West of England (WOE)

EVIDENCE BASE FOR WOE NET ZERO BUILDING POLICY

Operational Carbon for Non-Domestic Buildings

JULY 2021

CONFIDENTIAL

West of England (WOE)

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EXECUTIVE SUMMARY

This study will provide the evidence base for revised Local Plan policies for carbon reduction in non-domestic buildings. The work has been commissioned by the West of England Authorities; however, national data has been used with the intention that this study could be used by any local authority (LA).

This study provides indicative costings for policy elements that would together enable net zero regulated carbon in non-domestic buildings. The scope of this work is focused on regulated emissions since unregulated emissions vary very widely depending on building type and use.

Given that cost modelling for non-domestic buildings is difficult due to the diversity of buildings, this study is high level, drawing on previously published costs.

The policy elements costed are:

1. **Future Building Standard 2021 (FBS)**: Preferred option (option 2, 27% reduction) which will have come into effect by the time the Local Plans are adopted;
2. **BREEAM**: BREEAM Excellent is being considered in addition to a policy for net zero regulated emissions to ensure that buildings take a holistic approach to sustainability as required by BREEAM. This study touches on the relationship between BREEAM and the net zero policy options but BREEAM is not a focus of this report.
3. **Heat Decarbonisation:** A heat hierarchy policy that would expect the use of renewable heat (e.g. heat pumps) is being considered.
4. **Net zero regulated emissions**, either through
    a. Policy Approach 1: Part L 2021 plus maximised rooftop solar plus offset for any remaining emissions, or;
    b. Policy Approach 2: Using a 15kWh/m^2 space heating target and 55-65kWh/m^2/yr Energy Use Intensity target (total energy use including unregulated energy and based on building type) as set out in LETI. Then remaining emissions are offset if they cannot be mitigated onsite as may sometimes be the case in non-domestic buildings e.g. if roof space is limited.

Costings

This study firstly reviewed existing literature to draw out the costs of these policy elements. Secondly the study then applied these costs to two types of example non-domestic building: an office and a school. Results summarised below:

1. **Future Building Standards 2021**

The Future Building Standard Impact Assessment presents Option 2 for Part L 2021, reducing carbon by 27%, as the government's preference. These standards are seen as preparing the industry for more stringent fabric standards which will be introduced from 2025. Therefore, the figures for Option 2 have been focused on in this report. Ventilation policy and fabric standards are highlighted as a large proportion of the cost for non-domestic buildings.

Table A-1 – Additional capital cost to achieve Part L 2021 Option 2 target of 27% in CO_2 per building over the Part L 2013 standards. Adapted from Table 6 in the FBS report.

Asset Type	Cost Increase (£/m^2)	Percentage Increase
Office – deep plan, air conditioned	24	0.68%
Office – shallow plan, naturally ventilated	29	1.14%
Hotel	40	1.32%
Hospital	23	0.51%
Secondary School (includes sports facilities)	36	1.20%
Retail Warehouse	75	4.15%
Distribution Warehouse	51	2.82%

2. BREEAM

- 1-2% of construction costs (or £30-70/m^2 based on £3,000-3,500/m^2 construction cost) can be used as an indicative cost to achieve a BREEAM Excellent (2014) rating.
- An Excellent rating can reach 3-5% of construction cost for buildings such as healthcare.
- Following a review from Currie and Brown in 2018, it was noted that while BREEAM 2018 required further time input, any capital cost increase would be "relatively small".

3. Heat Decarbonisation

- Heat pumps vary widely based on the type in use; however, there are some values which can be used as a starting point for air source heat pumps.
- £9-16/m^2 or 0.4% can be used as an indicative cost for ASHP systems used throughout a building.

4. Net Zero Regulated Emissions

a. Solar PV

- For small systems (<50kWp), values used in the Future Building Standard of £1,100/kWp can be used. Given recent price decreases in solar equipment, this should be seen as a conservative estimate.
- For larger rooftop system (>50kWp), more relevant to non-domestic buildings, a range of value of £650-1000/kWp can be used with larger systems using the lower value.[1]

b. Carbon Offsetting

- The carbon offset price for carbon emissions is assumed to be £95 per tonne of carbon dioxide equivalent, based on the CSE report carried out on behalf of the West of England

[1] Spirit Energy, 2021, Solar for Business: Commercial Solar Panels. Available online at: https://www.spiritenergy.co.uk/commercial-solar-panels

Unitary Authorities[2] and based on the cost required to encourage deployment of rooftop solar PV.

Policy Considerations

1. In the Currie and Brown report from 2018 to meet net zero regulated carbon emissions, there was a 5-7% uplift in construction cost referenced. That figure was from a 'baseline' of Part L 2013 with gas heating[3]. The cost ranges from the modelling completed in this report are summarised below. All ranges do not include BREEAM costs.
   a. Cost to reach net zero regulated emissions from baseline of Part L 2013 with gas heating:
      i. Approach 1: 1.6-2.4%
      ii. Approach 2: 2.2-4%
   b. Cost to reach net zero regulated emissions from baseline of Part L standards for non-domestic buildings 2021 as part of the road to the Future Buildings Standard 2025:
      i. Approach 1: 0.9-1.2%
      ii. Approach 2: 1.5-2.8%
   c. The difference between the cost ranges in this report and the C&B 2018 report can be explained by a range of competing factors:
      i. The modelling considered here is for an office and school only, rather than a full range of non-domestic buildings.
      ii. Continued reduction in solar PV costs.
      iii. Continued reduction in carbon emissions factor used to calculate cost of offsetting.
      iv. Further modelling can be completed in future in order to review the nuances and known variations between compliance asset models, real asset models and operational performance. However, this is beyond the scope of this report.

2. BREEAM is not a replacement for net zero policy since it does not have net zero carbon emissions as the primary aim. Therefore it should be considered alongside but separately to any net zero building policy.

3. The amount of available roof space will impact the size of PV system which can be installed. For the school modelled in this report, because of the assumptions made on available roof area (of 70% of total roof area), a large PV system can be installed (c.300kWp) and no offsetting is required. However, for the office a much smaller PV system (c.100kWp) can be installed due to the available roof space.

4. A policy requiring the roof space to be maximised for PV where possible could be considered purely for the wider objective of increasing local renewable energy generation and contributing to grid decarbonisation. The solar PV does not necessarily need to be linked to the buildings energy demand. This would ensure the use of roof space that would otherwise go unused, and potentially reduce the need for solar farms in greenfield sites.

[2] Centre for Sustainable Energy, 2018, Cost of carbon reduction in new buildings. Online available at: https://www.cse.org.uk/downloads/file/cost-of-carbon-reduction-in-new-buildings.pdf
[3] ibid

1 INTRODUCTION

We have been jointly commissioned by the four local authorities (LAs) in the West of England (WoE): Bath and North East Somerset Council (B&NES); Bristol City Council (BCC); North Somerset Council (NSC) and South Gloucestershire Council (SGC), and in collaboration with the West of England Combined Authority (WECA), to provide part of the evidence base for revised Local Plan climate policies for the West of England Authorities and potentially the WoE Spatial Development Strategy (SDS). However, the intention is that this study can be used by any LA.

This study will specifically focus on the operational carbon of non-domestic buildings (Section A2 of the brief) and the cost uplifts anticipated with upcoming regulatory changes and new climate challenge targets. RIBA define operational carbon in the following way: *“The carbon dioxide produced as a result of the production and use of the energy from fossil fuels consumed for the day-to-day operation of the building or structure, including low/zero carbon renewable energy technologies both on and off-site, plus recognised offset schemes where essential”*[4]

[4] RIBA, 2019, RIBA Sustainable Outcomes Guide. Available online at: https://www.architecture.com/knowledge-and-resources/resources-landing-page/sustainable-outcomes-guide

2 OPERATIONAL CARBON OF NON-DOMESTIC BUILDINGS (A2)

2.1 LITERATURE REVIEW FOR DECARBONISATION COSTS

Several documents were reviewed for an assessment of costs associated with decarbonisation. Once reviewed, the findings will be summarised. The documents forming part of this review are:

- The Future Building Standard Consultation Impact Assessment, MHCLG, January 2021[5]
- Cost of carbon reduction in new buildings – Final Report, Currie & Brown for Centre for Sustainable Energy on behalf of the four unitary auth, 2018[6]
- The costs and benefits of tighter standards for new buildings – Final Report, Currie & Brown for Committee on Climate Change, 2019[7]
- Low Carbon Heat: Heat Pumps in London, Etude for the GLA, September 2018[8]

2.1.1 THE FUTURE BUILDING STANDARD CONSULTATION IMPACT ASSESSMENT, MHCLG, JANUARY 2021

This Impact Assessment is an addendum to the consultation document, which presents Options 1 and 2 for Part L 2021, reducing carbon by 22% and 27% respectively. For non-domestic buildings, the consultation states that Option 2 is the government's preference. This is because there are greater carbon savings achieved for this option, particularly due to higher fabric standards. These standards are seen as preparing the industry for more stringent fabric standards which will be introduced from 2025. Therefore the figures for Option 2 have been focused on in this summary.

Cost analysis was completed in Q2/3 2019 so the costs are reflective of the time. While it is not possible to know for certain how costs will change, it is more likely they will increase over time due to inflation. It is noted that for non-domestic buildings the cost variation can be +/-20%. Ventilation policy and fabric standards are highlighted as a large proportion of the cost for non-domestic buildings.

Dependent on the type of building, there is a significant variation in the £/m^2 required to meet the Part L 2021 Option 2 standards from Part L 2013. For example, air-conditioned offices and hospitals only need a small £/m^2 uplift, whereas retail warehouses and distribution warehouses require a much greater uplift from current standards. However, all of the assets require less than a 5% increase in the £/m^2 cost to meet Part L 2021 Option 2.

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[5] UK Government, 2021. Future Buildings Standard Consultation Impact Assessment (IA). Online Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/953664/201209_Future_Buildings_Standard_consultation_IA.pdf

[6] Centre for Sustainable Energy, 2018, Cost of carbon reduction in new buildings. Online available at: https://www.cse.org.uk/downloads/file/cost-of-carbon-reduction-in-new-buildings.pdf

[7] Currie & Brown and AECOM, 2019. The costs and benefits of tighter standards for new buildings. Online Available at: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/

[8] Etude, 2018, Low Carbon Heat: Heat Pumps in London. Online at: https://www.london.gov.uk/sites/default/files/low_carbon_heat_-_heat_pumps_in_london_.pdf

Table 2.1.1-1 – Additional Capital Costs to achieve Part L 2021 Option 2 target of 27% in CO2 per building over the Part L 2013 standards. Adapted from Table 6 in the FBS report.

