GLA Energy Efficiency Target

Development Case Studies

Greater London Authority

November 2017

Quality information

Prepared by	Checked by	Approved by
Philip Exton Senior Consultant	Christopher Pountney Associate Director	David Ross Regional Director

Revision History

Revision	Revision date	Details	Authorized	Name	Position
1	03 November 2017	Draft – For Issue	CP	Christopher Pountney	Associate Director
2	10 November 2017	Final Draft	DR	David Ross	Regional Director
3	27 November 2017	Update to comments	DR	David Ross	Regional Director
4	29 November 2017	Final	DR	David Ross	Regional Director

Prepared for:
Greater London Authority

Prepared by:

AECOM Limited
Aldgate Tower
2 Leman Street
London
E1 8FA
aecom.com

Table of Contents

1 Introduction

1.1. The Greater London Authority (GLA) is currently investigating opportunities for improvements in the levels of energy efficiency for new domestic and non-domestic development within London.

1.2. The GLA commissioned consultants Buro Happold to establish options for an energy efficiency target to be included in the new London Plan. Buro Happold's 'Driving Energy Efficiency savings through the London Plan - Data Analysis' report evaluated the benefits and costs of alternative energy efficiency targets through high-level analysis based on a large dataset of existing projects submitted to the GLA as well as Buro Happold's own project portfolio. Following the analysis the GLA undertook viability testing for the following energy efficiency improvement targets:

- 10% improvement over Part L 2013 baseline for domestic developments
- 15% improvement over Part L 2013 baseline for non-domestic developments

1.3. The aim of this study is to complement the Buro Happold high-level analysis across a distribution of buildings and undertake a more detailed evaluation of the implication of these energy efficiency improvements targets on specific examples of residential and non-domestic developments submitted to the GLA.

2 Approach

Selected Developments

2.1. The developments evaluated within this report are based on a range of developments that have recently been submitted for planning or which are currently being developed for a planning application. They have been selected through consultation with the GLA and are considered representative of development in London.

2.2. This study cannot focus on every building type and design option. However, the expectation is that the Buro Happold and AECOM studies together should give a good indication of the technical feasibility and cost implications of meeting the proposed energy efficiency targets for common building types.

2.3. In total there are six developments studied within this report; three domestic and three non-domestic. The development types have been chosen to show a wide range of characteristics within the scope of the study.

2.4. The following table outlines the residential development types assessed and their characteristics. The development types have also been chosen to align with some of the development types and scales that the GLA have used for the viability assessment of new London Plan policies.

Case Study	Description	Number of Units	Application Type
1	Terraced houses and four storey apartment blocks	80	Major non-referable
2	Apartment blocks of five to seven storeys	300	Major referable
3	40 Storey tower	150	Major referable

2.5. The table below outlines the three non-domestic buildings that have been assessed as part of this study.

Case Study	Development type	Treatable Floor Area (m^2)	Application Type
1	School	2,500	Major non-referable
2	Hotel	7,000	Major referable
3	Office	15,000	Major referable

Energy Modelling

2.6. This section of the report describes the modelling approach for estimating the energy and CO_2 emission performance when assessing energy efficiency improvements to each of the developments.

Part L of the Building Regulations and GLA policy

2.7. Part L 2013 of the Building Regulations in England sets standards for the energy performance of new buildings and works on existing buildings. The procedure for demonstrating compliance with the Building Regulations for new buildings is by calculating the predicted annual CO_2 emissions for a proposed building and comparing it with the CO_2 Target Emission Rate (TER) of a comparable 'notional' building.

2.8. Policy 5.2 of the London Plan uses Part L as the methodology for assessing on-site CO_2 emission performance of new building applications. However, its targets go beyond that currently required by Part L:

- Developments to meet the Part L TER through energy efficiency measures alone.
- Developments to achieve a 35% improvement beyond the Part L TER through additional on-site measures.

2.9. The benefits of using the Part L methodology as the basis for GLA setting its own energy efficiency and CO_2 emission targets are that it provides a consistent approach in the setting of targets between Building Regulation and the London Plan and avoids the need to develop, operate and maintain an alternative methodology with potentially separate software packages. Furthermore, it provides an independently governed and standardised methodology for assessing building energy performance.

2.10. The Government has announced a potential future review of Part L. The Government published in October 2017 its Clean Growth Strategy[1]. It makes several references to the fact that the Government has commissioned an independent review of Building Regulations and fire safety which will report in spring 2018. Subject to the conclusions of that review, the report states that the Government intends to consult on changes to Part L of the Building Regulations. The extent of this review potentially includes both strengthening energy performance standards for new and existing buildings, as well as exploring solutions to energy performance improvements not performing as well as predicted, including potential actions on compliance and enforcement of energy performance.

CO_2 Emission Factors

2.11. Part L 2013 uses the SAP 2012 carbon emission factors for estimating CO_2 emission performance of new buildings. In November 2016, BEIS published a consultation on changes to SAP 2012 including new emission factors. If SAP is updated with new emission factors, it is unclear whether/when Part L will be revised to account for the changes in SAP.

2.12. The energy efficiency improvements tested in the Buro Happold assessment were based on the Part L 2013 methodology with SAP 2012 emission factors. In order to directly

[1] https://www.gov.uk/government/publications/clean-growth-strategy

compare the performance of the development case studies in this analysis with the Buro Happold assessment, the same approach has been used.

2.13. For comparison, analysis has also been undertaken using the SAP consultation 2016 emission factors. The Government's response to the consultation was published on 17th November 2017. The consultation document stated that the Government will adopt the methodological approach for calculating the emissions values for fuels as proposed in the consultation. However, according to the consultation response the inclusion of the SAP 2016 emission figures will be subject to consultation on changes to the Building Regulations, which is intended to be undertaken in 2018. The consultation document also stated that the Governments will seek to update the greenhouse gas emission factors and primary energy factors at the time of the next Building Regulations change. Therefore, the final emission factors could differ to the ones presented in the consultation and used in this assessment.

Fabric Energy Efficiency

2.14. In addition to the CO_2 emission requirements, domestic buildings are required to meet the Fabric Energy Efficiency (FEE) criterion for Part L of the Building Regulations. The FEE is a measure of space heating and cooling energy demand for domestic buildings, and is measured in kilo-Watt hours (kWh).

2.15. The benefit of the FEE metric is that it focuses on the energy demand performance of a building based on its built form and fabric specification, which encourages energy demand reduction before considering energy efficient services and renewable technologies. This is in comparison to the Part L CO_2 emission metric, which accounts for all of the regulated energy demands within the building (e.g. additionally includes domestic hot water use and lighting), the efficiency of the building services in meeting demand and any local energy generation. Therefore, assessing the energy efficiency performance of dwelling developments using both the Fabric Energy Efficiency and CO_2 emission metrics will provide a more holistic view of the measures incorporated.

2.16. Setting an energy efficiency target based on the FEE metric, in addition to a target based on Part L, could be an opportunity to explore in the future but would need sufficient data and analysis of that data to inform a suitable target. The FEE results have, therefore, been provided in this report for comparison and the GLA could consider gathering evidence on FEE from planning applications to inform a future FEE target.

Modelling methodology

2.17. This section outlines the modelling methodology used for the assessment. The approach taken has been to replicate the procedures that developers follow for demonstrating compliance with current London Plan energy and carbon policy. Government approved Part L software has been used to estimate CO_2 emissions.

Domestic developments

2.18. The National Home Energy Rating (NHER) SAP 2012 calculation software ‘Plan Assessor’ version 6.2.3 was used to model the energy demands and associated CO_2 emissions for the domestic developments.

2.19. In order to generate the site wide emissions for each development, a representative sample of dwelling types has been modelled for each development. This is the approach that would be taken for new domestic development applications.

