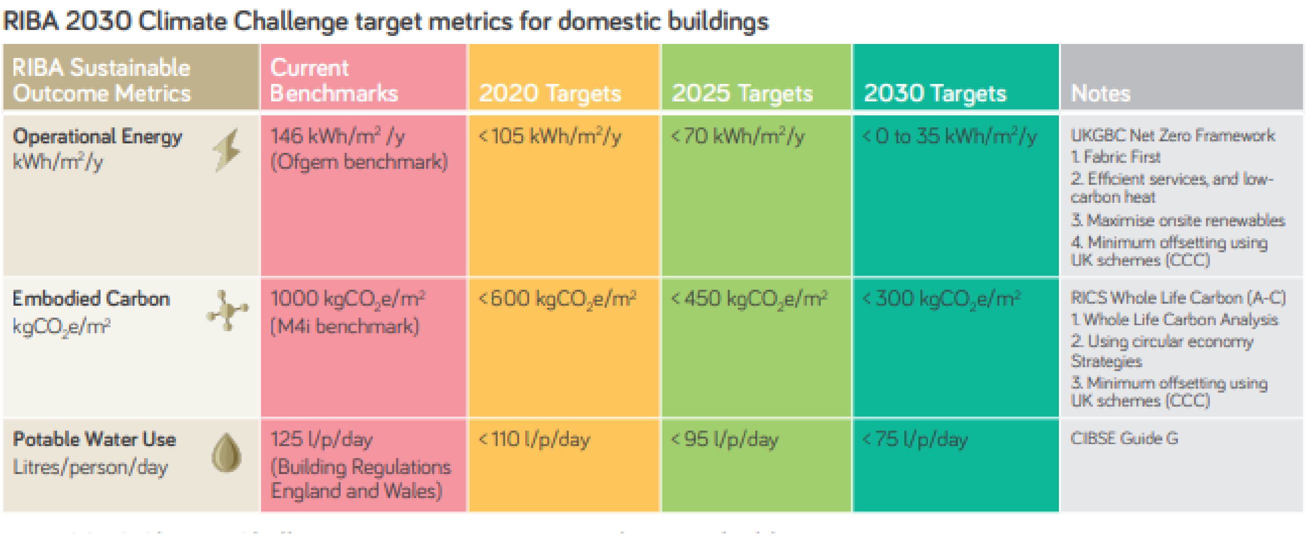


Offsetting of Carbon

As part of this initiative to reduce embodied energy the RIBA has issued a 2030 Climate Challenge to get architects to think how they might achieve these difficult targets in the real world. UK offsetting refers to the contribution that could be made by a national renewable energy grid. The challenge consists of the following aspects:

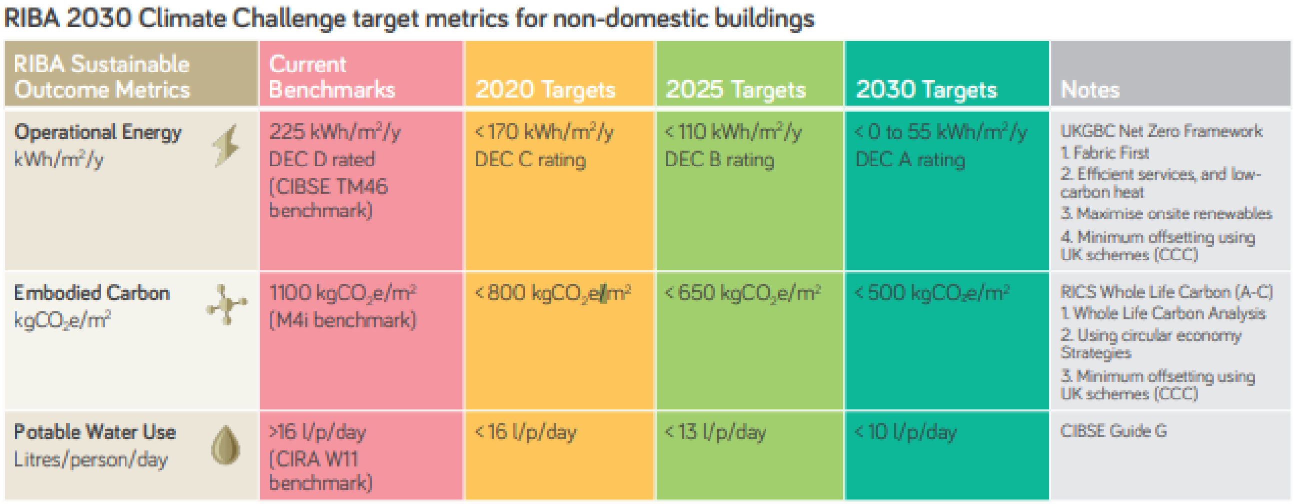
1. Reduce operational energy demand by at least 75%, before UK offsetting
2. Reduce embodied carbon by at least 50-70%, before UK offsetting
3. Reduce potable water use by at least 40%
4. Achieve all core health and wellbeing targets

It also uses the following metrics for assessing progress towards the targets:



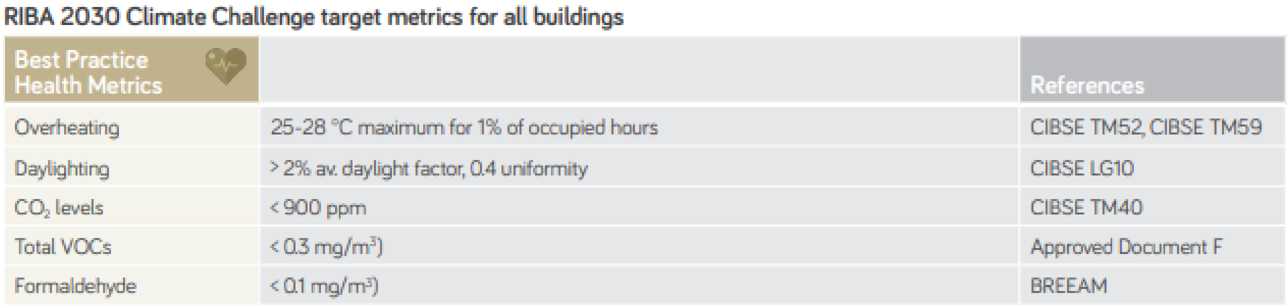
RIBA 2030 Climate Challenge target metrics for domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	146 kWh/m² /y (Ofgem benchmark)	< 105 kWh/m²/y	< 70 kWh/m²/y	< 0 to 35 kWh/m²/y	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon kgCO₂e/m²	1000 kgCO₂e/m² (M4i benchmark)	< 600 kgCO₂e/m²	< 450 kgCO₂e/m²	< 300 kgCO₂e/m²	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day	125 l/p/day (Building Regulations England and Wales)	< 110 l/p/day	< 95 l/p/day	< 75 l/p/day	CIBSE Guide G



RIBA 2030 Climate Challenge target metrics for non-domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	225 kWh/m²/y DEC D rated (CIBSE TM46 benchmark)	< 170 kWh/m²/y DEC C rating	< 110 kWh/m²/y DEC B rating	< 0 to 55 kWh/m²/y DEC A rating	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon kgCO₂e/m²	1100 kgCO₂e/m² (M4i benchmark)	< 800 kgCO₂e/m²	< 650 kgCO₂e/m²	< 500 kgCO₂e/m²	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day	>16 l/p/day (CIRA W11 benchmark)	< 16 l/p/day	< 13 l/p/day	< 10 l/p/day	CIBSE Guide G



RIBA 2030 Climate Challenge target metrics for all buildings

Best Practice Health Metrics		References
Overheating	25-28 °C maximum for 1% of occupied hours	CIBSE TM52, CIBSE TM59
Daylighting	> 2% av. daylight factor, 0.4 uniformity	CIBSE LG10
CO₂ levels	< 900 ppm	CIBSE TM40
Total VOCs	< 0.3 mg/m³)	Approved Document F
Formaldehyde	< 0.1 mg/m³)	BREEAM

Illustrations from the RIBA 2030 Climate Challenge document[29]

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[29] riba-2030-climate-challenge.pdf (architecture.com)

Appendix A is separately documented

Appendix B is separately documented

Appendix C – Local Authority Policy Positions on Carbon Reductions 2019[30]

Local Authority	Summary of policy	Status
Glasgow City Council	New residential buildings to be Passivhaus	Adopted
Bristol City Council	35% reduction in emissions and then the remainder offset. Passivhaus alternative.	Emerging - consultation stage (May 2019)
Exeter City Council	New council buildings to be Passivhaus	N/A
Norwich City Council	New council housing to be Passivhaus	N/A
Camden Council	Subject to London Plan	Adopted 2017
Lambeth Council	Subject to London Plan	Adopted 2015
Greater London Authority	35% beyond BRegs and the to Zero Carbon via offset	New London Plan is emerging (at EIP stage Apr 2019)
Reading Borough Council	Minimum 19% reduction in TER Major new housing should be a 35% reduction followed by carbon offset.	Emerging - at examination (May 2019)
Suffolk Coastal Draft Plan	20% reduction beyond Bregs	Emerging - at examination (May 2019)
Guildford Borough Council	20% beyond BRegs	Emerging - undergoing consultation (May 2019)
Bedford Borough	19% beyond BRegs	At examination (May 2019)
Brighton and Hove City Council	19% beyond Bregs. Passivhaus as an alternative to BREEAM	Adopted March 2016
Cambridge City Council	19% beyond Bregs.	Adopted Oct 2018
Greater Manchester Combined Authority	19% beyond BRegs	Emerging - undergoing consultation (May 2019)
Eastleigh Borough Local Plan	19% beyond Bregs. Flexibility use Passivhaus alongside BREEAM	Emerging - at examination (May 2019)
Havant Borough Council	19% beyond Bregs	Emerging - pre-submission (May 2019)
Ipswich Borough Council	19% beyond Bregs. Flexibility to use Passivhaus to demonstrate reduction is achieved	Adopted Feb 2017

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[30] Information collected by The Passivhaus Trust, UK.

