Assessment of the Viability of Carbon Emission Targets for New Builds – Main Report

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Contents

1. INTRODUCTION TO THE PROJECT

Since 2011, Guildford Borough Council (GBC) has had a requirement in place to reduce carbon dioxide emissions by 10% through the use of Low and Zero Carbon (LZC) technologies. This is set out in Action 4 of its Sustainable Design and Construction Supplementary Planning Document (SPD).

GBC would like to determine what the additional cost would be for a developer if this target was strengthened to 15 and 20% against a 10% baseline cost. To do this GBC commissioned EVORA EDGE (EDGE) to provide a report detailing the typical costs of implementing LZC technologies that would meet these standards. In doing so it aims to support the policies contained in the new Local Plan and in the existing SPD.

The purpose of EDGE's remit is therefore to answer two questions:

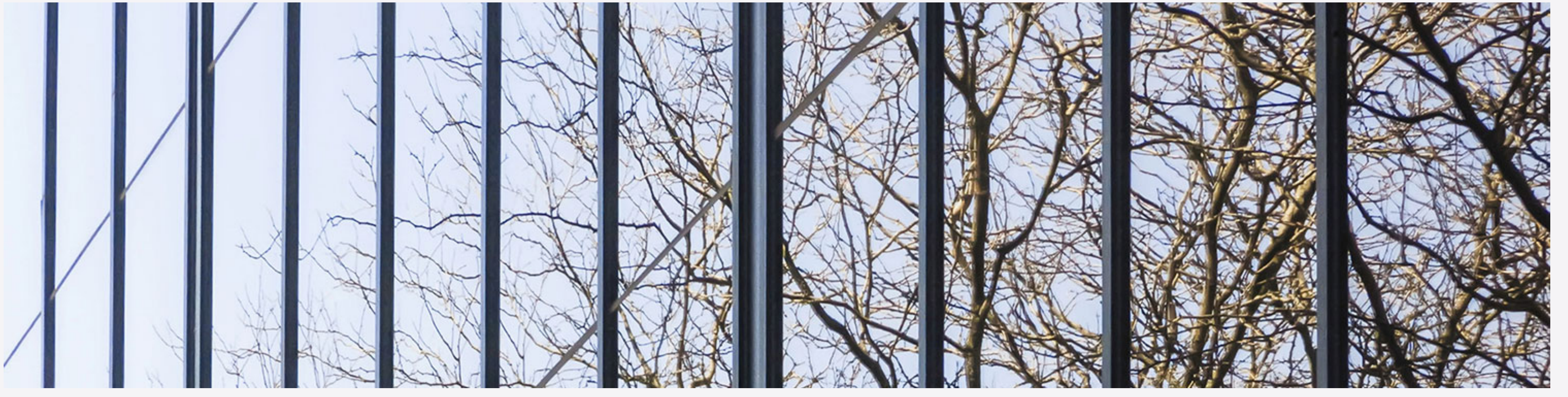
1. Is it technically feasible to construct buildings that go beyond the requirements of a Target Emission Rate (TER) by between 15 and 20%?
2. What are the indicative cost implications of this type of enhanced policy for developers?

This report provides answers to these questions, and to present a complete picture, EDGE also considers the cost implications to developers of the extant policy (to achieve a 10% reduction against the TER). To answer these questions we created four benchmarks against which we assessed multiple building simulations. Building costs were taken from SPONS Architects & Builders Price Book and SPONS Mechanical & Electrical Price Book – 2017 editions.

The four benchmarks are:

- ✓ The Building Emission Rate is equal to or lower than the Target Emission Rate (BER≤ TER). This is a requirement of Criterion 1 of Approved Documents Part L1A and Part L2A of Building Regulations 2010 (Part L)

- ✓ The BER must be 10% lower than the TER. This is the ‘Extant Policy’
- ✓ The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as ‘Proposed Policy A’
- ✓ The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as ‘Proposed Policy B’.



2. EXECUTIVE SUMMARY

Set out below is a summary of the answers to the two questions raised in Section 1. *Introduction to The Project*. Additional information and greater detail on our findings are provided in Section 9 *Project findings.*

Question 1: Is it technically feasible to construct buildings that go beyond the requirements of a Target Emission Rate (TER) by between 15 and 20%?

It is possible in the majority of cases to construct a building that is capable of passing Proposed Policy A and Proposed Policy B by augmenting or replacing non-LZC technologies with LZC technologies. All system types modelled, including systems with complex secondary circulation, can pass Proposed Policy A and all can pass Proposed Policy B – albeit with one caveat: one system type, a four pipe fan coil unit (FCU) with full mechanical ventilation, resulted in a possible fail against Proposed Policy B depending on how the results were analysed[1]. This is because not all of the 20% reduction was a result of LZC technologies. In terms of new builds, FCU systems are suitable for very large buildings where the viscosity of refrigerants introduces technical challenges in terms of pipe lengths.

Question 2: What are the indicative cost implications of this type of enhanced policy for developers?