Non-domestic developments

2.20. Integrated Environmental Solutions (IES) Virtual Environment software version 7.0.8 was used to model the energy demands and associated CO_2 emissions for the non-domestic developments. A single building has been modelled in each case.

3 Energy Efficiency Measures

Introduction

3.1. The approach taken has been to test three options for reducing CO_2 emissions through improved energy efficiency measures. It assesses both the potential for achieving the proposed energy efficiency targets and the relative influence of fabric and service measures.

1. Fabric led:
   - Fabric specification improvement over values in the Part L notional building
   - Service specification in line with values in the Part L notional building
2. Service led:
   - Service specification improvement over values in the Part L notional building
   - Fabric specification in line with values in the Part L notional building
3. Blend:
   - A combination of the fabric and service measures assessed in (1) and (2)

3.2. The energy efficiency measures tested in this study broadly align with those considered by Buro Happold in their analysis.

Overheating Risk in Domestic Developments

3.3. Each of the domestic developments used in this study had an established overheating strategy, which was determined through dynamic overheating modelling in line with GLA guidance. Additional overheating modelling has not been undertaken after applying the additional energy efficiency measures investigated in this exercise.

3.4. Improved energy efficiency levels could potentially increase the overheating risk through reducing heat loss to outside where the internal temperature is higher than the external temperature (e.g. where there are high solar gains). However, improved energy efficiency levels can also potentially reduce the overheating risk by reducing the flow of heat from the outside to inside where the external temperature is higher than that inside. Which takes greater prominence depends on a number of factors including the building design and the way it is used by the occupants. The impact on the risk of overheating has been minimised through keeping key parameters related to the level of solar gains (including the glazing ratio, shading and g-value) the same as the original tested design.

3.5. In line with GLA guidance, all developments will need to undertake dynamic overheating modelling based on the energy efficiency measures proposed to meet the energy efficiency target. Through following the GLA's guidance on preparing energy assessments it will be evident whether there are any overheating risks and developers will be required to address these risks and put in place mitigating actions. It is important for the developer to select mitigation measures that do not negatively impact on the building's energy demand and that the energy efficiency and carbon targets can still be met.

Domestic Development

3.6. The following section outlines the energy efficiency measures that were assessed as part of this study for the domestic development case studies.

Insulation

3.7. The two main thermal insulation types used for walls, roofs and floors of domestic developments are mineral wool and rigid insulation, such as PIR or PUR rigid board. The selection of insulation type depends on a number of factors, including construction process, thermal performance and requisite fire performance. Generally rigid insulation is chosen over mineral wool for developments targeting low U-values as it has an improved thermal performance, which reduces the thickness of insulation, and subsequently the thickness of the element build-up.

3.8. In recent months there has been increased focus on construction products with respect to fire safety, and careful attention is needed and should continue to be given when selecting materials for construction build ups, particularly for buildings over 18m high. The government has commissioned an independent review of building regulations and fire safety, which is due to report in 2018.

3.9. The thermal performance assessed within this analysis has been limited to that which can be met with either type of insulation and thus satisfy Part B of the Building Regulations through either the inclusion of limited combustible materials or through whole system testing which is required for more potentially combustible builds.

3.10. The following U-values have been assessed for this analysis (including the Part L notional values).

Element	Part L notional values	Additional U-values assessed
External Wall	0.18 W/m^2K	0.15* W/m^2K
Curtain Wall Opaque Panel	0.18 W/m^2K	0.30 W/m^2K
Roof	0.13 W/m^2K	0.11 W/m^2K
Ground floor	0.13 W/m^2K	0.11 W/m^2K

** 0.15 W/m^2K limited to traditional built houses, 0.18 W/m^2K used for apartment blocks*

3.11. It is assumed that any potential increase in wall thickness due to insulation selection would not result in a reduction in habitable floor area; rather the envelope would be extended outwards.

Thermal Bridging

3.12. Thermal bridges are junctions between building components where insulation is not continuous and leads to increased heat loss. Heat loss through junctions can be reduced through increased insulation continuity. The total heat loss of a building is heavily factored on its geometry and more complex building designs will have a greater number of junctions resulting in an increase in heat loss through thermal bridging.

3.13. The measure of heat loss through a junction is known as its psi-value. The total heat loss through all junctions on the total external area for a particular dwelling is known as the y-value.

3.14. The following measures have been tested:

- SAP default y-value of 0.15 $W/m^2 K$ i.e. thermal bridging improvements have not been incorporated[2].
- Adoption of Accredited Construction Details (ACD) to achieve improved thermal bridging performance: The y-value has been estimated for the specific dwellings tested based on actual length of the junctions and the thermal performance of the approved detail (psi-value). It should be noted that ACD details are only available for traditional construction (though there may be some common junction types for non-traditional construction such as concrete frame). For the development scenarios that are not of traditional construct it has been assumed that the performance values of the approved details can still be met. However, this would require thermal modelling for each junction to determine the psi-value.
- In addition further improvements to the thermal performance of common repeating junctions have also been investigated including more efficient lintels.
- It has also been assumed that balconies will be bolted on to the façade and have continuous insulation, which will reduce the heat loss.

Glazing

Type

3.15. Two sets of glazing type have been tested:

- High performance double glazed with an average U-value of 1.2 $W/m^2 K$
- High performance triple glazed with an average U-value of 0.8 $W/m^2 K$

3.16. The energy performance of the double glazing unit tested is towards the high end of the market for double glazing. The triple glazing performance is also considered high performance as it would represent the minimum performance specification for a PassivHaus standard glazing unit.

3.17. It has been assumed that each glazing type will have similar light transmittance and will not impact on daylight levels. This would need to be investigated to ensure that a different glazing ratio is not required.

Curtain Wall

3.18. Curtain wall systems are non-structural integrated glazing and wall systems for buildings, which are common for taller residential buildings in London. A tall building has been included within this study to test the use of a curtain wall system against the proposed energy efficiency target.

[2] Under the current SAP methodology the y-value used in the notional building to generate the Part L target would be 0.05 $W/m^2 K$, which is significantly lower than the default value of 0.15 W/m^2K. Therefore, not measuring the performance of thermal bridging could be considered a significant penalty in terms of meeting Part L target emissions.

3.19. For curtain walls, two sets of glazing panes have been used:

- High performance double glazed system with a U-value[3] of 1.0 W/m^2 K
- High performance triple glazed system with a U-value[4] of 0.75 W/m^2 K

3.20. The double glazed unit is considered around the typical performance of buildings of this type, with the triple glazed unit representing a step change in performance.

G-value

3.21. Glazing g-values have been selected for each project to limit the solar gain and reduce the risk of overheating. The g-values tested range from 0.6-0.4, which broadly represents the upper and lower limits of typical glazing units.

Glazing ratio

3.22. The glazing ratio of each of the domestic development scenarios has been determined through the balancing of daylight and overheating requirements. Therefore, to avoid daylighting or overheating issues the glazing ratio has been assumed to be the same as the original design proposals for each of the developments and was not changed for any of the options tested in this assessment.

Thermal mass

3.23. For residential buildings the options for increasing the thermal mass beyond what is achieved by the construction type are limited due to blockwork being covered by plasterboard and the inclusion of suspended ceiling above the soffit to conceal electric and ventilation services.

Ventilation

3.24. Both centralised mechanical extract ventilation (CMEV) and mechanical ventilation with heat recovery (MVHR) has been considered as part of this evaluation.

3.25. In comparison with natural ventilation, MVHR reduces space heating demand by recovering heat that would otherwise be lost. MVHR is particularly suited to air tight buildings. MVHR may also be selected due to environmental factors, such as local air quality or noise issues. For the purposes of this study a reasonably high performance MVHR unit has been selected to estimate CO_2 emission reductions with a performance of 0.47 W/l/s for the specific fan power and a heat recovery efficiency of 93%. For larger dwellings with three or more wet rooms it has been assumed that the system will have reduced performance of 0.7 W/ls with a 91% heat recovery efficiency due to the extra ducting required.