Asset Type	Cost Increase (£/m^2)	Percentage Increase
Office – deep plan, air conditioned	24	0.68%
Office – shallow plan, naturally ventilated	29	1.14%
Hotel	40	1.32%
Hospital	23	0.51%
Secondary School (includes sports facilities)	36	1.20%
Retail Warehouse	75	4.15%
Distribution Warehouse	51	2.82%

Table 2.1.1-2 – Cost information used for new non-domestic building specification options, including any variations between building type. Adapted from table B.1 in report.

Element	Specification	Unit	Cost (£ per unit)
Masonry External Wall – two dense block work leaves with insulated cavity and render finish	0.26 W/m^2.K 0.18 W/m^2.K	m^2	£232 £239
Metal Frame External Wall – rainscreen, insulated cavity, particle board, metal stud wall and plasterboard	0.26 W/m^2.K 0.18 W/m^2.K	m^2	£359 £375
Ground Floor – insulation and concrete slab and hardcore	0.22 W/m^2.K 0.15 W/m^2.K	m^2	£61-70 £66-76
Raised Exposed Floor – insulation and concrete slab and screed	0.22 W/m^2.K 0.15 W/m^2.K	m^2	£41 £46
Flat roof – membrane, insulation, concrete deck	0.18 W/m^2.K 0.14 W/m^2.K	m^2	£214 £216
Pitched warehouse roof – insulated steel panels	0.18 W/m^2.K 0.14 W/m^2.K	m^2	£53 £71
Windows – including frame	1.6 W/m^2.K 1.4 W/m^2.K	m^2	£570 £600
Airtightness	5 m^3 m^2 hr 3 m^3 m^2 hr	m^2 Gross Internal Floor Area	£0 £5

Light fittings - general	60 llm/cW 95 llm/cW	m² lit floor area	£59 (£53 in warehouses) £67 (£60 in warehouses)
Light fittings - display	22 llm/cW 95 llm/cW	m² lit floor area	£45 £60
Light controls - occupancy	Manual on / auto off Auto on / off	m² controlled floor area	£2.5 £0
Cooling - air cooled chiller	SEER 3.6 SEER 4.4	kW capacity	£160 £180
Ventilation heat recovery	70% 76%	m³/second delivered air	£8000 £8200
Gas boiler	91% 93%	kW capacity	£45 £45
Roof mounted - photovoltaic panels mounted on frames on accessible concrete flat roof	Variable costs for systems >4kWp	Per kWp installed	£1,100

2.1.2 COST OF CARBON REDUCTION IN NEW BUILDINGS, CURRIE & BROWN, 2018

Although this report mainly focused on domestic considerations, there is some discussion around non-domestic assets. Generally, the report highlights the challenges in taking a standard approach to non-domestic buildings given the variable nature of type, design and operation.

The cost figures in the report relate to the pre-Future Building Standards policy position, which is based on the London Plan, relative to the building regulations current at the time of writing (Part L 1a 2013). As a result this is "*a 15% reduction in carbon emissions from energy efficiency, a total onsite reduction of 35% and the achievement of zero regulated carbon emissions using allowable solutions*". These figures are all in relation to a Part L 2013 building using gas heating.

In total the above targets can be reached with 5-7% of the capital costs, with an additional 2% for BREEAM Excellent (under BREEAM 2014). This is said to depend on *"location, the base design and experience of the design and construction team."*

In relation BREEAM 2018, at the time of publication of this report it was noted that there was insufficient data on its implications. However, it was generally noted, following a review from Currie and Brown, that while BREEAM 2018 required further time input, any capital cost increase would be "relatively small".

Table 2.1.2-1 – Summary of cost and target or savings for the relevant element

Focus	Cost	Target/Saving	Comments
Lighting – moving to LEDs with controls	£20/m^2	10-15% energy efficiency saving	
Energy efficiency measures (excluding PV and heat networks)	£37-£59/m^2 <2% of construction cost	10-15% energy efficiency saving	Equates to 2% of capital cost of overall development, assuming between £2,000-£3,000/m^2
Carbon reduction through onsite savings (including PV and low carbon heat solutions, e.g. heat pumps)	1% of construction cost	35% carbon reduction	Very dependent on building type and technologies suitable for decarbonisation, e.g. air conditioned office vs high rise hotel
Offset residual emissions	£42-£114/m^2 2-4% of construction cost	65% of regulated CO_2 emissions	
BREEAM Rating	1-2% of construction cost	Excellent	Can be 3-5% of construction cost for buildings such as healthcare Costs of the BREEAM certification can be considerable for smaller developments
Total	**6-9% of construction cost** **(excluding lighting)**	**Net zero regulated emissions**	For BREEAM, can be 8-12% of construction cost for buildings such as healthcare

2.1.3 THE COSTS AND BENEFITS OF TIGHTER STANDARDS FOR NEW BUILDINGS, CURRIE & BROWN, 2019

This study was commissioned by the Committee on Climate Change to review the opportunities for tightening building standards to help the UK meet its targets in the Climate Change Act.

The below tables provide the cost breakdown for different efficiency targets including an Air Source Heat Pump (ASHP) for two types of new build office. The savings are above the Part L 2013 standards.

The study found that to retrofit and meet these same fabric and services targets would take five to ten times the cost as for the new build.

Table 2.1.3-1 - Additional capital costs of improved energy efficiency for a new naturally-ventilated office in 2020. Adapted from figure 6.1.

Focus	Cost	Target/Saving	Comments
15% efficiency improvement with ASHP	£19/m^2 <1% of construction cost*	15% efficiency improvement	ASHP: £16/m^2 High efficiency lighting (without controls): £3/m^2
20% efficiency improvement with ASHP	£30/m^2 <2% of construction cost*	20% efficiency improvement	ASHP: £16/m^2 High efficiency lighting: £3/m^2 Fabric and Glazing: £11/m^2
25% efficiency improvement with ASHP	£40/m^2 <2% of construction cost*	25% efficiency improvement	ASHP: £16/m^2 High efficiency lighting: £3/m^2 Fabric and Glazing: £21/m^2

**Assumes typical construction cost of £2,000-£2,500/m^2*

Table 2.1.3-2 - Additional capital costs of improved energy efficiency for a new air-conditioned office in 2020. Adapted from figure 6.2.

Focus	Cost	Target/Saving	Comments
15% efficiency improvement with ASHP	£11/m^2 <1% of construction cost*	15% efficiency improvement	ASHP: £9/m^2 High efficiency lighting (without controls): £2/m^2
20% efficiency improvement with ASHP	£17/m^2 <1% of construction cost*	20% efficiency improvement	ASHP: £9/m^2 High efficiency lighting: £2/m^2 Fabric and Glazing: £6/m^2
25% efficiency improvement with ASHP	£32/m^2 <1% of construction cost*	25% efficiency improvement	ASHP: £9/m^2 High efficiency lighting: £2/m^2 Fabric and Glazing: £21/m^2

**Assumes typical construction cost of £3,000-£3,500/m^2*

2.1.4 LOW CARBON HEAT: HEAT PUMPS IN LONDON, ETUDE, 2018

In this report, the Greater London Authority commissioned Etude to review impacts of heat pump uptake in London. This report was designed to inform the policies of the London Plan and London Environment Strategy.

This report describes a taxonomy for heat pumps which relates to building type and heat pump size. There are three levels:

Table 2.1.4-1 – Proposed taxonomy of heat pump sizing

Size / Scale	kW Size Range	Context
Small scale / individual heat pumps	0-20 kW	Equivalent to a domestic gas boiler
Medium scale / communal heat pumps	20-170 kW	Can provide the heating system of a non-domestic building, e.g. school or office building. Can also be for an apartment building.
Large scale / district heat pumps	>170 kW	Can serve large non-domestic buildings (e.g. an office) or be integrated into the energy centre of a district heating network.

Heat pump costs are provided in the report based on the type of heat pump. It is noted that these costs will vary significantly depending on the context. Also, the costs of electrical infrastructure required is not included given the many variables affecting this figure.

Table 2.1.4-2 - Costings for building level heat pumps types

Description	Additional costs (£/m2 GIFA)	Additional costs (£)	Additional costs (Proportion of total construction costs)
Building level air source heat pump system with water distribution to Heat Interface Units (HIUs)	+ £11/m^2	+ £930/unit	+ 0.4%
Building level air source heat pump system with refrigerant distribution to fan coil units (FCUs) and separate system for DHW	+ £27/m^2	+ £2,380/unit	+ 1.0%
Communal ground loop with individual heat pumps	+ £82/m^2	+ £7,080/unit	+ 2.9%
Connection to Waste Heat Network with building level heat pump system	+ £59/m^2	+ £5,080/unit	+ 2.1%

Cost reductions can be expected to help with heat pump deployment in a couple of areas, with the assumption that these cost reductions would occur when there is a mass market scenario:

- As a result of a growing installer base made up of larger companies, a stream-lined supply chain and better sales channels; cheaper installation costs can be expected going forwards. This is estimated to be a 5-10% cost reduction on 2016 prices.
- Equipment related cost reductions are also likely but not on a similar scale as they are already a mature technology in Europe. This is estimated to be a 1-2% cost reduction on 2016 prices.

2.1.5 LITERATURE REVIEW SUMMARY

In this section, based on the literature summarised above, values have been suggested as a starting point for costings of various decarbonisation elements. These should be used in the context of the reports they are derived from.

Energy Efficiency

- Based on the figures in the reports reviewed a 10-15% improvement in energy efficiency saving equates to a ~2% increase (or £37-59/m^2) in construction costs.
- Fabric and glazing measure can fall within a £11-21/m^2 range, or <1% of construction costs.
- As a result of the recent UK government announcement[9] halogen bulbs will be phased out, therefore LEDs will be the only lighting allowed from September 2023 and will therefore be considered as a baseline cost.

Heat Pumps

- Heat pumps vary widely based on the type in use; however, there are some values which can be used as a starting point for air source heat pumps.
- £9-16/m^2 or 0.4% can be used as an indicative cost for ASHP system used throughout a building.

Solar PV

- For small systems (<50kWp), values used in the Future Building Standard of £1,100/kWp can be used. Given recent price decreases in solar equipment, this should be seen as a conservative estimate.
- For larger rooftop system (>50kWp), more relevant to non-domestic buildings, a range of value of £650-1000/kWp can be used with larger systems using the lower value.[10]

BREEAM

- 1-2% of construction costs (or £30-70/m^2 based on £3,000-3,500/m^2 construction cost) can be used as an indicative cost to achieve a BREEAM Excellent (2014) rating.
- An Excellent rating can reach 3-5% of construction cost for buildings such as healthcare.
- Following a review from Currie and Brown in 2018, it was noted that while BREEAM 2018 required further time input, any capital cost increase would be "relatively small".

