Title: Future Buildings Standard Consultation IA IA No: RPC Reference No: Lead department or agency: MHCLG	**IMPACT ASSESSMENT (IA)**
	Date: 19/01/2021
	Stage: Consultation
	Source of Intervention: Domestic
	Type of measure: Secondary Legislation
	Contact for inquiries: FutureBuildingsStandardConsultation@communities.gov.uk
Summary: Intervention and Options	RPC Opinion: N/A

Cost of Preferred (or more likely) Option (in 2019 prices)

Total Net Present Social Value	Business Net Present Value	Net Cost to business per year (EANDCB)	Business Impact Target Status
£192m	£-813m	£94.5m	TBC

What is the problem under consideration? Why is government intervention necessary?

Climate change is a significant domestic and global challenge, with the costs of greater carbon emissions likely to be experienced by those who are not responsible for their production. The UK was the first major world economy to pass a net zero emissions target into law, setting a target of bringing all greenhouse gas emissions to net zero by 2050.[1]

Improving the energy efficiency of both domestic and non-domestic buildings represents a significant opportunity to reduce carbon emissions. Heating and powering buildings currently accounts for 40% of the UK's total energy usage.[2] The minimum energy efficiency standards that MHCLG sets for buildings must put the United Kingdom on the right path to achieve our net zero target. The Government believes that by improving energy efficiency and moving to cleaner sources of heat, we can reduce carbon emissions and keep energy costs down now and in the future.

The Clean Growth Strategy outlined how more must be done to decarbonise buildings to help us achieve our 2050 target.[3] The performance-based targets set now through the Building Regulations are an important part of this, aiming to reduce carbon emissions of new buildings and avoid the need to retrofit in future. These emissions have high social costs, such as the reduction in air quality which leads to worse health outcomes and the longer-term impact of exacerbating climate change. Both air quality and climate change are costs which have not been fully accounted for by the market. Market failures include the cost of climate change not being fully reflected in energy prices and inadequate provision of information about the negative consequences of climate change. Similarly, there are limited

[1] The Committee on Climate Change, 2019. Net Zero – The UK's contribution to stopping global warming. Available online: https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

[2] Department for Business, Energy & Industrial Strategy, 2019. The Grand Challenge missions. Available online: https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions

[3] Department for Business, Energy and Industrial Strategy, 2018. Clean Growth Strategy. Available online: https://www.gov.uk/government/publications/clean-growth-strategy

incentives for building owners and developers to make improvements to buildings which could reduce their carbon emissions. Given this, government intervention is required.

Alongside work to decarbonise, we must make sure that homes and other residential buildings are able to cope with the warmer climate of the future. Overheating in buildings has been highlighted as a key risk for the health and productivity of people and businesses in the UK. It is estimated that there are around 2,000 heat-related deaths each year in England and Wales and, due to climate change, this number is expected to more than triple to over 7,000 by the middle of the century.[4]

What are the policy objectives and the intended effects?
The policy objectives and intended effects are to:

- Reduce carbon emissions and improve the energy efficiency of buildings.
- Ensure that when work is done to existing homes and non-domestic buildings it is done to a high standard of energy efficiency.
- Instigate changes in specifications, skills and supply chains needed to stimulate innovation and learning in the sector, to prepare industry for the Future Buildings Standard which we propose to introduce from 2025.
- Provide adequate ventilation provisions to align with more airtight construction.
- To protect the welfare and health of occupants of buildings by reducing the risk of transmission of airborne illnesses in certain non-domestic buildings.
- To protect the welfare of occupants who may be at risk of overheating in residential buildings

These are to be achieved through:

- An uplift to Part L of the Building Regulations, which deals with energy efficiency, for new non-domestic, existing non-domestic and existing domestic buildings.
- An uplift to Part F of the Building Regulations, which deals with ventilation, for new non-domestic, existing non-domestic and existing domestic buildings.
- Introduction of a new standard within the Building Regulations which will set standards to protect againt overheating in residential buildings.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in evidence base).
<u>Policy Option 0: Do nothing.</u> Keep existing standards for Part L and Part F for non-domestic buildings and work to all existing buildings. Do not introduce a new requirement for limiting overheating. This is the counterfactual option and so all costs and benefits are appraised relative to this situation, which means it has a baseline cost and benefit of zero.

<u>Policy Option 1: is intended to deliver a 22% improvement</u> on average per building compared to the existing Part L standard. We expect this would typically be delivered by: an increase in the efficiency of building services, and through on-site low carbon technology such as heat pumps or photovoltaic panels; improvements

[4] House of Commons Environmental Audit Committee, 2018. Heatwaves: adapting to climate change. Available online: https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/826/826.pdf

to the Part L standards for work to existing buildings, and; an introduction of a new requirement for limiting overheating. <u>Policy Option 2: intended to deliver a 27% improvement</u> on average per building compared to the existing Part L standard. We expect this would be delivered by: very high fabric standards, which means lower levels of heat loss from windows, walls, floors and roofs; improved services such as lighting, and; low carbon technology such as heat pumps or photovoltaic panels; improvements to the Part L standards for work to existing buildings, and; an introduction of a new requirement for limiting overheating. Despite having a lower net benefit than Option 1, Option 2 saves more carbon overall, making a greater contribution to the Government's net zero commitment by 2050. This option also has higher building fabric requirements, and acts as a more appropriate interim standard ahead of the Future Buildings Standard proposed to be introduced from 2025. For these reasons, Option 2 is our preferred option.				
Does implementation go beyond minimum EU requirements?		Yes		
Is this measure likely to impact on international trade and investment?		No		
Are any of these organisations in scope?	Micro Yes	Small Yes	Medium Yes	Large Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		-14.5		

SUMMARY: Analysis & Evidence

Policy Option 1

Description: Uplift to Part L and Part F standards for new and existing non-domestic buildings, and for existing domestic buildings, and the introduction of overheating requirements for new residential buildings. For new non-domestic buildings, Policy Option 1 is estimated to deliver circa 22% reduction in carbon emissions on average per building compared to 2013 standards.

FULL ECONOMIC ASSESSMENT

Price Base	PV Base	Time Period	**Net Benefit (Present Value (PV) (£m))**		
2019	2020	70	**Low**: £339m	**High:** £508m	**Best Estimate**: £423m

COSTS (£m)	**Total Transition** (constant Price) Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£2.5m	TBC	£3,664m
High	£3.8m	TBC	£5,495m
Best Estimate	£3.1m	TBC	£4,580m

Description and scale of key monetised costs by 'main affected groups'

The increased costs (present value) are £4,580m including transition costs of £3m. This comprises £882m for uplift of Part L standards for new non-domestic buildings, £35m for increased Part L fabric standards for existing non-domestic buildings, £1,376m for increased Part L standards for replacement of building services in existing non-domestic buildings, £90m for requirements for Building Automation and Control Systems (BACS) for new and existing non-domestic buildings, £175m for energy forecasting for new non-domestic buildings (TM54 analysis), £625m for Part F standards for non-domestic buildings, £612m for increased Part L standards for existing domestic buildings, £772m for requirements for Self-Regulated Devices on existing domestic buildings and £11m for Part F standards for existing domestic buildings.

For new buildings, the initial capital costs will be borne by developers, but these costs may ultimately be passed to landowners. Maintenance and replacement costs will be borne by the building owners/occupiers. For works to existing buildings, costs will be borne by the building owners/occupiers.

Other key non-monetised costs by 'main affected groups'

These changes are unlikely to have a substantial impact on the demand for new buildings, or carrying out relevant works in existing buildings, so this has not been monetised.

BENEFITS (£m)	**Total Transition** (constant Price) Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	£0m	TBC	£4,002m
High	£0m	TBC	£6,004m
Best Estimate	£0m	TBC	£5,003m

Description and scale of key monetised benefits by 'main affected groups'

Energy savings: £3,772m. Non-financial benefits including carbon savings and air quality savings: £1,206m. The total carbon savings are 13.4 $MtCO_2$(e). Productivity benefits from mitigating residential overheating risks: £26m.

Other key non-monetised benefits by 'main affected groups'
The energy savings to consumers will be greater than shown because of reduced payments for VAT which will be a cost to the exchequer. No allowance is made for fuel security benefits, employment opportunities from developing energy savings or low carbon/primary energy products, or spill-over benefits of innovation.
Key assumptions/sensitivities/risks
The analysis has taken a common set of assumptions on fuel prices, traded and non-traded carbon values, emissions factors and air quality damage costs from 2019 Green Book supplementary guidance. The low and high estimates are +/- 20% of the best estimate. All calculations are in 2019 prices.

Direct impact on business (Equivalent Annual)			Score for Business Impact Target (qualifying provision only): TBC
Costs: £76.6m	Benefits: £5.9m	Net: £-70.7m	

Summary: Analysis & Evidence **Policy Option 2**

Description: Uplift to Part L and Part F standards for new and existing non-domestic buildings, and for existing domestic buildings, and the introduction of overheating requirements for new residential buildings. For new non-domestic buildings, Policy Option 2 is estimated to deliver circa 27% reduction in carbon emissions on average per building compared to 2013 standards.

FULL ECONOMIC ASSESSMENT

Price Base	PV Base	Time Period	**Net Benefit (Present Value (PV) (£m)**		
2019	2020	70	**Low**: £153m	**High:** £230m	**Best Estimate**: £192m

COSTS (£m)	**Total Transition** (constant Price) Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£2.5m	TBC	£3,991m
High	£3.8m	TBC	£5,986m
Best Estimate	£3.1m	TBC	£4,988m

Description and scale of key monetised costs by 'main affected groups'

The increased costs (present value) are £4,988m, including transition costs of £3m. This comprises of a higher cost of £1,290m for uplift of Part L standards for new non-domestic buildings compared to Option 1, due to higher fabric requirements. For all other 'affected groups', the costs remain the same as in Option 1.

For new buildings, the initial capital costs will be borne by developers, but these costs may ultimately be passed to landowners. Maintenance and replacement costs will be borne by the building owners/occupiers. For works to existing buildings, costs will be borne by the building owners/occupiers.

Other key non-monetised costs by 'main affected groups'

These changes are unlikely to have a substantial impact on the demand for new buildings, or carrying out relevant works in existing buildings, so this has not been monetised.

BENEFITS (£m)	**Total Transition** (constant Price) Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	£0m	TBC	£4,145m
High	£0m	TBC	£6,217m
Best Estimate	£0m	TBC	£5,181m

Description and scale of key monetised benefits by 'main affected groups'

Energy savings: £3,862m. Non-financial benefits including carbon savings and air quality savings: £1,293m. The total carbon savings are 14.5 $MtCO_2$(e) - this carbon saving makes this the preferred option over option 1. Productivity benefits from mitigating residential overheating risks: £26m.

Other key non-monetised benefits by 'main affected groups'

The energy savings to consumers will be greater than shown because of reduced payments for VAT which will be a cost to the exchequer. No allowance is made for fuel security benefits,

employment opportunities from developing energy saving or low carbon/primary energy products or spill-over benefits of innovation.
Key assumptions/sensitivities/risks The analysis has taken a common set of assumptions on fuel prices, traded and non-traded carbon values, emissions factors and air quality damage costs from 2019 Green Book Supplementary guidance. The low and high estimates are +/- 20% of the best estimate. All calculations are in 2019 prices.

Direct impact on business (Equivalent Annual)			Score for Business Impact Target (qualifying provision only): TBC
Costs: £99.7m	Benefits: £5.2m	Net: £-94.5m	

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Evidence Base (for summary sheets)

Background and scope of the proposal

1.1. This impact assessment informs the consultation *The Future Buildings Standard: Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for non-domestic buildings and dwellings; and overheating in new residential buildings.* The proposed policy changes will affect new non-domestic buildings in England, existing dwellings and non-domestic buildings in England when undertaking specific building works, and new residential buildings in England. It considers two options to uplift the current Part L energy efficiency standards in 2021 for new non-domestic buildings. It considers updating Part F (Ventilation) of the Building Regulations for new non-domestic buildings. It also considers Part L and Part F for work done to existing domestic and non-domestic buildings. Lastly, it considers the wider impact of energy efficiency in new residential buildings of overheating. No additional costs or benefits are assigned to the reintroduction of the FEES metric for new homes. The analysis conducted for Future Homes Standard consultation impact assessment, as published in October 2019, already assumed a level of fabric efficiency equivalent to that mandated through the reintroduced FEES. This impact assessment will be updated in a final impact assessment which will be published in due course.

Future work (outside scope of the impact assessment)

1.2. This impact assessment does not detail the impacts of changes to Part L or Part F for new dwellings, which were published in October 2019 as part of The Future Homes Standard consultation and impact assessment. The Government's response to this has been published alongside the Future Buildings Standard consultation and this impact assessment. Regulations for Parts L and F for new dwellings are expected to be made in late 2021 which will be accompanied by a final impact assessment for these proposals.

1.3. This impact assessment relates to the elements of the consultation which are proposed to be introduced from 2021. It does not consider the costs and benefits of the Future Buildings Standard, which is proposed to be introduced from 2025. Before the Future Buildings Standard is introduced the Government will consult on the full technical details and produce an associated impact assessment.

Rationale for intervention

1.4 Climate change is a significant domestic and global challenge, with the costs of greater carbon emissions likely to be experienced by those who are not responsible for their production. Improving the energy efficiency of both domestic and non-domestic buildings represents a significant opportunity to reduce carbon emissions.

1.5 However, a number of market failures exist in energy efficiency in homes and non-domestic buildings, which means that without government intervention, the decarbonisation of these building types would be limited, or not take place at all:

- **Negative Externalities:** polluters (builders and building occupiers) do not incur the true cost of the emissions they emit by heating and powering their homes, offices, schools, etc. This is because the costs of climate change and increased greenhouse gas emissions, such as reductions in air quality and consequently human health, are not reflected in the price consumers pay for fuel. Thus, the private cost they incur via fuel bills do not cover the full cost of heating and powering buildings. This means the cost is not fully accounted for by the market, leading to the external cost falling on society. Even if an appropriately high and sustained carbon price were applied, the mix of other market failures can act as a barrier to action. This is not consistent with the Polluter Pays Principle and thus requires government intervention.

- **Imperfect information – Energy prices:** a lack of information on potential changes in energy prices mean that building buyers/tenants/mortgage providers do not value better performing buildings as they would if they had better information. This is the case at the point of construction, sale, or rent of a building. In particular, for most businesses energy costs are typically too small a percentage of their operating costs to make energy efficiency a substantial consideration when choosing the building they will occupy. In the domestic sector, consumers lack information on how to save on energy bills, and the full extent of savings they would make as a result of energy efficiency measures. Even where consumers do have the information, they may fail to take advantage of energy efficiency savings for a variety of reasons:

    - A failure to set high energy efficiency standards at point of build can lock a building into higher energy consumption, giving those consumers who do want to act limited scope to make savings because any building work would be disruptive and expensive.
    - Occupants often feel less incentivised to refurbish their buildings to higher energy standards, as the payback periods through lower fuel bills alone can be long and unattractive. This effect is also present in the housing market, where there is limited evidence that higher performance results in a price premium when they come to sell or rent the building.
    - Lack of capital, lack of information and fear of hassle can act as barriers to households and businesses acting to renovate and improve existing buildings even if these would be cost effective in the medium or long term.

- **Information asymmetry – Overheating**: Overheating in buildings has been highlighted as a key risk to the health and productivity of people and businesses in the UK. It is estimated that there are around 2,000 heat related deaths each year in England and Wales, and due to climate change, this number is expected to more than triple by the middle of the century[5].There is a mismatch in the information that a home buyer and the housebuilder have with regard to overheating, with it not widely recognised by the public as an issue because most people live in the existing stock where overheating is less common. They therefore do not know to look for this issue when buying a new property. As the benefits of the mitigation are to the occupier and not the builder, for example increased productivity from a good nights sleep and

[5] House of Commons Environmental Audit Committee, 2018. Heatwaves: adapting to climate change. Available online: https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/826/826.pdf

reduced risk of death by overheating, the builder has no incentive to mitigate overheating due to it not being reflected in purchasing decisions and prices.

- **Public goods**: many of the benefits of climate change mitigation that could arise through improved energy efficiency in buildings, for example cleaner air, are public goods. Due to their unique characteristics of non-rivalry and non-excludability, public goods are not provided in a free market as producers are unable to make a profit from supplying them.

1.6 Given that businesses and consumers may not be incentivised to reduce their own emissions, government intervention is required to correct this:

  - The Climate Change Act (2008) sets out emission reduction targets that the UK must legally comply with. The Act committed the UK to reducing it's Greenhous Gas Emissions (GHGs) by 80% by 2050, relative to 1990 levels. In June 2019, following advice from the Climate Change Committee (CCC), which was established under The Climate Change Act, the UK Government committed to achieving net zero GHGs by 2050, becoming the first major world economy to pass a net zero emissions target into law.

  - The Clean Growth Strategy sets out proposals for decarbonising all sectors of the UK economy, and outlines how more must be done to decarbonise buildings if we are to achieve our legally binding 2050 target. At Spending Review 2020, the Government allocated over £1 billion in 2021/22 to decarbonise buildings in England and support the creation of clean heat networks. The Government's Ten Point Plan also included commitments to consult on non-domestic building standards and strengthen energy efficiency requirements.

1.7 The minimum energy efficiency standards that we set for buildings must put us on the right path to achieve our net zero target. As well as prioritising the decarbonisation of new and existing homes where there are cost-effective, practical and safe opportunities to do so, we intend to make improvements to Building Regulations requirements for new and existing non-domestic buildings, which are an important means of reducing carbon emissions. The Government believes that by improving energy efficiency and moving to cleaner sources of heat, we can reduce carbon emissions and maintain affordable energy for consumers, both now and in the future.

Policy Objectives

2.1. Domestic and non-domestic buildings together have been estimated to account for 40% of the UK's total energy use. The UK has set in law a target to bring its greenhouse gas emissions to net zero by 2050 – one of the most ambitious targets in the world. Most building work carried out in England must comply with the Building Regulations. We must ensure that standards, both in energy efficiency and in overheating, as determined by the Building Regulations, are ambitious enough to put us on the right track to meet the 2050 target and to adapt to rising temperatures over the coming years.