Milton Keynes Council	19% beyond Bregs on site, another 20% via renewables/low carbon energy and the remaining emissions offset by payment	Emerging - at examination (May 2019)
Oxford City Council	19% Reduction from Bregs. Increasing 2026 and Zero Carbon by 2030	Emerging - submission stage (May 2019)

Exeter City Council initiative – EXESeed (Exeter Sustainable Energy Efficient Developments)

"The EXESeed Framework has appointed local small and medium sized building contractors as well as national building contractors. This will help the local economy and help provide employment opportunities for local people. The Framework will encourage contractors to create local apprenticeship opportunities creating additional benefit to the local economy. Exeter City Council would like to encourage other public sector bodies such as local authorities, universities and the NHS to use the Framework to provide access to building contractors committed to delivering low energy sustainable developments."[31]

Ashden: A toolkit for city regions and local authorities.[32]

Appendix D – reasons for Passivhaus criteria: Form factor and economics

Economic analysis

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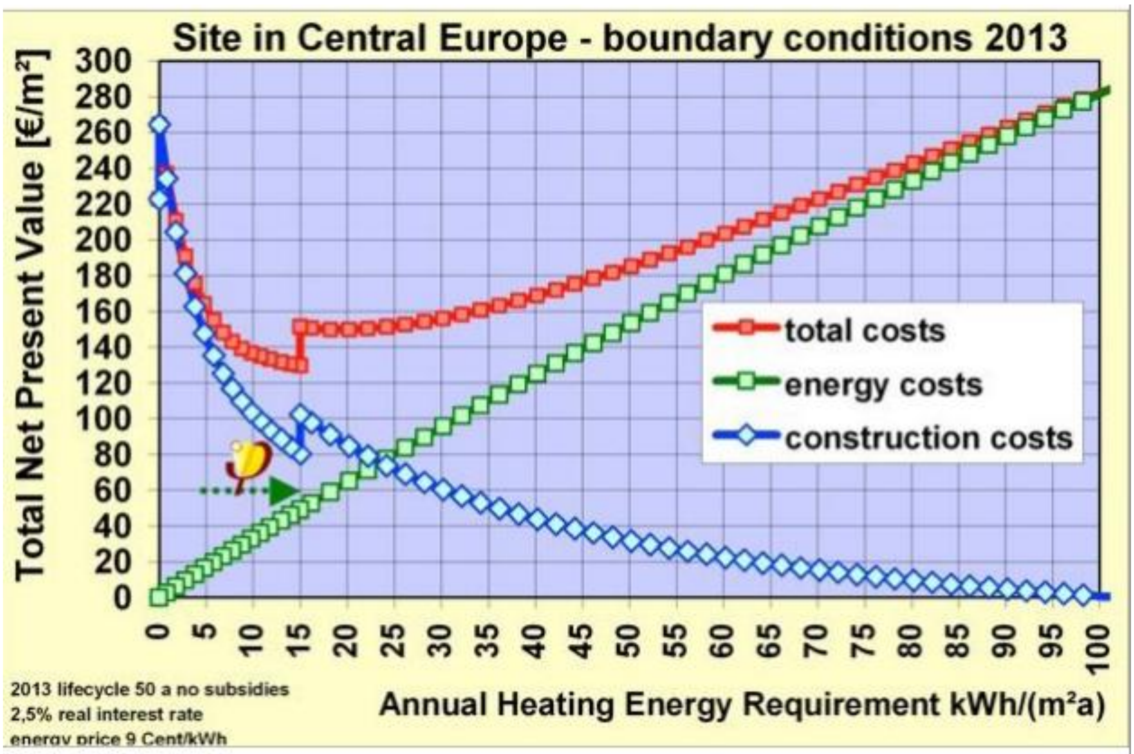
[31] Exeter City Council (houseplanninghelp.com) accessed on Passivhaus Trust website 04/02/2021

[32] Tools for Councils • Ashden, accessed on Passivhaus Trust website 04/02/2021

The basis for the Passivhaus criteria is economic and takes into account the capital or construction costs and the total running costs for the building over its lifetime. The minimum total net present value falls at 15 kWh/m^{2}a which is the space heating demand target for a Passivhaus building.



Lifecycle costs: Feist (editor), *Economy of Energy Efficiency*, working group on cost efficient Passive Houses, 42, Passive House Institute, Darmstadt, 2013

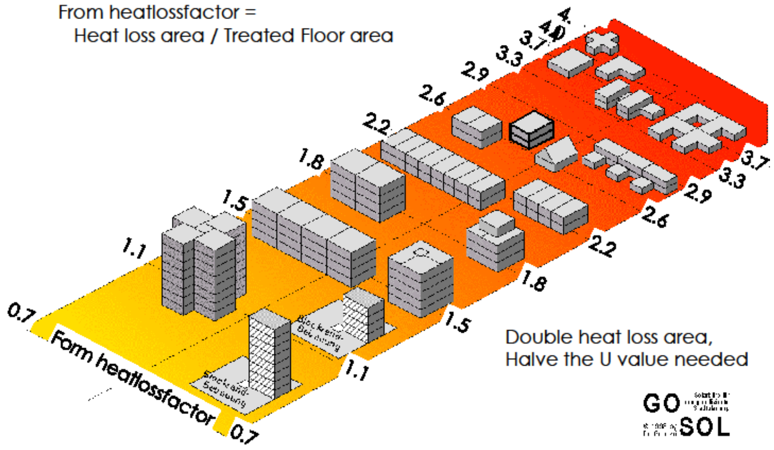
Form factor analysis

Typical U-values for walls floors and roofs to achieve this would be around 0.10 – 0.15 W/m^{2}K depending on the form factor of the building as is indicated in the diagram and table below. Passivhaus buildings are thermal bridge free, or have very small thermal bridges that have been mitigated against and calculated using thermal bridging software.

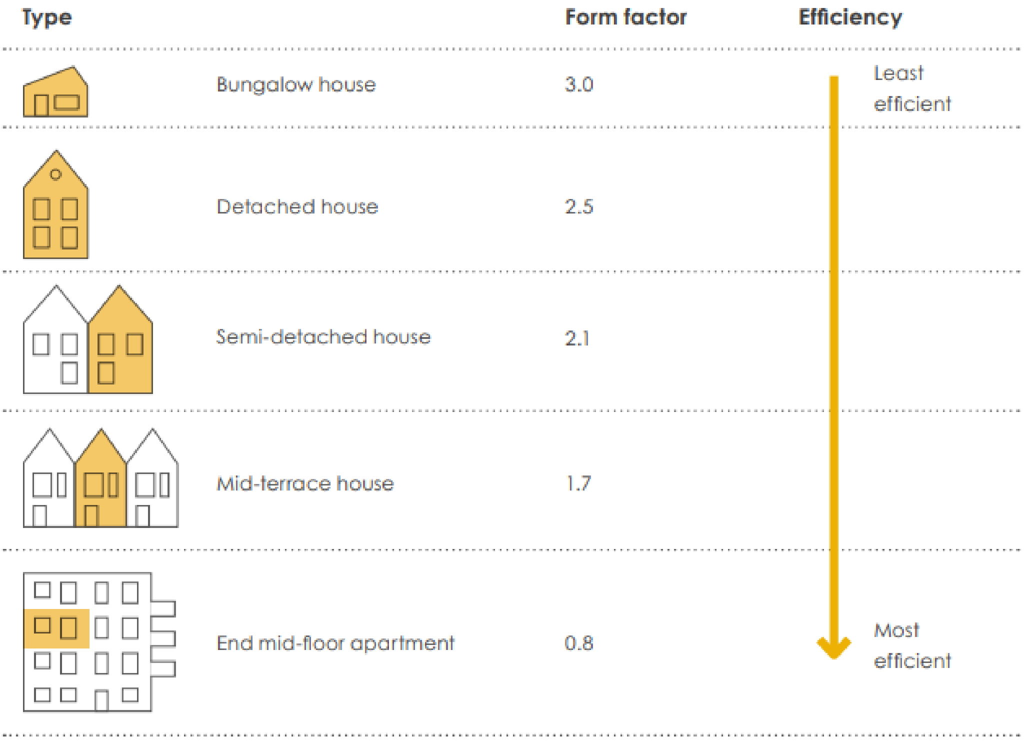
The air tightness of a Passivhaus building is below 0.6 ach and it incorporates a high efficiency mechanical ventilation system with heat recovery.

Form heat loss factor	U-value target
<2	0.15
2-3	0.10-0.15
3-4	0.10
>4	0.05-0.10

Heat loss Form factor illustration



Or from the LETI Design Guide:



Type		Form factor	Efficiency
	Bungalow house	3.0	Least efficient
	Detached house	2.5	
	Semi-detached house	2.1	
	Mid-terrace house	1.7	
	End mid-floor apartment	0.8	Most efficient

Figure 1.12 - Types of homes and their form factor

Standards & Technology Report

Three Dragons

17th March 2021

CONTENTS

01

| INTRODUCTION

SECTION 1 - INTRODUCTION

Ward Williams Associates ("WWA") have been commissioned by Three Dragons to carry out a review of additional costs associated with adopting various environmental standards on differing building types.

WWA have based the different environmental standards on a report commissioned by Three Dragons and their environmental consultant Enhabit. In assessing the additional costs, WWA have based their costs estimates on the increased scope of work each environmental standard means in building terms, based on Appendix A of the Three Dragons/Enhabit Report entitled "*Lancaster City Council – Climate Review Local Plan Review – "Policy Response – Decarbonising Standards and Technology Report*" dated February 2021.

WWA have been asked to consider the following three environmental standards as a base case:

(i) Part L 2021 – to assess whether the Minister of Housing and Local Communities (MHCLG) impact assessment figures are accurate; (ii) Part L 2021 including a non-fossil fuel heating system;

(iii) Future Homes Standard 2025; and
(iv) Passivhaus Classic.