[9] UK Government, 2021, End of halogen light bulbs spells brighter and cleaner future. Available online at: https://www.gov.uk/government/news/end-of-halogen-light-bulbs-spells-brighter-and-cleaner-future
[10] Spirit Energy, 2021, Solar for Business: Commercial Solar Panels. Available online at: https://www.spiritenergy.co.uk/commercial-solar-panels

2.2 NON-DOMESTIC BUILDING EXAMPLES

Based on the literature reviewed, an illustrative analysis of two non-domestic buildings, an office and a school, has been completed. The methodology and assumptions made in modelling these two buildings are described below.

2.2.1 METHODOLOGY

Our energy modelling and analyses focused on two building typologies which were selected due to their common occurrence and the available supporting modelling & literature:

- **Office building:** 3-storey, mechanically ventilated and cooled office building, 4,358 m^2
- **School:** 2-storey, naturally ventilated school building, with no cooling provision, 9,318 m^2

Two approaches for the office and school were developed with different fabric efficiencies, systems, system efficiencies and ventilation strategies aiming to explore how close each of these approaches would reach to the RIBA 2025 and RIBA 2030 target.

These approaches focus primarily on reducing the energy demand of a new development, which is usually the most robust and cost-effective way to reduce operational carbon emissions. **Approaches 1 & 2, described below, are being considered by West of England for policy.** Onsite renewable energy was then maximised, followed by carbon offsetting or remaining regulated emissions.

Approach 0 is provided for illustrative purposes in order to show the difference between the renewable heat policy that the LAs are considering (whereby other technologies, e.g. heat pumps, would take preference over gas) and the current practice of gas.

In summary, these approaches are structured as below:

Table A-1 – Policy approaches modelled.

Approach 0 - (for illustration, not policy consideration)	Approach 1	Approach 2
Fabric and system efficiencies as per Part L 2021 (Option 2 – preferred by government)	Fabric and system efficiencies as per Part L 2021 (Option 2 – preferred by government)	Fabric and system efficiencies as per LETI (London Energy Transformation Initiative) Climate Emergency Design Guide
Gas Boiler	Air source heat pump (ASHP)	Air source heat pump (ASHP)
Net Zero regulated emissions	Net Zero regulated emissions	LETI/RIBA route to net zero
BREEAM Excellent	BREEAM Excellent	BREEAM Excellent

In terms of the exact modelling process, this is described below and the values used are in Table 2.2.1-2 and Appendix A.

The modelling presented is likely to be an underestimation of energy performance and therefore the scenarios costed may not achieve net zero. Further modelling can be completed in future in order to review the nuances and known variations between compliance asset models, real asset models and operational performance. However, this is beyond the scope of this report.

Energy Modelling

1. Part L models were used to create the model of consumption for each of the approaches and buildings, with different energy efficiency measures applied;
2. Unregulated energy was then included in addition to this modelling. This created the full demand profile for the buildings;
3. Solar PV onsite generation was modelled for each building and used to reduce onsite energy consumption. This produced the figure for the total remaining energy usage onsite.

Cost Modelling

1. Offsetting of remaining carbon emissions from regulated energy is calculated as a cost, alongside the cost of the solar PV and energy efficiency measures applied;
2. An assumed £/m^2 construction cost is used to calculate these costs as a percentage of the total construction cost;
3. Approach 0 is used as the 'baseline' given that it will become policy as the Future Building Standard and the cost differential for approaches 1&2 above this is calculated as the uplift for these policies above the FBS.

Table 2.2.1-2 – Specification of measures used in each approach

Specification / Approach	A0 - Part L 2021 with Gas Boiler	A1 - Part L 2021 with ASHP	A2 – Best Practice Fabric
Fabric and Systems Efficiency approach followed	Future Buildings Standard consultation for Part L 2021 uplift – Option 2		LETI Climate Emergency Design Guide
External Wall- U value (W/m².K)	0.18		0.15
Roof-U value (W/m².K)	0.15		0.12
Floor-U value (W/m².K)	0.15		0.12
Window U value (W/m².K) Window g-value Window Light Transmittance	1.4 0.29 0.6		1.0 0.29 0.6
Air permeability (m³/h.m² @ 50Pa)	3		1
Ventilation system	Mechanical Ventilation with Heat Recovery (MVHR) – Plate Heat Exchanger 76% eff.		MVHR – Plate Heat Exchanger 90% eff.
Space heating system	Gas boiler; 93% efficiency	Air-source heat pump; Heating SCoP 2.8	Air-source heat pump; Heating SCoP 2.8
Central Air Handling Unit (AHU) Specific Fan Power (SFP) (W/l.s)	1.8		1.2

Unregulated loads	Office: 40.9 kWh/m^2 per year - as per NCM[11] profiles Secondary school: 20 kWh/m^2 per year – as per NCM profiles In addition server rooms have been added at 8kWh/m^2 [12,13]

2.2.2 COSTS USED IN MODELLING

A high-level cost assessment has also been undertaken to understand the cost implications of each approach and how they compare to one another.

For the non-domestic buildings, our cost assessment is aligned with the Future Buildings Standard Consultation Impact Assessment (IA) report (2021)[14] and the 'The costs and benefits of tighter standards for new buildings' report by Currie & Brown and AECOM (2019)[15]. The assumptions followed to estimate the high-level extra cost of each policy approach are summarised in the table below.

Table 2.2.2-1 - Non-Domestic - Assumptions followed for estimating the high-level extra cost for the energy efficiency measures of each approach.

Approach	Assumptions
A0 – Part L 2021 with Gas Boiler	▪ Office - deep plan, air conditioned • £24/m^2 as per FBS ▪ Secondary School • £36/m^2 as per FBS ▪ Solar PV: £800/kWp
A1 – Part L 2021 with ASHP	▪ Office - deep plan, air conditioned • £24/m^2 as per FBS • £9/m^2 for ASHP as per Currie & Brown and AECOM, 2019 ▪ Secondary School • £36/m^2 as per FBS • £9/m^2 for ASHP as per Currie & Brown and AECOM, 2019 ▪ Solar PV: £800/kWp
A2 – Best Practice Fabric	▪ Office - deep plan, air conditioned • £24/m^2 as per FBS • £9/m^2 for ASHP as per Currie & Brown and AECOM, 2019

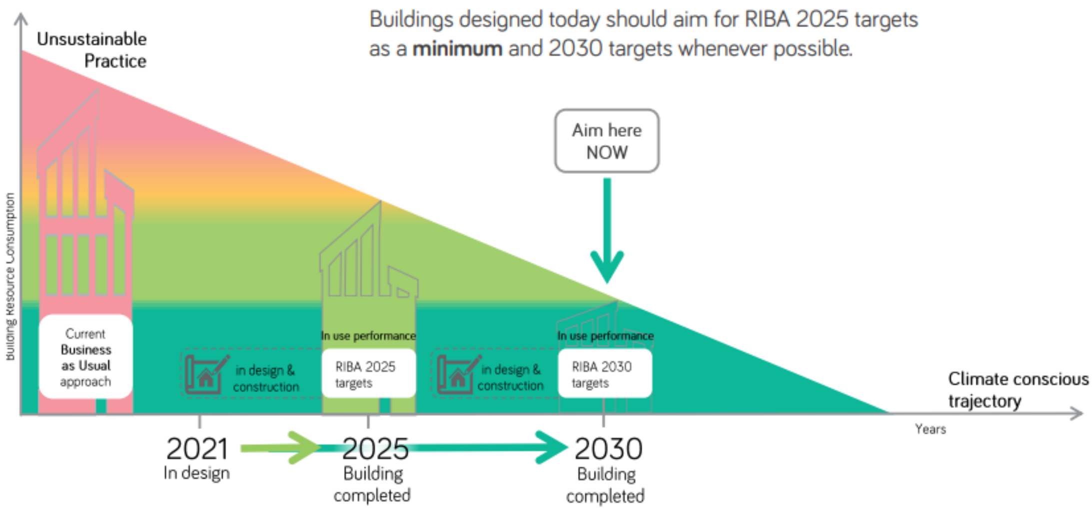
[11] National Calculation Methodology
[12] UKGBC, 2020, Building the Case for Net Zero: A feasibility study into the design, deliver and cost of new net zero carbon buildings. Online available at: https://www.ukgbc.org/wp-content/uploads/2020/09/Building-the-Case-for-Net-Zero_UKGBC.pdf
[13] Sung Min Hong, 2015. Benchmarking the energy performance of the UK non-domestic stock: a schools case study. Online available at: https://discovery.ucl.ac.uk/id/eprint/1464471/1/SHONG_Thesis_Final_31Mar15.pdf
[14] UK Government, 2021. Future Buildings Standard Consultation Impact Assessment (IA). Online Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/953664/201209_Future_Buildings_Standard_consultation_IA.pdf
[15] Currie & Brown and AECOM, 2019. The costs and benefits of tighter standards for new buildings. Online Available at: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/

	• £21/m² for fabric and glazing as per Currie & Brown and AECOM, 2019 ▪ Secondary School • £36/m² as per FBS • £9/m² for ASHP as per Currie & Brown and AECOM, 2019 • £21/m² for fabric and glazing as per Currie & Brown and AECOM, 2019 • £26/m² for MVHR as per Spon's architects' and builders' price book 2019 ▪ Solar PV: £800/kWp

2.2.3 TARGETS

RIBA and the wider construction industry set targets for new build and retrofit projects, in response to the legislation of net zero by 2050 in the UK. The RIBA 2030 Climate Challenge Trajectories establishes that operational energy demand needs to be reduced by at least 75% before offsetting[16]. Reductions for embodied carbon, potable water use and health and wellbeing are also covered. This is in line with other organizations' targets including the RIBA EUI target for an office of 55kWh/m² and is 60kWh/m² for a school, including onsite renewable energy contribution[17].