3.26. The notional building is based on natural ventilation (with extract in bathrooms and kitchens). Therefore the inclusion of MVHR has the potential to make significant improvements over the Part L baseline.

3.27. CMEV extracts air from kitchens and wet rooms (e.g. shower or bath rooms) through a ducting system powered by a centralised fan. Central extract ventilation has been included

[3] based on glazing 1.4 W/m^2 K and opaque 0.3 W/m^2 K including thermal bridging
[4] based on glazing 0.9 W/m^2 K and opaque 0.3 W/m^2 K including thermal bridging

in the domestic development types as it was proposed in the original design proposals. CMEV therefore replaces the notional assumption of standalone extract fans. However, unlike MVHR the CMEV system does not supply air or provide heat recovery as incoming air is normally provided via structural air leakage with background ventilation openings, such as trickle vents. A low specific fan power of 0.17 W/l/s has been used where CMEV is included.

3.28. The energy performance values of the MVHR and CMEV are based on actual units and manufacturers' data which have been registered under the approved SAP product database. They represent above average energy performance but below the best performing units.

3.29. Whilst MVHR units can make significant savings within the SAP methodology, studies have identified a number of instances where mechanical ventilation systems (both MVHR and MEV) have not performed as intended. Two particular studies are highlighted below.

- The Zero Carbon Hub report an expert team visiting 33 dwellings across 6 construction sites in 2015 to see how effectively their mechanical ventilation systems (both MEV and MVHR) were designed, installed, commissioned and handed over to occupants[5]. The review team found things going wrong at multiple stages of the construction process at every site. The systems tested showed significant under-performance; at 5 of the 6 sites, fans were operating at only half the required duty or lower. Nearly all of the 13 occupants interviewed by the team as part of this process across the sites had turned off their ventilation systems, finding them too noisy, especially at night. The report provides strategic recommendations to both the Government and industry as well as key actions for project teams to help actual ventilation performance achieve the minimum ventilation rates specified in Building Regulations.
- A review was undertaken of the performance of MVHR systems tested as part of the Innovate UK's Building Performance Evaluation programme[6]. A total of 85 dwellings with MVHR systems was considered across 29 different projects. A review of the air flow designs showed that the majority of systems met the minimum requirements of the building regulations. However, only 16% of systems were found to have been commissioned correctly and, consequently, only 56% of installations met the design air flow value. A review of ductwork types revealed that the measured air flow in 88% of systems utilising rigid ducting were equal to or greater than their design air flow values, whereas around 40-45% of systems utilising flexible ducting met their respective design values. The review provides recommendations for improvement including to the ventilation system's design, installation, usability and maintenance.

3.30. As highlighted earlier, the Government has commissioned an independent review of Building Regulations and fire safety which will report in spring 2018. Whilst the review does focus on fire safety, issues identified related to compliance with Building Regulations may have wider implications to other parts of the Building Regulations.

[5] Ventilation in New Homes, Zero Carbon Hub (2016)
[6] http://www.fourwalls-uk.com/wp-content/uploads/2016/03/MVHR-Meta-Study-Report-March-2016-FINAL-PUBLISHED.pdf

Air permeability

3.31. An air permeability rate[7] of 5 m^3/h m^2 has been used with the CMEV options and an air permeability of 3 m^3/h m^2 has been used in combination with MVHR. The Buro Happold study highlighted many examples of air permeability of 3 m^3/h m^2 or better.

Heating systems

3.32. For development scenarios where individual heating systems would likely be appropriate, additional control measures to improve energy efficiency beyond the Part L notional building specification, such as delayed thermostat, have been assessed.

3.33. For development scenarios where it is likely that low carbon or renewable heating technology will be installed the approach has been to assume a gas boiler with the same Part L notional boiler efficiency, i.e. 93.5% efficient gas boiler, so that no improvement or loss is recorded from the heating system. This approach has been taken to isolate and focus on energy efficiency within this study.

Lighting

3.34. Low energy lighting within SAP methodology is defined as fixed light fittings that have a luminous efficacy of more than 45 lumens per circuit-watt and a total output of more than 400 lamp lumens. Fluorescent tubes, compact fluorescent lamps and LEDs meet this standard and currently there is no differentiation in energy performance for each of these types in SAP.

3.35. The notional building assumption to generate the Part L target is that all light fittings are low energy. Therefore at this current time there is no opportunity to improve CO_2 emissions from lighting.

3.36. For the purposes of this analysis it is assumed that all light fittings are low energy as defined by the SAP methodology.

Mechanical Cooling

3.37. The residential developments assessed in this study do not require mechanical cooling for meeting the GLA's overheating comfort criteria. Therefore, mechanical cooling does not form part of the study.

Non-domestic Development

3.38. The following section outlines the energy efficiency measures that were investigated as part of this study for the non-domestic development scenarios.

Insulation

3.39. As discussed above, non-domestic buildings need to also consider insulation combustibility. In terms of energy efficiency however, there is a significant difference in insulation strategy in cooling-led buildings. The level of insulation is tempered by the need to remove excessive heat gains from the building at times during the year. Cost-optimal modelling undertaken by DCLG in support of the changes to Part L in 2013 indicated that

[7] Measured at 50 Pascal (Pa)

the insulation standards in the Part L 2013 notional building were an appropriate balance for cooling-led buildings.

Thermal Bridging

3.40. The approved software de-rates the building envelope by 10% (as allowed by the NCM modelling guide), which for most large buildings is usually adequate to cover design / construction uncertainties. In terms of buildings with curtain walls or rain-screen cladding, the overall U-value should already include thermal bridging if calculated to Centre for Window and Cladding Technology (CWCT) guidance.

3.41. The approach for the buildings modelled has been to match the NCM modelling guide for thermal bridging.

Air Permeability

3.42. Improved air tightness is important to reduce heat loss / gain through infiltration. In non-domestic buildings, larger floor to wall area ratios usually means that air tightness improvements are achievable with moderate changes to construction practices. The notional building assumes an air permeability of 3 $m^3/h\ m^2$for the buildings considered in this study, which is a reasonable level of air tightness.

Glazing

3.43. The glazing units are selected to deliver three primary performance criteria: thermal control (U-value); solar control (g-value); and light transmittance ($T_{visible}$). Ideally, for cooling led buildings the g-value should be minimised and the light transmittance maximised. This performance can be delivered in different ways with different technologies.

3.44. For cooling led buildings triple glazing may not improve performance as it can increase cooling demands due to a reduced rate of transfer of internal gains to the external environment. Performance improvements can also be achieved by applying low-emissivity coatings to the glazing panes and using different gases in the cavities.

Glazing ratio

3.45. Part L 2A Criterion 3 sets limits to the solar gains entering the occupied zones in non-domestic buildings. The building should have appropriate passive control measures to limit solar gains during the summer period in order to reduce the need for, or installed capacity of, air-conditioning systems. For each zone that is either occupied or mechanically cooled, the solar gains through the glazing are calculated over the period from April to September and should be no greater than for a particular reference glazing system. The approved calculation software checks the solar gains at the same time as calculating the annual CO_2 emissions (i.e. Criterion 1).

3.46. Criterion 3 is a limiting check on the overall glazing design. Thus, higher glazing ratios are possible by improving the g-value or adding solar shading. Typically, this is an additional cost and becomes a design decision to be taken by the design team. Therefore, the glazing ratio has been assumed to be the same as the original design proposals for and static for each of the energy efficiency options assessed in this assessment.

Curtain walling

3.47. New build high quality offices tend to have curtain wall systems with fairly high amounts of vision elements (i.e. 60% to 90%). It is worth noting that the benefit of improving the building envelope is affected by the shape/depth of the office floor plate.