In addressing each of the above standards WWA have considered the cost effect on a stand-alone 3-bedroom house including a garage, with a Gross Internal Floor Area (GIFA) of 114m2, in line with Housing Design Standards.

Taking these figures, WWA have been asked to assess the likely impact on differing house typologies, such as terraced housing, semi-detached units, and detached units, as well as low rise apartments.

Furthermore, WWA have been asked to assess the economies of scale for differing sizes of development.

Finally, WWA have been asked to consider the likely period over which costs will reduce to reflect "normal" practice.

SECTION 2 – ENVIRONMENTAL STANDARDS

WWA have been asked to consider the following three environmental standards as a base case:

(i) Part L 2021 – to assess whether the Minister of Housing and Local Communities (MHCLG) impact assessment figures are accurate;
(ii) Part L 2021 including a non-fossil fuel boiler heating solution;
(iii) Future Homes Standard 2025; and
(iv) Passivhaus Classic.

WWA have reviewed the each of the above compared to the current Building Regulations as of March 2021 and based their assessment on the increased scope as outlined in the Three Dragons/Enhabit Report "*Lancaster City Council – Climate Emergency Local Plan Review – "Policy Response – Decarbonising standards and technology report*" dated February 2021.

In all cases, WWA have assessed the costs based on the extra over cost for building a 3-bedroom semi-detached house to the proposed regulation rather than current regulations, not as an extra over between each one. It is assumed that the house will provide a GIFA of 114m^2, in keeping with housing space standards including a garage.

2.1 Part L 2021

In order to meeting the proposed Part L 2021 Regulations, developers will be required to undertake a series of additional work to achieve the standard, as well as changing their approach to current working practices.

Meeting this standard will involve increasing the thickness of insulation in the roof, although the current floor and wall insulation remains unchanged. Windows will need installing differently so as not to create a thermal bridge.

There are no changes to the current air permeability requirements.

Consideration is to be given to external solar shading to prevent overheating. WWA consider the extent of solar shading could be mitigated, if the masterplanning of the scheme at the outset considered dwelling orientation. In our costs we have therefore provided a range for the additional costs to include solar shading and exclude solar shading, on the basis it would not be required on every unit; a sensible approach when considering several units on one development may be to take a mid-point in the range proposed, as an average. Solar shading could be in the form of shading added to the external envelope or planting of additional mature trees.

02

ENVIRONMENTAL STANDARDS

SECTION 2 – ENVIRONMENTAL STANDARDS (Cont'd)

2.1 Part L 2021 (Cont'd)

There are also considerations on the boiler type installed, the use of photovoltaic cells, the introduction of a heat recovery system from waste shower water.

The full scope of additional works and assessed costs against each item are detailed in Appendix A of this Report.

WWA have assessed, that based on current pricing levels the additional costs over current requirements including external solar shading could be £8,000 or excluding solar shading could be £5,000, which based on the cost of constructing a house in an average location in the UK would be an extra of 3% excluding solar shading and 5% if solar shading were required.

There is no requirement under these Regulations to adopt a non-fossil fuel heat source, however if this approach was adopted, evidence we have from the market (including costs received by developers with whom we are currently working, as well as independent research with consultants and suppliers) indicates an extra over cost for adopting an Air Source Heat Pump (ASHP) solution over a traditional gas-fired boiler to currently be in the order of £16,000 for a 3- or 4-bedroom house including solar shading, or £13,000 excluding solar shading. These alternative costs are included at Appendix A1 of this Report.

SECTION 2 – ENVIRONMENTAL STANDARDS (Cont'd)

2.2 Future Homes Standard

In order to meeting the proposed Future Homes Standard, developers will be required to undertake a series of additional work to achieve the standard, as well as changing their approach to current working practices.

Meeting this standard will involve increasing the thickness of insulation in the floors, external walls, and roof. Windows will need installing differently so as not to create a thermal bridge and will required to have triple glazing fitted as standard.

There are no changes to the current air permeability requirements.

Consideration is to be given to external solar shading to prevent overheating. WWA consider this could be designed out to an extent, if the masterplanning of the scheme at the outset considered dwelling orientation. In our costs we have therefore provided a range for the additional costs to include solar shading and exclude solar shading, on the basis it would not be required on every unit; a sensible approach when considering several units on one development may be to take a mid-point in the range proposed, as an average. Solar shading could be in the form of shading added to the external envelope or planting of additional mature trees.

A low carbon heating system will be required as standard compared to the 2021 standard. The other requirements are in keeping with the 2021 Standard.

The full scope of additional works and assessed costs against each item are detailed in Appendix B of this Report.

WWA have assessed, that based on current pricing levels the additional costs over current requirements, including external solar shading could be £17,000, or excluding solar shading could be £14,000, which based on the cost of constructing a house in an average location in the UK would be an extra of 9% excluding solar shading and 11% if solar shading were required.

SECTION 2 – ENVIRONMENTAL STANDARDS (Cont'd)

2.3 Passivhaus Classic

There is a considerable amount of data available on the additional costs likely to be incurred in achieving the Passivhaus Standard, such as that commissioned by The Passivhaus Trust, which identified the cost premium for achieving the Standard in 2015 was in the order of 15%, but now considered to be in the order of 7 – 8% compared with standard house construction costs. This was underpinned by recent costs reported by Exeter City Council.

Meeting this standard will involve increasing the thickness of insulation in the floors, external walls, and roof. Windows will need installing differently so as not to create a thermal bridge and will required to have triple glazing fitted as standard.

Consideration is to be given to external solar shading to prevent overheating. WWA consider this could be designed out to an extent, if the masterplanning of the scheme at the outset considered dwelling orientation. In our costs we have therefore provided a range for the additional costs to include solar shading and exclude solar shading, on the basis it would not be required on every unit; a sensible approach when considering several units on one development may be to take a mid-point in the range proposed, as an average. Solar shading could be in the form of shading added to the external envelope or planting of additional mature trees.

A low carbon heating system will be required as standard compared to the 2021 standard, whilst there is also a requirement to install a Mechanical Ventilation and Heat Recovery system (MVHR). This is the key additional cost but installing the MVHR is considered to reduce the impact on the heating system, as evidence has shown there is often no need to heat the whole dwelling, with heating systems often omitted from the other floor, with this being heated from the recovered heat from elsewhere in the house. This results in heating systems in dwellings achieving the Passivhaus standard costing less than in dwellings constructed to current Building Regulations alone.

The full scope of additional works and assessed costs against each item are detailed in Appendix C of this Report.

WWA have assessed, that based on current pricing levels and including preliminaries, overheads and profit and a risk allocation of 5% the additional costs including external solar shading could be £8,000, or excluding solar shading could be £5,000, which based on the cost of constructing a house in an average location in the UK would be an extra of 3% excluding solar shading and 5% if solar shading were required.

03

IMPACT ON DIFFERING HOUSING TYPOLOGIES

SECTION 3 – IMPACT ON DIFFERING HOUSING TYPOLOGIES

Without specific designs, it is difficult to determine the effect on differing typologies without reverting to crude percentage uplifts on current build rates or applying an uplift on the average square metre build rates.

Using Nationally Described Space Standards published by the Department for Communities and Local Government, we have taken a selection of different typologies and made assumptions as outlined in the table below, then applied an uplift cost to achieve each of the Standards outlined in Section 2 of this report. Again, we have applied a range, depending on the extent of solar shading required to individual dwellings and the table below relates to an average UK location with a BCIS location factor of 100:

Typology	Assumed Bedspaces	GIFA (m^2)	Standard Increased Cost for Relevant Standard			
			Part L 2021 (£)	Part L 2021 (including non-fossil fuel heating) (£)	Future Homes Standard (£)	Passivhaus Classic (£)
Terraced	2 Bedroom	75	3,300 – 5,300	8,500 – 10,600	9,200 – 11,200	3,300 – 5,300
Bungalow	3 Bedroom	84	3,700 – 6,000	9,500 – 11,800	10,300 – 12,500	3,600 – 6,000
Semi Detached (excluding garage)	3 Bedroom	93	4,100 – 6,600	10,600 – 13,000	11,500 – 13,900	4,000 – 6,600
Detached	4 Bedroom	106	4,700 – 7,500	12,000 – 15,000	13,000 – 15,800	4,600 – 7,500
Detached	5 Bedroom	120	5,300 – 8,400	13,500 – 16,900	14,750 – 17,900	5,250 – 8,500
Apartment Block (see note below)	See note	520	22,500 – 36,500	59,300 – 73,000	63,500 – 77,500	22,800 – 36,500

Note: Apartment Block is assumed to be a block of eight 1- or 2-bedroom apartments (2 x 1 bed and 6 x 2-bed) over two floors, with separate external access to each apartment (i.e., no communal areas)

04

ECONOMIES OF SCALE

SECTION 4 – ECONOMIES OF SCALE

Having reviewed the economies of scale, there are certain items which will benefit from mass delivery. Specifically, these relate to the provision of photovoltaic cells and non-fossil fuel heating systems. Both of these could benefit from centralised electricity or power generation and evidence gained from other sites underpins this.

In respect of photovoltaic systems, it is considered the extra over cost on an individual unit basis represents around £45/m^2, based on the GIA. Developing centralised "farms" of cells, with an increased ability to feed into the local grid has been seen to reduce this to around £25/m^2. However, this is not based on the number of units delivered but the space available for the panel "farm", and it is difficult to ascertain the "sweet spot" in terms of the number of units. Typically, each panel on a new development is now costing around £275.

Non-fossil fuel heat generation certainly benefits from economies of scale, where centralised systems supply an increased number of units, which effectively brings the cost for an alternative approach down. The additional costs outlined in Sections 3 and 4 above, are based on individual systems supplying individual units. With increased density the ability to introduce a "district heating" type system increases, as does the range of solutions. On an individual basis, Air Source Heat Pumps (ASHP) represent the most cost-effective solution, as the initial costs involved in a Ground Source Heat Pump (GSHP) solution are prohibitive.