2.2. This is the second stage of a two-part consultation on proposed changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations, as well as addressing overheating in residential buildings. The consultation document provides full details of the policy objectives. A summary of these policy objectives is provided here, which reflects the policy in the Future Building Standard consultation document.

2.3. The aims are to:

- Reduce carbon emissions and improve the energy efficiency of buildings through an uplift to Part L of the Building Regulations.
- Instigate changes in specifications, skills and supply chains needed to stimulate innovation and learning in the sector through an interim uplift to Part L of the Building Regulations, to prepare industry for the Future Buildings Standard which we propose to introduce from 2025.
- Provide adequate ventilation provisions through an uplift to Part F of the Building Regulations to align with more airtight construction.
- To prevent the transmission of airborne illnesses in certain non-domestic buildings through enhanced ventilation standards set in Part F of the Building Regulations
- Introduce a new Building Regulation on overheating in new residential buildings to protect welfare of occupants.

2.4. The intended effects are to:

- Ensure that when work is done to existing homes and non-domestic buildings it is done to a high standard of energy efficiency.
- To protect the welfare and health of occupants of buildings through improved internal environmental conditions, the prevention of overheating and reduced risks of the spread of illness.

Uplift of Part L minimum standards for new non-domestic buildings

2.5. The key consideration of the consultation and this impact assessment is the level of interim uplift to the energy efficiency requirements of Part L of the Building Regulations for new non-domestic buildings in 2021.

2.6. Section 3.4 of the Future Buildings Standard consultation document sets out two options for the interim uplift to the current Part L energy efficiency standards in 2021 for new non-domestic buildings:

a. **Option 1** is intended to deliver **a 22% improvement** on average per building compared to the existing Part L standard.[6] We expect this would typically be delivered by an increase in the efficiency of building services, and through on-site low carbon technology such as heat pumps or photovoltaic panels.

b. **Option 2** is intended to deliver **a 27% improvement** on average per building compared to the existing Part L standard.[6] This is the Government's preferred option as it saves more carbon overall than Option 1, and we expect this would be delivered by very high fabric standards. This means lower levels of heat loss from windows, walls, floors and roofs, improved efficiency of building services such as lighting, and through on-site low carbon technology such as heat pumps or photovoltaic panels.

2.7. The specifications for Part L 2021 options 1 and 2 as used in the cost benefit analysis are provided in Table 4 and Table 5.

2.8. How the new requirements may be met for examples of some common building types is set out below, though it is important to note that it is possible to meet the performance standards through a variety of mechanisms and technologies, allowing flexibility in design to meet the individual circumstances of the building. Therefore, these examples are not intended to be prescriptive but rather included as a way of demonstrating how requirements might typically be met.

<u>Retail warehouses and distribution warehouses</u>

2.9. The technical standard for warehouse-type buildings is the same for both Option 1 and Option 2 and improvements are principally driven by increasing the efficiency of building services, particularly lighting, and by the addition of renewables (represented by photovoltaics). For warehouse-type construction, the case for improving the insulating performance of building fabric is not as strong as for other building types. This is a result of their lower heat demand and the technical difficulty of improving insulation standards in large, open structures.

2.10. The primary energy and CO_2 targets for warehouse type buildings reflect that such buildings would typically have a relatively large roof area on which photovoltaic panels can be fitted. We expect that some retail warehouses will be able to adopt low-carbon heating sooner than distribution warehouses. The 36% improvement for retail warehouses will encourage developers to adopt low-carbon heating where suitable for their development.

<u>Offices and schools</u>

[6] Mean percentage CO_2 emissions reduction, weighted by the projected build-rates for different building types used in the accompanying impact assessment.

2.11. The proposed improvements for these building-types are driven by increasing the efficiency of building services including lighting, ventilation and by the addition of renewables (represented by photovoltaics). To form the target for these building types, point-of-use electric water heating is used, which has a lower CO_2 and primary energy impact than a gas-fired storage and distribution system. For Option 2 these improvements are enhanced by an increase in insulation performance.

Hotels and hospitals

2.12. A large part of the carbon and energy footprint of these buildings is from domestic hot water use. Domestic hot water consumption accounts for approximately two-thirds of the modelled primary energy of hotels and around one-third for hospitals.

2.13. Hotels and hospitals can make energy efficiency improvements through increasing services efficiency, the addition of renewables, and, for Option 2, increasing fabric insulation standards. However, because of the clinical or service needs of delivering large amounts of hot water quickly, the opportunities for reducing the energy consumption of domestic hot water for such buildings are more limited. We consider that it would not be appropriate in the short-term to expect buildings with a high hot water demand to service their domestic hot water needs through electric heating, be it heat pumps or direct electric point-of-use systems. A small improvement is proposed in Option 1 and Option 2 for hotels and hospitals.

Performance metrics for the new Part L minimum standard for new non-domestic buildings

2.14. Section 3.5 of the consultation proposes the following three performance metrics for buildings to be measured against:

- Primary energy target;
- CO_2 emission target; and
- Minimum standards for fabric and fixed building services.

2.15. Section 3.5 of the Future Buildings Standard consultation also sets out the rationale and policy intent for using these three performance metrics.

Phasing out high carbon fossil fuels for new non-domestic buildings

2.16. The full proposals for this policy are set out in Chapter 3 of the Future Buildings Standard consultation document. Currently, for new non-domestic buildings, the notional building receives the same fuel type as the actual building. We propose to modify this approach, by reducing the number of notional building heating system types, to discourage the use of high carbon fossil fuels in new buildings.

Increased fabric standards in new and existing non-domestic buildings

2.17. Sections 3.7 and 3.8 of the consultation set out the full proposals for changes to fabric standards in new and existing non-domestic buildings respectively. This includes uplifts to the minimum fabric standards of new non-domestic buildings alongside uplifts to the minimum standards for new and replacement thermal elements in existing non-domestic buildings.

Building services in new and existing non-domestic buildings

2.18. Sections 3.10 and 3.11 of the consultation set out the full proposals for changes to building services in new and existing buildings respectively. Some of the specific areas these sections cover are outlined below.

Self-regulating devices in new and existing non-domestic buildings

2.19. Self-regulating devices must be installed in new non-domestic buildings and in existing non-domestic buildings where specified work is being carried out. An example of a self-regulating device is a thermostatic radiator valve (TRV) on a radiator, which would control the temperature of the room it is in.

Making buildings fit for installing low carbon heat in new and existing non-domestic buildings

2.20. Our preferred approach is for new and existing buildings to have a space heating system which operates at a low temperature. For existing non-domestic buildings, this would be applicable when a whole wet heating system is replaced, including both the heating appliance and the emitters. This would provide benefits now and make it easier to install heat pumps or district heating in future.

Building Automation and Control Systems (BACS) for new and existing non-domestic buildings

2.21. A BACS is a centralised system used to monitor and control a building’s environment and services. We propose that new non-domestic buildings and existing non-domestic buildings where relevant work is being carried out that have a heating system over 290kW should be equipped with a BACS to avoid the need to retrofit buildings at a later date.

Modular and portable buildings for new non-domestic buildings

2.22. Section 3.13 of the consultation sets out the full proposals for modular and portable buildings in the Future Buildings Standard consultation. A modular or portable building is constructed using off-site methods involving either buildings constructed through the linking together of modular construction units or using portable buildings which can be relocated to new sites. We are proposing to recalibrate relaxation factors applied to modular and portable buildings.

Airtightness for new and existing non-domestic buildings

2.23. Section 3.14 of the consultation sets out the full proposals for airtightness testing for new and existing non-domestic buildings. We are proposing to introduce the Pulse test as an approved airtightness testing methodology; and approve a new airtightness testing methodology.

Energy forecasting in larger non-domestic buildings

2.24. Section 3.15 of the consultation sets out the full proposals for monitoring the as-built performance of non-domestic buildings. Monitoring in-use performance in non-domestic buildings is important for targeting and achieving energy savings in practice. We are proposing to continue to reference CIBSE's TM39 as the standard to which new buildings should be sub-metered. We are also proposing energy forecasting based on CIBSE's TM54 framework.

Part F standards for non-domestic buildings

2.25. Chapter 4 of the consultation outlines the proposals for changes to Part F in both new and existing non-domestic buildings. We are proposing to update our guidance to include the most recent industry standards. We are also proposing measures to mitigate the transmission of infection via aerosols in certain non-domestic buildings. This includes whether ventilation systems should be designed with additional fresh air capacity, whether all new ventilation systems in offices should have a means of monitoring the performance of the system, and whether new standards should be set for systems that recirculate air in offices.

Overheating in residential buildings

2.26. The full proposals for this policy are set out in Chapter 5 of the Future Buildings Standard consultation document. We are proposing to introduce a new part of the Building Regulations on reducing the risk of overheating in new residential buildings e.g. houses, flats, care homes, halls of residence. Our preferred means of mitigating overheating is through passive means as far as practicable. The proposed new requirements will include providing the means to reduce overheating risk through reducing unwanted solar gains and providing sufficient purge ventilation; ensuring the overheating strategy is usable by occupants; and providing sufficient information to occupants so they are able to use the overheating mitigation strategy.

Part L standards for existing domestic buildings

2.27. The full proposals for this policy are set out in Chapter 6 of the Future Buildings Standard consultation document. The chapter sets out proposed minimum standards for when work is carried out in existing dwellings, which includes significant proposed uplifts to minimum standards of new elements, including walls, floors, roofs, windows and doors. These standards apply most commonly when building an extension or replacing windows. There are also proposals to uplift roof U-values which apply when a roof is being renovated; a change to minimum standards for building services; and new proposed regulation to require self-regulating controls when a heating appliance is replaced.

Part F standards for existing domestic buildings

2.28. The full proposals for ventilation policy for existing domestic buildings are set out in Chapter 7 of the Future Buildings Standard consultation document. We are proposing to give additional guidance when undertaking energy efficiency measures and clarity on guidance for replacing windows in existing buildings. There is also a proposal for simplifying Part F approved documents, which incorporate the proposed updated standards for new dwellings as detailed in the Future Homes Standard consultation.

Guidance

2.29. Chapters 3, 4, 6 and 7 outline proposed changes to statutory guidance for Part L and Part F. This is done in sections 3.12, 4.3, 6.8 and 7.3. Draft guidance is presented alongside this consultation and impact assessment.

Estimation of costs and benefits

Summary of impacts

3.1. A summary of the impacts considered under this impact assessment are provided below in Table 1, relative to the counterfactual (Option 0). All figures are Net Present Values (NPVs) over 10 years of policy and a subsequent 60 year life of the buildings. Negative NPVs are given in parenthesis and represent costs. The figures represent the aggregate impact across the building mix. Table 1A then shows a breakdown of the impacts on the 'main affected groups' from the preferred policy Option 2.

3.2. Overall, the additional costs and benefits are significantly influenced by the range of the policies proposed, but particularly by the policy on ventilation for non-domestic buildings, which makes up a large proportion of the total cost to business. Both the costs and the total benefits are greater for Option 2, which principally originates from the higher fabric standards of new non-domestic buildings. Combining the costs and benefits, Option 2 delivers a lower net benefit than Option 1, with an overall estimated net benefit of £192 million compared to a net benefit of £424 million for Option 1. Option 2, however, has greater carbon savings which makes a greater contribution to the Government's net zero commitment by 2050. This option also has higher building fabric requirements and acts as a better interim standard for industry to begin building to, ahead of future requirements proposed to be introduced from 2025. Additional benefits in the health and welfare of building users are also likely to be greater under the enhanced energy efficiency of Option 2. For these reasons, Option 2 is the Government's preferred option for this consultation.

3.3. The equivalent annual net cost to business of the preferred Option 2 is £94.5 million in 2019 prices. For new non-domestic buildings the initial capital costs will fall on the developers, and maintenance/replacement costs will be borne by the building owner. The occupier/building owner will experience the benefits through reduced fuel bills. For existing non-domestic buildings it is the building owner who will be responsible for the cost, whilst the businesses/occupants will experience the benefits of reduced fuel bills. In the case of publicly owned non-domestic buildings such as hospitals and schools, local or national government will bear the cost, but will also experience the benefits of reduced fuel bills. For existing domestic buildings the costs will fall to homeowners and landlords, whilst the benefits of reduced fuel bills will be experienced by the bill payer (homeowner or occupant). For all types of building, wider society will benefit from reduced carbon emissions and improved air quality.

Table 1: Summary of costs and benefits		
	Option 1	**Option 2**
Transition costs Energy savings (£m) Incremental costs (£m)	(3) 3,772 (4,576)	(3) 3,862 (4,985)
Total financial benefit/(cost) (£m)	**(807)**	**(1,126)**
Carbon savings - non-traded (£m) Carbon savings - traded (£M)	607 290	680 294
Total carbon savings (£m)	**897**	**974**
Air quality savings (£m)	309	320
Comfort taking (£m)	(1)	(1)
Productivity impact (£m)	26	26
Total Net benefit/(cost) (£m)	**423**	**192**
Amount of gas saved (GWh)	46,022	51,709
Amount of electricity saved (GWh)	71,135	72,438
Amount of CO_2 saved - non-traded (MtCO2(e))	8.5	9.6
Amount of CO_2 saved - traded ($MtCO_2$(e))	4.8	4.9
Cost effectiveness – non-traded (£/tCO_2) [7]	21.5*	51.0*
Cost effectiveness – traded (£/tCO_2)	(27.8)*	20.9*
Present value net benefit/(cost) business (£m)	(608)	(813)
Equivalent annual net benefit/(cost) to business (£m) [Annualised over 10 years]	(70.7)	(94.5)

[7] Table 1 illustrates the current Cost Effectiveness figures for the policies with Ventilation included in the figures. Taking out ventilation measures, which are not primarily intended for CO_2 abatement reasons, produces the following Cost Effectiveness figures:

	Policy 1	Policy 2
Cost Effectiveness - non-traded (£/tCO_2)	(33)	2
Cost Effectiveness - traded (£/tCO_2)	(133)	(80)

Table 1A: Summary of costs and benefits for the 'main affected groups' under preferred Option 2						
	New Non-Domestic Buildings (inc. TM54[8] Analysis)	**Existing Non-Domestic Buildings**	**Domestic Buildings (incl. SRDS and Overheating)[9]**	**Ventilation[10]**	**BACS**	**Total**
Energy savings (£m)	1,040	1,685	739	144	255	3,862
Incremental costs (£m)	(1465)	(1,411)	(1384)	(636)	(90)	(4,985)
Total financial benefit/(cost) (£m)	**(426)**	**274**	**(645)**	**(492)**	**165**	**(1,126)** [11]
Carbon savings - non-traded (£m)	(35)	(167)	822	0	60	680
Carbon savings - traded (£m)	95	169	0	13	17	294
Total carbon savings (£m)	**60**	**2**	**822**	**13**	**77**	**974**
Air quality savings (£m)	97	112	78	13	20	320
Comfort taking (£m)	0	0	(1)	0	0	(1)
Productivity impact (£m)	0	0	26	0	0	26
Total Net benefit/(cost) (£m)	**(269)**	**388**	**280**	**(465)**	**261**	**192**
Amount of gas saved (GWh)	(2,834)	(12,797)	62,894	0	4,447	51,709
Amount of electricity saved (GWh)	31,756	32,777	0	4,267	3,638	72,438
Amount of CO_2 saved - non-traded ($MtCO_2(e)$)	(0.5)	(2.4)	11.6	0.0	0.8	9.6
Amount of CO_2 saved - traded ($MtCO_2(e)$)	1.5	2.9	0.0	0.2	0.3	4.9
Cost effectiveness – non-traded (£/tCO_2) [12]	N/A	N/A	47	N/A	(246)	51.0
Cost effectiveness – traded (£/tCO_2)	244	(76)	N/A	N/A	(854)	(20.9)

[8] We have only monetised the costs of TM54 analysis as this stage. Energy forecasting should enable building users to identify where energy is not as high as anticipated and where savings can be made. More work will be done to monetise these benefits for the final impact assessment.

[9] All rows apply to existing homes except overheating which applies to new homes. For overheating we have only monetised the productivity benefits associated with occupiers getting a better sleep. Costs have not been monetised at this stage.

[10] Ventilation figures are for new non-domestic and include £11m in costs for domestic. This £11m is not included in the calculation of cost to business and EANDCB.

[11] This includes an additional £3m in transition costs incurred by businesses to familiarise their employees with the new technical requirements.

[12] Where there have been no emissions saved, or the policy is not designed to save emissions (e.g. ventilation), the cost effectiveness metric is treated as not applicable.

Present value net benefit/(cost) business (£m)	(374)	34	0	(481)	11	(813)
Equivalent annual net benefit/(cost) to business (£m) [Annualised over 10 years]	(43)	4	0	(56)	1	(94.5)

Overview

3.4. The impact of the proposed policy changes will be experienced at the point of construction for new buildings. For existing buildings the policy changes will affect building work where this work has an effect on the energy performance of the building. All policy changes have been designed to save energy over the life of the building. The policy will have an impact on manufacturers of construction products, the construction industry, building owners and tenants. Given the long lives of the buildings affected there is considerable uncertainty about future values. Therefore for this assessment, it is assumed that there is an indicative ±20% uncertainty on the central estimate.

3.5. To estimate the overall costs and benefits of the proposed policy options, we have modelled the changes in construction and installation costs, energy use and related CO_2 emissions using the standards proposed for Part L, Part F and overheating, compared with a baseline of costs and energy use implied by the current Part L and Part F standards. For overheating there is no minimum standard in the Building Regulations currently, so proposed standards have been compared with typical construction practices.

3.6. At this consultation stage, not all of the policies above have been captured in the cost-benefit analysis. This is to allow for more time to define and quantify the input assumptions and to allow for stakeholder views and additional data to be collected through the consultation process. Those currently captured by the analysis are described in paragraph 3.7. Those which are not currently captured are described in paragraph 3.8, with the intention that the majority of these are included in the analysis produced for the final impact assessment.