3.48. For curtain walls, two sets of glazing panes have been used:

- High performance double glazed system with a U-value[8] of 1.35 W/m^2 K
- High performance triple glazed system with a U-value[9] of 1.00 W/m^2 K

3.49. The double glazed curtain wall system is considered typical for central London offices. The triple glazed system represents a significant improvement in thermal performance over the double glazed system.

Thermal mass

3.50. Thermal mass is a passive method for minimising energy demand. The benefit is most clearly seen in naturally ventilated or mixed-mode non-domestic buildings. The dynamic simulation modelling approved software tools can include the benefit of increased thermal mass. However, the benefits of thermal mass need to be carefully considered during the design process, for example, by exposing concrete soffits. For this reason, we have not addressed thermal mass explicitly in the measures considered in this study.

Heating and hot water

3.51. For the purposes of estimating the savings through energy efficiency measures it has been assumed that the space heating and hot water will be provided by gas boilers. This is in line with GLA requirements for estimating the CO_2 emission savings from energy efficiency measures and is the approach that new building developments are expected to take.

3.52. The Part L notional efficiency for gas boilers is 91%. This study looks at the potential improvements in CO_2 emissions through improved gas boiler efficiency of 95%. This is considered a high efficiency boiler, however there are a number of manufactures that provide datasheets stating this level of system efficiency. It should be noted that 95% seasonal efficiency relies on the heating system running in condensing mode for nearly all the time (i.e. return water temperature between 50°C and 30°C). To design a heating system to operate nearly always in condensing mode means the heat emitters would likely have to be oversized, which may have cost implications. For the hot water, the boiler would also have to supply at a higher temperature to eliminate legionella and this can push up the return temperature impacting the energy efficiency performance of the system. Therefore, a very specific design strategy is required to use the performance value as listed in the manufacturer's datasheet in the Part L model.

---

[8] Based on double glazed pane with a U-value of 1.6 W/m^2 K for glazing including frame and 0.6 W/m^2 K for the opaque panel. The U-value also includes provision for thermal bridging

[9] Based on triple glazed pane with a U-value of 1.2 W/m^2 K for glazing including frame and 0.6 W/m^2 K for the opaque panel. The U-value also includes provision for thermal bridging

Lighting

3.53. Energy associated with lighting is usually an important component of the annual building energy demand. Lighting energy is dependent on the system design, the number and location of luminaires, the luminaire technology and efficacy and the control strategies. The Part L methodology requires the lighting to be defined at a zonal level. This can be in one of three ways:

1. Calculation of the power density of the lighting system
2. Definition of the luminaire efficacy
3. Selection of lamp types from a pre-defined list

3.54. In this analysis, the lighting efficacies have been defined. The Part L notional assumption for lighting efficacy is 60 lm/W. The two alternatives approximate high-efficiency fluorescent fittings (75 lm/W) and high-quality LED luminaires (100 lm/W).

3.55. In all cases, daylight dimming and occupancy sensing controls were assumed. The parasitic power for controls has been added by calculating the total parasitic power and area weighting by floor area of all the zones with lighting controls. The lights are metered and have warnings for out of range values and there are overriding time switch controls on the occupancy controls. The Part L notional building also assumes occupancy and daylight controls and as such a CO_2 improvement would not be registered for this element of the design specification.

Mechanical cooling

3.56. Where mechanical cooling is required, it is supplied by air cooled chillers. This is a standard solution and is selected since it is an appropriate technology for all buildings. The notional building assumes a Seasonal Energy Efficiency Ratio (SEER) of 4.5. The cooling SEER in the improved service options has been assumed to be 5.5.

3.57. Heat pumps, including air, water and ground source, may operate at higher efficiencies. However, these were not included in this analysis since they are not always technically feasible (for instance, depending on the building footprint), financially viable and additional CO_2 emission improvements would be considered under the renewable technology rather than an energy efficiency measures under the GLA's energy hierarchy.

Auxiliary Energy

3.58. Mechanical ventilation is usually supplied centrally via an Air Handling Unit (AHU). Improving the efficiency of the AHU (specific fan power) usually requires a larger footprint; hence, available roof space can be a limiting factor.

3.59. Fan coil systems have additional fans in the terminal units. Terminal fans with DC-powered motors can have a specific fan power between 0.2-0.3 W/l/s. The Part L notional building uses a specific fan power of 0.3 W/l/s. The study looks at the impact of improving the specific fan power to 0.2 W/l/s, which is considered a typical improvement measure for fan coil units. Improving the specific fan power will correspond to a slightly larger fan coil unit. There are various products from different manufacturers on the market that achieve this performance. The improved terminal unit performance will not have any further implications on the central AHU or plant room.

3.60. In offices, efficiency gains can be made by switching to chilled beams. Market data from BSRIA indicates that chilled beams make up 20-25% of the air conditioning technology market (BSRIA Worldwide Market Intelligence, 2012). These systems do not typically require additional fan power in the terminal unit. Chilled beams have a lower peak output than fan coil units and therefore the design needs to be carefully considered, but AECOM's experience is that they have been more commonly used in standard office applications (as opposed to high-intensity use scenarios). Chilled beams have been included as an option in the office model in this study.

3.61. In hotels, the guestrooms may be served by air cooled VRF systems. In these cases, the NCM system type can be set as 'Fan Coil Systems' and the terminal unit SFP set to zero as these are already accounted for in the seasonal heating and cooling efficiencies.

Cost Assumptions

3.62. Buro Happold's 'Driving Energy Efficiency savings through the London Plan - Data Analysis' report provided cost uplifts to be tested in the viability assessment for the new London Plan.

3.63. The Buro Happold analysis assessed the capital cost uplifts of meeting the proposed energy targets over and above the Part L notional performance values:

- Domestic: a median estimate of £6,500 per unit for domestic developments to meet a 10% CO_2 emission reduction from Part L 2013
- Non-domestic: a median estimate of £55/m^2 per unit for non-domestic developments to meet a 15% CO_2 emission reduction from Part L 2013

3.64. Based on the findings of the Buro Happold analysis, median capital cost uplifts were estimated over and above the current energy efficiency performance of applications referred to the GLA. The following cost uplifts were tested by the GLA for the London Plan viability assessment:

- Domestic: a cost uplift of £1,500 per unit was applied for residential developments to meet a 10% CO_2 emission reduction from Part L 2013
- Non-domestic: No capital cost uplift was applied for non-domestic buildings to meet a 15% CO_2 emission reduction from Part L 2013

3.65. The above costs were derived from the median costs from the Buro Happold modelling dataset. They account for the fact that many developments already go beyond simply meeting the Part L CO_2 emission target through energy efficiency measures alone. Indeed, the above suggests that non-domestic buildings are already commonly achieving the proposed new energy efficiency targets.

3.66. As part of this study, the capital cost uplift is provided for each development tested so that they can be compared with the median figure used in the London Plan viability assessment.

3.67. The cost data from Buro Happold's analysis has been provided by consultants Currie & Brown and used within this report for consistency. Where necessary, additional cost data has been provided by AECOM cost consultants for the specific measures investigated for the particular buildings in this analysis. These include costs for:

- Curtain wall systems non-domestic and domestic
- Chilled beam for non-domestic
- Air Handling Units with improved specific fan power (SFP)
- Heat recovery ventilation for non-domestic building

4 Development Results

4.1. This section presents the results of the modelling exercise. The three alternative energy efficiency options have been applied to each of the six developments (or case studies).

Case Study 1: Masonry Houses and Four Storey Flats

4.2. The following table outlines the measures tested for each route to improving energy efficiency in comparison to that used in the Part L notional building.