Our findings show that the additional cost of construction as a proportion of total construction costs is, in many cases, affected more by the requirements of Part L and by existing policy than by the two proposed policies. This is because to pass Part L, and to reach the Extant Policy, it is necessary to construct

[1] The simulation of a four pipe FCU was undertaken on a large office building, but the results are transferable to other types of uses (retail, industrial etc.)

a highly-efficient building envelope (i.e. the structure) with low U-values and thermal bridging etc., and to comply with the Extant Policy there is already a requirement for LZC technologies. In addition to this we note the following:

- The average increase in construction costs, to improve a Part L compliant building so that it complies with Proposed Policy B, the most stringent of the proposed policies, is between 2.62 and 3.14%.
- The average increase in construction costs, to take a building that is compliant with the Extant Policy to a building that complies with Proposed Policy A (which requires the BER to be 15% lower than the TER) is between 0.83 and 0.99%.
- The average increase in construction costs, to take a building that is compliant with the Extant Policy to a building that complies with Proposed Policy B (which requires the BER to be 20% lower than the TER) is between 1.51 and 1.81%.

Within these averages there are more specific findings of note:

- The more complex the building services, and by association the building, the greater the installation costs for building services as a percentage of total construction costs. This includes LZC technologies.
- Naturally ventilated buildings, which do not have large centralised domestic hot water systems using secondary circulation, can more easily pass all benchmarks, and the costs associated with this are lower as a percentage of constructions costs. This would typically include dwellings such as houses and flats.
    - For this type of development, on average, it will cost an additional 0.41 to 0.49% to reduce CO_2 emissions beyond that already required by the existing policy (for the BER to be more than 10% lower than the TER) to construct a dwelling that complies with either of the proposed policies.
    - For this type of development, on average, it will cost an additional 0.97% to 1.16% to reduce CO_2 emissions beyond that required by Part L to construct a dwelling that complies with either of the proposed policies.

- On the other hand, other types of residential development, such as a nursing home/home for the elderly, which may need large centralised pumped domestic hot water systems, requires up to 2.09% additional spend (above and beyond the Extant Policy) to reduce CO_2 emissions to a point that would comply with Proposed Policy A, and 2.53% to construct to a point that would comply with Proposed Policy B. Improving this type of development from the level required to pass Part L to a point that complies with Proposed Policy A would cost up to 3.62%, and up to 4.22% to comply with Proposed Policy B.
- Non-domestic property will typically require the following additional costs:
    - Part L to Proposed Policy A – this will increase costs by up to 2.65%
    - Part L to Proposed Policy B – this will increase costs by up to 3.80%
    - Extant Policy to Proposed Policy A – this will increase costs by up to 1.16%
    - Extant Policy to Proposed Policy B – this will increase costs by up to 2.25%

3. REPORT STRUCTURE

Our reporting structure incorporates four asset specific sub-reports as an appendices. These sub-reports provide a review and analysis of asset specific simulations and asset specific costs. For reasons of practicality and project costs the list of both assets and systems modelled is not exhaustive – however, assets have been selected to ensure that a suitably diverse range of system types and system complexities is represented. The results of these sub-reports have been reviewed, analysed and summarised as part of this overarching summary report. The asset specific reports cover the following asset types:

1. Domestic property (houses and flats)
2. Domestic/Non-domestic property (care homes and retirement homes with commercial systems)
3. Non-domestic property (large offices)
4. Non-domestic property (retail units)

Finally, a series of Building Information Models or BIMS have been created recording energy simulations and cost studies. Separately to the BIMs are a number of SAP[2] models since domestic SAP and non-domestic NCM[3] compliant software are not yet compatible. These BIMs and SAP files will be included in an evidence pack. Access to IES VE[4] and IES IMPACT will be required to review the BIMs and access to the STROMA SAP software[5] is required for the SAP files. For more information on our use of BIM etc. see Section 7.0 Project M*ethodology*.

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[2] The Standard Assessment Procedure (SAP) is the methodology used to assess and compare the energy and environmental performance of dwellings
[3] The National Calculation Method (NCM) is the procedure for demonstrating compliance with the Building Regulations for buildings other than dwellings
[4] https://www.iesve.com/
[5] https://www.stroma.com/software/sap-software-fsap

4. THE TARGET EMISSION RATE (TER) IN PLANNING POLICY AND BUILDING REGULATIONS

In England, building standards - otherwise known as regulations, are mandated to provide protection to consumers and to ensure that government policy is implemented. Approved Documents L1A and L2A (ADL1A and ADL2A) of Building Regulations 2010 require that reasonable provision shall be made for the conservation of fuel and power in buildings by:

a. Limiting heat gains and losses-
    I. Through thermal elements and other parts of the building fabric; and
    II. From pipes, ducts and vessels used for space heating, space cooling and hot water services;
b. Providing fixed building services which-
    I. Are energy efficient
    II. Have effective controls; and
    III. Are commissioned by testing and adjusting as necessary to ensure they use no more fuel and power than is reasonable in the circumstances.

Both ADL1A and ADL2A mandate minimum energy performance standards known as the Target Emission Rate (TER) under what is known as Criterion 1. In addition, ADL1A has a further minimum standard known as a Target Fabric Efficiency Rate (TFEE).