3.7. The policies included in the cost-benefit analysis and the narrative below include:

- Uplift of Part L minimum standards for new non-domestic buildings – see Costs and Benefits – Improved Part L standards for new non-domestic buildings
- Existing non-domestic buildings – Part L standards – see Cost and Benefits – Improved Part L standards for new thermal elements and replacement of controlled fittings, Renovation of Roofs for Existing Dwellings and Building services
- Building services for new non-domestic buildings, including:
    - Self-regulating devices – see mandating self-regulating devices (SRDs)
    - Future-proofing – see Costs and Benefits – Improved Part L standards for new non-domestic buildings

    - Building Automated Control Systems – see Building Automated Control Systems (BACS)
- Part F in non-domestic buildings (excluding increased ventilation to mitigate against infection risk in buildings other than offices)
- Overheating in new homes – see Overheating in new residential Buildings;
- Existing domestic buildings – Part L standards – see Cost and Benefits – Improved Part L standards for new thermal elements, replacement of controlled fittings and renovation of roofs for existing dwellings
- Building services for existing domestic buildings, including:
    - Self-regulating devices – see mandating self-regulating devices (SRDs)
- Part F in existing buildings
- Guidance – Training

3.8. The policies not included in the cost benefit analysis and the narrative below include:

- Performance metrics to assess the energy performance of new non-domestic buildings, including primary energy and CO_2 – we expect there to be minimal familiarisation impacts of changing the performance metrics. Trained Energy Assessors calculate these metrics using a piece of software, the Simplified Building Energy Model (SBEM). These new performance metrics are all already calculated by the Energy Assessors using SBEM, they will simply have to report different metrics.
- Phasing out high carbon fossil fuels - costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Uplift to minimum standards for fabric in new non-domestic buildings – these are backstop values to ensure good quality building fabric, the main standards are the performance metrics.
- Uplift to minimum building services efficiencies in new non-domestic buildings – these are backstop values to ensure efficient building services, the main standards are the performance metrics.
- Modular and portable buildings for new non-domestic buildings – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Airtightness for new non-domestic buildings – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Overheating in new residential buildings other than homes – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Uplift to roof U-values when they are being renovated in existing dwellings – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Part F increased ventilation rates to mitigate against infection risk for buildings other than offices – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.
- Standards for sub-metering – costs/benefits have currently not been monetised and will be considered further in the final impact assessment.

3.9. The figures in the following analysis are based on central estimates.

Assumptions applicable to all analysis

4.1. This impact assessment follows the Green Book and the accompanying supplementary guidance on the valuation of energy use,[13] fuel prices, traded and non-traded carbon values and emission factors.

4.2. Energy savings are valued at the variable rate in macroeconomic calculations in accordance with the supplementary Green Book guidance. This is appropriate for social analysis and assumes that the retail energy savings enjoyed by the consumer occupying an energy efficient building does not fully reflect the social benefit.

4.3. In general, a discount rate of 3.5 per cent has been used for the first 30 years of the building's life and 3 per cent for subsequent years.

4.4. Unless otherwise stated, prices and estimates shown below are in 2020 base year, 2019 prices.

4.5. The appraisal time period for estimating the impact of the policy is 10 years which is consistent with that used in the 2013 Part L impact assessment and in other impact assessments associated with the construction industry.

4.6. For the analysis of new buildings or extensions to existing buildings, we assume a 60 year asset life. This helps to ensure that there is a full appraisal of the 'lock in' impact of higher fabric standards. An example of this is the impact of higher external wall standards, which will have an impact over a long period of time, potentially the entire lifetime of the building. For building fabric insulation (external walls, floors, roofs) we have assumed an asset life of 60 years, except for external windows which we have assigned an asset life of 30 years. This is comparable with indicative values provided in Annex E of BS EN 15459 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings. For services we have assumed an asset life of 15 years for gas boilers, 20 years for light fittings, 20 years for ventilation equipment, 20 years for thermostatic radiator valves (TRVs) to align with the asset life for heat emitters, and 10 years for lighting controls. Given the 10 years of policy being assumed, the total period for the IA is therefore 70 years so that the full 60 year impact of a building constructed in year 10 is assessed.

4.7. For the analysis of the replacement of controlled fittings (e.g. windows) and controlled services (e.g. boilers), and the installation of self-regulating devices (SRDs), the asset life was that of the measure itself. Hence, for replacement windows, the costs and benefits were determined over a 30 year asset life. In this example, given the 10 year of policy being assumed, the total period for the impact assessment is therefore 40 years so that the full 30 year impact of a building constructed in year 10 is assessed.

4.8. Only the elements of lifecycle cost that differentiated from the baseline cost were considered. For example, general repair and decoration costs were excluded from the analysis as these would be common to all new construction or works to existing buildings irrespective of the energy performance options presented in this document.

[13] Valuation of energy use and greenhouse gas emissions for appraisal (April 2019)

4.9. Replacement costs were considered for both the counterfactual and policy options to identify the impact of any changes in initial specification on renewal costs assuming a like for like renewal at the end of first life. Replacement costs were included where relevant for the analysis of new buildings or extensions. For instance, in the new non-domestic analysis an external window is assumed to have a lifetime of 30 years, and so a replacement after 30 years is assumed. Replacement costs were assigned to specific components within a specification and avoided replacements of components that would be expected to have a longer lifespan. For example, boiler replacements did not include replacement of a hot water tank or to the gas or water supplies. Replacement costs included an additional allowance for the costs of working in an existing property and for disposal of the end of life components.

4.10. The following phasing assumptions have been made for this consultation stage about the numbers of works on buildings to the new 2021 standards in the first few years of the policy. These phase-in assumptions will be revisited for the final IA. The phase-in assumptions for new non-domestic buildings reflect the time lag created by the design and planning, and the construction of new buildings. This contrasts with the ability to undertake works on existing buildings more rapidly, particularly in the domestic sector. In existing domestic buildings, where work tends to be simpler and more standardised, it is assumed that 100% of the works are to the new standards from 2021. In the existing non-domestic sector, where works tend to be more complicated and it may take longer to 'build out' old standards, it is assumed that 50% of the works in 2021 are to previous standards.

Table 2: Phase-in assumptions (% works captured by Part L 2021)

	2021	2022	2023	2024	2025 onwards
New Non-Domestic	20%	50%	75%	95%	100%
Existing Domestic	100%	100%	100%	100%	100%
Existing Non-Domestic	50%	100%	100%	100%	100%

Source: MHCLG

Costs and Benefits: Uplift of Part L minimum standards for new non-domestic buildings

Uplift in standards

Buildings modelled

4.11. For this part of the analysis, we have used net floor area projection as a proxy for annual rate of new non-domestic buildings in our modelling. This has been divided between 7 building types as shown in Appendix A.

4.12. The assessment of costs and benefits has been undertaken based on the 7 building archetypes. To enable consistent target setting and comparison, these building types are similar to those employed in the Part L 2013 review. The key differences are the inclusion of a hospital building and a naturally ventilated shallow-plan office. All of these building types were implemented for MHCLG's cost optimal analysis published in 2019.[14] The building types are summarised in Table 3.

Table 3: Non-domestic building types			
Building type	**Wall type**	**Floor type**	**Floor area (m²)**
Office – deep plan, air conditioned	Metal frame	Raised	12,100
Office – shallow plan, naturally ventilated	Masonry	Ground-contact	2,160
Hotel	Masonry	Ground-contact	1,087
Hospital	Metal frame	Ground-contact	13,387
Secondary School (includes sports facilities)	Masonry	Ground-contact	7,864
Retail Warehouse	Metal frame	Ground-contact	4,962
Distribution Warehouse	Metal frame	Ground-contact	4,962

Costs and benefits

4.13. For the uplift of Part L standards for new non-domestic buildings, two options are being proposed (Option 1 and Option 2). The costs and benefits of these proposals have been assessed across the 7 building types detailed previously.

4.14. Table 4 and Table 5 show the specifications assessed for each building type - current Part L 2013 and the two consultation options. These are based on the notional (reference) building which is used to set the standard.

[14] DCLG, *Technical housing standards – nationally described space standard*, 2015. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524531/160519_Nationally_Described_Space_Standard____Final_Web_version.pdf; and MHCLG, *Energy Performance of Buildings Directive: Second Cost Optimal Assessment for the United Kingdom (excluding Gibraltar)*, 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770783/2nd_UK_Cost_Optimal_Report.pdf

Table 4: Specifications for Warehouses

	Parameter		Part L 2013	Option 1 and Option 2
Fabric[15]	**Wall U-Value (W/m²K)**		0.26	0.26
	Roof U-Value (W/m²K)		0.18	0.18
	Floor U-Value (W/m²K)		0.22 (unless uninsulated is better)	0.22 (unless uninsulated is better)
	Window	**U-Value (W/m²K)** ***including frame***	1.60	1.60
		G-value	0.40	0.40
		Light transmittance	71%	71%
	Roof light	**U-Value (W/m²K)** ***including frame[16]***	1.80	1.80 (vertical) 2.10 (horizontal)
		G-value	0.55 (top-lit buildings only)	0.40
		Light transmittance	60% (top lit buildings only)	71%
	Air tightness		3 (depending on building floor area)	5
Services	**Lighting luminaire (llm/cW)[17]**		60	95
	Daylight lighting control[18]		Yes (Single zone daylight dimming)	Yes (Single zone daylight dimming)
	Occupancy Lighting Control[19]		Yes (Manual on, auto off)	Yes (auto on auto off)
	Parasitic power of automatic lighting controls[20]		Daylight: lesser of 3% of installed lighting load or 0.3W/m² Occupancy: 0.3W/m²	0.1W/m²
	Display Lighting (llm/cW) (with time switching)		22	95
	Cooling SSEER[21] (where applicable excl. naturally ventilated)		Air conditioning with air cooled chiller (SSEER 3.6)	Air conditioning with high efficiency chiller (SSEER 4.4)
	Ventilation Heat Recovery[22] (where applicable excl. naturally ventilated)		70%	76%
	Demand Control Ventilation		Gas-sensors (Speed-control)	Gas-sensors (Speed-control)
	Space Heating Generator Efficiency		Gas Boiler (91% efficiency)	Gas Boiler (93% efficiency)
	Domestic Hot Water Generator Efficiency		Gas Boiler (91% efficiency)	Gas Boiler (93% Efficiency)
Renewables	**PV Area (% of highest floor roof area)**		0%	40%
	Panel efficiency		NA	20%
	Inclination Above Horizontal		NA	To match pitch of roof (6°)
	Orientation		NA	South
	Type		NA	Monocrystalline
	Ventilation		NA	Moderately Ventilated Modules
	Shading		NA	None or very little (<20%)
	Shading Factor		NA	1.0

15 All values are area-weighted.

16 Rooflight U-values input into the current version of SBEM are based on vertical. SBEM then uses BR 443 conventions to convert to horizontal before simulation. It is proposed that convention is changed so that horizontal U-values are declared by supplies and input into SBEM directly (therefore not needing automatic approximate correction).

17 LOR assumed to be 1 in all cases.

18 Only applied to areas with glazing.

19 Only applied where functionally suitable.

20 Where both daylight-sensing and occupancy-sensing controls apply parasitic power will only be applied once.

21 SSEER includes system delivery losses.

22 Including summer by-pass.

Table 5: Specifications for other Buildings					
Parameter			**Part L 2013**	**Option 1**	**Option 2**
Fabric[23]	**Wall U-Value (W/m²K)**		0.26	0.26	0.18
	Roof U-Value (W/m²K)		0.18	0.18	0.15
	Floor U-Value (W/m²K)		0.22 (unless uninsulated is better)	0.22 (unless uninsulated is better)	0.15
	Window	**U-Value (W/m²K) *including frame***	1.60	1.60	1.40
		G-value	0.40	0.40	0.29
		Light transmittance	71%	71%	60%
	Roof light	**U-Value (W/m²K) *including frame*[24]**	1.80	1.80 (vertical) 2.10 (horizontal)	1.50 (vertical) 1.80 (horizontal)
		G-value	0.55 (top-lit buildings only)	0.40	0.29
		Light transmittance	60% (top lit buildings only)	71%	60%
	Air tightness		3 (depending on building floor area)	5	3
Services	**Lighting luminaire (llm/cW)**[25]		60	95	
	Daylight lighting control[26]		Yes (Single zone daylight dimming)	Yes (Single zone daylight dimming)	
	Occupancy Lighting Control[27]		Yes (Manual on, auto off)	Yes (auto on auto off)	
	Parasitic power of automatic lighting controls[28]		Daylight: lesser of 3% of installed lighting load or 0.3W/m² Occupancy: 0.3W/m²	0.1W/m²	
	Display Lighting (llm/cW) (with time switching)		22	95	
	Cooling SSEER[29] (where applicable excl. naturally ventilated)		Air conditioning with air cooled chiller (SSEER 3.6)	Air conditioning with high efficiency chiller (SSEER 4.4)	
	Ventilation Heat Recovery[30] (where applicable excl. naturally ventilated)		70%	76%	
	Demand Control Ventilation		Gas-sensors (Speed-control)	Gas-sensors (Speed-control)	
	Space Heating Generator Efficiency		Gas Boiler (91% efficiency)	Gas Boiler (93% efficiency)	
	Domestic Hot Water Generator Efficiency		Gas Boiler (91% efficiency)	Gas Boiler (93% Efficiency)	
Renewables	**PV Area (% of highest floor roof area)**		0%	20%	
	Panel efficiency		NA	20%	
	Inclination Above Horizontal		NA	30°	
	Orientation		NA	South	
	Type		NA	Monocrystalline	
	Ventilation		NA	Moderately Ventilated Modules	
	Shading		NA	None or very little (<20%)	
	Shading Factor		NA	1.0	

23 All values are area-weighted.

24 Rooflight U-values input into the current version of SBEM are based on vertical. SBEM then uses BR 443 conventions to convert to horizontal before simulation. It is proposed that convention is changed so that horizontal U-values are declared by supplies and input into SBEM directly (therefore not needing automatic approximate correction).

25 LOR assumed to be 1 in all cases.

26 Only applied to areas with glazing.

27 Only applied where functionally suitable.

28 Where both daylight-sensing and occupancy-sensing controls apply parasitic power will only be applied once.

29 SSEER includes system delivery losses.

30 Including summer by-pass.

4.15. The increase in capital cost of achieving the consultation options, compared with the continuation of existing 2013 standards are shown in Table 6. Further breakdown of the costs of the different elements is provided in Appendix B.

Table 6: Additional Capital Costs (£m^2 Gross Internal Floor Area and %ge increase)

	Part L 2021 Option 1 (22% decrease in CO_2 per building)		**Part L 2021 Option 2** (27% decrease in CO_2 per building)	
Office – deep plan, air conditioned	£9	0.25%	£24	0.68%
Office – shallow plan, naturally ventilated	£10	0.42%	£29	1.14%
Hotel	£18	0.60%	£40	1.32%
Hospital	£7	0.14%	£23	0.51%
Secondary School (includes sports facilities)	£18	0.62%	£36	1.20%
Retail Warehouse	£75	4.15%	£75	4.15%
Distribution Warehouse	£51	2.82%	£51	2.82%
Average (based on build mix)	£25	0.88%	£24	0.68%

Source: Currie & Brown

4.16. The changes in energy use were assessed by using a consultation version of SBEM (cSBEM_v6.0.a Build04) building energy modelling software. Modified carbon emission and primary energy factors were used to rebase the Part L 2013 standard and used to calculate the proposed 2021 standards. These carbon emission and primary energy factors are in Appendix C.

4.17. Two key changes have been implemented through post-processing of the SBEM modelling results to account for proposed changes to SBEM:

- Evidence from the Department for Education has led to the conclusion that the real-world domestic hot water (DHW) demand is lower than the current values used in the National Calculation Methodology (NCM) templates. It was therefore proposed that the NCM templates should be modified to reflect this. The impact of this change will be different in each case as the design of each school will vary. The calculated impact of this change on the modelled school building is a 75% reduction in DHW demand.
- The current Notional Building DHW system has a delivery efficiency of 95%. This is approximately representative of a point-of-use DHW heater with a small amount of storage. In many cases this approach is impractical, for example, a gas-fired system would require a gas supply and flue close to each DHW outlet. With the aim of making the Notional Building DHW system more realistic, the modelling has been based on the following approach:
    - Buildings with a high DHW demand (within the set of modelled buildings, these are the hotel and hospital) have been modified so that the notional building results reflect a realistic centralised DHW system including a storage tank and circulation loop. The length of the circulation loop has been based

on the default equation in the SBEM Technical Manual which is based on the floor area of the building and which gives a conservatively long estimation of loop length. The heat loss from the circulation loop has been set to 8W/m. The DHW storage tank has been sized using the method set out in the Plumbers' Guide document and the tank losses based on factory-fitted 50mm thick insulation.

- Buildings with a lower DHW demand (within the set of modelled buildings, these are the school, both warehouses and both offices), have been modified so that the notional building results reflect a point-of-use electric water heater. Electric point-of-use water heaters are widely used and a more practical solution than gas equivalents. The carbon and primary energy intensity of this solution have been significantly reduced through the proposed changes to the factors for electricity.

4.18. The costs and benefits for Options 1 and 2 compared with continuation of the existing 2013 standards are shown in Table 7. Option 1 has a net benefit of £138m and Option 2 has a net cost of £94m. The net cost for Option 2 arises from additional capital costs but smaller additional energy savings compared to Option 1. It is noted that Option 1 results in additional gas usage and this is principally as a result of more efficient lighting releasing less heat energy and the consequent need for additional heating from the main heating plant.

4.19. In this analysis we have assumed that, in the absence of any policy change, all new non-domestic buildings will continue to be constructed to Part L 2013 standards, and their design specifications reflect those of the notional (reference) building used to set these standards. We consider that the notional building specifications are reasonably representative of buildings constructed to comply with Part L 2013 only.

4.20. However, we do recognise that some non-domestic buildings are being designed to higher standards than Part L. In particular, local planning authorities can apply policies in their local plans which require compliance with energy efficiency standards for new non-domestic buildings that exceed the requirements of the Building Regulations. As an example, the London Plan currently sets a target for major non-domestic developments to be 35 per cent tighter than Part L 2013. As a consequence of this and similar policies, the net benefit identified in this analysis is expected to be over-stated. We will consider this further for the final impact assessment – considering both the number of non-domestic buildings constructed to a higher standard than Part L across England and the extent to which they exceed the current Part L standards.