Evidence has shown that [currently] at around 150 units the options are increased. One of our current projects of 150 units is adopting a GSHP-based District Heating System. The cost is around £1.5m for the infrastructure, plus individual units in each dwelling, at a cost of around £4,000 per dwelling, which can be ignored as is similar to a fossil-fuel based system. This is a comparable cost with an ASHP system fitted in individual dwellings of lower density. What our research has indicated though is a lack of competitiveness in the market, causing the extra over costs to remain high and the technology is still untested over time, resulting in significant teething problems with both users and installers.

In respect of mass ASHP systems, the opportunities on low density developments are more limited. ASHPs have limited control mechanisms, meaning shared users of one pump would be limited in their flexibility to control the on and off times of the heat source, resulting in the introduction of buffer vessels and Heat Interface Units.

This has been addressed in high density developments, where the ASHP feeds a Heat Pump or Heat Interchange Unit in each individual apartment, allowing the occupier to draw of the heat when required; we understand the optimum mix is one ASHP serving between 8 – 12 one- or two-bedroom apartments. However, the capacity often is only suitable for winter heating of the building, resulting in a secondary hot water system having to be installed. Therefore, any saving from shared systems is often offset by the inclusion of additional costs for this. Anecdotal evidence puts the additional cost of adopting an ASHP solution in high density developments of 100 units or more at around £6,000 - £7,000 per unit.

SECTION 4 – ECONOMIES OF SCALE (Cont'd)

This is a more difficult problem to address in low density developments, where the insulation of the pipe between dwellings becomes more difficult and therefore expensive. Plant in high density developments is often on the roof and the pipework serving the apartments runs down service risers within the building. In low density, the pipework would have to run underground, resulting in more expensive insulation, deeper ducts etc. Any saving from sharing of ASHPs is then offset by the additional builders work and increased insulation of feeder pipework, plus the cost of Heat Pumps, a Heat Interchange Unit or secondary system for hot water. As part of this report, we have received useful input from Mitsubishi, who have offered further advise on systems as designs start evolving, apply general "rules of thumb" to their systems. Discussing clusters of four-bedroom houses with them, they believe between 4 and 6 units could share one heat pump, with the introduction of buffer vessels and/or Heat Interface Units. However, as outlined above, at present, the cost of several units sharing one ASHP does not dramatically reduce from the £8,000 extra on a per unit basis, due to the additional controls, equipment and builders work outlined above.

A couple of further considerations which have emerged during our continued research are issues with red-line boundaries and electricity capacity. In respect of the red-line boundary, we have heard of issues where two separate but adjoining freehold properties have had issues at purchase, when the ASHP is located on one of the properties but serving two. This, we understand, has led to issues about who is responsible for maintaining the system, and does the owner whose land the pump is not located on have the right to access the unit? Naturally, this could be overcome by siting the unit outside the demise of both owners, however, does indicate a potential problem.

In respect of electricity capacity, although the inclusion of an ASHP heating system removes the need for gas infrastructure (which in itself is a cost which is very specific to each individual site, but as a rule of thumb is in the order of £550 - £600 per plot), we have witnessed instances where the electricity infrastructure has had to be improved, to provide support to the systems being powered by the ASHP. Therefore, despite saving on the gas infrastructure additional costs of a similar magnitude have been experienced on the electricity supplies.

05

PERIOD FOR COST REDUCTION

SECTION 5 – PERIOD FOR COST REDUCTION

Many of the items involved in achieving the improved Standards have an additional cost due to an increased quantity. It is difficult to see this changing and the cost for the inclusion of these items will become the norm.

Mechanical Ventilation and Heat Recovery does seem to be becoming more of the norm in “standard” residential developments, due to the saving in the cost of installing heating systems. However, evidence has shown that Affordable Housing providers are more reluctant to adopt, simply because of the increased maintenance in routinely changing filters, and a lack of willingness by their tenants to understand the system. Indeed, on a current project we are managing, the private element of the housing comes with both Waste Water Heat Recovery Systems and MVHR, both of which have been requested to be omitted by the Registered Provider in both the Shared Ownership and Affordable for Rent tenures.

In respect of the new technologies, one of the key findings of our research was a lack of competition in the market particularly for non-fossil fuel-based heating systems. This is possibly keeping costs artificially high at present, and without an increased supply chain, it is difficult to establish when costs may start to reduce.

It is tempting to use the capital cost reduction of PVs as an example, where evidence shows these have reduced 25% since 2014 (according to information released by the UK Government). At present, without increased competition and an approach where such systems are seen as standard, it is difficult to see non fossil fuel-based systems reducing in line with this. However, there could be an argument to say the relative increase, when omitting construction inflation (averaging 5% per annum for several years) may mean future increases are offset as the technology becomes more embraced. Ascertaining when this may be at present is impossible to forecast.

Government incentives may be required on a large-scale basis so more systems are adopted, which will mean the technology is more widely available, increasing competition and driving costs down; this may be more appropriate now than ever, following the recent and current pandemic, and a shift in market attitudes and the Government policy of “Build Back Better”.

A further consideration is forecasting cost reductions is training of the existing and incoming workforce in understanding the new technologies. The CITB has recently published an analysis on “*Building Skills for Net Zero*” [March 2021]. This Report considers the implications on training the workforce in dealing with both new and existing buildings so as to achieve Net Zero carbon emissions. It considers five component pathways in the roadmap to achieving net zero as follows:

SECTION 5 – PERIOD FOR COST REDUCTION (Cont'd)

COMPONENT PATHWAYS	SKILLS SUMMARY
HYDROGEN DEPLOYMENT THROUGH THE GRID	Conversion of existing gas boilers to hydrogen is straightforward, however conversion of the transmission and storage infrastructure is unproven and generation of heat by hydrogen would require six times as much generation capacity as would be required for heat pumps. There is a cohort of 120,000 qualified gas engineers in the UK, and those with Gas Safe qualifications may only need one extra day's training. Even over the next five to ten years, only an additional 1,500 FTE workers on average would be required for this pathway.
FABRIC FIRST RETROFIT	Surveyors and energy specialists will need to assess the condition and model the performance of buildings, while a variety of tradespeople would be needed to implement recommendations. There would need to be a rapid and vast deployment of training facilities and courses. Around 12,000 workers a year would need to be trained over the first four years, with that annual recruitment need ramping up to 30,000 between years five and ten. After that, demand for some of these skills would be expected to wane, emphasising the need for a constant re-examination of training needs.
HEAT PUMPS	Again, this pathway would require rapid deployment, up to a peak of around 15,000 workers a year needed between years five and ten. There should be continued work for this workforce beyond that time, however, as installation work gives way to maintenance work. Heat pumps are certain to play some part in the decarbonisation strategy, and the skills needed to install and maintain them are highly sophisticated. Training the estimated 60,000 new workers may be resource intensive but that workforce should be required long term.
HEAT NETWORKS	Heat networks would require the quickest and most widespread increase in training, with much of the requirement likely to be at the strategic or systems level. Project planners, engineers, developers, design engineers and control system specialists would all be required. At an installation level, welders and general installers would need to be recruited and trained. In total, 9,500 additional FTE workers would likely be needed per year for the first four years, with numbers falling significantly after that point.
ONSITE ENERGY	This pathway includes a variety of technologies which can be used to enable decarbonisation, including onsite energy generation, energy storage, and smart systems. The installation of — for example — roof-mounted PV would not require significant amount of retraining, with traditional tradespeople such as scaffolders and plumbers likely to be able to upskill quickly.

The conclusions of the report state that "this will require an industry wide investment in skills training that must be early, planned and based on clear future demand". Whilst this training remains needed it is difficult to see how the industry can absorb the additional costs associated with the training and subsequent loss of productivity in the existing workforce whilst undertaking training, without significant Government intervention. A copy of the full CITB Report is included in Appendix D of this Report.

SECTION 5 – PERIOD FOR COST REDUCTION (Cont'd)

Another consideration is national buying agreements with the volume house builders. Evidence obtained by WWA shows some of the volume house builders obtain significant discounts compared to smaller more niche developers, however the level of these discounts is closely guarded. On the basis the technology becomes more widely adopted, led by buyer demand, it is certain the national housebuilders will buy at significantly reduced rates, meaning the increased premiums for adopting the various Environmental Standards will be driven down in many instances.

One area which may realise cost reductions is market acceptance of the product. As these technologies become more mainstream, costs will naturally reduce as they become the norm, and the workforce is suitably trained in their installation. This will reduce unit prices as further competition is attracted. Evidence from other technologies embraced by the industry over the last decade suggests a 10 – 20% reduction over a period of 5 – 10 years, and although it is by no means certain that the technologies mentioned in this report will reduce at a similar rate, it provides a sensible basis for assessment.

