Department for Levelling Up,
Housing & Communities

# 2021 changes to the energy efficiency requirements of the Building Regulations for domestic buildings

**Affecting new domestic buildings and existing domestic buildings when relevant building work is carried out.**

# Final Stage Impact Assessment

**Signed by the responsible minister**:

**Date**: 13th December 2021

| | |
|---|---|
| **Title:** 2021 changes to the energy efficiency requirements of the Building Regulations for domestic buildings: Final Stage Impact Assessment<br><br>**IA/ RPC Reference No:** RPC-DLUHC-5129(1)<br>**Lead department or agency:** DLUHC | **Impact Assessment (IA)**<br>**Date:** 15/12/2021<br>**Stage:** Final<br>**Source of intervention:** Domestic<br>**Type of measure:** Secondary Legislation<br>**Contact for enquiries:**<br>Enquiries.BR@communities.gov.uk |

## Summary: Intervention and Options

**RPC Opinion**: **Green**

**Cost of Preferred Option** (in 2019 prices, 2020 PV for EANDCB and BIT, 2021 PV base year for all other calculations)

| Total Net Present Social Benefit | Business Net Present Cost | Net cost to business per year (EANDCB) | Business Impact Target Status |
|---|---|---|---|
| £4,548m | £4,091m | £475m | £2,376m |

**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. Homes, both new and existing, account for 21% of greenhouse gas emissions in the UK[1], with an estimated 23.8 million dwellings in England.[2] The Net Zero Strategy outlines how more must be done to decarbonise homes for the Government to meet its ambitious commitment of achieving Net Zero emissions by 2050[3]. This includes reducing annual carbon emissions by more than half in the buildings sector by 2035 to meet the UK's Carbon Budget 6 targets.

The Heat and Buildings Strategy builds on that by giving more detail on the UK's overall approach to decarbonising buildings. It aims to provide a clear direction of travel for the 2020s; set out the strategic decisions that need to be taken this decade; and demonstrate how we plan to meet our carbon targets and remain on track for net zero by 2050. As part of this, it highlights the important role that improving the energy efficiency of homes must play.

Improving the energy efficiency of both new homes and existing homes using the standards set through the English Building Regulations represents a significant opportunity to reduce carbon emissions. These emissions have high social costs, such as lower air quality which can lead to worse health outcomes, as well as the longer-term impacts of exacerbating climate change.

There are a range of market failures that exist, meaning that these social costs have not been fully accounted for by the market and hence government intervention is needed to address the problem. These include; the cost of climate change not being fully reflected in energy prices; a lack of information about energy efficiency opportunities, and; the limited incentives for building owners and developers to make improvements which would reduce carbon emissions from homes.

[1] Department for Business, Energy & Industrial Strategy (2021) 2019 UK Greenhouse Gas Emissions, Final Figures - Data Tables, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972606/final-greenhouse-gas-emissions-tables-2019.xlsx

[2] English Housing Survey 2019-2020, Headline Report (2020), https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report

[3] Department for Business, Energy and Industrial Strategy (2021), Net Zero Strategy, https://www.gov.uk/government/publications/net-zero-strategy

**What are the policy objectives and the intended effects?**

The policy objectives and intended effects are:

- To reduce $CO_2$ emissions of new domestic buildings through changes to the energy efficiency requirements of the Building Regulations.
- To ensure that when relevant building work is done to existing homes, such as building an extension or replacing windows, it is done to a high standard of energy efficiency which limits $CO_2$ emissions.
- Encourage industry to prepare for the Future Homes Standard which we propose to introduce from 2025, with a consultation set for 2023.

**What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)**

Option 1: Do nothing. Keep the current 2013 energy efficiency requirements. 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.