Table 7: Summary of results from cost benefit analysis (improved Part L standards for new non-domestic buildings)

	Part L 2021 Option 1	Part L 2021 Option 2
Energy savings (£m)	950	1,040
Incremental costs (£m)	(882)	(1,290)
Total financial benefit/(cost) (£m)	**68**	**(251)**
Carbon savings - non-traded (£m)	(108)	(35)
Carbon savings - traded (£m)	91	95

Total carbon savings (£m)	**(17)**	**60**
Air quality savings (£m)	87	97
Net benefit/(cost) (£m)	**138**	**(94)**
Amount of gas saved (GWh)	(8,521)	2,834
Amount of electricity saved (GWh)	30,453	31,756
Amount of CO_2 saved - non-traded ($MtCO_2(e)$)	(1.5)	0.5
Amount of CO_2 saved - traded ($MtCO_2(e)$)	1.4	1.5
Cost effectiveness – non-traded (£/tCO_2)	N/A	120
Cost effectiveness – traded (£/tCO_2)	(33)	126

Source: Currie and Brown

Costs and benefits: Increased fabric standards for existing non-domestic buildings

4.21. For existing non-domestic buildings we have estimated the costs and benefits of the proposed improved standards for new thermal elements.

4.22. The consultation is also proposing to strengthen the standards for replacement of controlled fittings. In particular, the proposal is to strengthen the minimum standard for windows to a U-value of 1.6 W/m^2K. Upon reviewing available products in the markets, windows available were typically of a standard of 1.6 W/m^2K or better. Hence, it is assumed that there is no significant impact of raising this standard.

New thermal elements

4.23. The analysis is based on the impact to the construction of extensions. The proposal is to strengthen minimum performance standards as follows: walls would be built to a U-value of 0.26 W/m^2K; floors to 0.18 W/m^2K; windows/doors to 1.6 W/m^2K. It is estimated that the annual build rate for non-domestic extensions is 5% of the total floor area of the existing non-domestic building stock[31]. The projection of the non-domestic total building stock is shown in Table 8. For the purpose of this analysis, as a counterfactual, we have assumed that currently all works just meet the current standards; the exception being that upon market analysis, where installing windows/doors, they are typically already achieving the new proposed standard.

4.24. Our estimated projection of non-domestic building stock was based on an assumed increase in build rate of 0.28% per annum. The building stock includes offices, hotels, hospitals, secondary schools, retail warehouses and distribution warehouses.

Table 8: Projection of non-domestic total building stock

	Annual floorspace (m^2)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total	586,000,000	591,000,000	596,000,000	600,000,000	605,000,000	610,000,000	614,000,000	619,000,000	624,000,000	624,000,000

Source: Adroit Economics (data provided for 2021 to 2029 only, and assumes floor space in 2030 is the same as in 2029 which will be reviewed for the final impact assessment).

4.25. The energy saving benefits of these policy changes were determined using the consultation version of SBEM. For the purposes of this analysis we added an extension to

[31] It is assumed that the annual build rate for extensions is 0.5% of the total floor area of the existing non-domestic building stock; source: the Part L 2013 consultation impact assessment assumed that extensions will be constructed to between 0.1 and 0.8 per cent of the existing stock of non-domestic buildings each year depending on building type.

the air conditioned office and the school buildings used for the new non-domestic work. The extension to the office building comprises a 2,888m^2 two floor extension on the top of the existing building. The extension to the school building comprises a 1,953 m^2 mainly three floor extension adjacent to the existing building. Our consultants (PRP Architects) developed the plans for these extensions and suggested them as reasonable scenarios for this analysis based on their experience of retrofit projects. Further details of these plans and model specifications are given in Appendix D. The energy savings of improving the standards was determined for each extension. The savings were then scaled up to a national level by assuming that 50% of the floor area nationally was reasonably represented by the office extension and 50% by the school extension. We will review the scaling assumptions for the final impact assessment.

4.26. Details of the costs for the different elements are provided in Appendix B. These costs were scaled up to a national level in a similar approach to the benefits analysis above.

4.27. Table 9 shows the results of this analysis. This shows a net cost of £24m of raising standards for new thermal elements.

4.28. There are several reasons for the energy savings to be small relative to the incremental costs:

- For non-domestic buildings, factors including higher internal heat gains and shorter hours of occupancy (which typically exclude the night-time when it is colder), tend to reduce the space heating demand in comparison to domestic buildings. This limits the energy savings from improved fabric standards.
- The additional external wall insulation required forms the majority of the incremental costs. For the non-domestic building extensions considered here, it is assumed that the external walls have been insulated with a higher performing, thinner insulant which allows a target U-value to be achieved in a thinner wall construction. This type of insulation is particularly prevalent in commercial buildings where the overall footprint is constrained (such as the roof top extension scenario) as the thinner wall can directly translate into more lettable / usable internal area, the value of which is significantly greater than the cost of the insulation.

Table 9: Summary of results from cost benefit analysis (increased fabric standards for existing non-domestic)

	New thermal elements
Energy savings (£m)	4
Incremental costs (£m)	(35)
Total financial benefit/(cost) (£m)	**(31)**
Carbon savings - non-traded (£m)	7
Carbon savings - traded (£m)	(0)
Total carbon savings (£m)	**7**
Air quality savings (£m)	1
Net benefit/(cost) (£m)	**(24)**
Amount of gas saved (GWh)	561
Amount of electricity saved (GWh)	(18)
Amount of CO_2 saved - non-traded ($MtCO_2$(e))	0.10

Amount of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	334
Cost effectiveness – traded (£/tCO_2)	(15)

Costs and benefits: Building services in new and existing non-domestic buildings

Replacement of controlled services

4.29. For existing non-domestic buildings we have estimated the costs and benefits of the replacement/installation of controlled services.

4.30. The analysis is based on the impact to the replacement of the following controlled services:

- ***Ventilation:*** The proposal is to strengthen the minimum standard for specific fan power of typical air handling units to 2.3 W/l/s. It is estimated that there are 4,608 replacements a year (BSRIA).
- ***General lighting[32]:*** The proposal is to strengthen the minimum standard to 95 luminaire lumens/circuit-watt. It is estimated that 1/20th of the floor area of the existing building stock has replacement lighting fittings each year (this is based on the asset-life of 20 years).

4.31. For the purpose of this analysis, as a counterfactual, we have assumed that currently all above services installed just meet the current standards.

4.32. The consultation also proposes improvement to the minimum performance standard for gas boiler efficiencies of between 401kW-2MW output. Boilers are available and already used to deliver these efficiencies. The intention is to remove the poorest efficiency boilers from the market. If necessary, the costs and benefits will be evaluated in more detail in the final impact assessment if significant impacts are identified in the consultation from this improvement in standards.

4.33. The consultation also proposes improvement to the minimum performance standard for comfort cooling. We investigated the impact on split and multi-split air conditioning as this was considered to be the most prevalent type of replacement cooling plant. The proposal is to strengthen the minimum energy efficiency ratio (SEER) to 5.0. In reviewing available products from major manufacturers, the products identified were typically at this improved level of performance or better. Hence, it is assumed that implementing this improved level of performance will not have a significant impact on replacement air conditioning plant.

4.34. The energy saving benefits of these policy changes were determined using the consultation version of SBEM. We assessed the energy savings for replacing the controlled services to the improved standard for the air conditioned office, hotel and hospital buildings. The fabric and services energy efficiency specifications were taken from

[32] Display lighting has not been separately analysed. Typically, display lighting is already being replaced with LED lights and to a similar standard to the improved standard proposed in the consultation. Furthermore, display lighting tends to be used in the retail sector only and thus has a significantly reduced national impact compared to general lighting which is used in all sectors.

the baseline of MHCLG's cost optimal analysis published in 2019[33]. The energy savings of improving the replacement service standards were determined for each service and building type. For lighting, the savings were then scaled up to a national level by assuming that 33% of the floor area nationally was represented by savings achieved from each of the office, hotel and hospital buildings respectively. For the AHU, it was assumed that 50% of the AHUs were installed in buildings similar to offices[34] and 50% installed in buildings similar to hotels. We will review the scaling assumptions for the final impact assessment.

4.35. Details of the costs for the different elements are provided in Appendix B. These costs were scaled up to a national level in a similar approach to the benefits analysis above.

4.36. Table 10 shows the results of this analysis. This shows a net benefit of £411m of raising standards for the replacement of controlled services. This can be broken down into a net benefit of: £50m for replacement AHUs and £361m for replacement lighting. The significant additional gas consumption for replacement services is principally as a result of more efficient lighting releasing less heat energy and the consequent need for additional heating from the main heating plant.

Table 10: Summary of results from cost benefit analysis (increased standards for replacement of controlled services for existing non-domestic)

	Replacement of controlled services
Energy savings (£m) Incremental costs (£m)	1,681 (1,376)
Total financial benefit/(cost) (£m)	**305**
Carbon savings - non-traded (£m) Carbon savings - traded (£m)	(174) 169
Total carbon savings (£m)	**(6)**
Air quality savings (£m)	111
Net benefit/(cost) (£m)	**411**
Amount of gas saved (GWh)	(13,358)
Amount of electricity saved (GWh)	32,795
Amount of CO_2 saved - non-traded ($MtCO_2$(e))	(2.46)
Amount of CO_2 saved - traded ($MtCO_2$(e))	2.90
Cost effectiveness – non-traded (£/tCO_2)	238
Cost effectiveness – traded (£/tCO_2)	(84)

Mandating Self-Regulating Devices (SRDs) for New and Existing Non-Domestic Buildings

4.37. Part 1 of the Consultation evaluated the impact of this policy on new homes. This consultation evaluates the impact on other building works.

[33] DCLG, *Technical housing standards – nationally described space standard*, 2015. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524531/160519_Nationally_Described_Space_Standard____Final_Web_version.pdf; and MHCLG, *Energy Performance of Buildings Directive: Second Cost Optimal Assessment for the United Kingdom (excluding Gibraltar)*, 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770783/2nd_UK_Cost_Optimal_Report.pdf

[34] For the purpose of this analysis, it was assumed that an AHU would typically serve a floor area of around 1000m^2. The office building modelled has a floor area of 12,100m^2. To allow for this difference, the costs and benefits for the office building have both been reduced to 1/12th per building. This approach will be considered further for the final impact assessment.

4.38. Approved Document L2A and the associated Non-Domestic Building Services Compliance Guide currently recommend installing SRDs in new buildings to meet Part L. The policy change is to make this mandatory. It is assumed that all new non-domestic buildings currently install SRDs in practice to meet Part L. As such, it is assumed that there are no significant costs and benefits of this policy change to make such installation mandatory for new non-domestic buildings.

4.39. Likewise, the current Approved Document L2B and the associated Non-Domestic Building Services Compliance Guide, generally recommend installing SRDs in existing buildings when replacing a heat generator to meet Part L. As with new non-domestic buildings, the policy change is to make this mandatory but is assumed that SRDs are already installed in practice to meet Part L for existing buildings and that there are no significant costs and benefits of this policy change to make such installation mandatory.

4.40. Two notable exceptions are electric fan convectors and electric radiant heaters which are installed in a minority of non-domestic buildings. There is currently no recommendation to install SRDs upon the replacement of these heat generators.

Building Automated Control Systems (BACS)

<u>Introduction</u>

4.41. It is proposed to introduced a requirement for non-domestic buildings with heat/cooling systems over 290kW to have an ISO compliant BACS.

4.42. This assessment estimates the net impact of introducing the these requirements in 2021, for (i) new buildings and (ii) existing buildings undertaking relevant building work.

4.43. This assessment assumes that a Class A BACS is ISO compliant[35]. Some existing buildings will already have such a system, but others will have variants which are not ISO compliant. For this analysis, it has been assumed that the typical non-compliant system is a Class C BACS.

4.44. The analysis presented in this impact assessment estimates the costs and benefits of this policy proposal over a 10-year appraisal period. To do this, the analysis estimates:

- the number of new buildings/refurbishments with systems over 290kW
- the proportion expected to have non-compliant BACS under the counterfactual

[35] There are four performance classes of BACS set out in BS EN 15232 from Class A (high energy performance) to Class D (non-energy efficient). Class C is the standard benchmark class and the requirement for Part L 2013. The cost benefit analysis assumes that a Class A BACS system will be installed in buildings to meet the policy requirement. The alternative option would be a Class B system, but it has been assumed that this does not provide sufficient communication functionality, hence it has been assumed that building owners/developers will instead choose to install a Class A system to comply with policy, which does provide sufficient communication functionality. This assessment assumes that the level of communication functionality required is as set out in ISO 16484. This states that a suitable BACS must “allow communication with connected technical building systems and other appliances inside the building, and to be interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers”. The Class B provides for a slightly lesser communication requirement for “some” central-system communication, whereas Class A provides for fuller communication functionality, such as “centralised communication of room-level temperature controls”.

- the cost of upgrading to a compliant BACS
- the benefits of upgrading to a compliant BACS in terms of reduced energy usage and reduced CO_2e emissions.

Number of Buildings Affected

4.45. Table 11 shows the number of new buildings and building refurbishments (which trigger policy) estimated to have systems over 290kW.

Table 11: Number of new build and refurbished buildings with systems over 290kW (2021-2030)

	Commercial Offices	Local Government Buildings	Education	Hotels
New Build	200	1,800	800	100
Refurbishment.	700	3,600	2,100	600
Total	**900**	**5,400**	**2,900**	**700**

Source: Adroit Economics

Counterfactual assumptions

4.46. The analysis needs to calculate the 'net' cost of policy, namely the total cost of BACS installations over the appraisal period, less the costs of those systems that would have been installed anyway, in the absence of the proposed policy (termed the counterfactual).

4.47. Key assumptions made in calculating the counterfactual:

- All buildings installing or replacing heating/ventilation systems over 290kW during the period 2021-30 will also install a BACS system as required by Part L 2013.
- Based on current practice, 95% of new buildings and those undertaking relevant work will be installing a compliant (Class A) BACS.
- Thus, only the remaining 5% of buildings in scope are assumed to install non-compliant (Class C) BACS. It is this 5% of buildings that will be affected by the proposed policy, namely incurring additional installation costs as a result of the policy.

4.48. On this basis, Table 12 suggests that, allowing for the counterfactual, approximately 430 buildings (c. 43 per annum), are expected to be affected by the policy during the period 2021-30 taking into account the phase-in assumptions. This comprises 129 new buildings and 299 existing buildings that are undertaking relevant work.

Table 12: Total Number of Buildings expected to install class C BACS under the counterfactual (2021-30)

	Commercial offices	Local government buildings	Education	Hotels	Total
New Build	8	82	33	6	129
Refurbishment	30	155	91	24	299

Source: Adroit Economics

4.49. The analysis uses the area of building floorspace as the basis for estimating the cost of installing a BACS. Minimum thresholds have been applied based on an estimate of the size of building likely to have a heating/cooling system over 290kW. The analysis assumes that the profile of the size of buildings installing BACS is the same as the existing stock profile.

4.50. Table 13 shows the estimate of the proportion of buildings of different sizes with BACS.

Table 13: Proportion of Buildings with BACS by Size band

sqm	Commercial offices	Local government buildings	Education	Hotels
1,250-2,500	0%	0%	0%	23%
2,500-5,000	53%	17%	43%	30%
5,000-7,500	24%	24%	26%	22%
7,500-10,000	9%	22%	11%	17%
10,000-50,000	13%	20%	10%	7%
50,000+	0%	18%	10%	0%

Source: Adroit Economics

4.51. The analysis multiplies the number of buildings set out in Table 12 by the midpoint floorspace within the size bands set out in Table 13. Table 14 shows the total square meterage of buildings, by building-type, anticipated to install a Class C BACS under the counterfactual during the 10-year appraisal period.

Table 14: Total floorspace of buildings installing BACS Class C (2021-30) – Counterfactual

	Commercial offices	Local government buildings	Education	Hotels
New Build	85,000	2,439,000	866,000	51,000
Refurbishment	197,000	2,701,000	1,080,000	125,000
Total	**282,000**	**5,140,000**	**1,946,000**	**176,000**

Source: Adroit Economics

Estimating the cost of installing BACs

4.52. The analysis estimates the cost of installing a BACS in buildings as follows:

- First, the average cost of a BACS per sqm, for different building types is identified[36].
- Second, an adjustment factor is applied to reflect the fact that the unit cost per sqm tends to be slightly less for larger buildings.
- Third, the weighted installation unit cost is applied to the total square meterage of each building type affected.

4.53. Table 15 shows the average unit cost per sqm for installing a BACS in different types of building. The Class A BACS unit costs were developed based on specifications for BACS systems prepared by SCMS Associates and the unit costs were provided by Robinson Low Francis (RLF). The counterfactual unit costs were subsequently provided by Currie and

[36] Note – it is assumed that the maintenance and operating cost of a Class A and Class C BACS is the same

Brown based on a revised specification prepared by AECOM to reflect a Class C BACS used in this analysis.

Table 15: Unit Cost of installing BACS (£ per sqm)				
	Commercial offices	**Local government buildings**	**Education**	**Hotels**
Counterfactual (Class C)	£97.12	£69.39	£35.76	£47.96
Policy (Class A)	£114.30	£82.45	£52.00	£66.79
Difference	**£17.18**	**£13.06**	**£16.24**	**£18.83**

4.54. Table 16 shows the adjustment factors applied to the average installation cost per sqm, reflecting economies of scale for larger buildings.

Table 16: BACS unit cost adjustment factor	
Sqm	**Adjustment factor**
1,250-2,500	1.20
2,500-5,000	1.15
5,000-7,500	1.10
7,500-10,000	1.05
10,000-50,000	1.00
50,000+	0.95

Source: Robinson Low Francis (RLF)

Estimating the benefits of installing Class A BACS

4.55. The analysis has quantified three benefits that derive from the policy: energy savings, reduced CO_2e emissions and improved air quality.

4.56. Table 17 shows the assumptions used to estimate the energy savings from installing a Class A BACS. The analysis estimates that replacing a Class C BACS with a Class A BACS is likely to result in energy savings of between 20% to 32% depending on the building use[37]. Average energy use per building has been derived from the Building Energy Efficiency Survey 2013/14.