These minimum performance standards are in turn used as a benchmark by Local Planning Authorities as a basis for defining and ensuring sustainable development. Where this is the case, as part of planning processes, an energy statement or strategy is necessary to demonstrate how a development will comply with local policy. Using the TER as the primary benchmark for energy efficiency and carbon dioxide emissions is therefore both logical and efficient, as it aligns planning policy with building regulations. A summary of the five criterion is included below:

Table 1: The Criterions of ADL1A and ADL2A of Building Regulations

CRITERION	DESCRIPTION	SUMMARY
1	Achieving the TER	The regulations state that where a building is erected it shall not exceed the TER for the building that was approved
2	Limits on design flexibility	This subjects any new development to limiting parameters for both building fabric and building services
3	Limiting the effects of heat gains in the summer	This requires a demonstration to show the building has appropriate passive control measures to limit solar gains
4	The building performance is consistent with the BER or DER	Buildings should be constructed and equipped to show that performance is consistent with the calculated BER or DER
5	Provisions for the energy efficient operation of the building	The owner of the building should be provided with sufficient information about the building so that the building can be operated in an efficient manner
EPBD (Recast requirement)[6]	Consideration of alternative energy systems	Alternative energy systems should be considered as part of the design process

[6] As part of the latest version of ADL1A and ADL2A (effective 6th April 2014) the person who is to carry out the development must analyse and take into account the technical, environmental and economic feasibility of using high-efficiency alternative systems in the construction to include, if available-

1. Decentralised energy supply systems based on energy from renewable sources such as PV, solar or wind
2. Cogeneration, such as combined heat and power
3. District or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources
4. Heat pumps, including air source and ground source

5. CURRENT POLICY

Since 2011, Guildford Borough Council has had a requirement in place to reduce carbon dioxide emissions by 10% through the use of Low and Zero Carbon technologies. This is set out in Action 4 of its Sustainable Design and Construction Supplementary Planning Document (SPD). Action 4 requires the following:

- Residential developments of 1 or more (gross) units to achieve a 10% reduction in carbon emissions through the use of on-site low and zero carbon technologies[7]
- Non-residential developments of 1,000sqm or more (gross) floor space to achieve a 10% reduction in carbon emissions through the use of on-site low and zero carbon technologies

Low and Zero Carbon technologies are defined in the SPD glossary as technologies that produce energy with low or zero carbon emissions, rather than fabric improvements.

[7] This is unless the applicant can demonstrate that the use of low and zero carbon technologies are not feasible and this is agreed in writing by the council

6. PROPOSED POLICY AND POLICY PRECEDENT (LONDON, MANCHESTER AND WOKING)

The Planning and Energy Act 2008 sets out the allowance for local authorities to set locally derived energy efficiency targets higher than those in the Building Regulations Part L within their local plans. Guildford Borough Council is considering increasing the required reduction in carbon dioxide emissions from 10% to 15 or 20%. This section of the report considers if it (Guildford Borough Council) is acting unilaterally in its approach, or if there is a precedent for other major cities such as London and Manchester, and local towns such as Woking (Borough Council), to reduce CO_2 emissions by more than is mandated by Building Regulations. Where this is the case, to consider whether or not there are additional requirements to achieve these reductions through on-site LZC technologies or through heat networks.

Our findings are that Guildford Borough Council is not acting unilaterally. London, as an example, has far more challenging targets for both CO_2 emission reduction and LZC utilisation. Manchester on the other hand sits somewhere between Guildford's proposed policies and its extant policies in terms of CO_2 emission reduction targets, but is less prescriptive in terms of LZC utilisation. Finally, Woking Borough Council appears to be more prescribed in its targeted requirement for CO_2 emission reduction targets for domestic property than non-domestic property. More detail can be found below for both cities.

6.1. London

London has set challenging emission reduction targets through the London Plan. The London Plan is the statutory spatial development strategy for the Greater London area that is written by the Mayor of London and published by the Greater London Authority. The current London plan was published in March 2016 and provides the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years.

Policy 5.1 deals with the Plan's approach to climate change mitigation and sets out an energy hierarchy[8] and challenging targets to reduce CO_2 emissions from new developments. These targets are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations - leading to zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019. The targets are as follows:

Table 2: CO^2 reduction targets under the London Plan

Domestic Buildings

YEAR	IMPROVEMENT (REQUIRED) ON 2010 BUILDING REGULATIONS
2010 to 2013	25%
2013 - 2016	40%
2016 - 2031	Zero Carbon

Non-Domestic Buildings

YEAR	IMPROVEMENT (REQUIRED) ON 2010 BUILDING REGULATIONS
2010 to 2013	25%
2013 - 2016	40%
2016 - 2019	As per building regulations requirements
2019 - 2031	Zero Carbon

Policy 5.4.2 states that there is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20% through the use of on-site renewable energy generation, wherever feasible. Development proposals should seek to utilise renewable energy technologies such as,

[8] This includes a requirement to consider decentralised energy and CHP under Policy 5.6

biomass heating; cooling and electricity; renewable energy from waste; photovoltaics; solar water heating; wind and heat pumps. Major Developments are defined as these:

- For dwellings: where 10 or more are to be constructed (or if number not given, area is more than 0.5 hectares).
- For all other uses: where the floor space will be 1000 sq. metres or more (or the site area is 1 hectare or more).