Option 2: Preferred option. New homes target that delivers a 30% improvement on 2013 standards, aggregated across the build-mix, based on performance-based targets for primary energy, $CO_2$ emissions and fabric energy efficiency (more details in paragraph 4.5 - 4.7) . For existing homes, improvements to the standards of new and replacement thermal elements will make homes that have replacement windows more energy efficient, as well as improving the efficiency of extensions and loft conversions. **This is the Government's preferred option because it reduces $CO_2$ emissions relative to Option 1, therefore making a greater overall contribution to the Government's Net Zero commitment**. The uplift in standards for new homes are also likely to encourage higher levels of low carbon heating being installed now, and hence will act as an appropriate interim standard ahead of the full Future Homes Standard and Future Buildings Standard proposed to be introduced from 2025. The increase in standards are achievable by industry now and can be met using common construction techniques and readily available products.

| | | | | |
|---|---|---|---|---|
| Is this measure likely to impact on international trade and investment? | | No | | |
| Are any of these organisations in scope? | **Micro**<br>Yes | **Small**<br>Yes | **Medium**<br>Yes | **Large**<br>Yes |
| What is the $CO_2$ equivalent change in greenhouse gas emissions?<br>(Million tonnes $CO_2$ equivalent) | | **Traded:**<br>0.1 | **Non-traded:**<br>70 | |

Summary: Analysis & Evidence Policy Option 2

**Description: New homes target that delivers a 30% improvement on 2013 standards. All figures are Net Present Values (NPVs) over 10 years of policy and a subsequent 60-year life of the buildings.**

**FULL ECONOMIC ASSESSMENT**

| Price Base | PV Base | Time Period | Net Benefit (Present Value (PV)) (£m) | | |
|---|---|---|---|---|---|
| 2019 | 2021 | 70 | **Low:** £3,638million | **High:** £5,458million | **Best Estimate:** £4,548million |

| COSTS (£m) | Total Transition (Constant Price) Years | | Average Annual (excl. Transition) (Constant Price) | Total Cost (Present Value) |
|---|---|---|---|---|
| **Low** | £9.8m | | | £5,820m |
| **High** | £14.6m | | | £8,730m |
| **Best Estimate** | **£12.2 million** | | | **£7,275m** |

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

The increased costs (present value) for **new homes** are £6,588m plus transition costs of £11.1m. The initial capital costs will be borne by developers. The costs would fall with moderate efficiency gains through learning over time. Over the medium-long term, development costs may become factored into land prices and therefore passed onto landowners. Higher costs may also lead to higher purchase costs of homes/higher rents for buyers/renters.

Maintenance and replacement costs will be borne by the building owner/occupier, apart from those properties owned by Private Rented Sector landlords and Housing Associations. For PRS, costs may be passed on in the form of higher rent prices (with occupiers of the home benefitting from lower fuel bills, see benefits section). For HAs it is unlikely businesses will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG, as HAs may demand higher grants to accommodate for the higher costs of building SRS housing (with occupiers of the home benefitting from lower fuel bills, see benefits section).

Transitional costs are likely to fall on businesses and Local Authority building control who will need to get their employees up to speed with the new standards. This includes employees such as contractors, architects, energy assessors and building control etc.

The increased costs (present value) for **existing homes** are £475m for increased standards, £141m for standards for Self-Regulating Devices and £59m for larger radiators. These costs are borne by the person who owns the home and is paying for the work to be done, including Private Rented Sector landlords and Housing Associations. For PRS, costs may be passed on in the form of higher rent prices (with occupiers of the home benefitting from lower fuel bills, see benefits section), whilst for HAs it is unlikely businesses will be able to pass on the costs due to social rented sector rents being set by HMG. In this case, costs may be passed onto HMG as HAs may demand higher grants to accommodate for the higher costs of building SRS housing (with occupiers of the home benefitting from lower fuel bills, see benefits section).

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

These changes may have a small impact on the demand and supply of new homes; however, this is not expected to be substantial. Consequently, this has not been monetised.

| **BENEFITS (£m)** | **Total Transition** (Constant Price) Years | | **Average Annual** (excl. Transition) (Constant Price) | **Total Benefit** (Present Value) |
|---|---|---|---|---|
| **Low** | | | | £9,459m |
| **High** | | | | £14,189m |
| **Best Estimate** | **£0** | | | **£11,824 million** |

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

The benefits (present value) include energy savings of £2,043m, which will be experienced by occupiers of both new and existing homes in the form of lower fuel bills. This includes occupiers in Owner Occupied homes, as well as Private Rented and Social Rented Sector homes.

Non-financial benefits including $CO_2$ savings and air quality savings of £9,780m. The total CO2 savings are 70 $MtCO_2(e)$. These will benefit society as a whole, with lower carbon emissions and improved air quality leading to better health outcomes, and reduced risk of longer-term impacts of exacerbating climate change, such as increased risk of extreme weather, flooding, high temperatures, water shortages and loss of ecosystems.