Table 17: Energy use per building type and energy saving assumptions				
	Commercial offices	**Local government buildings**	**Education**	**Hotels**
Energy use for cooling & heating per sqm	143	157	149	199
% saving Class C to Class A BACS	30%	30%	20%	32%

4.57. The analysis estimates the total annual energy savings by multiplying the savings per sqm set out in Table 17 by the area of floorspace as set out in Table 14. The benefits of a BACS is assumed to last for the typical lifetime of the system, 25 years.

[37] BS 15232 Annex A Table A.1

4.58. The value of the energy savings, reduced CO_2e emissions and improved air quality is determined using HMT guidance detailed at the start of this section.

Summary of Results from the Cost Benefit Analysis

4.59. The results of the analysis are shown in Table 18. The analysis suggests that a net benefit of £261m (NPV) is likely to derive from the policy.

Table 18: Summary of results for cost benefit analysis (BACS)	
Energy savings (£m) Incremental costs (£m)	255 (90)
Total financial benefit/(cost) (£m)	**165**
Carbon savings - non-traded (£m) Carbon savings - traded (£m)	60 17
Total carbon savings (£m)	**77**
Air quality savings (£m)	20
Net benefit/(cost) (£m)	**261**
Amount of gas saved (GWh)	4,447
Amount of electricity saved (GWh)	3,638
Amount of CO_2 saved - non-traded ($MtCO_2$(e))	0.82
Amount of CO_2 saved - traded ($MtCO_2$(e))	0.29
Cost effectiveness – non-traded (£/tCO_2)	(243.0)
Cost effectiveness – traded (£/tCO_2)	(763.4)

Technical Building Systems

4.60. When a technical building system is installed, replaced or upgraded, the overall energy performance of the complete system or altered part, as appropriate, should be assessed and the results should be documented and passed on to the building owner. This applies to new and existing buildings. There should be negligible impact of this new requirement as this reflects standard industry practice for commissioning such systems.

Costs and Benefits: Energy forecasting for larger non-domestic buildings

4.61. The proposal is that an energy forecast, using CIBSE TM54 should be required for buildings over 1,000m² of Gross Internal Floor Area (GIFA). The impact assessment seeks to assess the cost associated with this requirement. The cost of undertaking TM54 modelling is strongly influenced by a wide variety of variables, most crucial are:

- **Number of zones in the building**: This is a more important factor than GIFA;
- **Complexity of HVAC systems:** Mechanical ventilation systems are significantly more complicated to model in sufficient detail to accurately predict energy use;
- **Complexity of building usage data:** The quickest/cheapest approach is to use the Part L National Calculation Methodology (NCM) standard assumptions throughout or a bespoke analysis can be undertaken for the particular building;

- **Number of modelling iterations required:** If the client has no specific requirement for the TM54 result then one iteration is sufficient. However, if the intention is to inform the design and meet a specific target then multiple iterations will be needed.

4.62. Considering these four factors, TM54 modelling fees were estimated for three scenarios, a low, medium and high cost [Source: AECOM]:

- **Low cost:** £4,100. Single-zone speculative warehouse, one iteration, NCM assumptions throughout.
- **Medium cost:** £44,800. Open-plan office, three iterations, bespoke building operation modelled.
- **High cost:** £81,200. Large complex hospital, four iterations, bespoke building operation modelled.

4.63. Table 19 shows the results for the Medium scenario. It is based on a build rate of 574 non-domestic buildings per year with a floor area greater than $1000m^2$ [Source: Adroit Economics]. It results in a net cost of £175m. The net costs are proportionate for the Low and High scenarios.

4.64. Energy forecasting should provide estimates of energy consumption which will be better aligned to actual use than estimates based on compliance calculations. This should provide information which developers can use to guide design decisions and which building users can later use to identify where energy consumption is not as anticipated, and where savings can be made. These benefits have not been estimated at this stage, but we will look to include analysis of these in the final impact assessment.

Table 19: Summary of results from cost benefit analysis (energy forecasting)	
Energy savings (£m) Incremental costs (£m)	- (175)
Total financial benefit/(cost) (£m)	**(175)**
Carbon savings - non-traded (£m) Carbon savings - traded (£m)	- -
Total carbon savings (£m)	**-**
Air quality savings (£m)	-
Net benefit/(cost) (£m)	**(175)**
Amount of gas saved (GWh)	-
Amount of electricity saved (GWh)	-
Amount of CO_2 saved - non-traded ($MtCO_2(e)$)	-
Amount of CO_2 saved - traded ($MtCO_2(e)$)	-

Costs and Benefits: Part F standards for non-domestic buildings

4.65. Approved Document F has been modified to update references to the most recent versions of design guidance for non-domestic buildings. It is assumed that current practice is to follow the most recent design guidance. As such, it is assumed that there are no significant costs and benefits of this policy change.

4.66. In addition, an assessment has been made of the impacts of requiring new-build offices to include a ventilation system capable of providing an increased ventilation rate to be used during a period when infection rates are raised, such as in a future pandemic, with the current normal rate to be used at other times. This analysis considers a scenario where ventilation systems are sized to allow an increase in fresh air rates to 50% above the current standard.

4.67. Typical office mechanical ventilation systems do not have sufficient capacity to provide this increase without redesign. For the purposes of this assessment, the impacts have been assumed to follow the affinity laws of fluid flow driven by fans or pumps; in real system design the impacts will not perfectly follow these laws as the range of product sizes available is not infinite and changes in system size may affect other design decisions such as plant location and duct routes etc.

4.68. When considering the design of a system to deliver an increased ventilation rate for extended periods, the system needs to be able to operate adequately in both normal and increased ventilation modes. This can present a number of challenges related to certain components requiring a minimum air speed to work adequately. For example, bag filters need sufficient flow speed to inflate fully and operate efficiently and VAV box control can be challenging at low velocities. All of these challenges can be overcome but the full design implications are harder to quantify.

4.69. The key design impacts considered in this analysis can be summarised as:

- Ventilation system design:
    - Increased duct and AHU cross-sectional area (stated to be linearly proportional to flow rate increase);
    - Fan power demand (fan power demand change is stated to be proportional to the cube of the flow rate change);
    - Ventilation system noise (ventilation system noise is stated to have a logarithmic relationship to flow rate);
- Building design (costs and benefits not quantified):
    - Increased ceiling void height requiring either lower ceiling heights or a taller building height or a combination of both;
    - Increased riser space impacting net lettable area and/or building footprint;
    - Increased plant space requirement impacting net lettable area, building height and/or building footprint;
    - Requirement for larger electrical supply to AHU and building.

4.70. The values shown in Table 20 are based on the sample deep-plan office building used for the main impact assessment for new non-domestic buildings. This calculation has been based on the Option 2 scenario (which is the preferred option for consultation).

Table 20: Impact of increasing maximum ventilation flow			
Change in design maximum ventilation flow rate from current standard		0%	50%
Required increase in duct and AHU dimensions	Cross-sectional area	0%	50%
	Width and height (fixed aspect ratio)	0%	22%
When operating at normal ventilation rate in larger system	Change in fan power demand	0%	-70%
	Change in ventilation system noise	0.00 dB	-1.76 dB
Typical SFPs when operating at normal flow rate (W/l/s) [Assume SFP = 1.8 at maximum flow]		1.8	0.53
When operating at normal ventilation rate in larger system	Modelled fan energy demand (kWh/m²/yr)	12.55	3.72
	Annual gas demand (kWh/yr)	51,241	51,241
	Annual electricity demand (kWh/yr)	428,776	324,592
	Change in total building energy demand	0%	24%
Cost increases	Larger AHU plant for the 12,100m² deep plan office building	£0	£55,000
	Larger diameter ducts [No allowance for building height / size]	£0/m²	£21m²
	Addition of a fan driven HEPA filter in a separate fan-driven filter box prior to the FCU	£0/m²	£23m²

Source: AECOM and Currie and Brown

4.71. Table 21 applies these costs and benefits, scaled to the build-rate for the new-build deep-plan offices used in the Part L analysis earlier in the impact assessment. It shows a net cost of £455m.

4.72. At this stage, no attempt has been made to estimate the potential health benefits and the benefits of allowing ongoing use of these buildings in circumstances when infection risk is high. We will include further commentary on these benefits, and additional analysis as appropriate, in the final impact assessment.

4.73. In analysis to date, the requirement for additional ventilation capacity does not form part of the notional building used to assess compliance against Part L. If this policy was to be adopted, this requirement would be added to ensure that the energy savings achieved by the systems were not realised by subsequent reductions in the performance of other elements which affect Part L compliance.

4.74. The proposed policy also extends these measures to other types of non-domestic buildings where particular activities (e.g. singing, aerobic exercise) are likely to take place. Analysis to date has not taken into account the costs and benefits of extending this requirement to these additional building types which will be examined for the final impact assessment.

Table 21: Summary of results for cost benefit analysis (additional ventilation for offices)	
	50% increased ventilation
Energy savings (£m) Incremental costs (£m)	144 (625)
Total financial benefit/(cost) (£m)	**(481)**
Carbon savings - non-traded (£m) Carbon savings - traded (£m)	- 13
Total carbon savings (£m)	**13**
Air quality savings (£m)	13
Net benefit/(cost) (£m)	**(455)**
Amount of gas saved (GWh)	-
Amount of electricity saved (GWh)	4,267
Amount of CO_2 saved - non-traded ($MtCO_2(e)$)	-
Amount of CO_2 saved - traded ($MtCO_2(e)$)	0.2
Cost effectiveness – non-traded (£/tCO_2)	-
Cost effectiveness – traded (£/tCO_2)	2,322

Costs and Benefits: Overheating in residential buildings

4.75. An exploratory analysis has been produced to investigate the costs and benefits of introducing a new requirement on overheating for residential buildings. This cost benefit analysis is based on a piece of research published by MHCLG: *Research into overheating in new homes*[38]. At this stage, only the benefits derived from increased productivity have been carried forward into the full economic assessments of the policy options and the full cost benefit analysis (Table 1). The inclusion of other costs and benefits will be reassessed for the final impact assessment.

4.76. Within the overheating research[38] the impact of introducing requirements to mitigate the risk of overheating in new homes was assessed as follows:

- The assessment was undertaken on three dwelling typologies in three locations, with two alternative occupancy profiles; this gave 18 cases in total that were used to represent the English new-build housing stock.
- The CIBSE TM59 definition of overheating was used to assess compliance. The overheating risk was assessed based on ‘Category I buildings’, i.e. assuming that the dwellings have a high probability of being occupied by vulnerable and fragile persons at some point over their life.
- Five risk mitigation packages were assessed. These packages prioritised passive measures but also included active cooling. The impact on internal temperatures was modelled using dynamic thermal simulation software to identify those packages that met the CIBSE TM59 criteria for each case.

[38] https://www.gov.uk/government/publications/research-into-overheating-in-new-homes

- The risk mitigation package used in the cost benefit analysis for each case was that which met the CIBSE TM59 overheating criteria at minimum capital cost, though passive strategies were always prioritised over those with active cooling to reduce energy consumption.

4.77. Within this research[38] the benefits modelling comprised two components:

- Reduced mortality: This quantified the benefit from the reduction in the number of deaths due to lower internal temperatures using well defined temperature-mortality functions i.e. relationship between risk of death and daily maximum external temperature.
- Improved productivity: This quantified the productivity benefit from less sleep disturbance at lower night-time temperatures in bedrooms. (See Research into overheating in new homes – Phase 2 report for further details).

4.78. The cost analysis covered the effect on capital costs of risk mitigation measures, replacement costs for active cooling and fabric elements (such as external shading and window replacement), and fuel costs for electricity associated with running active cooling during the summer period.

4.79. The costs and benefits were assessed relative to a counterfactual case where no risk mitigation measures were installed during construction (other than those to meet Part L 2013). It was assumed that a proportion of residents will choose to retrofit room air-conditioners over the building lifetime to address summer overheating.

4.80. This analysis in the research has been updated alongside this impact assessment. The changes made are:

- CIBSE TM59 compliance has been assessed based on Category II, i.e. normal occupancy. This compliance criterion is more reflective of the general population.
- The window opening assumptions used to assess compliance have been amended. Previously the daytime window opening was limited to 30 degrees and this has now been amended to assume windows can be fully opened. This better reflects the potential of the dwelling design in mitigating overheating risk. The night-time bedroom windows were previously modelled with restrictors (maximum opening angle of 10 degrees) to reflect security concerns. This has been amended to allow windows to be fully open on the basis that safety measures, such as the height of window guarding, have been added into the draft overheating Approved Document.
- An additional lower cost risk mitigation package 6 has been included in the analysis. It consists of modifications to window openings: reduced glazing areas in flats (to 20% of floor area) and increase in openable window area in houses (to 20% of floor area); all windows openable in houses and flats apart from the windows in the bathrooms, toilets and en-suites.
- It is assumed that there is no impact of the policy change in London due to London Plan policies currently in place that require all major developments referable to the GLA to demonstrate compliance with CIBSE TM59 requirements.

- The data has been updated to align with the impact assessment that accompanied the Future Homes Standard consultation e.g. house build numbers.
- The most recent (2019) Green Book supplementary guidance: *Valuation of energy use and greenhouse gas emissions* has been used for the appraisal. This aligns with the impact assessment that accompanied the Future Homes Standard consultation.

4.81. The analysis shows that outside of London, the new build house typology modelled complies with the CIBSE TM59 criteria without any risk mitigation measures additional to the average design. It is the flat typologies that, in most cases, do not comply with the TM59 criteria and for these it is only necessary to introduce risk mitigation package 6 (the least cost mitigation package as detailed in the bullets above) to comply.

4.82. The initial analysis undertaken to date indicates an overall net benefit of £1,255m for installing risk mitigation measures at the time of construction relative to the counterfactual scenario. This equates to a net benefit of around £5,147 per dwelling. This net benefit principally arises from the significant capital cost saving from risk mitigation package 6. This mitigation package has a lower capital cost compared to current housing as it is based on a reduction in glazed areas (the cost of glazed elements being more expensive than external walls). This does not take account of the lost amenity from a reduction in glazing; flats are highly glazed because purchasers value large windows. We believe further work is needed to adequately assess this option, and this will be reassessed for the final impact assessment. Hence these costs and benefits have not been included in the full economic assessment and summary Table 1. Further details of the costs assumed are provided in Appendix B.

4.83. At this consultation stage, the benefits analysis carried forward into the full economic assessment and summary Table 1 only includes the benefit of improved productivity. This is summarised in Table 22. The productivity benefits calculated in the research were used to produce estimates of the type needed for this impact assessment. This was done using statistical analysis of the internal temperatures of homes from the research and new modelling.

Table 22: Summary of results for cost benefit analysis (overheating in new homes)	
Costs (£m)	0
Total financial benefit/(cost) (£m)	**0**
Productivity impact (£m)	26
Net benefit/(cost) (£m)	**£26**

4.84. For the final impact assessment, all costs and benefits will be re-examined . We intend to reintroduce the effect on capital costs as well as the mortality benefits and the benefits from avoiding the retrofit of domestic air conditioning.

Costs and benefits: Part L standards for existing domestic buildings

Improved Part L Standards for New Thermal Elements, Replacement of Controlled Fittings, Renovation of Roofs for Existing Dwellings and Building services

4.85. For existing homes we have estimated the costs and benefits of the proposed improved standards for new thermal elements and the replacement of controlled fittings. The standards for replacement services have not been improved beyond those currently required. For the purpose of this analysis, we have assumed that all current building works on new thermal elements are just complying with the existing standard i.e. no works would meet the improved standard in the absence of any changes to the Part L standards. We have assumed that 73% of replacement controlled fittings already meet the new standard[39].

4.86. We are proposing to raise the standard for the renovation of pitched roofs where insulation is between the rafters and for flat roofs or roof with integral insulation, such that they are improved to a U-value of 0.16 W/m^{2}K which is the current minimum standard for pitched roofs with insulation at ceiling level. This is not considered to have a significant cost impact or significantly affect the usability of a loft space e.g. resulting in an additional 10-15mm of insulation below the rafters for pitched roofs. Further analysis will be undertaken for the final impact assessment.

4.87. We are also proposing to require heating systems to be designed to run at 55 °C when they are being fully replaced. This work is thought to be significantly less common than either boiler replacement or individual radiator replacement when one fails. The costs of larger radiators are also thought to be small. Not needing to replace radiators again when low carbon heat is installed is considered to be a benefit. Further analysis will be undertaken for the final impact assessment.

4.88. **New thermal elements.** The analysis is based on the impact to the construction of extensions; the policy change also comprises loft conversions which will be considered further for the final impact assessment. There are approximately 135,000 extensions a year[40] which will be impacted. The proposal is to strengthen minimum performance standards as follows: walls would be built to a U-value of 0.18 W/m^{2}K; roofs to 0.15 W/m^{2}K; floors to 0.18 W/m^{2}K.

4.89. **Replacement of controlled fittings.** The analysis is based on the impact to the replacement of windows and doors. There are an estimated 2,530,000 windows and 580,000 doors replaced a year[41]. The proposal is to strengthen standards to a U-value of 1.4 W/m^{2}K for both windows and doors.

4.90. The energy saving benefits of these policy changes were determined using the consultation version of SAP 10.1[42] for an 84m^2 semi-detached house (the results from the

[39] Based on evidence of window ratings in circulation provided to MHCLG.
[40] MHCLG estimate based on previous Part L impact assessments and planning data
[41] Based on data reported by Competent Person Schemes
[42] https://www.bregroup.com/sap/sap10/

semi-detached home were assumed on average to be representative of the building stock[43] [44]).

- **New thermal elements:** We have modelled an extension of 20m^2, this has been estimated to be a common extension size[45]. The extension was modelled to the rear of the semi-detached property. The energy savings of improving the standards was determined and then scaled up to a national level by the total number of extensions built per year.
- **Replacement of controlled fittings:** Two sets of modelling were undertaken to evaluate the energy savings from improvements to the window standards and door standards respectively. Benefits from replacing the windows and doors in the semi-detached property was then scaled up to a national level by accounting for the total number of windows and doors replaced per year.