6.2. Manchester

Manchester's Core Strategy Development Plan Document (MCSDPD) was adopted on the 11 July 2012 and is the key document in the Manchester Local Plan. It sets out the long term strategic policies for Manchester's future development and will form the framework that planning applications will be assessed against. The requirements to reduce CO_2 emissions range dependent upon the target framework; from the mandatory connection to a CHP/district heating and/or where this is not feasible a range of between 10% to 15% increase is required on Part L 2010 (i.e. a reduction against the TER).

Policy EN 6 of the MCSDPD sets a target framework for CO_2 reductions from low or zero carbon energy supplies. Applications for residential development of 10 or more units and all other development over 1,000 sq. m will be expected as a minimum to meet a target emission rate, unless this can be shown not to be viable. This should be demonstrated through an energy statement, submitted as part of the Design and Access Statement. Such a statement will be expected to set out the projected regulated energy demand and associated CO_2 emissions for all phases of the development.

Developments smaller than the above threshold, but involving the erection of a building or substantial improvement to an existing building, will also be expected to meet the minimum target, where viable, but will not be expected to submit an energy statement.

The target framework relates to three broad development locations and their potential for low and zero carbon, decentralised energy. The areas are defined as follows:

- Target 1 Network development areas: Locations where the proximity of new and existing buildings, the mix of uses and density of development provide the right conditions to support district heating (and cooling).
- Target 2 Electricity intense areas: Locations where the predominant building type has an all-electric fit-out such as retail units and leisure complexes.
- Target 3 Micro-generation areas: Locations where lower densities and a fragmented mix of uses tend to mean that only building scale solutions are practical.

The proposed target framework in EN6 is expressed in terms of CO_2 reduction rather than a requirement for renewable energy, providing flexibility to the developer in terms of how the target is met. The target is framed with reference to building regulations so compliance is easy to measure using the Standard Assessment Procedure (SAP) and the National Calculation Methodology.

6.3. Woking Borough Council

Woking Borough Council's Woking Core Strategy[9] document sets out the requirement for sustainable construction under policy CS22. Its requirement for low and zero carbon technologies is set out under policy CS23.

[9] Woking Core Strategy, October 2012

Policy CS22 was updated by the document "Guidance note for the implementation of policies in the Core Strategy following the Housing Standards Review"[10]. This requires that "All new residential development will be required to achieve not less than a 19% improvement in the Dwelling Emission Rate (DER) over the Target Emission Rate (TER) as defined in Part L1A of the 2013 Building Regulations."

Under CS22 New non-residential development of 1,000 m^2 or more (gross) floor space is required to comply with BREEAM very good standards (or any future national equivalent), while all new development should consider the integration of Combined Heat and Power (CHP) or other forms of low carbon district heating in the development. It is EDGE's experience that it would be very difficult to achieve a BREEAM very good rating without going beyond the requirement of Part L and/or incorporating LZC technologies.

Finally, CS23 encourages but does not mandate the use of LZC technologies to include evidence based reasoning for the use or disregard of LZC technologies.

[10] http://www.woking2027.info/developmentplan/guidancestandards.pdf

7. PROJECT METHODOLOGY

Our methodology was to replicate the processes that a developer would have to undertake in respect of requirements around predicted energy consumption and resultant carbon dioxide emissions (the BER or DER) in order to:

1. Gain Planning Consent, and
2. Pass Building Regulations

This process involves the preparation of an energy statement or strategy which sets out how a development will comply with the sustainability policies of the Local Planning Authority in respect of energy consumption and carbon dioxide emissions, and this is closely aligned to the requirements of Building Regulations.

Approved Documents (AD) ADL1A and ADL2A of Building Regulations deal with the conservation of fuel and power in new buildings. Under Part L (ADL1A and ADL2A) a Target Emission Rate (TER) is set and a building's predicted Building Emission Rate (BER)[11] or Dwelling Emission Rate (DER)[12] is calculated and this must be equal to or lower than the TER.

To establish the TER and BER in ADL2A, software is required which uses a National Calculation Method (NCM) - developed by the Building Research Establishment (BRE) for central government. The software is known as SBEM (Simplified Building Energy Model) or the more advanced DSM (Dynamic

[11] For non-domestic properties
[12] For domestic properties

Simulation Method). Both use the same templates that inform an energy model, such as occupancy levels and hours of operation, but DSM is capable of greater granularity and increased functionality - and as a result is more suitable for dealing with complex buildings and/or as design support tool.

For compliance with ADL1A, separate software is required to calculate the domestic TER, DER and an additional domestic metric of a Target Fabric Energy Efficiency (TFEE) rate v a Dwelling Fabric Energy Efficiency (DFEE) rate. This software is known as SAP (Standard Assessment Procedure), which was also developed by the BRE for government.

While SAP and SBEM/DSM share certain metrics and calculations, for example around emission rate factors (the amount of CO_2 emitted by a fuel type), they are very different toolsets with SAP being a more basic tool than SBEM.