Figure 2.2.3-1 - RIBA trajectories and targets for 2020, 2025 and 2030



RIBA 2030 Climate Challenge *as built* target trajectories

[16] RIBA, 2021, RIBA 2030 Climate Challenge. Available online at: https://www.architecture.com/-/media/files/climate-action/riba-2030-climate-challenge.pdf
[17] ibid

RIBA 2030 Climate Challenge target metrics for non-domestic (new build offices)

RIBA Sustainable Outcome Metrics	Business as usual (new build, compliance approach)	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	130 kWh/m²/y DEC D (90)	< 75 kWh/m²/y DEC B (50) and/or NABERS Base build 5	< 55 kWh/m²/y DEC B (40) and/or NABERS Base build 6	Targets based on GIA. Figures include regulated & unregulated energy consumption irrespective of source (grid/ renewables). 1. Use a 'Fabric First' approach 2. Minimise energy demand. Use efficient services and low carbon heat 3. Maximise onsite renewables

RIBA 2030 Climate Challenge target metrics for non-domestic (new build schools)

RIBA Sustainable Outcome Metrics	Business as usual (new build, compliance approach)	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	130 kWh/m²/y	< 70 kWh/m²/y	< 60 kWh/m²/y	Targets based on GIA. Figures include regulated & unregulated energy consumption irrespective of source (grid/renewables). Refer to Department for Education Output Specifications for schools: 2025: Primary <55 kWh/m²/y, 2030: Primary <45 kWh/m²/y 1. Use a 'Fabric First' approach 2. Minimise energy demand. Use efficient services and low carbon heat 3. Maximise onsite renewables

2.2.4 ON-SITE RENEWABLE ENERGY

All approaches have been complemented with photovoltaic (PV) panels mounted on the building's roof. For the office and school buildings it has been assumed that they have flat roofs and that 70% of the roof area[18] will be allocated for PV panels. It has also been assumed that the PV panels are orientated facing South, which is the most efficient orientation for energy generation. However, panels which are east or west orientated will still provide significant solar generation output and on flat roofs. Therefore, these roof orientations shouldn't stop the deployment of solar PV.

The energy generation (kWh) per kWp installed in each orientation has been calculated based on SAP methodology for Severn Wales/Severn England, assuming 15° tilt and none/very little overshadowing:

- South: 914.5 kWh/kWp/year

A 15 degree tilt, or less, is standard for non-domestic roof mounted systems, however a larger tilt does allow for greater degree of 'self-cleaning'. For the rooftop PVs located on a pitched roof, it has been assumed that 1 kWp of installed PV panels requires 8m^2, while for the rooftop PVs located on a flat roof, it has been assumed that 1 kWp of installed PV panels requires 10m^2.

Any revenue from the rooftop PVs has not been considered in this assessment, as this is depending on the model used by the developer. A solar PV system adds significant value to the building with <10 year paybacks (depending on system size), providing both Corporate Social Responsibility benefits and energy cost savings

[18] LETI, January 2020, LETI Climate Emergency Design Guide. Online available at: https://www.leti.london/cedg

2.2.5 OFFSITE MEASURES: CARBON OFFSET PAYMENTS

An estimate of the cost to offset the residual operational carbon emissions through a carbon offset payment has also been provided.

The carbon offset price for carbon emissions is assumed to be £95 per tonne of carbon dioxide equivalent, based on the CSE report carried out on behalf of the West of England Unitary Authorities[19] and based on the cost required encourage deployment of rooftop solar PV. It is also the recommended price by the GLA on their Energy Assessment Guidance[20] (April 2020) from their 'London Plan Viability Study' report[21] and is used in the New London Plan. The recommended methodology is that the cumulative shortfall is multiplied by the carbon dioxide offset price (£95/tCO_{2e}), over a period of 30 years to determine the required cash-in-lieu contribution.

To further explain how the price of £95/tCO_{2e} is set, we will refer to a study[22] undertaken by the Centre of Sustainable Energy on how the West England Authorities could implement a carbon offsetting requirement and scheme. The primary risks identified by the study are setting the carbon price too low or high. This price may need to be reviewed frequently over the years, if the carbon intensity of the grid decreases along with the carbon benefit of on-site PVs. This may need to increase to £300-400/tonne with the SAP 10 carbon emission factor[14]. Additional work is underway to refresh WOE's carbon offsetting approach.

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[19] Centre for Sustainable Energy, 2018, Cost of carbon reduction in new buildings. Online available at: https://www.cse.org.uk/downloads/file/cost-of-carbon-reduction-in-new-buildings.pdf
[20] Greater London Authority, 2020. Energy Assessment Guidance-Draft. Online Available at: https://www.london.gov.uk/sites/default/files/gla_energy_assessment_guidance_april_2020.pdf
[21] Greater London Authority, 2017. London Plan Viability Study-Technical Report. Online Available at: https://www.london.gov.uk/sites/default/files/london_plan_viability_study_technical_report_dec_2017.pdf
[22] Centre for Sustainable Energy, 2018. Carbon offsetting in the West of England Authorities. Online Available at:https://www.bristol.gov.uk/documents/20182/3368102/Carbon+Offsetting+in+the+West+of+England.pdf/894f7c11-33e4-a8b4-ec89-383828553184

2.3 CARBON REDUCTIONS FOR EXAMPLE ASSETS

RESULTS AND FINDINGS FROM ON-SITE MEASURES ONLY

2.3.1 NON-DOMESTIC – OFFICE

- For the example office which has been modelled in this report, ***Figure 2.3.1-2*** below shows the total energy consumption (including regulated and unregulated) after onsite measures are applied, except for rooftop PV.
- ***Figure 2.3.1-3*** below shows the energy consumption (including regulated and unregulated) after all on-site measures are applied, including PV.
- Replacing a gas boiler with an air source heat pump results in a 16% reduction in operational energy excluding any reduction from improvements in fabric efficiency (Approach 1).
- In Approach 2, improving the fabric specification to align with current best practices can result in a total reduction of up to 22% from Approach 0 and a final energy consumption of 56.9kWh/m^2/year
- Due to the performance gap, these figures cannot be directly compared to the RIBA 2030 target. For reference, the RIBA 2030 target for new build offices is 55 kWh/m^2/year.
- There are high amounts of unregulated energy loads (40.9 kWh/m^2/year plus 8 kWh/m^2/year for servers) included in the model which is why the profile is dissimilar to domestic buildings.

*Figure 2.3.1-2 - Office – Total energy consumption and carbon emissions after all on-site measures, **excluding rooftop PV generation,** are applied, presented per policy approach.*

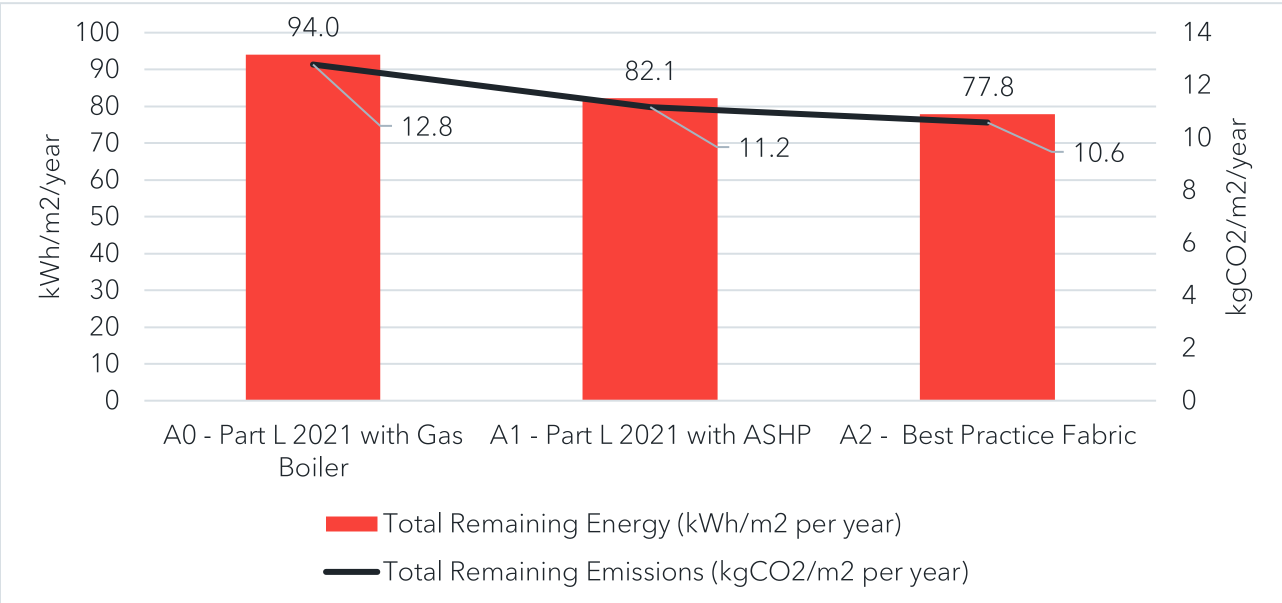
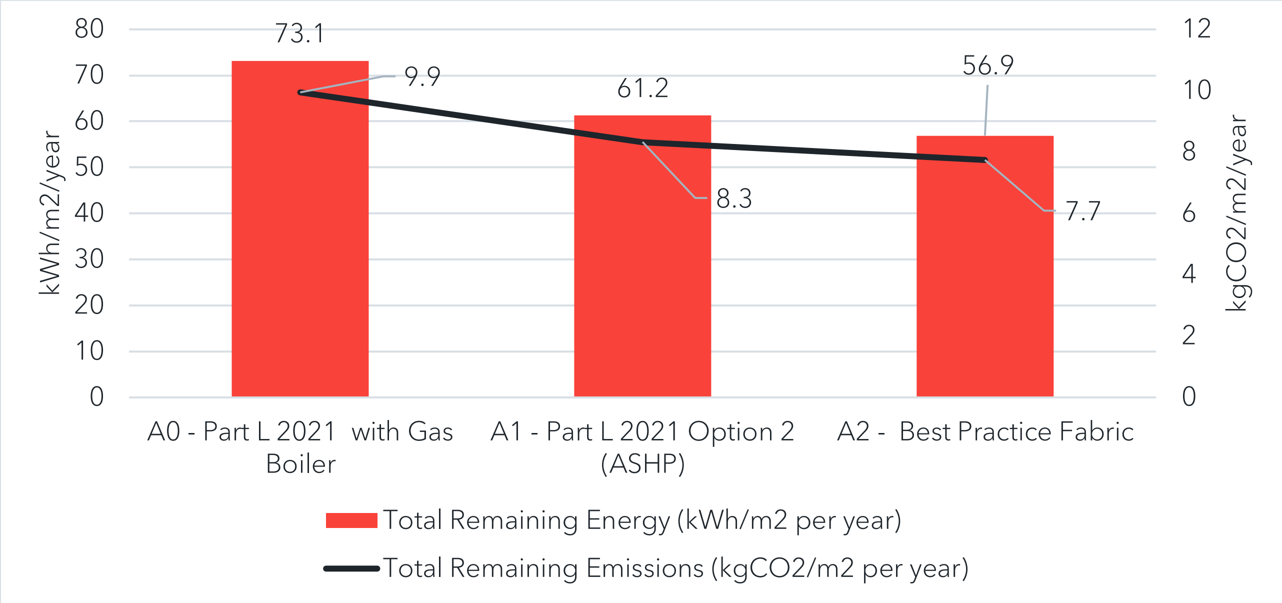


*Figure 2.3.1-3 - Office – Total energy consumption and carbon emissions after all on-site measures, **including rooftop PV generation**, are applied, presented per policy approach.*



For every approach, the percentage of the development's energy consumption that is met using on-site renewables was calculated, which is 26% for Approach 0, 30% for Approach 1 and 32% for Approach 2.