4.91. Details of the costs for the different elements are provided in Appendix B. These costs were similarly scaled up to a national level based on the values above.

4.92. Table 23 shows the results of this analysis. The policy changes result in a net benefit of £36m for raising the standards for new thermal elements and a net cost of £28m for raising the standards for replacement windows only.

Table 23: Summary of results from cost benefit analysis (improved standards for existing dwellings)

	New thermal elements	Replacement of controlled fittings	Total
Energy savings (£m)	174	69	243
Incremental costs (£m)	(430)	(182)	(612)
Total financial benefit/(cost) (£m)	**(255)**	**(113)**	**(369)**
Carbon savings - non-traded (£m)	269	79	348
Carbon savings - traded (£m)	-	-	0
Total carbon savings (£m)	**269**	**79**	**348**
Air quality savings (£m)	22	7	29
Comfort taking (£m)	-	(1)	(1)
Net benefit/(cost) (£m)	**36**	**(28)**	**8**
Amount of gas saved (GWh)	20,902	5,764	26,666
Amount of electricity saved (GWh)	-	-	-
Amount of CO_2 saved - non-traded ($MtCO_2$(e))	4	1	5
Amount of CO_2 saved - traded ($MtCO_2$(e))	-	-	-
Cost effectiveness – non-traded (£/tCO_2)	61	100	69
Cost effectiveness – traded (£/tCO_2)	-	-	-

Mandating Self-Regulating Devices (SRDs) for Existing Dwellings

[43] The semi-detached model represents both the semi-detached and end of terrace build forms. Based on the 2017 English Housing Survey, this is the most prevalent build form (35% of the existing build stock). Whilst the mean floor area of the build stock is higher (94 m^2), this figure is impacted by large detached properties and 59% of all dwellings are under 90sqm – hence, aligns well with the size of the semi-detached house adopted here.

[44] The fabric values for the baseline semi-detached home reflect new build standards from ADL 1995.

[45] There is a lack of evidence on the typical size of a domestic extension, a key reason likely being that many are constructed under permitted development rights and planning permission is not applied for. PRP Architects, one of the AECOM-led team of consultants supporting this review, judge that a typical single-storey domestic extension is 20-25m^2 floor area. They suggest that this size also corresponds with the common industry assumption for estimating the size of a single storey extension as 4m x 5m.

4.93. Part 1 of the Consultation evaluated the impact of this policy on new homes. This consultation evaluates the impact on other building works.

Existing dwellings

4.94. SRDs should be installed when replacing a heat generator. It is most typical for a home to have a wet central heating system with a gas boiler and the most common approach to compliance with the new SRD requirement would be to install a room thermostat in one location (say the main living room) and install a thermostatic radiator value (TRV) on all radiators in other locations (except for the radiators in the main living room).

4.95. Installing a room thermostat is already within Approved Document L1B (via the Domestic Building Services Compliance Guide) as reasonable provision to comply with Part L, hence it is assumed that a room thermostat will currently be installed during a boiler replacement, if not present beforehand.

4.96. Approved Document L1B and the Domestic Building Services Compliance Guide currently state that it is good practice to install TRVs during boiler replacement, but the guidance does not suggest that it is necessary to install them to comply with Part L. Hence, there will be an impact of making this practice mandatory.

Number of homes affected

4.97. It is assumed that there are 1,630,000 replacement gas boilers per year in the UK[46].

4.98. Table 24 shows that English homes comprise 83% of the UK stock. Hence, this results in 1,350,000 replacement gas boilers in England per year.

4.99. The number of oil boilers in the English housing stock is 4.5% of the number of gas boilers[47]. Assuming the same asset life of both boiler types, this results in 60,000 replacement oil boilers in England per year.

4.100. Hence, in total, it is assumed that there is 1,410,000 (gas and oil) boiler replacements per year.

Table 24: Existing housing stock	
England	23,950,000 [48]
Scotland	2,590,000 [49]
Wales	1,420,000 [50]
Northern Ireland	780,000 [51]

46 2018, HICC data

47 2017, EHS Data

48 2017, EHS Data

49 2017 https://www2.gov.scot/Topics/Statistics/Browse/Housing-Regeneration/HSfS/KeyInfoTables

50 2017, Housing stock data https://statswales.gov.wales/Catalogue/Housing/Dwelling-Stock-Estimates/dwellingstockestimates-by-localauthority-tenure

51 2017, Department of Finance- NI https://www.finance-ni.gov.uk/publications/annual-housing-stock-statistics

Total UK	28,740,000
Proportion in England	83%

4.101. Two thirds of dwellings already have TRVs present[52]. For the purpose of this analysis, we have assumed a 50/50 split between those homes with a TRV in every room (and thus already comply with the policy), and homes with a TRV in habitable rooms only.

4.102. Hence, it is assumed prior to boiler replacement, homes with TRVs can be presented as three groups as follows:

- Group 1 (TRVs present in all rooms): One third of all homes; 470,000 homes per year.
- Group 2 (TRVs present in habitable rooms only): One third of all homes; 470,000 homes per year.
- Group 3 (TRVs present in no rooms): One third of all homes; 470,000 homes per year.

4.103. The policy will only impact on Group 2 and 3 homes.

Counterfactual

4.104. Without the policy being introduced, some homes in Groups 2 and 3 will voluntarily install TRVs upon boiler replacement.

4.105. 2,200,000 homes have installed TRVs over the last 5 years[53]. Based on this, it is assumed as the counterfactual that 440,000 homes annually upon boiler replacement will put TRVs on either radiators in habitable rooms or radiators in all rooms if the new policy was not introduced.

4.106. It is assumed that there is a 50/50 split between installations in Group 2 and 3 homes:

- Those homes in Group 2 will now have TRVs in all rooms (i.e. move to Group 2 to Group 1)
- Those homes in Group 3 will be split such that 50% move to Group 1 and 50% move to Group 2.

4.107. Therefore those impacted by the policy change, subtracting those homes that are predicted to install TRVs without the policy change, are shown in Table 25.

Table 25: Homes requiring TRVs upon boiler replacement per year			
	Group 1 (Currently have TRVs in all rooms)	Group 2 (Currently have TRVs only in habitable rooms)	Group 3 (Currently have TRVs in no rooms)
Number of boiler replacements annually	470,000	470,000	470,000

52 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/277552/FINALHow_heating_controls_affect_domestic_energy_demand_-_A_Rapid_Evidence_Assessment.pdf

53 https://www.gov.uk/government/statistics/english-housing-survey-2017-to-2018-energy Table 1.11

Voluntary installation of TRVs in Group 2 homes	220,000	(220,000)	
Voluntary installation of TRVs in Group 3 homes	110,000	110,000	(220,000)
Number of homes impacted by the policy per year	None (all 800,000 homes are compliant)	360,000	250,000

Benefits

4.108. An 84m^2 semi-detached house was modelled using the consultation version of SAP 10.1 to assess the baseline energy consumption per home (the results from the semi-detached home were assumed on average to be representative of the building stock). Its fabric and services energy efficiency specifications were taken from the baseline of MHCLG's cost optimal analysis published in 2019[54].

4.109. The 2016 BEIS consultation impact assessment for Boiler Plus[55] proposed a central estimate of 3% reduction in space heating demand through the fitting of TRVs, with a low and high estimate of 0% and 6% space heating demand reduction respectively[56]. In practice, there is limited robust evidence for the level of energy savings from TRVs[57] and there is expected to be significant variation in the achievable savings depending on consumer engagement with their control system.

4.110. The space heating savings are shown in Table 26 for each Group 2 and 3 home based on the central estimate.

Table 26: Benefits from SRD policy	
Space heating with no TRVs	14,910 kwh/yr
Group 3: Space heating saving if home installed with TRVs in all rooms	3% x 14,910 = 447 kwh/yr
Group 2: Space heating saving if home installed with TRVs in non-habitable rooms	155 kwh/yr (This accounts for the fraction of non-habitable floor area in the home)

Costs

4.111. The capital cost for supplying and fitting a TRV is estimated at £25 per TRV when installed as concurrently with a boiler replacement (source: Currie & Brown). Based on the design

[54] DCLG, *Technical housing standards – nationally described space standard*, 2015. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524531/160519_Nationally_Described_Space_Standard____Final_Web_version.pdf; and MHCLG, *Energy Performance of Buildings Directive: Second Cost Optimal Assessment for the United Kingdom (excluding Gibraltar)*, 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770783/2nd_UK_Cost_Optimal_Report.pdf

[55] https://www.gov.uk/government/consultations/heat-in-buildings-the-future-of-heat

[56] See Table B1, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/575300/Short_Term_Domestic_Boiler_2016_Initial_IA.pdf

[57] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/573888/Final_Report_-_Heating_Controls_Scoping_Review_Project.pdf

of the semi-detached home, Group 2 homes required 4 TRVs to be installed and Group 3 homes required 9 TRVs to be installed.

Results

4.112. Table 27 shows the results of this analysis. As can be seen there is a £246m net benefit associated with this policy under the central estimate. Given the significant uncertainty in the energy savings discussed above, the low and high estimates of space heating demand reduction have also been included in this table, noting that the low estimate assumes no energy saving associated with this policy.

Table 27: Summary of results from cost benefit analysis (SRDs)

	Central Estimate of Heat Reduction	Low Estimate of Heat Reduction	High Estimate of Heat Reduction
Energy savings (£m) Incremental costs (£m)	495 (772)	- (772)	991 (772)
Total financial benefit/(cost) (£m)	**(276)**	**(772)**	**219**
Carbon savings - non-traded (£m) Carbon savings - traded (£M)	474 -	- -	948 -
Total carbon savings (£m)	**474**	**-**	**948**
Air quality savings (£m)	48	-	96
Net benefit/(cost) (£m)	**246**	**(772)**	**1,263**
Amount of gas saved (GWh)	36,228	-	72,456
Amount of electricity saved (GWh)	-	-	-
Amount of CO_2 saved - non-traded ($MtCO_2(e)$)	6.7	-	13.3
Amount of CO_2 saved - traded ($MtCO_2(e)$)	-	-	-
Cost effectiveness – non-traded (£/tCO_2)	34	-	(24)
Cost effectiveness – traded (£/tCO_2)	-	-	**-**

Costs and Benefits: Part F standards for existing domestic buildings

Energy efficiency retrofit

4.113. When work is carried out on an existing dwelling, the rest of the building should not be made less satisfactory in relation to Part F requirements (adequate ventilation) than before the work was carried out. However, the current guidance is limited in how to meet this requirement. In discussion with MHCLG's Part F technical working group, it is expected that in many cases where energy efficiency retrofit results in a significant improvement in the airtightness of this property, it results in the under-ventilation of the property which is not suitably mitigated by additional purpose provided ventilation.

4.114. The proposal is to expand the existing guidance to cover the most common circumstances where energy efficiency measures are likely to reduce background ventilation levels and recommend necessary additional ventilation provisions. This is not a policy change, and hence has not been included in the cost benefit analysis. Illustrative costs are given here.

4.115. The guidance has been structured to cover different categories of energy efficiency retrofit projects. Projects defined as either ‘Category B’ and ‘Category C’ are deemed to require additional ventilation as a result of energy efficiency retrofit; Category C projects typically having a greater improvement to the airtightness of the building. Any substantive energy efficiency retrofit project will fall into one of these two Categories.

4.116. Illustrative capital costs have been determined for following the guidance for both Categories for a semi-detached home.

4.117. For Category B cases, it can be met by either natural ventilation or mechanical ventilation. The following assumptions have been used in the costs based on the design of the semi-detached home:

- Natural ventilation: 12 x 5000mm^2 background ventilators (slot-type in head of window), 1 x 15 l/s intermittent fan in bathroom (assumes any original fan needs to be replaced), 1 x 30 l/s intermittent fan in utility room, reconfigure existing canopy in kitchen to duct to outside.
- Continuous mechanical ventilation: 7 x 5000mm^2 background ventilators, 1 x 8 l/s continuous extract in bathroom, 1 x 8 l/s fan in utility room, 1 x 13 l/s extract fan in the kitchen.

4.118. For Category C cases, the natural ventilation solution is not sufficient, however the Category B mechanical ventilation is suitable. However, in this case, it is assumed that the windows will be replaced as part of the retrofit and the background ventilators fitted during manufacture whereas for Category B cases, both for natural and mechanical ventilation, the background ventilators will be fitted in-situ (which incurs a higher cost).

4.119. Based on cost data from Currie and Brown, the following costs have been estimated for Category B and C cases:

- Category B: £1,720 for natural ventilation and £1,645 for continuous mechanical ventilation per home.
- Category C: £1,460 for continuous mechanical ventilation per home. The lower cost for Category C is due to background ventilators being installed during window manufacture.

4.120. Note that these are the additional costs if there has been no consideration of ventilation during energy efficiency retrofit. Where ventilation needs are considered, at least some of these ventilation provisions should already be installed as current practice.

Replacement windows

4.121. Separate guidance is provided when just replacing windows without any other energy efficiency measure.

4.122. The Approved Document currently specifies that where the original windows are not fitted with background ventilators, and the room is not ventilated adequately by other means, it is good practice (not reasonable provision) to fit background ventilators, or an equivalent means of ventilation.

4.123. To help control condensation and improve indoor air quality, the proposal now makes reasonable provision to include additional ventilation when replacing existing windows which either have no background ventilators, or where the size of the background ventilators in the existing window is not known. The Approved Document specifies different minimum equivalent areas of background ventilators tailored to where the dwelling has no continuous mechanical ventilation, continuous mechanical extract ventilation or continuous mechanical supply and extract ventilation.

4.124. To assess the cost of the impact the following has been assumed:

- As for the existing dwelling analysis, 2,530,000 windows are replaced per year.
- Existing dwellings predominantly do not have continuous mechanical ventilation. Hence, assume installation 8000mm^2 of background (trickle) ventilators in each window (the proposal is for a minimum of 8000mm^2 for habitable rooms and kitchens and a minimum of 4000mm^2 for bathrooms).
- 50% of windows currently installed already have sufficient background ventilators and 50% of windows installed do not have any background ventilators installed. Hence, it is only the latter window installations that are subject to this policy.
- The additional cost of installing a window with an 8000mm^2 background ventilator compared to installing a window without a background ventilator is £2 (source: Currie and Brown).

4.125. The results of the cost benefit analysis are shown in Table 28. The analysis suggests a cost of £11m. The benefits have not been quantified and will be considered further in the final impact assessment. The benefits arise from the reduction in the risk of condensation and mould growth, and the improvement in indoor air quality. This benefits the health and comfort of the occupants as well as reducing the risk of damage to the building structure from moisture penetration.

Table 28: Summary of results for cost benefit analysis (replacement windows for existing dwellings)[i]	
Energy savings (£m) Incremental costs (£m)	- (11)
Total financial benefit/(cost) (£m)	**(11)**
Carbon savings - non-traded (£m) Carbon savings - traded (£m)	- -
Total carbon savings (£m)	**-**
Air quality savings (£m)	-
Net benefit/(cost) (£m)	**(11)**
Amount of gas saved (GWh)	**-**
Amount of electricity saved (GWh)	**-**
Amount of CO_2 saved - non-traded ($MtCO_2$(e))	**-**
Amount of CO_2 saved - traded ($MtCO_2$(e))	-

i) n.b. changes to guidance on energy efficiency retrofit (paragraphs 4.113 to 4.120) do not represent policy changes and do not form part of the cost benefit analysis. The results in Table 28 represents all costs and benefits assigned to updates to Part F guidance for existing domestic buildings.

Training

4.126. There are transition costs incurred by businesses to familiarise their employees with the new technical requirements. The overarching methodology for Part L for new non-domestic buildings has not changed e.g. businesses will continue to use SBEM or dynamic thermal models to assess Part L compliance for new non-domestic buildings. Furthermore, the higher standards that will come into force should be able to be met in the main through straight forward amendments to current practices rather than radical changes in the way new buildings are constructed. However, for the new requirements for reducing overheating risk there will be some familiarisation required.

4.127. We assume that training is necessary for developers and associated professional services to design the buildings to the new regulations and requirements and procure the appropriate building components. Also for the supply chain to be ready to meet this demand and for building control to assess the building applications and work.

4.128. Our estimated costs for training and dissemination are based on the previous change to Part L (2013) when applied to non-domestic buildings, both new and existing, which assumes that there will be external training courses and that information from the external course would then be disseminated further internally. These costs can be found in Table 29. In addition, we assume that there will be indirect familiarisation costs associated with employees learning how the changes would affect their work; and also for small builders, we assume an initial cost associated with rejected building applications due to error in not updating to new standards.

4.129. It is thought that people will attend one training course on all regulatory changes for homes. The training costs for the new requirement for overheating in new residential buildings are therefore already included in the impact assessment accompanying the Future Homes Standard consultation. There are only minor changes to the standards for existing homes. It is thought that the training costs would likely be covered in the same training course as that for new homes. Further to this the main part of industry engaged in the work on existing homes are smaller builders. These smaller builders are often informed about changes through building control (e.g. through feedback on building application) and builders' merchants.

Table 29: Transitional training cost to business (£m)	
	Cost of non-domestic policies – Part L (£millions) (2020 price year)
External Training Cost	0.44
Internal Training Cost	0.67
Total Training Cost	1.10
Familiarisation Cost	1.24
Application Cost to Small Builders	0.81
Total	**3.14**

4.130. Please note however that this estimate needs to be treated with caution as the scale and process for training and dissemination may be different for this set of regulations; we may use information gathered during consultation to produce a more robust analysis to inform the final impact assessment.

Transitional arrangements

4.131. The consultation seeks views on transitional arrangements for new standards and regulations. This will be reviewed in more detail for the final stage impact assessment, considering the consultation responses.

Comfort taking

4.132. Comfort taking is when reduction in heating bills leads to some householders choosing to heat their homes to higher temperatures. We have adopted the approach taken in the Green Deal impact assessment[58] of 15 per cent comfort taking for existing dwellings, albeit noting that the analysis was based mostly on existing social housing rather than the privately rented or owner-occupied stock. This is applied to the replacement of doors and windows, but not the implementation of SRDs (as this measure is the one controlling the temperature of rooms), and not the analysis on extensions (as heating bills are not assumed to be significantly reduced).