A

APPENDIX A - DETAILED BUILD UP PART L 2021

Part L 2021

Carbon emission target : (11.0 KgCO2/ m^2/yr). At least 31% less emissions compared with 2013 Part L
Notes: Fabric specs based on a typical semi-detached home
Assumptions: 3 bed semi-detached GIA = 114m^2 Roof area = 57 m^2 Wall area= 68 m^2 of which 38% glass and 62% brick

GIA 114 *m*^{2}

Item	***Information***	***Comments/ Financial effect***	***Quantity***	***Unit***	***Rate***	***Total per house***
Building Fabric						
Floor U-value 0.13 W/m^2*.K*	*No change to current building reg. requirements*	*No financial effect*	*57*	*m*^{2}	-	-
External wall U-value 0.18 W/m^2*.K*	*No change to current building reg. requirements*	*No financial effect*	*41*	*m*^{2}	-	-
Roof U-value 0.13 W/m^2*.K*	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. The current building reg would require an additional 70 mm of mineral wool insulation for example*	*Increase in terms of cost per thickness of added insulation - estimated rate for increased thickness of 70mm - £9/m2*	*57*	*m*^{2}	*9*	*513*
Windows U-value 0.14 W/m^2*.K*	*Performance to be achieved considering some specifications (Frame factor=0.7, Solar Energy Transmittance = 0.63, Light transmittance = 0.80), and the way the window is installed to make sure there are no heat losses through the frame*	*Cost effect based on workmanship (assumptions on cost/ window) - no cost on manufacture of window/ frame. Assume typical house costs £1,000 per window for double glazing, with around 12 windows*	*1*	*house*	*600*	*600*
Doors Opaque U-value 1.0 W/m^2*.K Semi-glazed 1.2*	*No change to 2013 reg. requirements . Semi-glazed doors have up to 60% glass. If a door has more than 60 % glass it is treated as a window.*	*No financial effect*	*1*	*house*	-	-
Air permeability at 50 Pa (5.0 m*^{3} */(h.m*^{2} *))	*No change to current building reg. requirements*	*No financial effect*	*1*	*house*	-	-
Overheating	*CIBSE guide > 28 ˚C for 15 /year in bedrooms at night (22: 00 - 07:00) , or 3% elsewhere from May to September . TM59 manual proposes solutions to achieve shaing atrategies to reduce the amount of solar heat gain through glazing either by limiting the amount of glass openings to South, West, and East facades, or adding cross ventilation and window apertures, shading provided by balconies, brise soleil, shutters, blinds, external awnings, trees, etc.*	*Considerations should be based on planning . Cost effect in terms of shading provided by balconies (brise soleil, shutters); assume average house has 5 nr windows effected by solar gain. Range of £1,500 - £3,000 per house. Average taken. Can be lowered through planning of scheme*	*1*	*house*	*2,000*	*2,000*
Heating appliance	*Gas boiler (92 ErP): Specification requires an energy rating of at least 92 %*	*Cost effect in considering the use of the reports' proposed range of building systems technologies . Supply cost only for boiler. Assumed at £300 for typical house*	*1*	*house*	*300*	*300*

Heat Emitter type	*Low temperature heating or large radiators (around 35 ˚C)*	*No difference in installation cost*	*1*	*house*	-	-
Ventilation System type	*Natural ventilation with intermittent extract fans : no change to current building reg. requirements*	*No financial effect*	*1*	*house*	-	-
Photo Voltaic (PV)	*For houses, the amount of power required to be produced by PV panels on a house is arrived at by the formula of 40 % of the ground floor area divided by 6.5 to give a figure in kWp (40 % groung floor area / 6.5) - For a 70 m2 - 2 storey house, with GF area being 35 m2 (35 x 40/1000/6.5 = 2.154 kWp would be the energy legislated for.* ***<u>This represents 15 panels at around £270 per panel.</u>***	*Assume installation of 3KW PV per dwelling*	*1*	*house*	*4,000*	*4,000*
Waste water heat recovery	*All showers must be connected to WWHR unit, including showers over baths. Specs require WWFR with 36 % recovery efficiency*	*Assume 1 system per house*	*1*	*house*	*450*	*450*
Thermal Bridges Psi value (W/ m.K)	*No change to current building reg. requirements*	*No financial effect*	*1*	*house*	-	-
						7,863
Preliminaries & Oveheads & Profit			*0*	*%*	*Excluded*	-
Contingency			*0*	*%*	*Excluded*	-
Total Cost						***7,863***
					Including Solar Shading	***8,000***
					Excluding Solar Shading	***5,000***

A1

APPENDIX A 1-
DETAILED BUILD UP
PART L 2021 with Non-Fossil Fuel Boiler

Part L 2021
Non Fossil Fuel Boiler

Carbon emission target : (11.0 KgCO2/ m^2/yr). At least 31% less emissions compared with 2013 Part L
Notes: Fabric specs based on a typical semi-detached home
Assumptions: 3 bed semi-detached GIA = 114m^2 Roof area = 57 m^2 Wall area= 68 m^2 of which 38% glass and 62% brick

GIA *114* *m^2*

Item	***Information***	***Comments/ Financial effect***	***Quantity***	***Unit***	***Rate***	***Total per house***
Building Fabric						
Floor U-value 0.13 W/m^2.K	*No change to current building reg. requirements*	*No financial effect*	*57*	*m^2*	*-*	*-*
External wall U-value 0.18 W/m^2.K	*No change to current building reg. requirements*	*No financial effect*	*41*	*m^2*	*-*	*-*
Roof U-value 0.13 W/m^2.K	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. The current building reg would require an additional 70 mm of mineral wool insulation for example*	*Increase in terms of cost per thickness of added insulation - estimated rate for increased thickness of 70mm - £9/m2*	*57*	*m^2*	*9*	*513*
Windows U-value 0.14 W/m^2.K	*Performance to be achieved considering some specifications (Frame factor=0.7, Solar Energy Transmittance = 0.63, Light transmittance = 0.80), and the way the window is installed to make sure there are no heat losses through the frame*	*Cost effect based on workmanship (assumptions on cost/ window) - no cost on manufacture of window/ frame. Assume typical house costs £1,000 per window for double glazing, with around 12 windows*	*1*	*house*	*600*	*600*
Doors Opaque U-value 1.0 W/m^2.K Semi-glazed 1.2	*No change to 2013 reg. requirements . Semi-glazed doors have up to 60% glass. If a door has more than 60 % glass it is treated as a window.*	*No financial effect*	*1*	*house*	*-*	*-*
Air permeability at 50 Pa (5.0 m^3 /($h.m^2$))	*No change to current building reg. requirements*	*No financial effect*	*1*	*house*	*-*	*-*
Overheating	*CIBSE guide > 28 ˚C for 15 /year in bedrooms at night (22: 00 - 07:00) , or 3% elsewhere from May to September . TM59 manual proposes solutions to achieve shaing atrategies to reduce the amount of solar heat gain through glazing either by limiting the amount of glass openings to South, West, and East facades, or adding cross ventilation and window apertures, shading provided by balconies, brise soleil, shutters, blinds, external awnings, trees, etc.*	*Considerations should be based on planning . Cost effect in terms of shading provided by balconies (brise soleil, shutters); assume average house has 5 nr windows effected by solar gain. Range of £1,500 - £3,000 per house. Average taken. Can be lowered through planning of scheme*	*1*	*house*	*2,000*	*2,000*
Heating appliance	*Low-carbon heating (e.g. Heat pump) Fossil fuel systems are to be phased out and replaced with low carbon technologies such as all electric heat pumps.*	*Additional cost excludes Renewable Heat Incentive; air source heat pump used as price basis; cost is extra over fossil fuel system; full system*	*1*	*house*	*8,000*	*8,000*

Heat Emitter type	*Low temperature heating or large radiators (around 35 ˚C)*	*No difference in installation cost*	*1*	*house*	*-*	*-*
Ventilation System type	*Natural ventilation with intermittent extract fans : no change to current building reg. requirements*	*No financial effect*	*1*	*house*	*-*	*-*
Photo Voltaic (PV)	*For houses, the amount of power required to be produced by PV panels on a house is arrived at by the formula of 40 % of the ground floor area divided by 6.5 to give a figure in kWp (40 % groung floor area / 6.5) - For a 70 m2 - 2 storey house, with GF area being 35 m2 (35 x 40/1000/6.5 = 2.154 kWp would be the energy legislated for.* ***This represents 15 panels at around £270 per panel.***	*Assume installation of 3KW PV per dwelling*	*1*	*house*	*4,000*	*4,000*
Waste water heat recovery	*All showers must be connected to WWHR unit, including showers over baths. Specs require WWFR with 36 % recovery efficiency*	*Assume 1 system per house*	*1*	*house*	*450*	*450*
Thermal Bridges Psi value (W/ m.K)	*No change to current building reg. requirements*	*No financial effect*	*1*	*house*	*-*	*-*
						15,563
Preliminaries & Oveheads & Profit			*0*	*%*	*Excluded*	*-*
Contingency			*0*	*%*	*Excluded*	*-*
Total Cost						***15,563***
					Including Solar Shading	***16,000***
					Excluding Solar Shading	***13,000***

B

APPENDIX B -
DETAILED BUILD UP
FUTURE HOMES STANDARD

Future Homes Standard

Carbon emission target : (3.6 KgCO2/ m^2/yr). At least 75% less emissions compared with 2013 Part L
Notes: Fabric specs based on a typical semi-detached home
Assumptions: 3 bed semi-detached GIA = 114m^2 Roof area = 57 m^2 Wall area= 68 m^2 of which 38% glass and 62% brick

GIA	*114*	*m^2*
Perimeter		*m^2*

Item	***Information***	***Comments/ Financial effect***	***Quantity***	***Unit***	***Rate***	***Total***
Building Fabric						
Floor U-value 0.11 W/m^2.K	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. Tipically on a suspended timber floor an extra 70 mm concrete screed floor only an additional 30 mm of insulation can achieve the 0.11 U-value required. In both cases perimeter insulation of 50 mm is assumed to reduce thermal bridges .*	*Assumed concrete ground floor slab*	*57*	*m^2*	*7*	*399*
External wall U-value 0.15 W/m^2.K	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. Typically, with a full fill cavity wall current insulation levels would need to be increased by 65 mm . With a Timber I-studs construction insulation increase would be 50 mm . and with a structural insulated panel wall insulation requirement would be an additional 65 mm to achieve the 0.15 u-value*	*Assumed traditional cavity wall*	*21*	*m^2*	*10*	*212*
Roof U-value 0.11 W/m^2.K	*No change to Part L 2021 requirements*	*Same effect as Part L 2021*	*57*	*m^2*	*9*	*513*
Windows U-value 0.8 W/m^2.K	*Performance upgrades from double to triple glazing.*		*22*	*m^2*	*55*	*1,197*
Doors Opaque and Semi-glazed U-value 1.0 W/m^2.K	*No change to Part L 2021 requirements*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
Air permeability at 50 Pa (5.0 m^3 /(h.m^2))	*No change to current building reg. requirements*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
Overheating	*The overheating stategy should be already in the original design stage work so no requirements envisaged : No change to Part L 2021 requirements*	*Same effect as Part L 2021*	*1*	*house*	*2,000*	*2,000*
Heating appliance	*Low-carbon heating (e.g. Heat pump) Fossil fuel systems are to be phased out and replaced with low carbon technologies such as all electric heat pumps.*	*Additional cost excludes Renewable Heat Incentive; air source heat pump used as price basis; cost is extra over fossil fuel system; full system*	*1*	*house*	*8,000*	*8,000*