Using the SAP 10.1 emission factor of 0.136 $kgCO_2$/kWh results in a total of carbon to be offset, which can be found in the graphs above. This factor aligns with current grid carbon intensity in 2021 but it will continue to reduce over time as the UK electricity grid continues to decarbonise, i.e. fossil fuels use for energy production reduces further.

2.3.2 NON-DOMESTIC – SCHOOL

- For the example school which has been modelled in this report, ***Figure 2.3.2-4*** below shows the total energy consumption (including regulated and unregulated) after onsite measures are applied, except for rooftop PV.
- ***Figure 2.3.2-5*** below shows the energy consumption (including regulated and unregulated) after all on-site measures are applied, including PV.
- In Approach 2, improving the fabric specification to align with current best practices can result in a total reduction of up to 59% from Approach 0 and a final energy consumption of 23.4kWh/m^2/year.
- Due to the performance gap, these figures cannot be directly compared to the RIBA 2030 target. For reference, the RIBA 2030 target for new build schools is 60 kWh/m^2/year.
- Similar to the office analysis, the high amount of unregulated energy loads (20 kWh/m^2/year plus 8 kWh/m^2/year for servers) explains why the equivalent reductions per policy approach aren't as steep as they are for domestic buildings.

*Figure 2.3.2-4 - School – Total energy consumption and carbon emissions after all on-site measures, **excluding rooftop PV generation**, are applied, presented per policy approach*

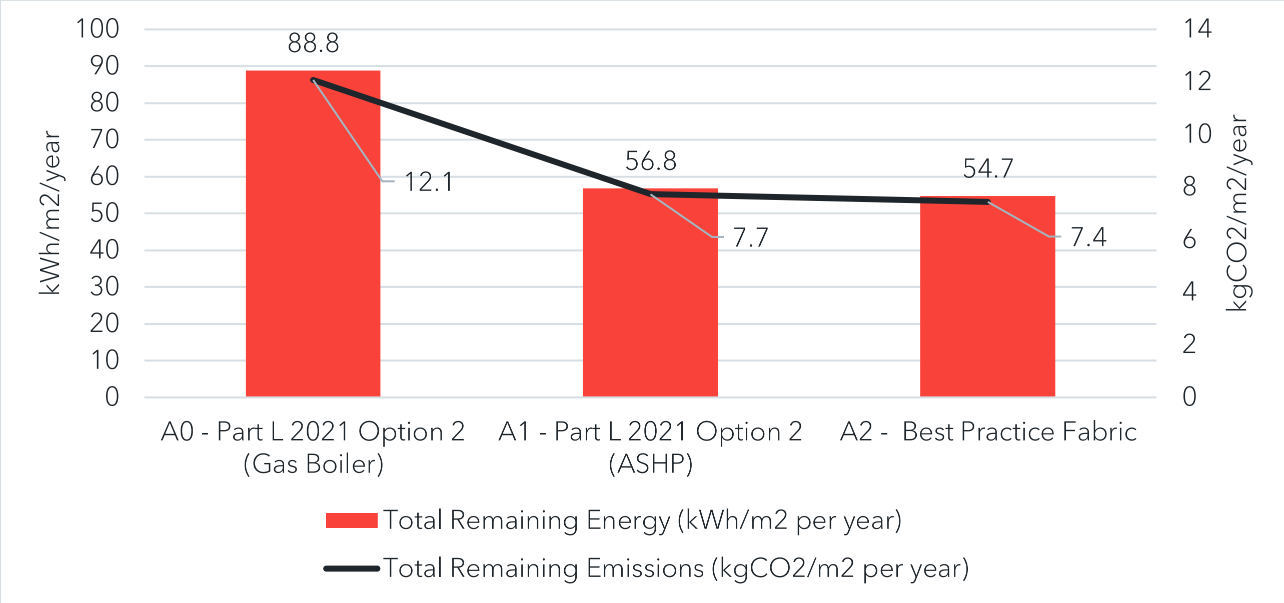
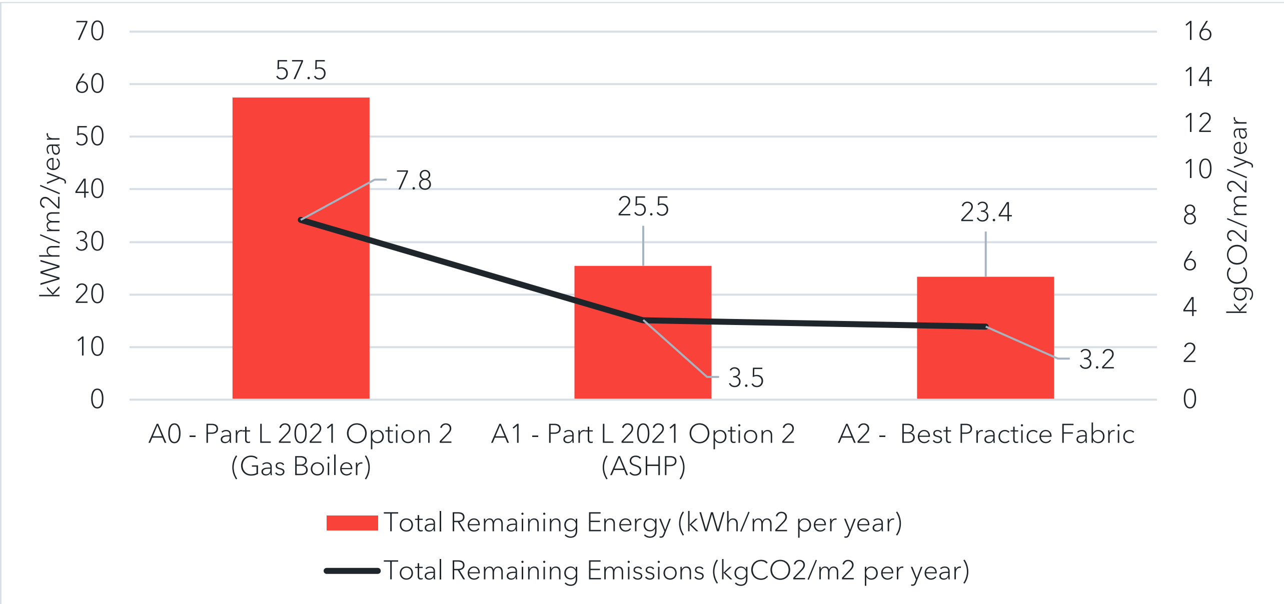


*Figure 2.3.2-5 - School – Total energy consumption and carbon emissions after all on-site measures, **including rooftop PV generation,** are applied, presented per policy approach*



For each approach, we calculated the percentage of the development's energy consumption that is met using on-site renewables, which is 30% for Approach 0, 41% for Approach 1 and 43% for Approach 2.

Using the SAP 10.1 emission factor of 0.136 $kgCO_2/kWh$ results in a total of carbon to be offset, which can be found in the graphs above.

2.3.3 BREEAM CREDITS

The BREEAM energy credits for Approach 2 for each of these example buildings has been calculated using the standard reporting tool[23]. This shows what achieving Approach 2 would achieve in terms of BREEAM credits, it delivers an Excellent level and 5 credits for both building typologies.

The below table summarises the figures used for modelling, credits achieved and minimum standard level.

Table 2.3.3-1 - BREEAM credit calculation

Value	Office	Secondary School
Heating and cooling energy demand (Actual / Notional) (MJ/m^2/yr)	102.00 / 116.41	11.64 / 30.23
Building primary energy consumption (Actual / Notional) (kWh/m^2/yr)	86.51 / 130.78	79.95 / 94.43
Total BREEAM credits achieved	**5**	**5**
Total contribution to overall building score	2.96%	2.96%
Minimum standard levels	**Excellent**	**Excellent**

2.3.4 COST SUMMARY

In order to meet the policy approaches discussed, the costs discussed in Table 2.2.2-1 have been applied. Those figures have been multiplied by the building's footprint in m^2 to give the total cost included in the graphs. The graphs below show the cost breakdown to ensure that the buildings modelled achieve net zero.

Given that the office modelled here has a smaller gross internal area and is already air conditioned, it requires less cost to meet the aims of each approach (i.e the extra-over cost of each approach is lower). The cost of installing MVHR in the school is a significant cost (£16.5/m^2) in meeting Approach 2 in addition to the fabric and glazing cost (£21/m^2) which applies to both the office and school.

It is likely that the Future Building Standard 2021 Option 2 will be taken forward, which is Approach 0 modelled here. Therefore, it is the uplift from the cost of Approach 0 which is an important metric when considering the cost implication of how Approach 1 and 2 compare since Part L 2021 will become the baseline cost of development. For clarity these are presented below along the graphs of total cost for all approaches.

In the Currie and Brown report from 2018 to meet net zero regulated carbon emissions, there was a 5-7% uplift in construction cost referenced that figure was from a 'baseline' of Part L 2013 with gas heating[24]. The cost ranges from the modelling completed in this report are summarised below.

- Cost to reach net zero regulated emissions from baseline of Part L 2013 with gas heating:

[23] Version of tool used: "BREEAM_UK_NC_2018_Assessment_Scoring_and_Reporting_Tool_v3.4"
[24] Centre for Sustainable Energy, 2018, Cost of carbon reduction in new buildings. Online available at: https://www.cse.org.uk/downloads/file/cost-of-carbon-reduction-in-new-buildings.pdf

- Approach 1: 1.6-2.4%
  - Approach 2: 2.2-4%
- Cost to reach net zero regulated emissions from baseline of Part L standards for non-domestic buildings 2021 as part of the road to the Future Buildings Standard 2025:
  - Approach 1: 0.9-1.2%
  - Approach 2: 1.5-2.8%

All ranges do not include BREEAM costs.