7.1. The Use of BIM

We undertook SAP modelling for domestic properties and SBEM modelling for non-domestic properties. A core part of our work involved the creation of a building information model or BIM using IES engineering software - the Virtual Environment or VE. PDF drawings were provided to EVORA EDGE by Guildford Borough Council on a proposed development scheme in Guildford for this study. These were converted into DWG files and scaled using Autodesk AutoCAD, and then in turn converted to DXF drawings so that they could be imported into the VE. We then imported additional models of commercial buildings from previous projects using gbXML and/or GEM files to create a 'virtual mixed use scheme'. This allowed us to model various types and numbers of buildings using a federated BIM which was shared between two principal energy modellers – one dealing with SAP and one dealing with SBEM.

The BER and TER calculations were all undertaken in the same model(s) and the BIM's geometry was used to create SAP models. Construction costs for domestic and non-domestic properties were all undertaken within the BIM using IMPACT software CostPlan which was developed as part of an Innovate UK funded project to increase the functionality of BIM projects. The BIM and the SAP outputs and models are available for future use and the nomenclature of itemised costs are based on the RICS *New Rules of Measurement Order of cost estimating and cost planning for capital building works*. A representation of the federated BIM is shown below.

An important part of our methodology was to create a base case building. Part L of Building Regulations has five criterion and a requirement for any developer to analyse and take into account the technical, environmental and economic feasibility of using high-efficiency alternative systems in construction, if available[13]. For a building to pass the exacting requirements of Part L it must be designed and constructed to a standard that meets or betters the TER of a Notional Building. A building that is constructed to the limiting parameters of ADL1A or ADL2A will fail Criterion 1, which is the Criterion that requires the BER ≤ TER and DER ≤ TER. In addition, our modelling has shown that a domestic building is likely to fail the requirement for the DFEE ≤ TFEE even where the DER ≤ TER.

[13] These systems are to include decentralised energy supply systems based on energy from renewable sources, cogeneration, district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources, and heat pumps.

Each model simulated is identical in every respect other than its building services, which may or may not include renewable energy systems. To ensure that the model is capable of passing Part L the building fabric is based upon the requirements of a Notional Building, and these remain unchanged throughout the various iterations of the model(s). By ensuring that the building construction and fabric remains as a constant, we can calculate a ‘base building’ construction cost. This in turn allows us to identify where additional expenditure is required to facilitate the CO_2 reduction targets of the four benchmarks detailed in Section 1. *Introduction to The Project*.

Building services solutions typical to the asset type were modelled. Each type of system was referenced as System 1, System 2 etc. System 1 starts with the least number of LZC technologies possible for a typical services solution, and as the targets become more challenging, then more efficient conventional systems and/or LZC technologies are incorporated into the model(s) to augment or replace less efficient and/or non LZC technologies. System 2 onwards on the other hand starts with an LZC technology, for example replacing primary fossil fuel heating with heat pumps.

Although costs are building specific. In other words they relate specifically to the buildings simulated, costs have been taken back to a functional unit of £ per m^2. This allows the findings of this report to be applied to different types and sizes of buildings. The details of our modelling are contained within the sub-reports in Appendix A.

7.2. Disclaimers

With any building, existing or proposed, there are almost an infinite number of design parameters for architects and engineers to consider including:

- Structure
- Orientation and Massing
- HVAC and Lighting Types
- Combination of HVAC and Fuel Types
- LZC Technologies

Whilst we have considered many scenarios, it is not possible to cover all potential design parameters. The aim of this research is to identify if it is possible to pass four benchmarks using the geometry and construction type of buildings which either already exist, or are proposed as part of a planning application; while assuming common design parameters and HVAC systems which are based upon a Notional Building or best (typical) market practice.

To do this we have looked at a number of building and system types adopting a hierarchical approach to favour the most efficient system(s). Where values or efficiencies are detailed in the Notional Building these are adopted. However where these values are not provided, or where they seem low when assessed against technologies readily available in the market, then these were replaced by values or efficiencies detailed in either Part L2A, or the Energy Technology List (ETL)[14], or other reputable or market sources.

[14] The ETL (or Energy Technology Product List, ETPL) is a government-managed list of energy-efficient plant and machinery, such as boilers, electric motors, and air conditioning and refrigeration systems that qualify for full tax relief.

Costs are indicative and for benchmarking purposes only. They exclude VAT and fees associated with design, professional services and project management. They do however include for preliminaries, profit and overheads for the services contractor. Build costs have typically been taken at the median of a range of costs detailed in SPONS 2017 unless indicated otherwise. Greater detail and information on our costing methodology has been provided in the sub-reports.

8. THE LZC TECHNOLOGIES MODELLED AND EXCLUDED FROM OUR RESEARCH

Table 3: LZC technologies reviewed by the study

ITEM	TECHNOLOGY	MODELLED	EXCLUDED
1	Heat pumps	Yes – we modelled air source heat pump (ASHP), air-to-air and air-to-water systems and we modelled ground source heat pump (GSHP) to water systems. These were typically found to be viable technologies[15] although we noted that some of the results in SAP were counter-intuitive in respect of GSHP.	No
2	Photovoltaics	Yes – we modelled solar PV. These were typically found to be viable technologies	No
3	Solar Heat	Yes – we modelled solar heat. These were typically found to be viable technologies for domestic dwellings.	No
4	CHP	Yes – we modelled both building sited gas fired CHP and district gas fired CHP (i.e. heat networks where the primary source of heat and power is through CHP)	No

[15] Viability is determined by the ability to reduce CO_2 emissions by a target rate and not on simple payback, discounted cash flow/IRR, or life cycle costs.