Elements	Notional	1. Fabric	2. Services	3. Blend
External Walls (W/m^2K)	0.18	0.15 Houses 0.18 Flats	0.18	0.15 Houses 0.18 Flats
Doors (W/m^2K)	1.0	1.0	1.2	1.0
Windows[1] (W/m^2K)	1.4	0.8 – Triple	1.2 – Double	1.2 – Double
g-value	0.63	0.4 south facing units 0.5 all other	0.4 south orientated units 0.6 all other	0.4 south orientated units 0.6 all other
Glazing Ratio (glazing to total façade area)	31%	31%	31%	31%
Party wall (W/m^2K)	0.00	0.00	0.00	0.00
Roof (W/m^2K)	0.13	0.11	0.13	0.11
Ground (W/m^2K)	0.13	0.11	0.13	0.11
Thermal Bridging (W/m^2K)	Standardised psi-values or y-value 0.05 W/m^2K if default used	ACDs + Lintel improvement	Default (0.15)	ACDs + Lintel improvement
Ventilation	Natural ventilation with extract fans	CMEV for kitchen and bathrooms	High Performance MVHR	High Performance MVHR
Air permeability ($m^3/h\ m^2$ @ 50 Pa)	5	5	3	3
Heating assumptions	Individual gas boiler with controls eq. 93.5% efficient	Houses: Individual gas boiler 89.8% with controls Flats: Communal Gas boiler. Performance matched to Part L notional i.e. no improvement		

1 – Measured for the whole window opening including frame

4.3. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. Of the three options tested only Option 3 was able to meet the proposed 10% improvement target. This suggests that for this particular development MVHR for all building types may be needed to meet the 10% target.

	1. Fabric	2. Services	3. Blend
Part L 2013 target emissions (tCO_2/year)	122	119	122
CO_2 emissions after energy efficiency measures (tCO_2/year)	114	112	109
Improvement (%)	7%	6%	11%

4.4. As well as having an impact on CO_2 emissions the energy efficiency measures will also impact on the energy demand of the development. The performance of the energy efficiency measure options against the Part L FEE requirement has been provided for each domestic development for reference.

Fabric Energy Efficiency Standard

	1. Fabric	2. Services	3. Blend
TFEE (kWh/year)	374,603	366,423	375,414
DFEE (kWh/year)	301,893	346,898	323,832
Improvement (%)	19%	5%	14%

4.5. It can be seen that the largest FEE improvement is from Option 1. This is likely to be due to the inclusion of triple glazing in all of the dwellings for Option 1. It should be noted the FEE calculation does not factor in the demand reduction from the mechanical heat recovery and would help account for Option 3 being poorer than Option 1 in the FEE calculation but better than Option 1 when based on CO_2 emissions.

4.6. The table below shows the additional costs of installing these energy efficiency measures. The table has been set out as follows and the same approach taken for the cost tables for the other 5 developments

- The first set of cost data shows the additional cost calculated by AECOM to achieve energy efficiency improvements beyond that required to meet Part L.
- The second set of cost data shows the current median cost (for residential developments in this case) uplift in achieving the proposed new target over and above the Part L notional performance values. Note that this is across a range of development types and hence expected differences to those determined by AECOM for one specific development.

4.7. It is noted that the cost for this development is below that of the median in the Buro Happold data-set. This is expected to particularly reflect that these buildings are all constructed at low-level and do not require more expensive elements such as curtain walling where the cost is greater to exceed Part L notional building specifications.

	Unit	Fabric	Services	Blend
Improvement over Part L 2013	%	7%	6%	11%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/unit)	£5,454	£4,305	£5,190
Buro Happold median cost uplift for meeting 10% improvement over Part L 2013	(£/unit)	£6,500	£6,500	£6,500

4.8. The above table shows that Option 3 has the greatest CO_2 emission improvement over Part L. However, it is at a lower cost than Option 1. This suggests that Option 3 is a more cost-effective solution. In particular, it saves on the relatively high cost for triple glazing and includes the less expensive addition of MVHR and improved airtightness. The performance of Option 2 is significantly limited by the use of the default value for thermal bridging.

Case Study 2: Apartment blocks of five to seven storeys

4.9. The following table outlines the measures tested for each route to improving energy efficiency.

Elements	Notional	1. Fabric	2. Services	3. Blend
External Walls (W/m^2K)	0.18	0.18	0.18	0.18
Doors (W/m^2K)	1.00	1.00	1.20	1.20
Windows[1] (W/m^2K)	1.4	0.8 – Triple	1.2 - Double	1.2 – Double
g-value	0.63	0.4 south facing units 0.5 all other	0.4 south orientated units 0.6 all other	0.4 south orientated units 0.6 all other
Glazing Ratio (glazing to total façade area)	42%	42%	42%	42%
Party wall (W/m^2K)	0.00	0.00	0.00	0.00
Roof (W/m^2K)	0.13	0.11	0.13	0.11
Ground (W/m^2K)	0.13	0.11	0.13	0.11
Thermal Bridging (W/m^2K)	Standardised psi-values or y-value 0.05 W/m^2K if default used	ACDs + Lintel improvement	Default (0.15)	ACDs + Lintel improvement
Ventilation	Natural ventilation with extract fans	CMEV for kitchen and bathrooms	High Performance MVHR	High Performance MVHR
Air permeability ($m^3/h\ m^2$ @ 50 Pa)	5	5	3	3
Heating assumptions	Individual gas boiler with controls eq. 93.5% efficient		Communal Gas boiler. Performance matched to Part L notional i.e. no improvement	

1 – Measured for the whole window opening including frame

4.10. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. The results suggest the need for both fabric and service improvements (Option 3) to achieve the 10% reduction target. It is noted that this Option does not require the installation of triple glazing. However, it does suggest limited potential to meet the target without MVHR installed.

	1. Fabric	2. Services	3. Blend
Part L 2013 target emissions (tCO_2/year)	221	217	221
CO_2 emissions after energy efficiency measures (tCO_2/year)	205	200	191
Improvement (%)	7%	8%	14%

4.11. The performance of the development against the Part L FEE criterion is also shown below. Both Option 1 and Option 3 have similar reductions from the TFEE.

Fabric Energy Efficiency Standard

	1. Fabric	2. Services	3. Blend
TFEE (kWh/year)	577,810	578,179	583,845
DFEE (kWh/year)	500,284	545,144	501,620
Improvement (%)	13%	6%	14%

4.12. The table below shows the additional costs of installing these energy efficiency measures. As for the previous development, the lower costs calculated by AECOM may reflect that these building types do not require more expensive curtain wall systems.

	Unit	1. Fabric	2. Services	3. Blend
Improvement over Part L 2013	%	7%	8%	14%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/unit)	£4,784	£4,515	£5,010
Buro Happold median cost uplift for meeting 10% improvement over Part L 2013	(£/unit)	£6,500	£6,500	£6,500

4.13. Similar to Case Study 1, Option 3 shows the greatest improvement and is the more cost-effective solution. The reasons behind the performance and cost differentials are broadly the same as Case Study 1 with differences relating to the dwelling designs (e.g. significantly less triple glazing in this case study which results in less cost uplift for Option 1).

Case Study 3: 40 Storey tower

4.14. The following table outlines the measures tested for each route to improving energy efficiency.

Elements	Notional	1. Fabric	2. Services	3. Blend
Curtain Wall (W/m^2K)	0.18	Triple glazed 0.75 based on 55% glazing ratio	Double glazed 1.00 based on 55% glazing ratio	Triple glazed 0.75 based on 55% glazing ratio
g-value	0.63	0.5	0.5	0.5
Glazing Ratio	34%[10]	55%	55%	55%
Party wall (W/m^2K)	0.00	0.00	0.00	0.00
Roof (W/m^2K)	0.13	0.11	0.13	0.11
Ground (W/m^2K)	0.13	0.11	0.13	0.11
Thermal Bridging (W/m^2K)	Standardised psi-values	ACDs	Default psi-values[11]	ACDs
Ventilation	Natural ventilation with extract fans	CMEV for kitchen and bathrooms	High Performance MVHR	High Performance MVHR
Air permeability ($m^3/h\ m^2$ @ 50 Pa)	5	5	3	3
Heating assumptions	Individual gas boiler with controls eq. 93.5% efficient		Communal Gas boiler. Performance matched to Part L notional i.e. no improvement	

4.15. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. The results show that Option 3 is the only option that meets the proposed target. Both triple glazing and MVHR would be required to achieve the target value for this particular building which increases the cost.