The difference between the cost ranges in this report and the C&B 2018 report can be explained by a range of competing factors:

- Performance gap resulting from modelling
  - In comparing these reports, it would suggest that these modelled scenarios are off reaching zero carbon by the following amounts from the baseline of Part L 2013 by the following construction cost percentage:
    - Approach 1: 2.6-5.4%
    - Approach 2: 1-4.8%
- The modelling considered here is for an office and school only, rather than a full range of non-domestic buildings. As a result, this study should be viewed in context, with further consideration required to be given to a wider set of building typologies in order for conclusions on cost uplifts to be drawn for a wider set of non-domestic buildings.
- Continued reduction in solar PV costs.
- Continued reduction in carbon emissions factor used to calculate cost of offsetting.

The graphs below show the percentage cost uplift above Part L 2021 Option 2.

- The amount of available roof space will impact the size of PV system which can be installed. For the school, because of the assumptions made on available roof area (of 70% of total roof area) a large PV system can be installed (c.300kWp) and no offsetting is required.
- Offsetting has only been calculated for remaining regulated energy.

2.3.4.1 Office – Total Cost and Percentage Uplift above Part L 2013

Figure 2.3.4.1-1 – Office – Cost required to meet each approach above Part L 2013 (energy efficiency, onsite PV and offset payment for regulated energy)

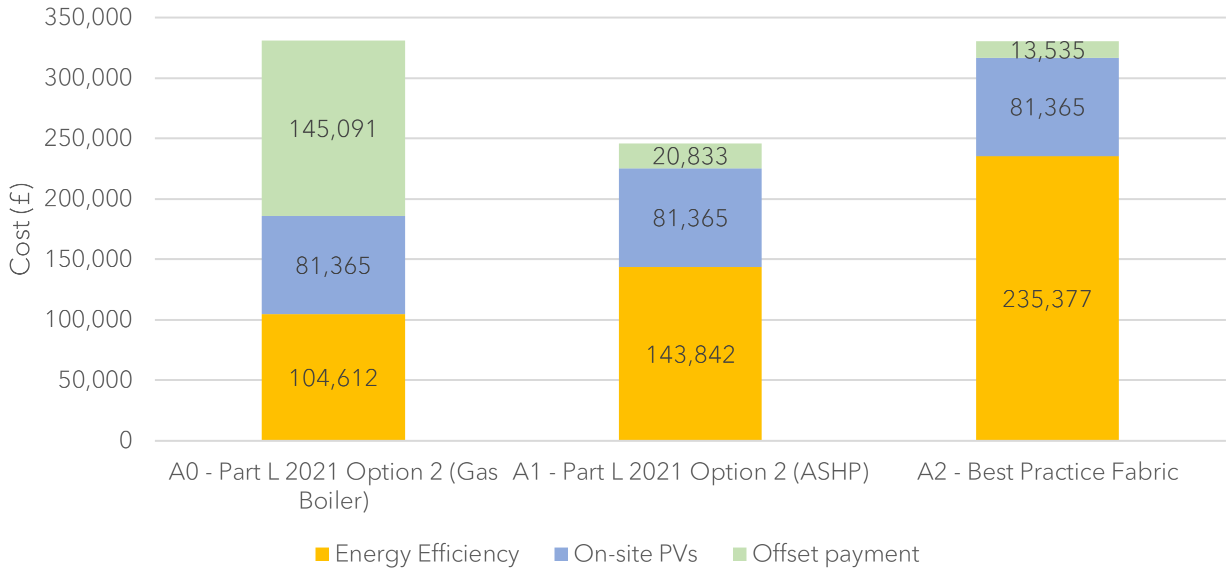
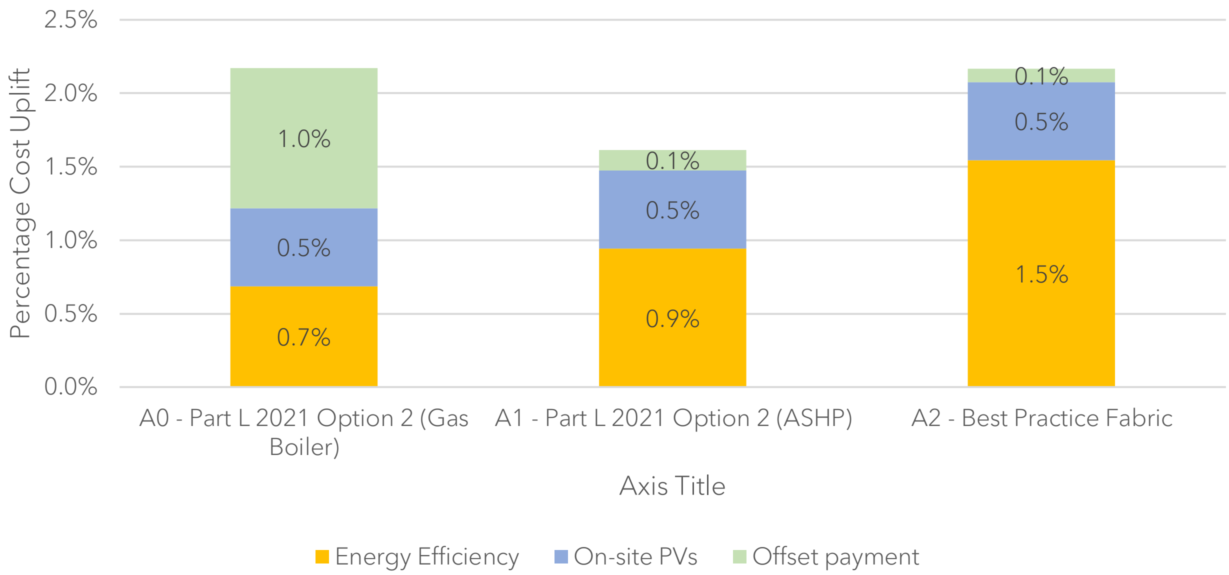


Figure 2.3.4.1-2 – Office – Percentage cost uplift required to meet each approach above Part L 2013 (energy efficiency, onsite PV and offset payment for regulated energy). Assuming base build cost of £3,500/m² from FBS.



2.3.4.2 Office – Total Cost and Percentage Uplift above Part L 2021

Figure 2.3.4.2-1 – Office – Cost required to meet each approach above Part L 2021 (energy efficiency, onsite PV and offset payment for regulated energy)

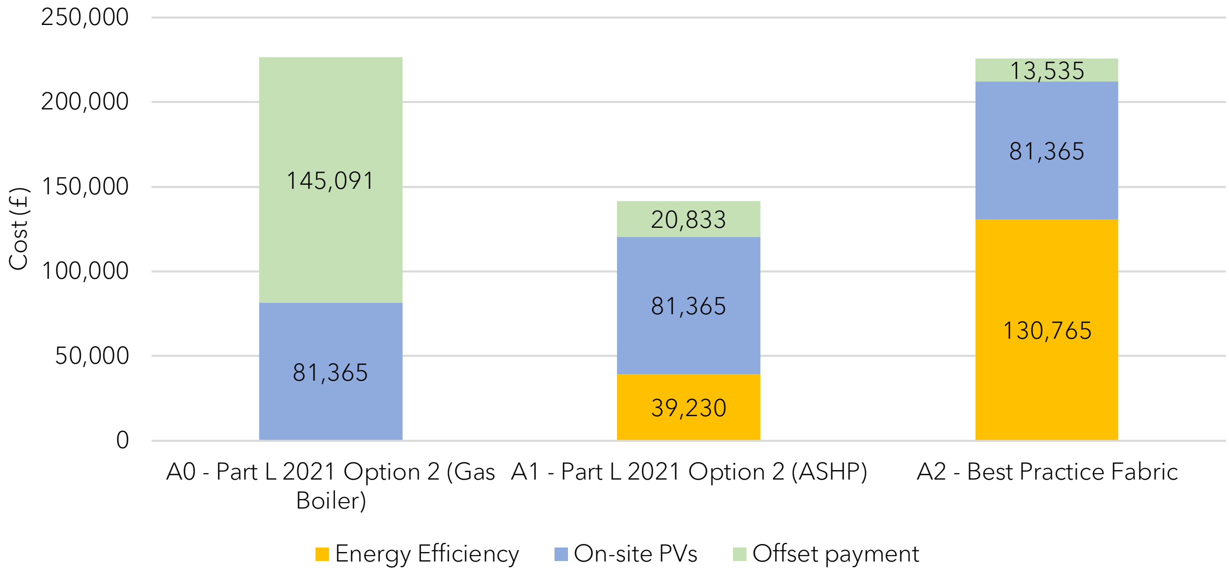
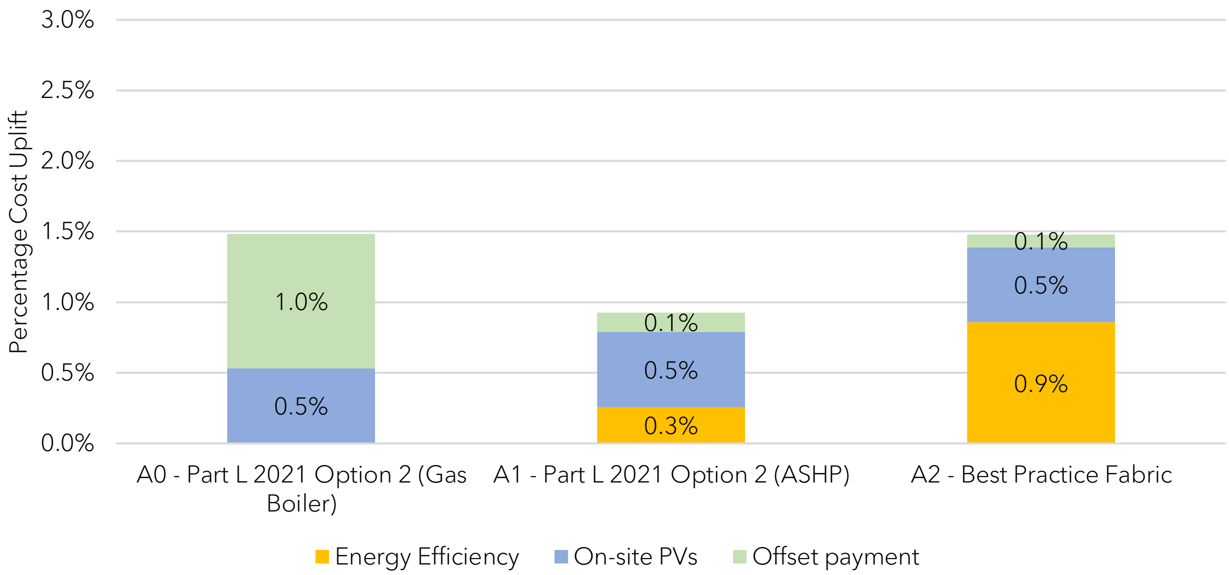


Figure 2.3.4.2-2 – Office – Percentage cost uplift to meet each approach above Part L 2021 (energy efficiency, onsite PV and offset payment for regulated energy). Assuming base build cost of £3,500/m² from FBS.