ITEM	TECHNOLOGY	MODELLED	EXCLUDED
		These technologies were typically found to be viable when properly applied[16] - although we did note a potential lack of synergy between SAP and the NCM on the predicted performance of a heat network.	
5	Wind	No	The British Wind Energy Association (BWEA) suggests that turbines become feasible where there is an average annual wind speed of 7 m/s and that most small/micro wind turbines start to generate electricity in wind speeds of approximately 3–4 m/s. Most turbines achieve their maximum rated output at a wind speed of 10–12 m/s. The NOABL wind map indicates that the wind speeds in Guildford are less than most turbines would require to make them feasible. For this reason, we have not run simulations on wind turbines.
6	Biomass	No	We excluded biomass due to the location of the mixed use site upon which our development was based. However due to the low emission factor in SAP, which is also used in NCM modelling, biomass systems such as biomass CHP (or energy from waste) perform well against the TER. Biomass systems need careful consideration. Storage of fuel is an issue, and in built up locations pollutants

[16] To be viable CHP needs a year round heat load, typically resulting in >4,500 hours runtime. This means that so-called micro-CHP is often unsuitable for individual dwellings or buildings. Exceptions would be domestic properties with swimming pools etc. which require heating in summer months.

ITEM	TECHNOLOGY	MODELLED	EXCLUDED
			such as NOx and noise may render these technologies unsuitable, or there may be a requirement for additional expenditure to mitigate the effect of the pollutants reducing the economic case for their use.

9. PROJECT FINDINGS

Set out below are our project findings. We have structured this section of the report around the two principal questions raised in Section 1.

Question 1: Is it technically feasible to construct buildings that go beyond the requirements of a Target Emissions Rate (TER) by between 15 and 20%?

It is possible in the majority of cases to construct a building that is capable of passing Proposed Policy A and Proposed Policy B by augmenting or replacing non-LZC technologies with LZC technologies. All system types modelled, including systems with complex secondary circulation, can pass Proposed Policy A and all can pass Proposed Policy B – albeit with one caveat: one system type, a four pipe fan coil unit (FCU) with full mechanical ventilation, resulted in a possible fail against Proposed Policy B depending on how the results were analysed[17]. This is because not all of the 20% increase was a result of LZC technologies. In terms of new builds, FCU systems are suitable for very large buildings where the viscosity of refrigerants introduces technical challenges in terms of pipe lengths.

Question 2: What are the indicative cost implications of this type of enhanced policy for developers?

Our project findings are recorded in Table 4. These show the typical costs (£ per m^2) across our asset types for constructing a building that passes each of the four benchmarks used in this study. The final two columns show lower and upper end percentages for improving a base case building to meet Proposed Policy A and Proposed Policy B, the latter being the most stringent of the proposed policies. Two base case buildings have been analysed, a

[17] The simulation of a four pipe FCU was undertaken on a large office building, but the results are transferable to other types of uses (retail, industrial etc.)

building that can comply with the requirements of Part L of Building Regulations, and a building that can comply with the requirements of the existing planning policy: namely the BER or DER to be 10% lower than the TER.

This calculation of the percentage increase has been arrived at by adopting, what we will refer to in this report, as '**the developer's choice'**. This approach starts with the lowest cost building and system required to reach the base case building. In the example below, the lowest cost relates to System 1 at £1,988.21 per m^2. We then present, horizontally, the increase in costs required so that the base case building can meet the Extant Policy, Proposed Policy A and Proposed Policy B. These costs are shown in the green box. We highlight this calculation methodology because any developer has a choice and could take a vertical approach - choosing a different system to comply with regulations or planning policy altogether, which then has a different cost. This vertical approach is highlighted in the red box.

A lower and a higher percentage cost increase is also provided in Table 4 based on our developer's choice method. The lower is based on our simulation results with a fixed increase of 20% applied. However, the higher percentage is to ensure that the cost of building services/LZC, and the corresponding impact to a developer, is not underestimated since the SPONS figures provide value ranges, being at the RIBA Work Stages (A to F).

	SPONS 2017 range of costs m2 (adjusted for location)	Part L	Extant Policy	Proposed Policy A	Proposed Policy B
Residential (flats & houses)	£1,368.00 to £2,064.00				
System 1		£1,988.21	£1,999.25	£2,007.44	£2,007.44
System 2		£2,018.45	£2,018.45	£2,018.45	£2,018.45
System 3		£2,067.17	£2,067.17	£2,067.17	£2,067.17
System 4		£2,066.33	£2,066.33	£2,066.33	£2,066.33
Sub total(s)		£8,140.16	£8,151.20	£8,159.39	£8,159.39
Sub total average		£2,035.04	£2,037.80	£2,039.85	£2,039.85

Using the developer's choice methodology our findings are as follows:

- The average increase in construction costs, to improve a Part L compliant building so that it complies with Proposed Policy B, the most stringent of the proposed policies, is between 2.62 to 3.14%.
- The average increase in construction costs, to take a building that is compliant with the Extant Policy to a building that complies with Proposed Policy A (which requires the BER to be 15% lower than the TER) is between 0.83 and 0.99%.
- The average increase in construction costs, to take a building that is compliant with the Extant Policy to a building that complies with Proposed Policy B (which requires the BER to be 20% lower than the TER) is between 1.51 and 1.81%.