4.133. When valuing comfort taking, the full retail price of energy/fuel is used since it is to be assumed that consumers are willing to pay at least the full retail price for the welfare gains achieved through higher energy/fuel consumption.

4.134. We have not included comfort taking for analysis of non-domestic buildings because users do not tend to control their indoor environment.

Direct Cost To Business

4.135. The equivalent annual net direct cost to business (EANDCB) for the combination of all proposals is calculated for each option and is shown in the summary tables. For our preferred option (Option 2), there is a net annual cost to business of £94.5m. This is largely driven by the proposed changes to ventilation, which has total present value financial costs of £481m.

[58] Department for Business, Energy & Industrial Strategy, 2012. Green Deal: final impact assessment. Available online: https://www.gov.uk/government/publications/green-deal-impact-assessment

Wider Impacts

Economic and financial impacts

COVID-19

5.1. The impacts of the outbreak of COVID-19 have been varied but uncertain. Although this has had an immediate economic impact, the long term effects are still unclear. Much of the analysis and data used in this impact assessment predates COVID-19, and therefore has not taken into account any of the potential economic impacts of the pandemic. If these longer-term impacts become clearer before the final impact assessment, there may be the opportunity to reflect in the modelling.

Competition

5.2. The principal markets affected by this 2021 policy are the markets for the development of new non-domestic buildings and the refurbishment of all existing buildings. The supply chains for the production of materials used in the identified markets may also be affected, and will likely need to change the types and number of different products they supply (for example, different thicknesses of insulation, or higher performance materials).

5.3. The proposed higher standards will mean that building contractors will have to comply with more stringent energy efficiency and building emissions targets: as a result of this, some capital costs, for example where additional materials are required, may rise. The need to develop and employ different construction techniques and methods may also result in additional time and financial cost to developers. In addition, we are introducing new requirements to mitigate the risk of overheating in new residential buildings: however costs are predicted to be neutral or positive. As the changes in costs are expected to affect all building contractors equally, any competitive effects in the market for building development are likely to be negligible. However, it is possible that smaller developers with less buying power may face proportionally higher cost increases than larger businesses. This is considered separately in the section below on small businesses.

5.4. The improved efficiency standards may have an impact on manufacturers and suppliers to the construction industry by increasing the demand for higher specification materials and products. Suppliers of low cost or low quality products and materials may be adversely affected by the change in regulations because developers will use them less frequently. However, the change in regulations is also expected to provide opportunities for manufacturers and suppliers of low/zero carbon generation technologies and high energy efficiency products.

5.5. The introduction of new requirements to mitigate the risk of overheating in new residential buildings is expected to increase demand for products to reduce solar gain. There are a number of alternative solutions (such as lower g-value glazing and various methods of internal and external solar shading) and suppliers which should help ensure a competitive market for such products.

Innovation

5.6. Particularly with respect to raising the Part L standards for new non-domestic buildings, there should be the potential for new firms to enter the market due to the setting of higher standards and the flexibility for developers to choose building technologies to meet these standards. This should encourage innovation among manufacturers.

5.7. The proposed options for new non-domestic buildings would likely result in an increased use of low and zero carbon generation technologies. There is competition in the supply of such technologies with a mix of large and small suppliers. As the cumulative production of such technologies rises, learning effects coupled with competition should bring down the unit cost. This learning effect has been built into our modelling of costs.

5.8. The introduction of new requirements for the mitigation of overheating, and the increase in demand for solutions such as lower g-value glazing and solar shading, should similarly encourage innovation among manufacturers to improve performance and/or reduce costs.

Small businesses

5.9. Small businesses affected by the policy options considered in this impact assessment principally comprise of developers, constructors, architects, engineers and other technical specialists. The impacts of a change in building standards are likely to be most significant for developers as any change in costs will affect their cost of business. For other parties, impacts are most likely to comprise a short term need to understand and revise practices to reflect the new requirements, however this is unlikely to be above the level that would be typically expected as part of ongoing professional development.

5.10. The policy options most likely to affect small businesses will be those related to extensions where work is dominated by small construction and design practices. This is particularly the case for domestic extensions but is also often the case with extensions to non-domestic space. The policy options considered in this IA may affect the cost of extension projects or replacement of controlled services because the capital cost of some of the products required will be higher than those assumed in the counterfactual scenario. However, these costs will be passed on to the project client as part of the cost of the project, assuming that the work is undertaken on typical terms for a standard small building project. The client incurring these additional costs would often also be the stakeholder receiving the associated benefit from reduced operational energy consumption. The additional cost of the uplifted policy option is around 0.7% of the overall costs for domestic extensions and, on average, 0.1% for the assessed non-domestic extensions[59]. There is no mitigating action being taken because these costs will be likely passed from the small business onto the client.

[59] For the two non-domestic extensions modelled, the costs were 0.14% and 0.03% (average 0.085%).

5.11. Some new non-domestic construction will be undertaken by small businesses. The policy options under consideration are unlikely to have a more significant impact on smaller business in comparison to larger ones in that they largely relate to product selection and use. Therefore they would be subject to the same economies of scale that are present in the market currently.

5.12. We intend to use the consultation process to gather up-to-date information about the effects of the regulations on small business. It is worth noting that in the responses to the consultation in Part L 2013, small and micro businesses preferred less significant changes to energy performance standards for each of new and existing, domestic and non-domestic buildings, which seems to indicate that these businesses will be disproportionately impacted by these types of changes involving increases in standards. Although the Building Regulations are not designed to provide explicit support to different types of business, we are able to mitigate these impacts through enhanced levels of engagement with the sector. Ahead of implementation we will continue to work with all parts of industry to identify risks, work through potential mitigations and successfully implement the new standard.

Social impacts

Housing supply

5.13. Of the policies included in this assessment, only overheating is of direct relevance for the supply of new homes. We do not believe that the introduction of this measure will have a material effect on the supply of homes. Other measures proposed for new non-domestic buildings will impact the construction industry more generally, but we do not anticipate these will result in impacts on housebuilding and housing supply.

Health and well-being impacts

5.14. There should be a reduction in the risk of overheating in new residential buildings and consequently improvement to occupants' health, welfare and productivity.

5.15. There are improvements in indoor air quality, and consequently occupants' health and well-being, from the proposed changes to Part F. In particular, the additional guidance for existing dwellings should improve compliance and reduce the risk of under-ventilation following energy efficiency upgrades. The proposed measures to allow protection against airborne infections are likely to provide additional health benefits during periods of increased risk of transmission.

5.16. There are also potentially beneficial improvements in health and quality of life from the effect of increased energy efficiency on thermal comfort. We do need to be mindful of the potential effects that tighter building envelopes could have upon indoor air quality and indoor temperatures in summer. Hence the parallel review of Parts F and L, and the consultation on new requirements and guidance to reduce the risk of overheating in new residential buildings.

Environmental impacts

5.17. The environmental impacts are central to this policy and are therefore covered in the main body of this impact assessment.

Administrative burdens

5.18. Administrative burdens are identified as the costs to businesses from legal requirements to provide information.

5.19. For Part L we propose that the energy performance of installed building services should be assessed, documented and passed on to the building owner. It is already a Building Regulations requirement to carry out commissioning and to collate information. This change represents a formalisation of existing commissioning practices and means that the information will be handed over to building owners. The additional burden is assumed to be nil.

5.20. For Part F, this consultation is proposing to introduce new mandatory requirements on the developer or installer to provide information about the commissioning of ventilation equipment to the building owner in non-domestic buildings and when work is done to existing homes. There are costs associated with collating, emailing and printing; but these are believed to be minimal. The benefits of improved compliance would likely outweigh the costs significantly.

5.21. The consultation proposes a new regulation to require information on the overheating strategy to be given to the owner of a new residential building. There may be costs associated with collating, emailing and printing this information but these are believed to be minimal due to this information being readily available from the design. Further, some of this information may overlap with that being given for the purposes of ventilation and energy efficiency. Once this is collated for one dwelling it can be reused for any with the same design. It is estimated that this will cost in the order of <£10 per dwelling. The benefits gained from occupants using their overheating strategy effectively would likely outweigh the costs significantly.

Appendix A – Floorspace Projections

Below is the independent analysis conducted by Adroit Economics of floorspace projections broken down by building type. This is used in our cost benefit modelling.

Table A.1: Assumed projection of floorspace by building type

Building Type	Annual floorspace increase (000m^2)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Office – deep plan, air conditioned	979	979	979	979	979	979	979	979	979	979
Office – shallow plan, naturally ventilated	527	527	527	527	527	527	527	527	527	527
Hotel	392	396	400	404	408	412	416	420	424	428
Hospital	396	397	398	399	399	400	401	402	403	404
Secondary School (includes sports facilities)	654	659	663	668	673	678	683	688	693	698
Retail Warehouse	326	327	328	329	331	332	333	334	335	336
Distribution Warehouse.	870	872	875	878	880	883	885	888	891	893

Source: Adroit Economics

These estimates of new build completions are produced by an independent consortium. They are indicative and should be used for appraisal purposes only and do not represent an official forecast of changes in supply.

Please note, these projections are not an estimate of the net change in building stock. They do not account for changes of use, conversions or demolitions, which are all elements of net change in stock but are outside the remit of this impact assessment; nor do they capture the impact of policy interventions that could increase industry's capacity to build new buildings.

Appendix B – Cost Breakdown

General (with the exception of overheating analysis)

The developed costs are based on the expert view of Currie & Brown's cost specialists, drawing on evidence from their internal cost datasets, recent published cost data and information provided by suppliers.

The cost analysis is intended to reflect typical national costs from Q2-3 2019 that might be incurred by medium sized housebuilders or developers using traditional (i.e. masonry) construction methods and with a reasonably efficient supply chain, design development and construction processes. However, costs incurred by individual organisations will vary according to their procurement strategies, the location of their activity (e.g. costs will be higher in London and the South East of England) and the detail of their product. These variations in design, location and delivery method could result in a cost range of +/- c.30% or more for domestic buildings and +/-c20% for non-domestic buildings. Notwithstanding these variations, the proportional uplifts associated with moving from one specification to another are likely to be similar across different market segments[60].

To provide context to the cost variations assessed in the study an indicative overall build cost (£ per m^2) for each building archetype was estimated using Currie & Brown internal data. This figure is indicative of the level of cost that might be expected for a building built in accordance with the requirements of Part 2013. The build cost should be taken as indicative only as it is sensitive to a wide range of design and specification variables in addition to the economies of scale and regional variations discussed previously.

Base costs for future years are those for the 2019 price year, and subject to adjustments for learning for technologies that have not yet reached a mature market position. It should be noted that construction costs can vary considerably and rapidly with market conditions, particularly where activity levels result in a change in the availability of skills and materials. In these situations, it is not unusual to see quite large (several percentage points) change in overall costs over a period of months.

[60] Costs increases may be outside the described range for highly bespoke designs, however these homes are typically more expensive to build and so the relative impact on build costs may be similar or potentially smaller than for more typical homes built in higher volumes.

Table B.1 includes details of the cost information used for new non-domestic building specification options, including any variations between building type, costs are only shown for those specifications that vary between the considered options.

Table B.1: Cost data for elements that vary between the selected specifications for new non-domestic buildings

Element	Specification	Unit	New cost (£ per unit)
Masonry External Wall – two dense block work leaves with insulated cavity and render finish	0.26 $W/m^2.K$	m^2 (element)	£232
	0.18 $W/m^2.K$		£239
Metal Frame External Wall – rainscreen, insulated cavity, particle board, metal stud wall and plasterboard	0.26 $W/m^2.K$	m^2 (element)	£359
	0.18 $W/m^2.K$		£375
Ground Floor – insulation and concrete slab and hardcore	0.22 $W/m^2.K$	m^2 (element)	£61-70 depending on building type[61]
	0.15 $W/m^2.K$		£66-76 depending on building type[61]
Raised Exposed Floor – insulation and concrete slab and screed	0.22 $W/m^2.K$	m^2 (element)	£41
	0.15 $W/m^2.K$		£46
Flat roof – membrane, insulation, concrete deck	0.18 $W/m^2.K$	m^2 (element)	£214
	0.14 $W/m^2.K$		£216
Pitched warehouse roof – insulated steel panels	0.18 $W/m^2.K$	m^2 (element)	£53
	0.14 $W/m^2.K$		£71
Windows – including frame	1.6 $W/m^2.K$	m^2 (element)	£570
	1.4 $W/m^2.K$		£600
Airtightness	5 m^3 m^2 hr	m^2 Gross Internal Floor Area	£0
	3 m^3 m^2 hr		£5
Light fittings - general	60 llm/cW	m^2 lit floor area	£59 (£53 in Warehouses)
	95 llm/cW		£67 (£60 in Warehouses)
Light fittings - display	22 llm/cW	m^2 lit floor area	£45
	95 llm/cW		£60
Light controls - occupancy	Manual on / auto off	m^2 controlled floor area	£2.5
	Auto on / off		£0
Cooling - air cooled chiller	SEER 3.6	kW capacity	£160
	SEER 4.4		£180
Ventilation heat recovery	70%	m^3/second delivered air	£8,000
	76%		£8,200
Gas boiler	91%	kW capacity	£45
	93%		£45
Roof mounted - photovoltaic panels mounted on frames on accessible concrete flat roof	Variable costs for systems >4kWp	Per kWp installed	£1,100

[61] The specification required to achieve the target u value varies as a result of the differing floor area to perimeter ratios in each archetype building.

Table B.2 includes details of the cost information used for domestic and non-domestic extension specification options and for replacement of controlled windows or doors in homes. The tables only show those specifications that vary between the considered options.

Table B.2: Cost data for elements that vary between the selected specifications for domestic and non-domestic extensions			
Element	Specification	Unit	Cost (£ per unit)
Domestic external wall – brickwork external leaf and mineral wool insulation	0.28 W/m².K	m² (element)	£189
	0.18 W/m².K		£194
Non-domestic external wall – rendered blockwork external leaf and PIR insulation	0.28 W/m².K		£230
	0.26 W/m².K		£232
Ground Floor	0.22 W/m².K		£139
	0.18 W/m².K		£143
Domestic pitched roof	0.18 W/m².K		£175
	0.15 W/m².K		£177
Non-domestic flat roof	0.18 W/m².K		£260
	0.15 W/m².K		£262
Windows	1.6 W/m².K		£230
	1.4 W/m².K		£240
Doors (partially / unglazed) – composite only	1.8 W/m².K	Per door	£830
	1.4 W/m².K		£850

Table B.3 includes details of the cost information used for replacement of controlled services in non-domestic buildings, including any variations between building type, costs are only shown for those specifications that vary between the considered options.

Table B.3: Cost data for elements that vary between the selected specifications for domestic and non-domestic extensions			
Element	Specification	Unit	New cost (£ per unit)
Ventilation – air handling units – small ($1m^3/s$) excluding any heat recovery systems[62]	2.6 W/l/s	m^3 / s	£14,500
	2.3 W/l/s		£16,000
Ventilation – air handling units – large ($13m^3/s$) excluding any heat recovery systems	2.6 W/l/s	m^3 / s	£3,900
	2.3 W/l/s		£4,300
Lighting – general – including fittings but excluding common works such as removal of existing fittings, etc.	60 llm/cW	m^2 Gross Internal Floor Area	£59
	95 llm/cW		£67

[62] It should be noted that specifying air handling units to deliver a specified fan power performance is complex and involves a wide range of project specific parameters. In this study it was assumed that no associated works to ducting were undertaken and that reductions in fan power per m3 supplied is achieved through the specification of high quality units and potentially increasing the unit size to enable it to operate more efficiently.

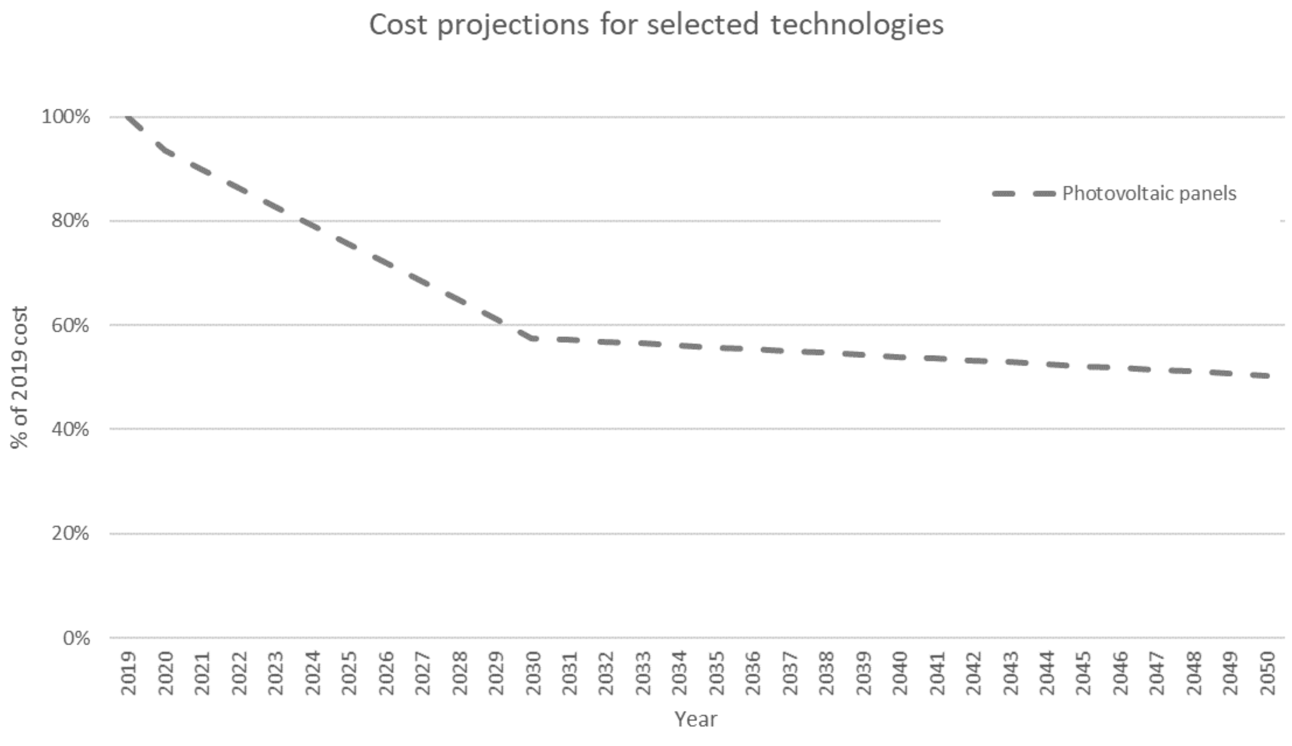
Cost projections

Cost projections were assigned to each specification option to capture any expected change in the current cost over time. For many building elements no adjustment was applied to the current costs because the technology is deemed mature and unlikely to experience a significant reduction in cost per unit of performance. This does not mean that cost in the future will be unchanged, only that it is not projected to change in a manner that is disproportionate to the wider construction cost base.