Heat Emitter type	*Low temperature heating , no change to Part L 2021*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
Ventilation System type	*Natural ventilation with intermittent extract fans : no change to current building reg. requirements*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
Photo Voltaic (PV)	*None ; no change to Part L 2021*	*Same effect as Part L 2021*	*1*	*house*	*4,000*	*4,000*
Waste water heat recovery	*None; No change to Part L 2021*	*Same effect as Part L 2021*	*1*	*house*	*450*	*450*
Thermal Bridges Psi value (0.05W/ m.K)	*No change to current building reg. requirements*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
						16,771
Preliminaries & Oveheads & Profit			*0*	*%*	*Excluded*	*-*
Contingency			*0*	*%*	*Excluded*	*-*
Total Cost						***16,771***
					Including Solar Shading	***17,000***
					Excluding Solar Shading	***14,000***

Notes:

Air source heat pumps genenrally cost £400 - £500 per KW less than Ground Source heat pumps, however it may be more economical to group a series of houses together on one ground source heat pump rather than installing a series of air source heat pumps. The atual costs would need determining on a project by project basis.

C

APPENDIX C - DETAILED BUILD UP PASSIVHAUS CLASSIC

Passivhaus calssic

Carbon emission target : N/A - reduced CO2 results from lower energy use .
Notes: Fabric specs based on a typical semi-detached home
Assumptions: 3 bed semi-detached GIA = 114m^2 Roof area = 57 m^2 Wall area= 68 m^2 of which 38% glass and 62% brick

GIA	*114*	*m^2*				
Item	***Information***	***Comments/ Financial effect***	***Quantity***	***Unit***	***Rate***	***Total***
Building Fabric						
Floor U-value ≤ 0.11 W/m^2.K	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. Tipically on a suspended timber floor an extra 70 mm concrete screed floor only an additional 30 mm of insulation can achieve the 0.11 U-value required. In both cases perimeter insulation of 50 mm is assumed to reduce thermal bridges .*	*Assumed concrete ground floor slab - as Future Homes*	*57*	*m2*	*7*	*399*
External wall U-value ≤ 0.15 W/m^2.K	*Requirement in an increase in thickness of insulation which will vary according to the characteristics of the material used. Typically, with a full fill cavity wall current insulation levels would need to be increased by 65 mm . With a Timber I-studs construction insulation increase would be 50 mm . and with a structural insulated panel wall insulation requirement would be an additional 65 mm to achieve the 0.15 u-value*	*Assumed traditional cavity wall*	*21*	*m2*	*10*	*212*
Roof U-value ≤ 0.11 W/m^2.K	*No change to Part L 2021 requirements*	*Same effect as Part L 2021*	*57*	*m^2*	*9*	*513*
Windows U-value ≤ 0.8 W/m^2.K	*Performance upgrades from double to triple glazing.*	*Same as Future Homes Requirement*	*22*	*m^2*	*55*	*1,197*
Doors Opaque and Semi-glazed U-value ≤ 0.8 W/m^2.K	*Door performance upgrade mainly achieved with thicker insulated door panels; omit letter box; letter box to be provided externally*		*1*	*house*	*500*	*500*
Air permeability at 50 Pa (5.0 m^3 /(h.m^2))	≤ 0.6 ach @ 50 Pa	*Sealing of joints via membrane*	*1*	*house*	*1,140*	*1,140*
Overheating	≤ 10 % of hours in the year above 25 ˚C (5% recommended)	*Same effect as Part L 2021* *Can be designed out*	*1*	*house*	*2,000*	*2,000*
Heating appliance	*Low-carbon heating (e.g. Heat pump) No change to Part L 2050 requirements*	*Increased specification of insulation and sealing of building, together with MVHR reduces heating costs.*	*1*	*house*	*(2,280)*	*(2,280)*

Heat Emitter type	*Low temperature heating , no change to Part L 2021*	*Same effect as Part L 2021*	*1*	*house*	*-*	*-*
Ventilation System type	*MVHR*		*1*	*house*	*4,560*	*4,560*
Photo Voltaic (PV)	*None ; no change to Part L 2050*	*Not required*	*0*	*house*	*-*	*-*
Waste water heat recovery	*No ,not required in the passivhaus standard but can be optionally added with beneficial effects as a further energy saving measure.*	*Not required*	*0*	*house*	*-*	*-*
Thermal Bridges Psi value (0.05W/ m.K)	< 0.01 All junctions of the external walls, floors and roofs, window and door frames, external corners and ridges must be designed from the outset to thermal bridge free.	*Part of design, no actual cost*	*0*	*house*	*-*	*-*
						7,630
Preliminaries & Oveheads & Profit			*0*	*%*	*Excluded*	*-*
Contingency			*5*	*%*	*Excluded*	*381*
Total Cost						***8,011***
					Including Solar Shading	***8,000***
					Excluding Solar Shading	***5,000***

D

APPENDIX D -
CITB REPORT -
BUILDING SKILLS FOR NET ZERO

CITB **Industry Insights and Analysis**
March 2021

Building Skills for Net Zero

Introduction

The UK has responded to the climate emergency with a legally binding target to reduce greenhouse gas emissions to Net Zero by 2050.

Reduce greenhouse gas emissions to Net Zero by

2050

Energy efficiency measures means retraining and creating new roles by 2028

350,000 people

With 40% of total emissions coming from construction and the built environment, the construction industry has a key role to play. This report, Building Skills for Net Zero, demonstrates that this target cannot be met without a rapid and lasting transformation of the construction sector. This revolution must include industry-wide investment in skills, far-reaching skills policy reform and an unprecedented recruitment drive. The challenge is huge, and one in which every construction employer must play a role.

The climate emergency will be one of the biggest drivers of economic, political and social change of our generation. And for construction, the Net Zero emissions target is also a huge opportunity to drive change both within the industry and in the wider world. It is a chance to increase diversity within the sector, opening ourselves up to new pools of talent, and to improve the environments in which we work and the quality of the assets we build.

This opportunity comes alongside the COVID-19 pandemic and an expected rise in unemployed workers coming from other sectors. Construction is therefore in a perfect moment to position itself as an attractive industry in which to work.

A 'business as usual' approach will not deliver Net Zero. While our research reveals a widespread lack of industry confidence that Government will do enough to create a pipeline of work to drive towards Net Zero, there is a small but growing group of businesses who are already engaged at the leading edge of low energy new build and energy efficiency retrofit. Our industry is already delivering, but it needs to happen at scale.

Using data from the Climate Change Committee (CCC)'s balanced scenario, our modeling suggests that an additional 350,000 FTE workers will be needed by 2028, to be mainly involved in delivering improvements to existing buildings that will reduce energy demand. That represents an increase of around 13% on the current size of the workforce, based on current technologies and ways of working. This has the potential to give thousands of people a valuable new career opportunity as we emerge from a time of national crisis.

To tackle a recruitment challenge of this scale, the construction industry must do more to attract the best talent possible, and to change the image of the industry through a focus on bringing in more women, workers from BAME communities, people with disabilities and other under-represented groups.

To create new pathways into construction and ensure the provision of lifelong learning, training providers must identify the key skills needs and where the most significant gaps will be. New qualifications and training courses must then be designed to plug those gaps.

However, the training sector is predominantly demand-led, so a likely rapid increase in the need for low-carbon skills in the long term, particularly in retrofit, will not be met unless that demand is created. Because of the time it takes to develop high quality training and mobilise the sector to deliver at scale, action on this must be taken immediately.

This is not something that the construction industry can tackle alone. It will require the industry to work with other sectors both within the built environment and outside. Our research in this area shows that collaboration is key. We will need Government to provide clearer signals about future pipelines of work, and a rapid response from the training sector to deliver the right skills.

Building Skills for Net Zero

Our comprehensive research report on Building Skills for Net Zero draws on in-depth interviews with 48 industry stakeholders and a detailed survey of nearly 300 people. The aim of the research is to outline the skills implications for the workforce of the Government's commitment to achieve Net Zero by 2050.

We also used the CCC's data on their balanced scenario to model which skills will be required and to what extent over the next 30 years, for the UK, Wales and Scotland, based on proposed solutions to the decarbonisation problem.

Employer sentiment

Among respondents to our survey, there was broad agreement on the importance of the Net Zero agenda with three quarters of respondents saying that decarbonisation was either important or very important to themselves or their company.

Of respondents have a good understanding of how they need to change their business

70%

Of respondents saying they would be willing to diversify

88%

Of respondents would retrain if necessary

90%

Furthermore, 70% say they have a good or very good understanding of how they will need to change their business because of the need to decarbonise, with a high proportion, 88%, saying they would be willing to diversify and 90% would retrain if necessary.

Whilst this shows a willingness in industry to adapt to the Net Zero future, the need to start that process of adaptation now is clear. More than three quarters (78%) of those we spoke to believe there will be a shortage of skills in their specific occupation when it comes to decarbonisation work.

The most regularly cited reasons for the absence of appropriate skills in specific roles were lack of training, lack of funding for training, regulatory changes, and an absence of agreed standards in that particular occupation.