2.3.4.3 School – Total Cost and Percentage Uplift above Part L 2013

Figure 2.3.4.3-1 - School – Cost required to meet each approach above Part L 2013 (energy efficiency, onsite PV and offset payment for regulated energy)

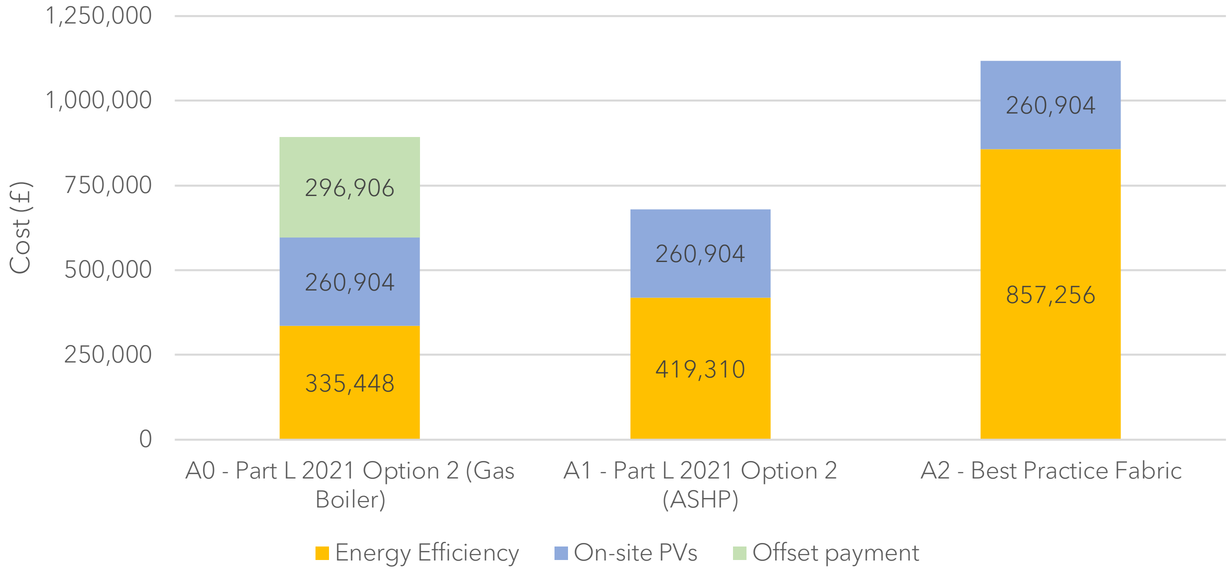
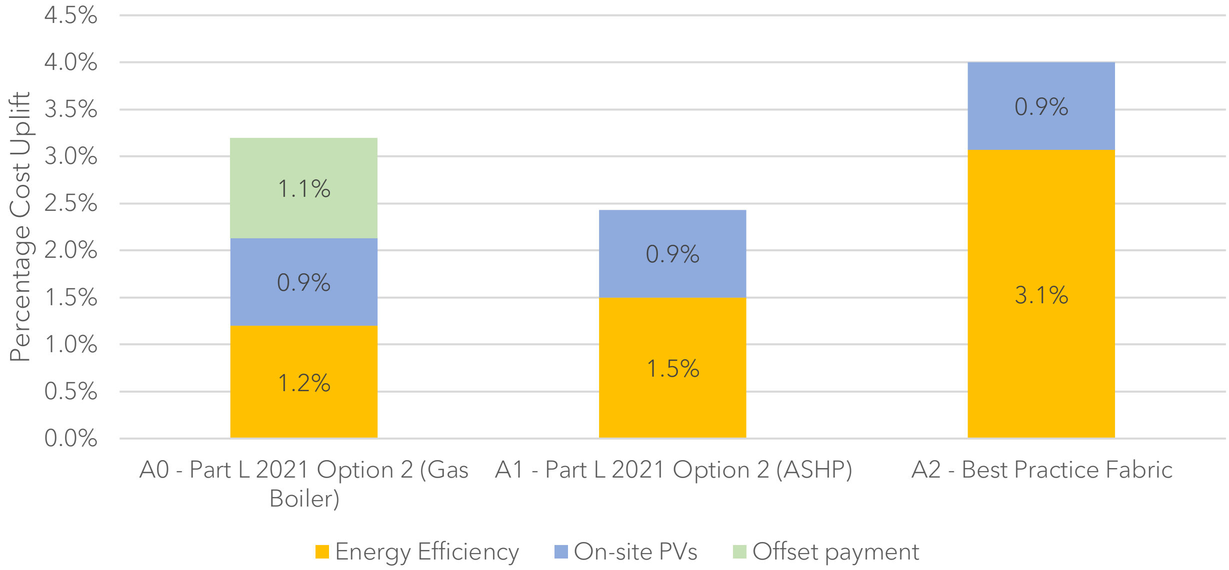


Figure 2.3.4.3-2 - School – Percentage cost uplift required to meet each approach above Part L 2013 (energy efficiency, onsite PV and offset payment for regulated energy). Assuming base build cost of £3,000/m^2 from FBS.



2.3.4.4 School – Total Cost and Percentage Uplift above Part L 2021

Figure 2.3.4.4-1 – School – Cost uplift to meet each approach above Part L 2021 (energy efficiency, onsite PV and offset payment for regulated energy).

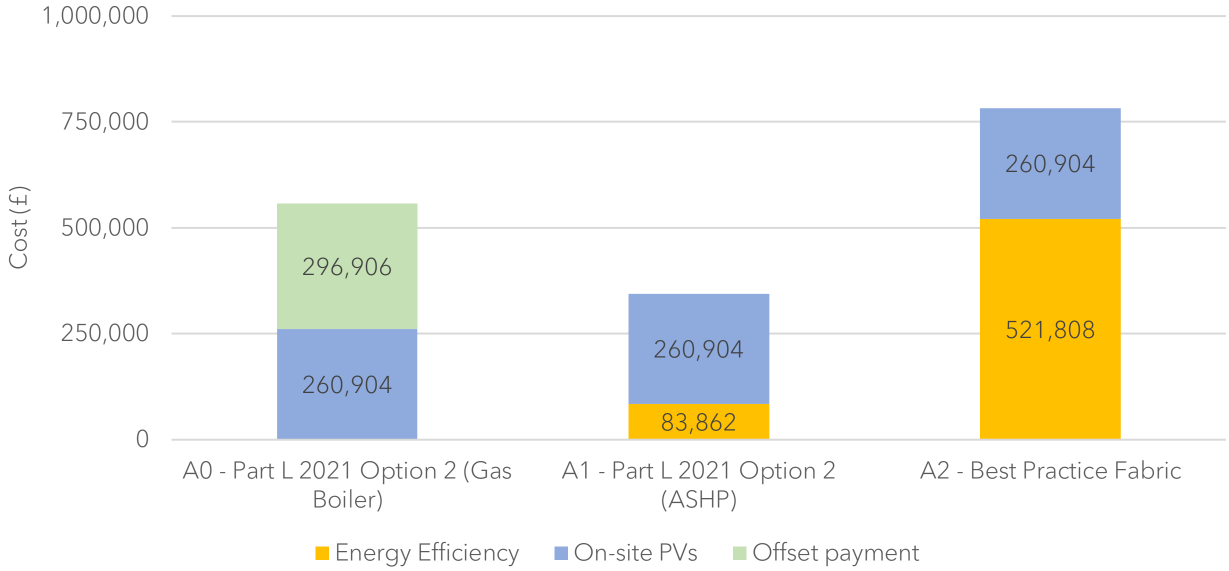
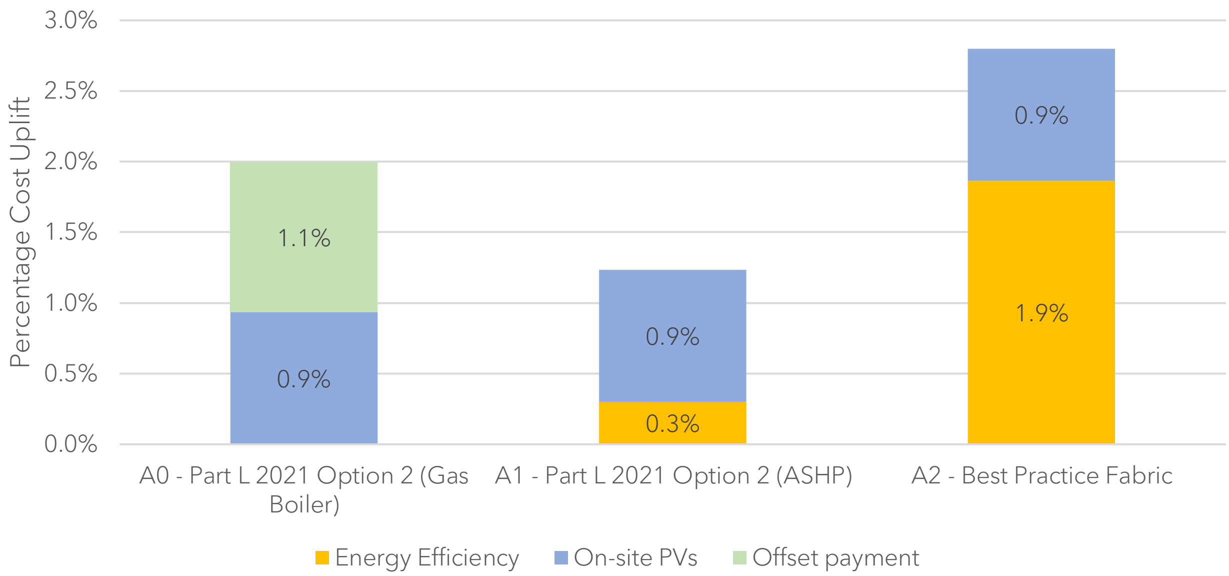


Figure 2.3.4.4-2 – School – Percentage cost uplift to meet each approach above Part L 2021 (energy efficiency, onsite PV and offset payment for regulated energy). Assuming base build cost of £3,000/m² from FBS.