4.16. The inclusion of triple glazing is required in this particular case due to the high proportion of glazing, which is higher than both Case Study 1 and Case Study 2. Based on AECOM's experience developers would not typically install triple glazing to meet current GLA energy policy. Therefore, the inclusion of an energy efficiency target could represent a step change for this type of building.

[10] SAP limits notional glazing area up to a maximum proportion of 25% of total floor area
[11] SAP conventions require that the thermal bridges for curtain walls are calculated which means that the default psi-values can be used for other junctions – rather than the default value

	1. Fabric	2. Services	3. Blend
Part L 2013 target emissions (tCO_2/year)	191	191	191
CO_2 emissions after energy efficiency measures (tCO_2/year)	175	179	158
Improvement (%)	8%	6%	17%

4.17. If double glazing was used in Option 3, the improvement would only result in a 7% CO_2 emission improvement over Part L 2013 (similarly the performance of Option 1 would also reduce as it includes triple glazing). Additional energy efficiency measures, beyond those investigated in the three options, would be needed to meet the 10% target for this case study if double glazing is used. As an example, the air permeability could be further improved; it is estimated that it would need to achieve 1 $m^3/h\ m^2$ @ 50 Pa to meet the 10% target. This level of performance is feasible but is approaching Passivhaus standards for air permeability. It would require changes in design and construction beyond common building practice in London, which would have cost implications for developments.

4.18. The table below shows the FEE performance of each of the options tested. The results show that the performance of Option 1 and 3 are similar, which is as expected as the fabric specifications are almost identical baring the improvement in air permeability of Option 3.

Fabric Energy Efficiency Standard

	1. Fabric	2. Services	3. Blend
TFEE (kWh/year)	562,595	562,595	562,595
DFEE (kWh/year)	461,171	537,492	449,581
Improvement (%)	18%	4%	20%

4.19. The table below shows the additional costs of installing these energy efficiency measures. In this case, the costs are higher than the Buro Happold median which is likely associated with the greater costs associated with higher rise buildings.

	Unit	1. Fabric	2. Services	3. Blend
Improvement over Part L 2013	%	8%	6%	17%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/unit)	£7,461	£6,719	£8,519
Buro Happold median cost uplift for meeting 10% improvement over Part L 2013	(£/unit)	£6,500	£6,500	£6,500

Case Study 4: Office

4.20. The following table outlines the measures tested for each route to improving energy efficiency.

			Notional	1. Fabric	2. Services	3. Blend
Curtain wall	W/m²K		1.6 Glazed/ 0.26 Opaque	Triple Glazed 1.00	Double Glazed 1.35	Triple Glazed 1.00
Vision element	g-value		0.4	0.4	0.4	0.4
	Tvisible		-	70%	70%	70%
Roof	W/m²K		0.18	0.10	0.18	0.10
Floor	W/m²K		0.22	0.15	0.22	0.15
Air permeability	(m^3/h m^2 @ 50 Pa)		3	3	3	3
HVAC	Type		Fan coil units		Chilled beams	
	Boiler	SCoP	91%	91%	95%	95%
	Chiller	SEER	4.5	4.5	5.5	5.5
	AHU	SFP	1.8	1.8	1.5	1.5
	FCU	SFP	0.3	0.3	-	-
	Heat recovery		70%	70%	80%	80%
Lighting	Lm/Watt		60	75	100	100
	Automatic controls		Daylight dimming and occupancy sensing			

4.21. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. The results show that the proposed 15% target can particularly be achieved through improved service performance.

	1. Fabric	2. Services	3. Blend
Part L 2013 target emissions (tCO_2/year)	376	376	376
CO_2 emissions after energy efficiency measures (tCO_2/year)	400	289	279
Improvement (%)	-7%	23%	26%

4.22. The following table shows the energy demand following each of the energy efficiency options tested. The energy requirements of the office building are dominated by the lighting and cooling loads. There is a disbenefit in improving the fabric thermal performance in Option 1 as additional cooling load is required to remove heat gains.

	Energy Demand (kWh)			
	Notional	1. Fabric	2. Services	3. Blend
Space Heating	128,226	70,219	129,753	71,746
Domestic Hot Water	39,689	39,689	39,689	39,689
Lighting	334,304	334,304	253,399	253,399
Cooling	540,381	589,229	496,113	543,434

4.23. The table below shows the additional costs of installing these energy efficiency measures. They are higher than the Buro Happold median across the various non-domestic buildings in their sample. The most significant cost uplifts compared to the notional building for this office design are the curtain wall system and the chilled beams. The office building modelled has a façade glazing ratio of approximately 75% glazed, which is typical of commercial buildings AECOM have worked on across London. Reducing the glazing would reduce the cost of the curtain wall system. However, it is common that high end offices of this type in central London are highly glazed to meet market expectation.

4.24. In principle, the energy efficiency measures could be relaxed for Options 2 & 3 as they both significantly exceed the proposed 15% target, which would reduce costs. Based on current practice, it is expected that many developers of this type of office building in London will choose to install energy efficiency measures that go beyond the 15% target to most cost-effectively achieve the overall 35% improvement over Part L 2013 required by London Plan Policy 5.2.

	Unit	1. Fabric	2. Services	3. Blend
Improvement over Part L 2013	%	-7%	23%	26%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/m^2)	£86	£177	£193
Buro Happold median cost uplift for meeting 15% improvement over Part L 2013	(£/m^2)	£55	£55	£55

Case Study 5: Hotel

4.26. The following table outlines the measures tested for each route to improving energy efficiency.

			Notional	1. Fabric	2. Services	3. Blend
External wall	W/m²K		0.25	0.15	0.25	0.15
Windows[1]	W/m²K		Double Glazed 1.60	Triple glazed 1.20	Double Glazed 1.60	Triple glazed 1.20
	g-value		0.4	0.4	0.4	0.4
	$T_{visible}$		70%	70%	70%	70%
Roof	W/m²K		0.18	0.10	0.18	0.10
Floor	W/m²K		0.22	0.15	0.22	0.15
Air permeability	(m^3/h m^2 @ 50 Pa)		3	3	3	3
HVAC	Type		Fan coil units	Fan coil units	Fan coil units	Fan coil units
	Boiler	SCoP	91%	91%	95%	95%
	Chiller	SEER	4.5	4.5	5.5	5.5
	AHU	SFP	1.8	1.8	1.5	1.5
	FCU	SFP	0.3	0.3	0.2	0.2
	Heat recovery		70%	70%	80%	80%
Lighting	Lm/Watt		60	75	100	100

1 – Measured for the whole window opening including frame

4.27. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. In contrast to the previous example, neither fabric or services improvements have significantly improved the performance.

	1. Fabric	2. Services	3. Blend
Part L 2013 target emissions (tCO_2/year)	569	569	569
CO_2 emissions after energy efficiency measures (tCO_2/year)	599	569	555
Improvement (%)	-5%	0%	2%

4.28. The following table shows the energy demand following each of the energy efficiency options tested. The majority of the energy demand for the hotel is from the domestic hot water. The improvements proposed have no impact on the domestic hot water demand and hence the limited potential for CO_2 reduction.