Within these averages there are more specific findings of note:

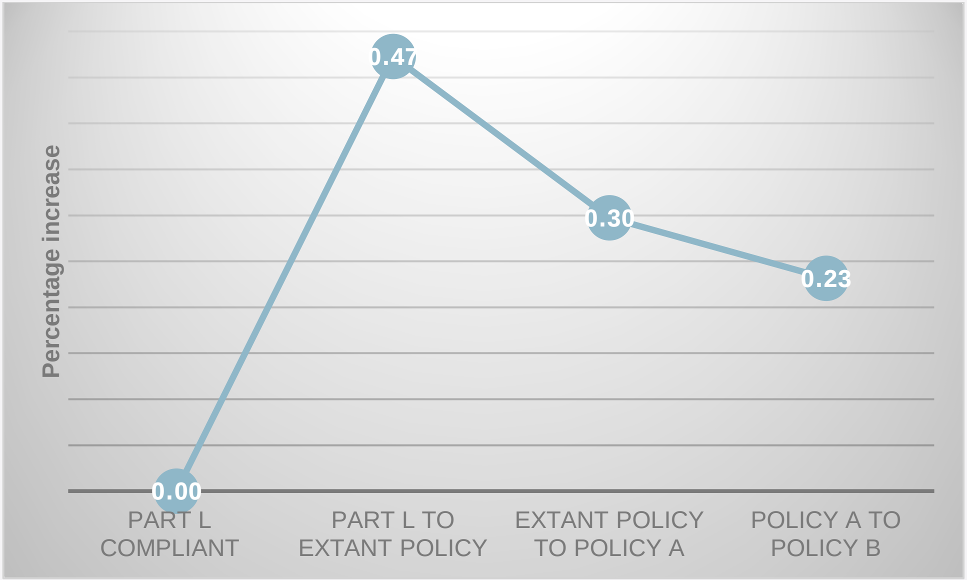
- The more complex the building services, and by association the building, the greater the installation costs for building services as a percentage of total construction costs. This includes LZC technologies.
- Naturally ventilated buildings, which do not have large centralised domestic hot water systems using secondary circulation, can more easily pass all benchmarks, and the costs associated with this are lower as a percentage of constructions costs. This would typically include dwellings such as houses and flats.
    - For this type of development, on average, it will cost an additional 0.41 to 0.49% to reduce CO_2 emissions beyond that already required by the existing policy (for the BER to be more than 10 per cent lower than the TER) to construct a dwelling that complies with either of the proposed policies.
    - For this type of development, on average, it will cost an additional 0.97% to 1.16% to reduce CO_2 emissions beyond that required by Part L to construct a dwelling that complies with either of the proposed policies.

- On the other hand, other types of residential development, such as a nursing home/home for the elderly, which may need large centralised pumped domestic hot water systems, requires up to 2.09% additional spend (above and beyond the Extant Policy) to reduce CO_2 emissions to a point that would comply with Proposed Policy A, and 2.53% to construct to a point that would comply with Proposed Policy B. Improving this type of development from the level required to pass Part L to a point that complies with Proposed Policy A would cost up to 3.62%, and up to 4.22% to comply with Proposed Policy B.
- Non-domestic property will typically require the following additional costs:
    - Part L to Proposed Policy A – this will increase costs by up to 2.65%
    - Part L to Proposed Policy B – this will increase costs by up to 3.80%
    - Extant Policy to Proposed Policy A – this will increase costs by up to 1.16%
    - Extant Policy to Proposed Policy B – this will increase costs by up to 2.25%

Our findings show that the additional cost of construction as a proportion of total construction costs is, in many cases, affected more by the requirements of Part L and by existing policy than by the two proposed policies. This is because to pass Part L and to reach the Extant Policy it is necessary to construct a highly-efficient building envelope (i.e. the structure) with low U-values and thermal bridging etc., and to comply with the Extant Policy there is already a requirement for LZC technologies.

Our research shows that the iterative percentage increase across all simulations to reach each benchmark is greatest when improving a Part L compliant building to a building that complies with the Extant Policy. This is shown in the line chart below. However even where this proves to not be the case, our research shows the majority of construction costs are incurred, not through building services or LZC technologies, but in the shell & core of a building which must, in any event, comply with the requirements of Part L. Equally, irrespective of the choice of building services or LZC solution(s), there will be a minimum cost of installation as even an inefficient boiler has a minimum cost. Therefore, the element or proportion of costs which can be taken as variable are small compared to the total construction costs.

Line Chart 1: iterative percentage increases between the four benchmarks based on the average of ALL simulations including those simulations not falling under the developer's choice methodology (i.e. accounting for both the horizontal and vertical cost approaches described earlier).



This chart shows that out of the additional expenditure required to construct a building to a standard that passes Proposed Policy B, irrespective of approach, 47% of this extra spend is a result of the Extant Policy, 30% is required to pass Proposed Policy A and 23% is required to pass Proposed Policy B.