As previously noted, skills to address the retrofit challenge appear to be the most urgently needed, as evidenced by both our quantitative and qualitative research.

One interviewee commented:

> "We should bear in mind that most people's base education doesn't really include much work to existing buildings. For most people, the focus of their training is on new construction and of course, new construction is probably just over 50% of work activity. Work for existing buildings isn't too far behind. Everybody will probably end up working on existing buildings and even traditional buildings [so] their base education needs to include those types of buildings."

John Edwards, Edwards Hart Consultants

The opportunity

Emissions from the built environment sector can be broken down into three groups:

01. Energy-related emissions from existing buildings
02. Energy-related emissions from new buildings
03. Embodied emissions.

EXISTING BUILDINGS AND RETROFIT

The UK Green Building Council estimates that up to 95% of emissions from the built environment over the next 30 years could come from buildings that exist today.

Most of the effort to decarbonise must therefore be focused on the energy efficiency retrofit of existing buildings. At least some retrofit work will be required on around 27 million residential and two million non-residential buildings to reduce emissions over the next 30 years. Even with new ways of working, we will need to recruit, train and in some cases retrain large numbers of people to do the work.

Outside of the social housing market, there is currently very little activity in energy efficiency retrofit, and very little capacity. The scale of the task should not be underestimated, nor the urgency of action. This research shows that scaling output is possible, but the amount of effort, and the degree of active planning and direction required, are unprecedented.

Latest data from the CCC based on their balanced scenario estimates a cost of £254bn for domestic and £108bn for non-domestic retrofit over the next 30 years. Previous CITB research has identified a skills deficit in the specialist skills needed to repair, maintain and improve traditional buildings. Even before taking the additional demand created by the drive for Net Zero into account, we estimated that, in England, 7,000 workers will need to be either recruited or retrained to meet the demand for work on these older buildings.

NEW BUILDINGS

Net Zero ambition will lead to tightened regulation around many elements of new building design and construction, particularly those aspects related to energy performance, such as insulation, airtightness, air quality and energy systems.

The consensus in our survey was that the industry is more than capable of building to higher standards, providing there is clarity from Government on what is required and the right incentives to take action are put in place.

For example it is likely that tightened building standards will lead to increased adoption of smart digital construction including offsite. The standardisation of processes that results from a manufacturing approach to construction can help to reduce errors and defects in construction and can lead to greater energy efficiency performance. Increased use of manufacturing approaches creates skills challenges as well as opportunities. While manufacturing requires different sets of skills from traditional onsite construction, its increased use also has the potential to open up construction to new entrants from other sectors and increase diversity in the industry.

EMBODIED EMISSIONS

Embodied emissions, such as those produced in the fabrications of materials and through construction processes, are a significant part of the sector's carbon footprint and will become increasingly important as energy-related emissions from buildings are reduced. The skills needed to reduce embodied emissions were not directly considered for this research, but plentiful training resources exist through initiatives like the Supply Chain Sustainability School.

The retrofit skills gap

There are major shortfalls facing the industry in a large number of specific trades and professions. Modelling from the CCC shows that rapid scaling up of supply will be needed over the next seven years reaching a peak in 2028.

We estimate that an additional 59,000 plumbers and HVAC workers will be required, primarily in the installation of heat pumps by 2028. The research also highlights that we require just over 86,000 project managers by the same date, this includes specific roles like Retrofit Coordinator. The requirement for building envelope specialists, including insulation installers, will be 27,000 in 2028.

Achieving Net Zero therefore requires action now, with a clear plan on how to build supply sustainably over the next decade.

It must also be recognised that scaling retrofit will inevitably lead to more widespread adoption of innovative approaches, technologies and delivery models, not least as a response to the shortages of skills. The wider adoption of smart digital construction including offsite fabrication in retrofit is therefore highly likely. This will create demand for skills that are associated with manufacturing processes including surveying, design and energy evaluation, logistics and onsite assembly.

Ian Hutchcroft from Energiesprong UK described how the industry cannot use ‘business as usual’ recruitment and training processes:

> “There isn’t enough skilled labour to work productively onsite to deliver £27m housing retrofits in ten or 20 years.”

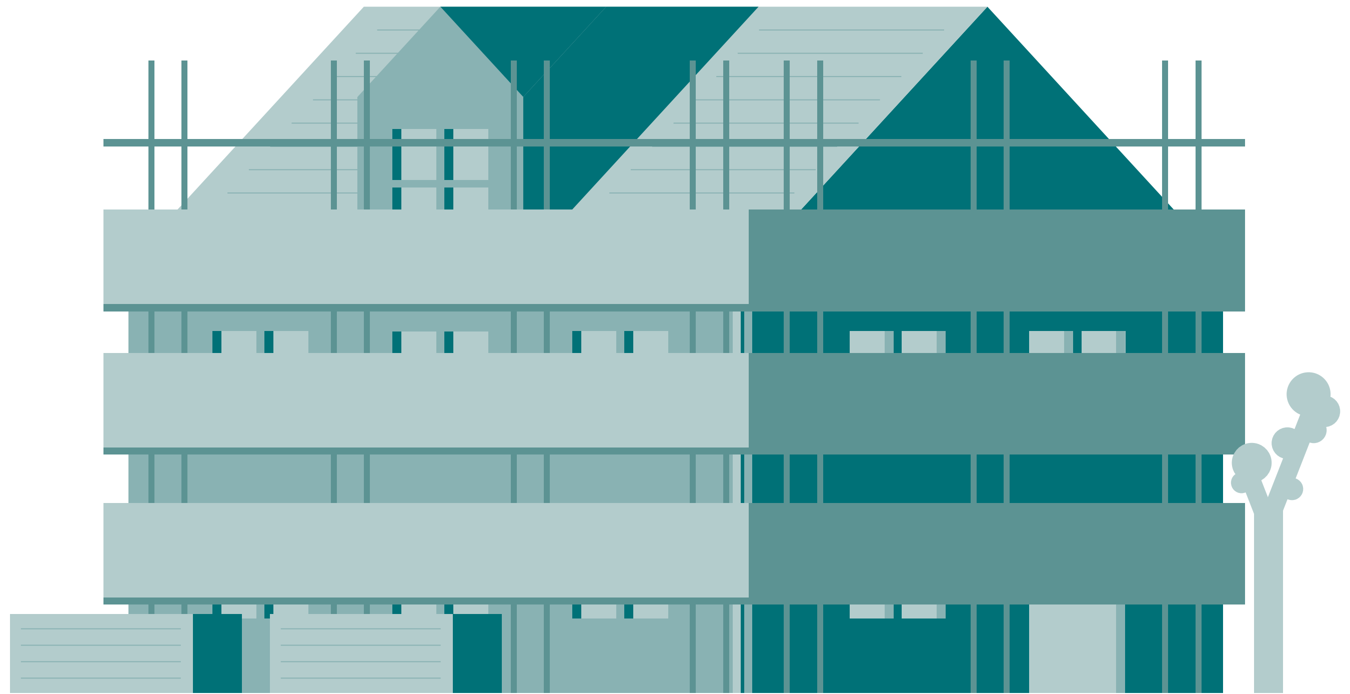
But in order for industry, training providers and employers to develop the right skills, we will need certainty that any investment made will not be wasted. Respondents to our survey and interviewees strongly felt that governments must create a viable market for retrofit and give a clear indication of a sustainable programme of work.

Skills for retrofit

The need to carry out retrofit across the whole existing building stock creates a requirement for specific skills in accordance with retrofit best practice including:

PRE-CONSTRUCTION

- Surveying skills to assess current condition and any requirements for repair
- Energy evaluation skills to model current performance
- Design skills for the design and specification of upgrade solutions.



CONSTRUCTION

- General repair and maintenance as an essential first step prior to retrofit measures, including understanding of suitable approaches on traditional buildings
- Project management for the supervision of the retrofit programme and management of risk
- Tradespeople to implement measures, such as draft proofing, insulation or replacing a gas boiler with a heat pump.

POST-CONSTRUCTION

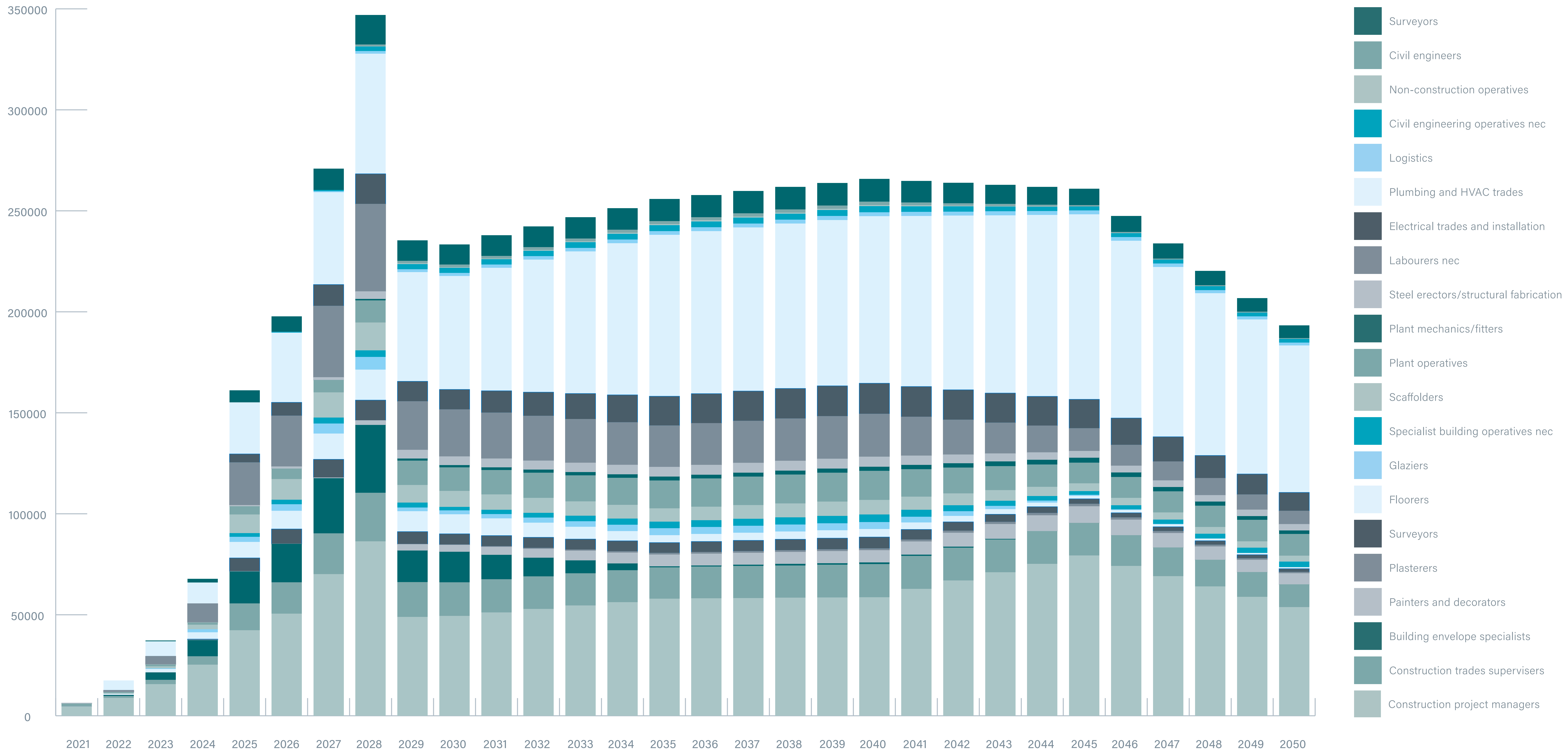
- Building performance evaluation skills to test and assure the performance of the retrofit.