	Energy Demand (kWh)			
	Notional	1. Fabric	2. Services	3. Blend
Space Heating	134,814	84,617	130,511	81,032
Domestic Hot Water	1,675,132	1,675,132	1,675,132	1,675,132
Lighting	55,216	55,216	41,591	41,591
Cooling	38,006	43,026	35,855	40,157

4.29. Another key factor affecting the apparently limited impact of including fabric and services measures on CO_2 emissions is the way that the domestic hot water distribution losses are calculated. The Part L notional building assumptions for distribution losses are lower than what would be found in practice and assumed in this particular hotel. This results in higher hot water energy consumption for the design performance than that of the notional building, which in turn makes CO_2 improvements over the target emission rate more challenging for this building type.

4.30. The table below shows the additional costs of installing these energy efficiency measures. Whilst the AECOM costs are lower, the 15% improvement has not been achieved.

	Unit	1. Fabric	2. Services	3. Blend
Improvement over Part L 2013	%	-5%	0%	2%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/m^2)	£23	£27	£46
Buro Happold median cost uplift for meeting 15% improvement over Part L 2013	(£/m^2)	£55	£55	£55

Case Study 6: School

4.31. The following table outlines the measures tested for each route to improving energy efficiency.

		Notional	1. Fabric	2. Services	3. Blend
Masonry wall	W/m²K	0.26	0.15	0.25	0.15
Windows[1]	W/m²K	1.6	Triple Glazed 1.4	Double Glazed 1.6	Triple Glazed 1.4
	g-value	0.4	0.4	0.4	0.4
	$T_{visible}$	-	70%	70%	70%
Roof	W/m²K	0.18	0.1	0.18	0.1
Floor	W/m²K	0.22	0.15	0.22	0.1
Air permeability	(m^3/h m^2 @ 50 Pa)	3	3	3	3
HVAC	Type	Natural ventilation	Natural ventilation	Mechanical Ventilation	Natural ventilation
	Efficiency	91%	91%	95%	95%
	SFP	-	-	0.8	-
	Heat recovery	-	-	70%	-
Lighting	Lm/Watt	60	75	100	100
	Automatic controls	Daylight dimming and occupancy sensing			

1 – Measured for the whole window opening including frame

4.32. The table below outlines the respective CO_2 emission improvement for each of the energy efficiency approaches modelled. Overall none of the options evaluated meet the proposed 15% energy efficiency improvement.

	1. Fabric	2. Services	3.Blend
Part L 2013 target emissions (tCO_2/year)	34	28	34
CO_2 emissions after energy efficiency measures (tCO_2/year)	31	29	29
Improvement (%)	7%	-3%	13%

4.33. Option 3 achieves the highest reduction with the inclusion of triple glazing and high efficiency gas boiler. The U-value used for modelling the triple glazing option is relatively modest in thermal performance and could also be met through high specification double glazing. The U-value performance was selected for the modelling as it was considered that the majority of schools would not specify high performance triple glazing due to funding constraints. A higher performing triple glazing unit could potentially meet the 15% target, however this would be at an additional cost.

4.34. Note that the reduction in the Part L target for Option 2 relates to use of a mechanically ventilated system which has not been included in Option 3.

4.35. The table below shows the additional costs of installing these energy efficiency measures. Again differences in costs reflect the specific designs considered in this study compared to the wider distribution within the Buro Happold study.

	Unit	1. Fabric	2. Services	3. Blend
Improvement over Part L 2013	%	7%	-3%	13%
Cost uplift above Part L 2013 notional building to meet % reduction over Part L 2013	(£/m^2)	£37	£62	£50
Buro Happold median cost uplift for meeting 15% improvement over Part L 2013	(£/m^2)	£55	£55	£55

5 SAP Consultation CO_2 emission figures

5.1. A simple analysis has been undertaken to assess the possible impact of a change in CO_2 emission factors on the energy efficiency target based on the proposed SAP 2016 CO_2 emission figures.

5.2. The average variance in CO_2 emission improvement between the SAP 2012 and SAP 2016 emission figures is approximately 1%, with the largest difference being approximately 2%. A summary of the results can be found in Appendix A

5.3. Overall the analysis found that the change in emissions factors is likely to be relatively small associated with energy efficiency measures alone. It is expected that when Part L is next updated, there may be other changes to the calculation methodology and the impact on the GLA's proposed energy efficiency targets should be more fully examined.

6 Conclusion

6.1. The GLA is considering the following energy efficiency improvement targets:

- 10% improvement over Part L 2013 baseline for domestic developments
- 15% improvement over Part L 2013 baseline for non-domestic developments

Domestic developments

6.2. The 10% improvement target was achieved for the three domestic developments evaluated here. The schemes are reliant on a high standard of fabric and services, including the use of triple glazing and/or MVHR, to achieve this target. This broadly aligns with the conclusions from the Buro Happold study.

6.3. The study suggests that developments with high proportions of glazing (case study 3) would require triple glazing to meet the target. This represents a step change from typical developments in London. For this case study, which used more expensive curtain walling, the cost uplift for inclusion of triple glazing was estimated to be around 9% when compared with the use of double glazed curtain walling in the Part L compliant notional building. As an alternative to triple glazing, it is possible to make energy efficiency improvements elsewhere to meet the 10% improvement target albeit they are similarly not standard practice in London; for example the air permeability could be improved to 1 $m^3/h\ m^2$ @ 50 Pa which is approaching Passivhaus standards and would require changes in design and construction beyond common building practice in London, with cost implications for developments.

6.4. MVHR is more commonly used than triple glazing in developments in London and when installed and maintained correctly MVHR can offer a practical route to achieving the target. However, as outlined in this report, studies have highlighted that when MVHR is not implemented correctly there can be performance issues. A series of recommendations on how the actual performance can better meet the minimum ventilation requirements in Building Regulations are referenced. GLA may wish to review these recommendations and consider those that it can help implement.

6.5. The following table summarises the estimated cost uplift (and associated CO_2 reductions) for the developments assessed compared to just complying with Part L 2013. The results show an uplift of £5-8k in Option 3 to achieve the 10% target. It is noted that all of the Option 3 designs exceed the energy efficiency targets and this may afford potential cost savings, albeit these energy measures may be beneficial in meeting GLA's CO_2 target of 35% improvement on Part L 2013.

	Cost uplift (£/unit) above Part L 2013 notional building to meet % reduction		
	1. Fabric	**2. Services**	**3. Blend**
Case Study 1: Masonry Houses and Four Storey Flats	£5,454 (7%)	£4,305 (6%)	£5,190 (11%)
Case Study 2: Apartment blocks of five to seven storeys	£4,784 (7%)	£4,515 (8%)	£5,010 (14%)
Case Study 3: 40 Storey tower	£7,461 (8%)	£6,719 (6%)	£8,519 (17%)

Non-domestic developments

6.6. The ability to achieve the non-domestic target was more variable which reflects the wider types of buildings and uses.

- The air-conditioned office building easily achieved the target. It is a highly serviced building and, in particular, the Part L notional building specifications for the building services can be improved upon.
- For the hotel, the fabric and service improvements were not able to significantly improve emissions beyond that of Part L 2013. The energy demand is dominated by domestic hot water use and none of the improvements measures reduced this demand.
- For the naturally ventilated school building, only 13% improvement was achieved through a combination of fabric and services improvements. However, further feasible fabric measures were identified which would likely allow the building to meet the 15% target.
- Overall, the analysis suggests that a 15% improvement over Part L 2013 should be achievable for some building types, particularly more heavily serviced buildings. Indeed, the Buro Happold analysis shows that nearly 50% of the non-residential buildings in its data-set already achieve this level of performance and setting this higher target is expected to improve energy efficiency further. It is important to acknowledge that by adopting this single target, not all building types will be able to meet it and this needs to be allowed for in the review of planning applications.

6.7. The following table summarises the estimated cost uplift with the associated CO_2 reductions for the developments assessed. Given the more individual nature of the non-domestic buildings, the additional costs vary more significantly between case studies. The office building significantly exceeded the energy efficiency target and this may afford potential cost savings, albeit these energy measures may be beneficial in meeting GLA's CO_2 target of 35% improvement on Part L 2013.