Appendix A

MODELLING DETAILS

APPENDIX A: MODELLING DETAILS FOR NON-DOMESTIC

		A0 - Part L 2021 with Gas Boiler		A1 - Part L 2021 with ASHP		A2 -Best Practice Fabric	
		Office	**School**	**Office**	**School**	**Office**	**School**
Dimensions	Total Floor Area (m^2)	4,358.8	9,318	4,358.8	9,318	4,358.8	9,318
U-value (W/m^2K)	Ground Floor	0.15				0.12	
	Exposed Wall	0.18				0.15	
	Flat Roof	0.15				0.12	
Windows	U-value (W/m^2K)	1.4				1	
	g-value	0.29				0.29	
	Light transmittance	0.6				0.6	
	U-value (W/m^2K) - Rooflight	1.8 (horizontal), 1.5 (vertical)				1.5	
	g-value - Rooflight	0.29				0.29	
	Light transmittance - Rooflight	0.6				0.6	
	frame factor	0.9				0.9	
	Type	double-glazed, argon filled, low-e, en=0.05, soft coat				triple-glazed argon filled	
	Door U-value (W/m2K)	1.2				1.2	
	Design air permeability rate (m^3/hm^2 @50Pa)	3				1	
Ventilation	Ventilation Type	MVHR	Natural Ventilation	MVHR	Natural Ventilation	MVHR	
	Heat Recovery	Plate Heat Exchanger	-	Plate Heat Exchanger	-	Plate Heat Exchanger	
	Heat Recovery Efficiency	76%	-	76%	-	90%	
	DCV Type	Demand control based on gas sensors - Speed control (when can be applied)		Demand control based on gas sensors - Speed control (when can be applied)		Demand control based on gas sensors - Speed control (when can be applied)	
Hot Water	Hot Water Generator Type	Instantaneous hot water only		Instantaneous hot water only		Instantaneous hot water only	
	DHW delivery efficiency	0.95		0.95		0.95	
Heating	Heating Group	Gas boilers		Electric heat pumps		Electric heat pumps	
	Heating emitter	Fan Coil	Radiators	Fan Coil	Radiators	Chilled Beams	Radiators
	Heating Controls	All system controls		All system controls		All system controls	
	Heat pump / Boiler - Space heating efficiency	0.93		SCoP=2.8		SCoP=2.8	

	Electric power factor	>0.95		>0.95		>0.95	
Cooling	Cooling system - type	Water cooled, 101-500kW	No Cooling	Water cooled, 101-500kW	No Cooling	Water cooled, 101-500kW	No Cooling
	Cooling system - seasonal efficiency	SSEER 4.4	-	SSEER 4.4	-	SSEER 5.5 - NEER 4.5	-
	Cooling system - nominal efficiency	default	-	default	-	default	-
	System adjustment	C, L2	-	C, L2	-	C, L2	-
	Pump type	Variable speed control of fans and pumps controlled via multiple sensors	-	Variable speed control of fans and pumps controlled via multiple sensors	-	Variable speed control of fans and pumps controlled via multiple sensors	-
	SFP	1.8	-	1.8	-	**1.2**	-
	SFP-Extract only systems	0.5					
Lighting *(Internal gains tab + Display Lighting and Controls tab)*	Gain 1 - Input Mode	Inference					
	Gain 1 - Lamp Type	Unset					
	Gain 1 Lamp Efficacy	95					
	Gain 1 - Light Output Ratio	1					
	Parasitic power of automatic lighting controls	0.1 W/m^2					
	Display lighting uses efficient lamps / Efficacy	Yes / 95					
	Display lighting Time switching	Yes					
	Local Manual switching	Yes (except common areas)					
	Constant Illuminance Control	No					
	Photoelectric options	Yes					
	Different sensor to control back half	No					
	Photoelectric control type	Dimming					
	Photoelectric sensor type	Standalone					
	Photoelectric time switch	No					
	Automatic Daylight zoning for lighting controls	No					
	Manual daylight zoning	1					
	Occupancy Sensing	Auto ON Auto OFF – every room in buildings					
	Occupancy Parasitic power (W/m^2)	0.1					
	Occupancy Sensing Time-switch	Yes					

Appendix B

TABULATED GRAPH DATA

APPENDIX B: TABULATED GRAPH DATA

TABULATED DATA FROM 2.3.1 - NON-DOMESTIC – OFFICE

Table B-1 – Data for Figure 2.3.1-2

Office	A0 - Part L 2021 with Gas Boiler	A1 - Part L 2021 with ASHP	A2 - Best Practice Fabric
Regulated Energy (kWh/m2 per year)	45.1	33.2	28.9
Unregulated Energy (kWh/m2 per year)	48.9	48.9	48.9
Total Remaining Energy (kWh/m2 per year)	94.0	82.1	77.8
Total Remaining Emissions (kgCO2/m2 per year)	12.8	11.2	10.6

Table B-2 – Data for Figure 2.3.1-3

Office	A0 - Part L 2021 with Gas Boiler	A1 - Part L 2021 Option 2 (ASHP)	A2 - Best Practice Fabric
Regulated Energy (kWh/m2 per year)	45.1	33.2	28.9
Unregulated Energy (kWh/m2 per year)	48.9	48.9	48.9
Generation - Rooftop PVs (kWh/m2 per year)	-20.9	-20.9	-20.9
Total Remaining Energy (kWh/m2 per year)	73.1	61.2	56.9
Total Remaining Emissions (kgCO2/m2 per year)	9.9	8.3	7.7

TABULATED DATA FROM 2.3.2 - NON-DOMESTIC – SCHOOL

Table B-3 – Data for Figure 2.3.2-4

Secondary School	A0 - Part L 2021 Option 2 (Gas Boiler)	A1 - Part L 2021 Option 2 (ASHP)	A2 - Best Practice Fabric
Regulated Energy (kWh/m2 per year)	60.8	28.8	26.7
Unregulated Energy (kWh/m2 per year)	28.0	28.0	28.0
Total Remaining Energy (kWh/m2 per year)	88.8	56.8	54.7
Total Remaining Emissions (kgCO2/m2 per year)	12.1	7.7	7.4

Table B-4 – Data for Figure 2.3.2-5

Secondary School	A0 - Part L 2021 Option 2 (Gas Boiler)	A1 - Part L 2021 Option 2 (ASHP)	A2 - Best Practice Fabric
Regulated Energy (kWh/m2 per year)	60.8	28.8	26.7
Unregulated Energy (kWh/m2 per year)	28.0	28.0	28.0
Generation - Rooftop PVs (kWh/m2 per year)	-31.3	-31.3	-31.3
Total Remaining Energy (kWh/m2 per year)	57.5	25.5	23.4
Total Remaining Emissions (kgCO2/m2 per year)	7.8	3.5	3.2

TABULATED DATA FOR 2.3.4.1 - OFFICE – TOTAL COST AND PERCENTAGE UPLIFT ABOVE PART L 2013

Table B-5 – Data for Figure 2.3.4.1-1 and Figure 2.3.4.1-2

	Energy Efficiency	On-site PVs	Offset payment	Total
Office - Cost (£)				
A0 - Part L 2021 Option 2 (Gas Boiler)	104,612	81,365	145,091	331,068
A1 - Part L 2021 Option 2 (ASHP)	143,842	81,365	20,833	246,040
A2 - Best Practice Fabric	235,377	81,365	13,535	330,277
Office – Percentage cost based on £3,500/sqm				
A0 - Part L 2021 Option 2 (Gas Boiler)	0.7%	0.5%	1.0%	2.20%
A1 - Part L 2021 Option 2 (ASHP)	0.9%	0.5%	0.1%	1.50%
A2 - Best Practice Fabric	1.5%	0.5%	0.1%	2.10%

TABULATED DATA FOR 2.3.4.2 - OFFICE – TOTAL COST AND PERCENTAGE UPLIFT ABOVE PART L 2021

Table B-6 – Data for Figure 2.3.4.3-1 and Figure 2.3.4.3-2

	Energy Efficiency	On-site PVs	Offset payment	Total
Office - Cost (£)				
A0 - Part L 2021 Option 2 (Gas Boiler)	0	81,365	145,091	226,456
A1 - Part L 2021 Option 2 (ASHP)	39,230	81,365	21,137	141,732
A2 - Best Practice Fabric	130,765	81,365	13,732	225,862
Office – Percentage cost based on £3,500/sqm				
A0 - Part L 2021 Option 2 (Gas Boiler)	0.0%	0.5%	1.0%	1.50%
A1 - Part L 2021 Option 2 (ASHP)	0.3%	0.5%	0.1%	0.90%
A2 - Best Practice Fabric	0.9%	0.5%	0.1%	1.50%

TABULATED DATA FOR 2.3.4.3 - SCHOOL – TOTAL COST AND PERCENTAGE UPLIFT ABOVE PART L 2013

Table B-7 – Data for Figure 2.3.4.1-1 and Figure 2.3.4.1-2

	Energy Efficiency	On-site PVs	Offset payment	Total
School - Cost (£)				
A0 - Part L 2021 Option 2 (Gas Boiler)	335,448	260,904	296,906	893,258
A1 - Part L 2021 Option 2 (ASHP)	419,310	260,904	0	680,214
A2 - Best Practice Fabric	857,256	260,904	0	1,118,160
School – Percentage cost based on £3,000/sqm				
A0 - Part L 2021 Option 2 (Gas Boiler)	1.2%	0.9%	1.1%	3.20%
A1 - Part L 2021 Option 2 (ASHP)	1.5%	0.9%	0.0%	2.40%
A2 - Best Practice Fabric	3.1%	0.9%	0.0%	4.00%

TABULATED DATA FOR 2.3.4.4 - SCHOOL – TOTAL COST AND PERCENTAGE UPLIFT ABOVE PART L 2021

Table B-8 – Data for Figure 2.3.4.4-1 and Figure 2.3.4.4-2

	Energy Efficiency	On-site PVs	Offset payment	Total
School - Cost (£)				
A0 - Part L 2021 Option 2 (Gas Boiler)	0	260,904	296,906	557,810
A1 - Part L 2021 Option 2 (ASHP)	83,862	260,904	0	344,766
A2 - Best Practice Fabric	521,808	260,904	0	782,712
School – Percentage cost based on £3,000/sqm				
A0 - Part L 2021 Option 2 (Gas Boiler)	0.0%	0.9%	1.1%	2.00%
A1 - Part L 2021 Option 2 (ASHP)	0.3%	0.9%	0.0%	1.20%
A2 - Best Practice Fabric	1.9%	0.9%	0.0%	2.80%

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