Employment requirement for Net Zero

Using current construction methods the industry needs to increase by 350,000 FTE workers over the next decade to deliver the volume of work needed to reach Net Zero by 2050.

This means we will need to prioritize new recruitment from outside the sector, retraining and productivity gains to have a realistic chance of hitting the target.

This chart shows the employment requirement for delivering the CCC's balanced scenario. The scenario is a blend of interventions incorporating an energy efficiency first approach which is driving increased demand to 2028, and then dipping to provide a sustained level of employment.



Recruiting and retraining for Net Zero

Interviewees and respondents to our survey reported that the focus of training across the sector is currently on new build, traditional and onsite construction techniques, with the consideration of embodied emissions being negligible.

According to our respondents this has led to difficulties in meeting decarbonisation goals on new build projects and limited engagement on repair, retrofit, traditional buildings, and MMC. Interviewees also reported a lack of support for these disciplines at all levels of training.

Our model forecasts the skills requirements for the main decarbonisation pathways being considered by the CCC to achieve Net Zero. It is likely that a balanced scenario will be followed by governments, which comprises a sequenced combination of all the measures on these pathways. This means that training for all these pathways will need to be ramped up.

Whichever route — or combination of routes — we go down, there is potential for employers to tap into talent at a Further Education (FE) level, which has often been underutilised by the sector. Industry can work with FE colleges to design appropriate courses and facilitate collaboration with employers. FE will be particularly important in light of the threat to apprenticeships posed by COVID-19.

Roadmap to Net Zero

A widespread programme of upskilling and reskilling will be needed to improve the industry capabilities in areas such as project management, system design and digitalisation.

Future demand will need to be constantly re-assessed as the industry transforms and we need to design training that helps the future workforce become highly adaptable. Training programmes, courses, qualifications and accreditation must all be designed to support workers through lifelong learning so that people can easily continue to retrain and upskill as demands evolve.

To reach Net Zero by 2050 a combined approach of the pathways in the table will be required.

COMPONENT PATHWAYS	SKILLS SUMMARY
HYDROGEN DEPLOYMENT THROUGH THE GRID	Conversion of existing gas boilers to hydrogen is straightforward, however conversion of the transmission and storage infrastructure is unproven and generation of heat by hydrogen would require six times as much generation capacity as would be required for heat pumps. There is a cohort of 120,000 qualified gas engineers in the UK, and those with Gas Safe qualifications may only need one extra day's training. Even over the next five to ten years, only an additional 1,500 FTE workers on average would be required for this pathway.
FABRIC FIRST RETROFIT	Surveyors and energy specialists will need to assess the condition and model the performance of buildings, while a variety of tradespeople would be needed to implement recommendations. There would need to be a rapid and vast deployment of training facilities and courses. Around 12,000 workers a year would need to be trained over the first four years, with that annual recruitment need ramping up to 30,000 between years five and ten. After that, demand for some of these skills would be expected to wane, emphasising the need for a constant re-examination of training needs.
HEAT PUMPS	Again, this pathway would require rapid deployment, up to a peak of around 15,000 workers a year needed between years five and ten. There should be continued work for this workforce beyond that time, however, as installation work gives way to maintenance work. Heat pumps are certain to play some part in the decarbonisation strategy, and the skills needed to install and maintain them are highly sophisticated. Training the estimated 60,000 new workers may be resource intensive but that workforce should be required long term.
HEAT NETWORKS	Heat networks would require the quickest and most widespread increase in training, with much of the requirement likely to be at the strategic or systems level. Project planners, engineers, developers, design engineers and control system specialists would all be required. At an installation level, welders and general installers would need to be recruited and trained. In total, 9,500 additional FTE workers would likely be needed per year for the first four years, with numbers falling significantly after that point.
ONSITE ENERGY	This pathway includes a variety of technologies which can be used to enable decarbonisation, including onsite energy generation, energy storage, and smart systems. The installation of — for example — roof-mounted PV would not require significant amount of retraining, with traditional tradespeople such as scaffolders and plumbers likely to be able to upskill quickly.

Key CITB actions

Net Zero will only be achieved through a rapid and enduring transformation of the construction sector.

This will require an industry-wide investment in skills and training that must be early, planned, and based on clear future demand.

CITB is working with the UK Green Jobs Taskforce, the Construction Leadership Council, the Scottish Construction Leadership Forum, and the Welsh Construction Forum to meet the Net Zero skills challenge. This report will help the UK, Scottish and Welsh governments to publish clear skills and jobs plans to support industry's energy transition.

In partnership with employers, we will continue to develop and review training standards that support the decarbonisation of the built environment. We will also work with the British Standards Institute to update existing PAS retrofit requirements, to ensure clarity and consistency for employers in the way that competency is assessed. We are supporting new training qualifications, including the Level 5 Diploma in Retrofit Coordination and Risk Management, Retrofit Assessor in Wales, and updates to existing qualifications such as the Insulation and Building Treatments NVQ. These will all be essential in meeting training needs associated with Net Zero. Employers will be able to access up to date, high-quality training courses through CITB's Training Directory, with courses provided by CITB approved organisations.

As national governments further define how they will look to meet decarbonisation ambitions, CITB will work with industry to identify and address the emerging skills gaps associated with the different Net Zero pathways. CITB has already funded the Offsite Ready project to encourage uptake of MMC and digital technologies through training courses. We will ensure our key funds, including the Skills and Training Fund, meet emerging skills needs associated with retrofit programmes. Through our partnerships with initiatives such as the Supply Chain Sustainability School and the Transforming Construction programme we will continue to build industry capacity for transformation and improvement.

Net Zero is a challenge but it also provides a unique opportunity for industry to modernise, grow, and create a green jobs revolution. To do this, industry will need to attract a more diverse workforce into key occupations with large forecast skills shortages. These range from surveyors and project managers, to assembly technicians, insulation fitters and general builders. We are beginning to address this challenge through our industry careers website Go Construct, employer apprenticeship funding, and by increasing work experience opportunities.

We will ensure that these activities are flexible so we can respond to the skills requirements as they change and grow. We will also support the industry's Fairness, Inclusion and Respect programme to make construction workplaces better for everyone and to open construction to a broader pool of talent.

Government skills policy reform

As an industry, we need to work with governments to develop the skills for Net Zero.

Urgent action is needed now to ensure the education and training infrastructure is responsive to emerging skills requirements and the future training needs of employers.

It is critical that the regulatory, investment and market approaches adopted by governments create a pipeline of the size and scale needed to hit Net Zero targets and to give employers the confidence to invest in new skills.

In the short-term, national governments must consider how programmes like the Green Homes Grant, the Net Zero Jobs Fund in Scotland, and the Optimised Retrofit and Innovative Housing Programmes in Wales provide this clear pipeline and encourage industry to invest in creating a green construction workforce. Governments should also consider how procurement can drive Net Zero skills and training uptake.

- ✓ CITB will continue to support the UK, Scottish and Welsh governments to map the skills implications of the plans they are currently developing to reach Net Zero in the built environment. We will seek to support local government approaches in the same way.
- ✓ Standards of construction training across the three nations need to be fit-for-purpose. In England, we will support the Institute for Apprenticeships and Technical Education (IFATE)'s announced route review of construction apprenticeship standards to ensure they continue to meet emerging requirements. We will also work with Skills Development Scotland and the Welsh Government's Skills, Higher Education and Lifelong Learning team to support relevant reviews and developments.
- ✓ Sustainability skills will need to be a central feature of any new pathway into industry. We are working with the UK Government to ensure new construction traineeships and associated fast-track apprenticeships being launched in England in 2021 will provide critical training and onsite experience in energy efficient building methods. We are also working with Welsh and Scottish governments to provide new pathways from FE into industry that will be responsive to developing Net Zero requirements.
- ✓ Existing qualifications should be regularly reviewed to ensure they deliver high-quality training for employers. Development of the FE White Paper and new National Skills Fund in England, implementation of the qualifications review in Wales, and engagement with the Scottish Qualifications Authority will support reform and improvement of construction qualifications.

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