	Cost uplift (£/m^2) above Part L 2013 notional building to meet % reduction		
	1. Fabric	2. Services	3. Blend
Case Study 4 – Office	£86 (-7%)	£177 (23%)	£193 (26%)
Case Study 5 – Hotel	£23 (-5%)	£27 (0%)	£46 (2%)
Case Study 6 – School	£37 (7%)	£62 (-3%)	£50 (13%)

Appendix A SAP Consultation CO_2 Emission Factors

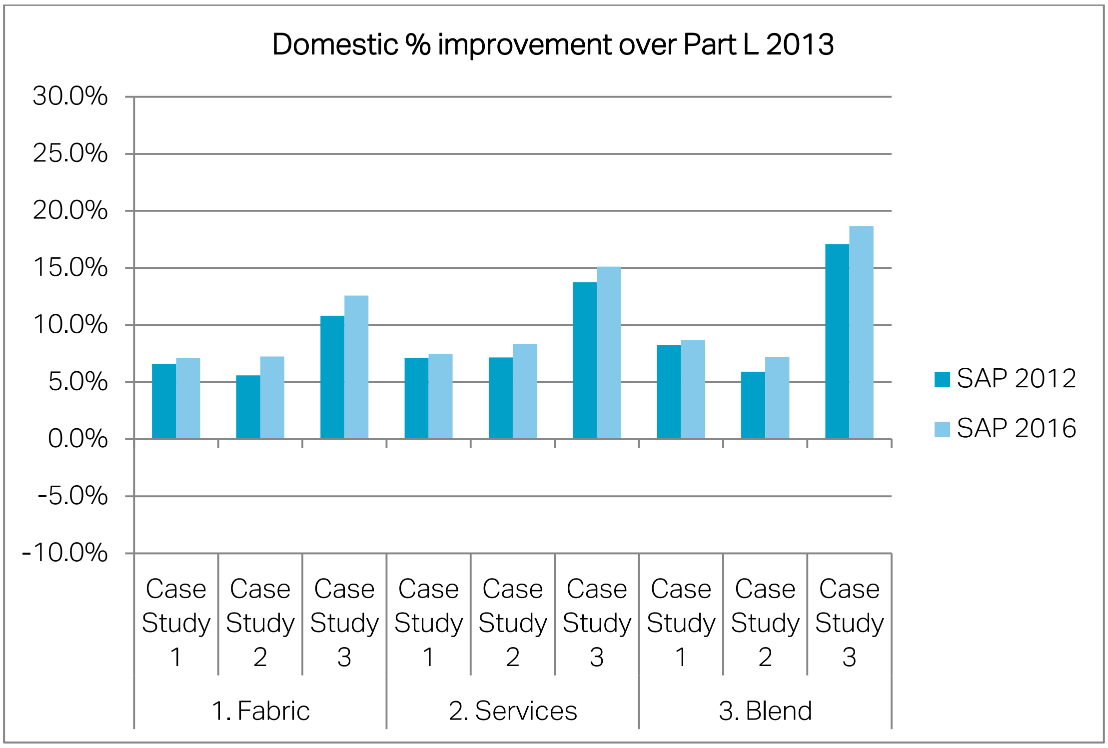
A simple analysis has been undertaken to assess the possible impact of a change in CO_2 emission factors on the energy efficiency target. The table below shows the proposed SAP 2016 CO_2 emission figures compared to the SAP 2012 values that have been used for this analysis.

Fuel	Emission Factor (kgCO_2/kWh)		Change
	SAP 2012	SAP 2016	
Grid Electricity	0.519	0.398	23%
Gas	0.216	0.208	4%

As can be seen in the table above the biggest change is in the CO_2 emission factor is grid electricity and it can therefore be expected that variations in energy consumption between the notional and design building will have the biggest impact on CO_2 emission performance.

While both the TER and DER/BER will use the same emission factors to estimate the total CO_2 emission performance, the TER and DER/BER will likely have different energy consumption requirements for grid electricity and gas, and additionally the proportion electricity and gas will also differ.

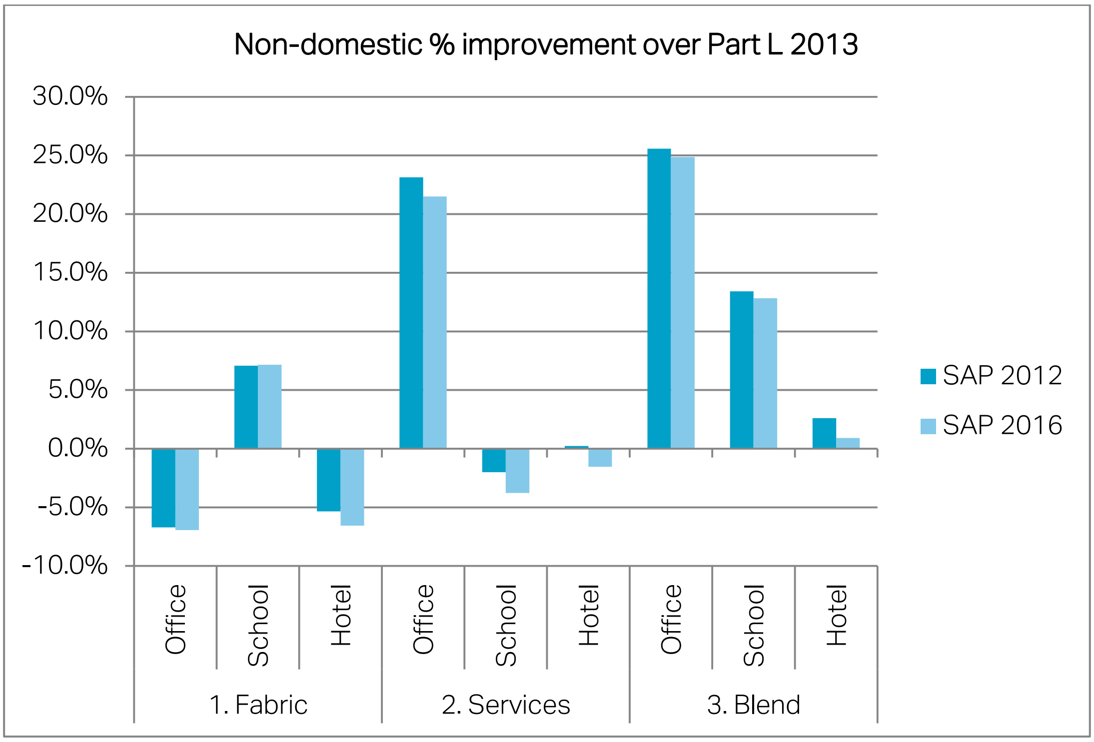
The following chart shows the % improvement for each of the domestic case studies and the energy efficiency options.



The above graph shows that for the dwellings tested, the SAP 2016 emission factors would result in the CO_2 emission saving increasing over the Part L notional than would be the case if the SAP 2012 emission factors were used. The average variance in CO_2

emission improvement between the SAP 2012 and SAP 2016 emission figures is approximately 1%, with the largest difference being approximately 2%.

The following graph shows the % improvement for each of the non-domestic case studies and the energy efficiency options.



The graphic shows that the improvement over the Part L baseline is slightly reduced for the all of the non-domestic buildings and associated energy efficiency options. This is primarily due to each of the buildings having a higher proportion of electricity consumption to gas consumption and/or a higher overall electricity consumption than their respective Part L notional building.

The average variance in CO_2 emission improvement between the SAP 2012 and SAP 2016 emission figures is approximately 1%, with the largest difference being around 2%.

Overall the analysis shows that the change in emissions factors is likely to be relatively small associated with energy efficiency measures alone. It is expected that when Part L is next updated, there may be other changes to the calculation methodology and the impact on the GLA's proposed energy efficiency targets should be more fully examined.

aecom.com