Table 4, below, summarises our findings. It details typical construction costs and compares these to the construction costs applied to the various iterations of our modelling. This formed an important part of our quality assurance as we wanted to ensure that costs which were applied through a Building Information Model (BIM) remained within the range of costs expected by industry.

Table 4: Project results (costs)

	SPONS 2017 RANGE OF COSTS M² (ADJUSTED FOR LOCATION)	PART L	EXTANT POLICY	PROPOSED POLICY A	PROPOSED POLICY B	BASE CASE BUILDING	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY LOWER	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY HIGHER
RESIDENTIAL (FLATS & HOUSES)	£1,320.00 [18] to £2,064.00							
SYSTEM 1		£1,988.21	£1,999.25	£2,007.44	£2,007.44	**Residential**	**Policy A Lower**	**Policy A Upper**
SYSTEM 2		£2,018.45	£2,018.45	£2,018.45	£2,018.45	**Part L**	0.97	1.16
SYSTEM 3		£2,067.17	£2,067.17	£2,067.17	£2,067.17	**Extant Policy**	0.41	0.49
SYSTEM 4		£2,066.33	£2,066.33	£2,066.33	£2,066.33	**Residential**	**Policy B Lower**	**Policy B Upper**
SUB TOTAL(S)		£8,140.16	£8,151.20	£8,159.39	£8,159.39	**Part L**	0.97	1.16
SUB TOTAL AVERAGE		£2,035.04	£2,037.80	£2,039.85	£2,039.85	**Extant Policy**	0.41	0.49
						NB our simulations show that a building that can pass Policy A can also pass Policy B with no or little cost differential. To demonstrate a cost differential would require the unrealistic sizing of LZC such as PV (a third of a kW etc.)		

[18] The lower rate is the lower rate for houses, the upper rate is the upper rate for flats – standard quality 3 to 5 stories. High quality apartments range from £2,275.00 to £2,900.00.

	SPONS 2017 RANGE OF COSTS M^2 (ADJUSTED FOR LOCATION)	PART L	EXTANT POLICY	PROPOSED POLICY A	PROPOSED POLICY B	BASE CASE BUILDING	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY LOWER	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY HIGHER
OFFICE BUILDING	£1,944.00 to £2,400.00							
SYSTEM 1		£1,998.90	£2,021.50	£2,038.63	£2,048.71	**Office**	**Policy A Lower**	**Policy A Upper**
SYSTEM 2		£1,961.75	£1,970.64	£1,978.34	£1,994.35	**Part L**	0.85	1.01
SUB TOTAL(S)		£3,960.65	£3,992.14	£4,011.05	£4,043.06	**Extant Policy**	0.39	0.47
SUB TOTAL AVERAGE		£1,980.33	£1,996.07	£2,005.53	£2,021.53	**Office**	**Policy B Lower**	**Policy B Upper**
						Part L	1.66	1.99
						Extant Policy	1.20	1.44
CARE HOME HOMES	£921.60 to £1,536.00							
SYSTEM 1		£1,501.09	£1,537.08	£1,546.41	£1,553.88	**Care Home**	**Policy A Lower**	**Policy A Upper**
SYSTEM 2		£1,530.21	£1,530.21	£1,556.87	£1,562.47	**Part L**	3.02	3.62
SYSTEM 3		£1,562.82	£1,595.08	£1,602.54	£1,610.01	**Extant Policy**	1.74	2.09
SUB TOTAL AVERAGE		£4,594.12	£4,662.37	£4,705.82	£4,726.36	**Care Home**	**Policy B Lower**	**Policy B Upper**
		£1,531.37	£1,554.12	£1,568.61	£1,575.45	**Part L**	3.52	4.22
						Extant Policy	2.11	2.53
RETAIL	£921.60 to £1,872.00							
SYSTEM 1		£1,375.38	£1,402.46	£1,413.29	£1,434.95	**Retail**	**Policy A Lower**	**Policy A Upper**
SYSTEM 2		£1,365.34	£1,365.34	£1,365.34	£1,365.34	**Part L**	2.76	3.31
SUB TOTAL(S)		£2,740.72	£2,767.80	£2,778.63	£2,800.29	**Extant Policy**	0.77	0.92
SUB TOTAL AVERAGE		£1,370.36	£1,383.90	£1,389.32	£1,400.15	**Retail**	**Policy B Lower**	**Policy B Upper**
TOTALS		£19,435.65	£19,573.51	£19,660.81	£19,729.10	**Part L**	4.33	5.20
AVERAGE COST		**£1,766.88**	**£1,779.41**	**£1,787.35**	**£1,793.55**	**Extant Policy**	2.32	2.78

	SPONS 2017 RANGE OF COSTS M² (ADJUSTED FOR LOCATION)	PART L	EXTANT POLICY	PROPOSED POLICY A	PROPOSED POLICY B	BASE CASE BUILDING	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY LOWER	PERCENTAGE COST INCREASE TO ACHIEVE PROPOSED POLICY HIGHER
						Average	**Policy A Lower**	**Policy A Upper**
						Part L	1.90	2.28
						Extant	0.83	0.99
						Average	**Policy B Lower**	**Policy B Upper**
						Part L	2.62	3.14
						Extant	1.51	1.81

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