For less mature specifications, the potential for future reductions in cost through learning was assessed based on existing published cost projections or by applying appropriate learning rates to global market projections.

Figure B.1 shows the future cost projections of photovoltaic panels technologies which was the only technology relevant to this consultation where learning rates were applied. These cost projections are relative to 2019 costs and do not account for other economic and market factors that will impact costs over this period (e.g. market conditions, interest and exchange rates, skills availability and commodity prices).

Figure B.1 Projected variation in base costs as a result of learning



Overheating analysis

The costs for this analysis are based on the cost data from the previous research and are tabulated below. The costs were estimated based on Spon's Architects' and Builders' Price Book 2018 and internal AECOM residential cost data. Costs are based on Q1 2018 outer London prices and include 12% uplift for preliminaries and 10% for overheads and profit. The build cost should be taken as indicative only as it is sensitive to design and specification variables in addition to the economies of scale and regional variations as discussed previously at the start of this Appendix.

Table B.4: CIBSE TM59 compliant risk mitigation measures (Package P6)		
Dwelling form	Dual aspect flat	Single aspect flat
Cost of package[a] (£)	-2,100	-250
Cost assumptions	Cost calculations based on a rate of - £295/m^2 for fixed (non-openable) windows - £350/m^2 for openable windows - £200/m^2 for masonry external wall	

[a] Includes the cost savings from reduced glazed areas, where applicable

Appendix C – Primary energy and carbon factors

The below tables contain the calculated primary energy and CO_2 emission factors used to develop the Part L 2021 options; these can also be found in cSAP and cSBEM.

Table C.1: Primary energy factors for electricity used in the analysis [kWh/kWh]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Standard tariff	1.602	1.593	1.568	1.530	1.487	1.441	1.410	1.413	1.449	1.504	1.558	1.604
7-hour tariff (high rate)	1.635	1.626	1.600	1.562	1.518	1.471	1.440	1.443	1.479	1.535	1.591	1.637
7-hour tariff (low rate)	1.521	1.512	1.488	1.453	1.411	1.368	1.339	1.342	1.376	1.428	1.480	1.522
Electricity sold to or displaced from grid, PV	1.715	1.697	1.645	1.567	1.478	1.389	1.330	1.336	1.405	1.513	1.623	1.718

Source: BRE, CO_2 and Primary Energy Summary Tables for AECOM 2019_04_26

Table C.2: Primary energy factors for other fuels used in the analysis [kWh/kWh]

	PEF
Mains gas	1.130
LPG	1.141
Heating oil	1.180

Source: BRE, CO_2 and Primary Energy Summary Tables for AECOM 2019_04_26

Table C.3: Primary energy factors for renewables in the analysis [kWh/kWh]

	PEF	Description of Application in Analysis
Renewable heat on-site	0	Applied to heat pumps and solar thermal. Both technologies offset demand and therefore primary energy for other heating fuels.
Renewable electricity on-site	0	PV – applied to portion of electricity generated by PV and used on-site (as calculated in draft National Calculation Methodology). The total electricity generated by PV also offsets grid-supplied electricity at the 'electricity sold to or displaced from grid, PV' PEFs in Table C.1 above.
Renewable electricity off-site (as part of grid mix, or exported to grid)	1	Affects grid electricity factors in Table C.1 above. PV – applied to portion of electricity generated by PV and exported to grid (as calculated in draft National Calculation Methodology). The total electricity generated by PV also offsets grid-supplied electricity at the 'electricity sold to or displaced from grid, PV' PEFs in Table C.1 above.

Source: BEIS/MHCLG, 21/06/19

Table C.4: Carbon emission factors for electricity used in the analysis [$kgCO_2e/kWh$]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Standard tariff	0.163	0.160	0.153	0.143	0.132	0.120	0.111	0.112	0.122	0.136	0.151	0.163
7-hour tariff (high rate)	0.171	0.168	0.161	0.150	0.138	0.125	0.117	0.118	0.128	0.143	0.158	0.171
7-hour tariff (low rate)	0.143	0.141	0.135	0.126	0.116	0.105	0.098	0.099	0.107	0.120	0.133	0.144
Electricity sold to or displaced from grid, PV	0.196	0.190	0.175	0.153	0.129	0.106	0.092	0.093	0.110	0.138	0.169	0.197

Source: BRE, CO_2 and Primary Energy Summary Tables for AECOM 2019_04_26

Table C.5: Carbon emission factors for other fuels used in the analysis [$kgCO_2e/kWh$]

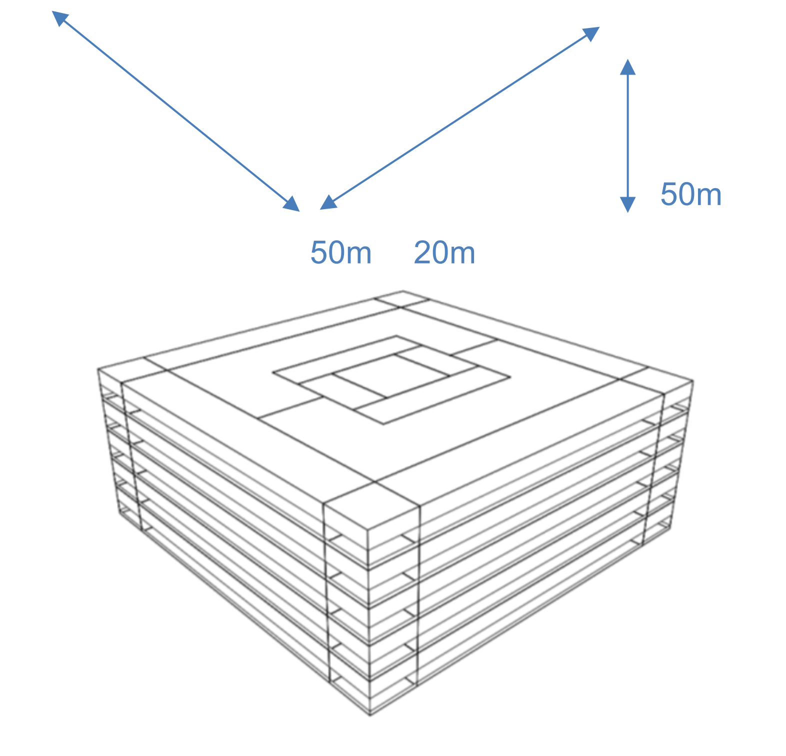
	CEF
Mains gas	0.210
LPG	0.241
Heating oil	0.298

Source: BRE, CO_2 and Primary Energy Summary Tables for AECOM 2019_04_26

Appendix D – Descriptions of the non-domestic extensions

Deep-Plan Office

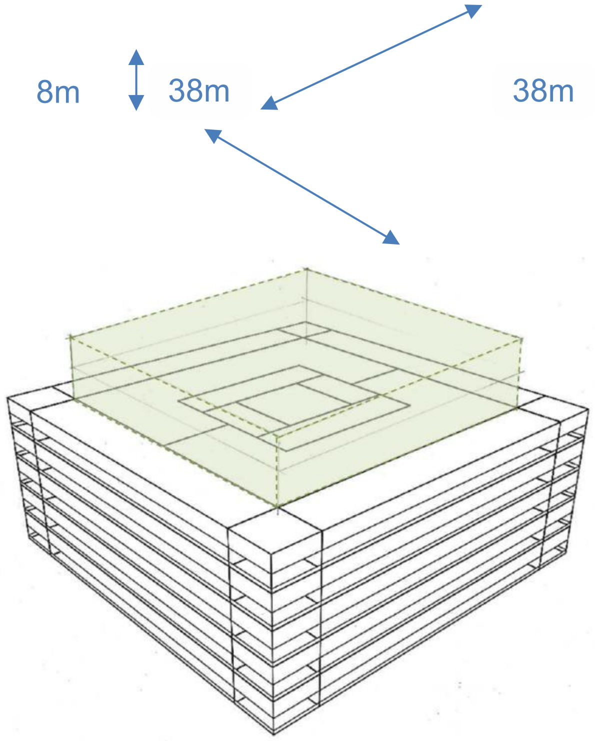
The existing office building is based on the deep-plan office building used in the impact assessment modelling for new non-domestic buildings with changes in specifications implemented to reflect an older building. This is a square five-storey building with strip glazing running around all four sides. A central atrium with 100m² footprint runs through the centre of the floorplate. The form of the existing part of the office building is described in Figure E.1.



Storeys:	5
Floor area:	12,100m²
Ground floor area:	2,500m²
Roof area:	2,500m²
External wall area:	4,000m² (includes glazing)
Glazed area:	1,500m²

Figure E.1: Screenshot of the office building form used for new non-domestic modelling

The modelled extension to this office building is a two-storey roof-top extension which is stepped back from the perimeter of the existing building. This extension includes a continuation of the central atrium through both new floors. The form of this extension is presented in Figure E.2.



Storeys:	2
Floor area:	2,688m² (excludes atrium void)
Ground floor area:	0m²
Roof area:	1,444m²
External wall area:	1,216m² (includes glazing)
Glazed area:	456m²

Figure E.2: Sketch of the office building form used for the existing building modelling with an extension

The building performance parameters for the existing building are based on the Energy Efficiency 2 (EE2) standard set out in Table 8.5d for an air-conditioned hotel in the *Energy Performance of Buildings Directive, Second Cost Optimal Assessment for the United Kingdom (2018)*. The cost optimal work did not include an air-conditioned office. The source data for the air-conditioned hotel was selected in preference to the naturally-ventilated office building because this is a reasonable proxy for an air conditioned office, and it was felt that the servicing strategy has a stronger influence on the building performance and the naturally-ventilated building lacks several of the necessary parameters.

Table E.1 shows the key building performance parameters for the modelled existing building and the two variations on the modelled extension. The baseline comprises, in general, the current standards for new thermal elements; the exception is that the window specification is U=1.6 W/m^{2}K as whilst the current standard is U=1.8 W/m^{2}K, windows available on the market were found to be typically of a standard of U=1.6 W/m^{2}K or better. The proposal allows for improvements in the current standard, allowing for increases for both the thermal performance of external walls and glazing. The specification of building services for the extension is based on the current minimum Part L requirements for an extension of this type, and it is assumed that an extension of this size would require additional central HVAC plant.

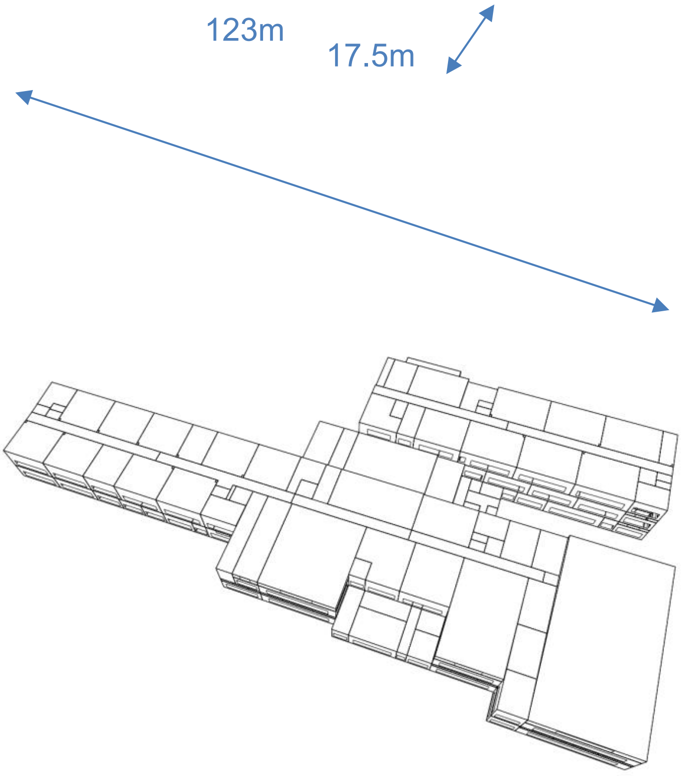
Table E.1: Key building performance parameters for the modelled office building and extension

Building Parameter		Existing Building	New Extension Options	
			Baseline	Proposal
Fabric	Roof U-value (W/m²K)	0.60	0.18	0.18
	External Wall U-value (W/m²K)	0.45	0.28	0.26
	Ground Floor U-value (W/m²K)	0.45	NA	NA
	Glazing U-value (W/m²K)	3.30	1.60	1.60
	Glazing G-value (W/m²K)	0.70	0.70	0.70
	Air tightness (m³/m²hr @50Pa)	15	15	15

HVAC	**HVAC system type**	Fan Coil Units	Fan Coil Units	Fan Coil Units
	Heating SCOP	0.78	0.86	0.86
	Cooling SSEER	2.20	4.00	4.00
	Central Specific Fan Power (W/l/s)	2.20	2.20	2.20
	Terminal Unit Specific Fan Power (W/l/s)	0.30	0.30	0.30
Lighting	**Lighting Efficacy (llm/cW)**	40	60	60
	Automatic Lighting Controls	None	Manual-on-auto-off	Manual-on-auto-off
	Automatic Lighting Controls Parasitic Power (W/m²)	NA	0.1	0.1

Secondary school

The existing school building is based on the secondary school building used in the impact assessment modelling for new non-domestic buildings with changes in specifications implemented to reflect an older building. This is a school with three wings emanating from a central core where dining, catering and office spaces are located. Two of the wings contain classrooms whilst the third is dominated by a double-height sports hall. Most of the building is two storeys, but one wing is three storeys and there are some areas which are a single storey high. The form of the existing part of the school building is described in Figure E.3.

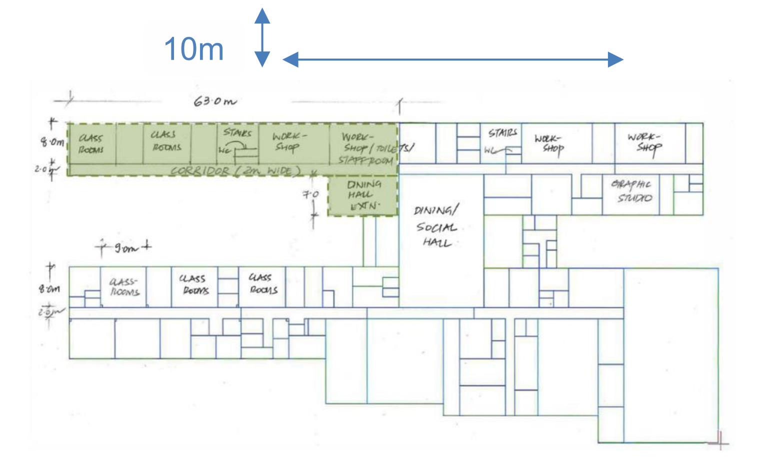


Storeys:	1 to 3
Floor area:	8,012m²
Ground floor area:	4,379m²
Roof area:	4,379m²
External wall area:	4,247m² (includes glazing)
Glazed area:	1,271m²

Figure E.3: Screenshot of the school building form used for new non-domestic modelling

The modelled extension to this office building is a two-storey roof-top extension which is stepped back from the perimeter of the existing building. This extension includes a continuation of the central atrium through both new floors. The form of this extension is provided in Figure E.4.

63m



Storeys:	3
Floor area:	1,952m²
Ground floor area:	719m²
Roof area:	719m²
External wall area:	1,550m² (includes glazing)
Glazed area:	527m²

Figure E.4: Sketch of the school building form used for the existing building modelling with an extension

The building performance parameters for the existing building are based on the Energy Efficiency 2 (EE2) standard set out in Table 8.5b for a secondary school in the *Energy Performance of Buildings Directive, Second Cost Optimal Assessment for the United Kingdom (2018)*; this standard is, in turn, based on the BRE Energy Conservation Guides.

Table E.2 shows the key building performance parameters for the modelled existing building and the two variations on the modelled extension. The baseline comprises, in general, the current standards for new thermal elements; the exception is that the window specification is U=1.6 W/m^{2}K as detailed for the office building above. The proposal allows for improvements in the current standard, allowing for increases for the thermal performance of external walls, ground floor and glazing. The specification of building services for the extension is based on the current minimum Part L requirements for an extension of this type, and it is assumed that an extension of this size would require additional central HVAC plant.

Table E.2: Key building performance parameters for the modelled school building and extension

	Building Parameter	Existing Building	New Extension Options	
			Baseline	Proposal
Fabric	Roof U-value (W/m²K)	0.60	0.18	0.18
	External Wall U-value (W/m²K)	0.45	0.28	0.26
	Ground Floor U-value (W/m²K)	0.45	0.22	0.18
	Glazing U-value (W/m²K)	4.80	1.60	1.60
	Glazing G-value (W/m²K)	0.70	0.70	0.70
	Air tightness (m³/m²hr @50Pa)	15	15	15
HVAC	HVAC system type	Radiators	Radiators	Radiators
	Heating SCOP	0.70	0.86	0.86
	Extract ventilation to WCs & stores	6ACH 0.4W/l/s	NA	NA
Lighting	Lighting Efficacy (llm/cW)	35	60	60
	Automatic Lighting Controls	Auto-on-off	Auto-on-off	Auto-on-off

	Automatic Lighting Controls Parasitic Power (W/m²)	0.1	0.1	0.1