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

The savings to consumers will be greater than shown because of reduced payments for VAT which will be a cost to the exchequer. As per Green Book guidance, this has not been costed as it is considered to be a transfer between consumers/businesses and the government. 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** | **Discount rate (%)** | 3.5% |
|---|---|---|

The analysis has taken a common set of assumptions on fuel prices, traded and non-traded carbon prices (sensitivity analysis in Appendix B), emissions factors and air quality damage costs from 2021 Green Book Supplementary guidance. The low and high estimates are +/- 20% of the best estimate.

These changes will not have an impact in areas where Local Authorities require domestic buildings to be built to a higher standard through planning.

Assumptions have also been made about the routes to compliance that developers are likely to take to comply with the regulations. This was produced by consultants and reflects views from industry. Sensitivity analysis can be found in Appendix B.

All calculations are in 2019 prices.

**BUSINESS ASSESSMENT (Option 2)**

| **Direct impact on business (Equivalent Annual, 2019 Prices, 2020 PV base year) £m:** | | | **Score for Business Impact Target (qualifying provisions only) £m:** |
|---|---|---|---|
| **Costs:** | **Benefits:** | **Net:** £475m Cost | £2,376m |

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# 1. Introduction

## Background and scope of the changes

1.1. This Impact Assessment (IA) supports the uplifts to the energy efficiency requirements of the Building Regulations. Specifically, and as defined in the legislation, this refers to the Energy Efficiency Requirements of Part 6 of the Building Regulations[4].

1.2. The Building Regulations and associated guidance set energy efficiency standards when building **new homes and for any building work done to existing homes**. The Building Regulations are a devolved matter and the changes in this impact assessment apply to England only. For further information on the Building Regulations, see *the Manual to the Building Regulations*[5].

1.3. The analysis which underpins this IA focuses on the costs and benefits associated with improving the energy efficiency of domestic buildings both at the point of construction of new homes and when work is carried out on existing homes. As such, the policies will have an impact on the construction industry, manufacturers of construction products, and the building owners and occupants.

1.4. Most changes for **new dwellings** are set out in the Future Homes Standard response document, *The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings*[6]. Two options were presented at consultation stage to uplift the current energy efficiency requirements in 2021 for new homes in England. Only the Government's chosen option is presented in this IA. The response document also considers the wider impacts for new homes, including airtightness, improving as-built performance and changes to transitional arrangements in 2021.

1.5. Additional changes for new dwellings, as well as the changes for **existing dwellings** are set out in the response document, *The Future Buildings Standard: 2021 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.* It includes uplifts to current standards in 2021 for existing homes in England, including minimum standards for new and replacement thermal elements, windows and doors. It also includes the Fabric Energy Efficiency Standard for new homes, uplifts to the minimum standards for building services in existing homes, and other minor changes to the energy efficiency requirements for existing dwellings.

## Future work (outside scope of the impact assessment)

1.6. This impact assessment only details the impacts of changes to the energy efficiency requirements of the Building Regulations for new and existing dwellings.

[4] The building regulations 2010, https://www.legislation.gov.uk/uksi/2010/2214/contents/made

1.7. This IA relates to the elements of the consultation which are to be introduced from 2021. It does not consider the costs and benefits of the full Future Homes Standard (FHS) or the Future Buildings Standard (FBS). Before the FHS and FBS are introduced in 2025, the Government will consult on the full technical details and produce an associated IA.

[5] Ministry of Housing, Communities and Local Government (2020), Manual to the Building Regulations, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901517/Manual_to_building_regs_-_July_2020.pdf

[6] The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings. Summary of responses received and Government response, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956094/Government_response_to_Future_Homes_Standard_consultation.pdf

# 2. Problem under consideration

2.1. Climate change is a significant domestic and global challenge, with the costs of greater carbon emissions likely to be experienced by those not responsible for their production. In June 2019 the UK became the first major economy to legislate for Net Zero greenhouse gas emissions, a target the Government committed to meeting by 2050. In addition to this commitment to reach Net Zero, the UK has ambitious interim targets, which are set out in the Carbon Budgets and Net Zero Strategy. In 2021 the Government lay legislation for Carbon Budget 6, which will require a 78% reduction in emissions by 2035, relative to 1990 levels.

2.2. Homes account for 21% of total greenhouse gas emissions in the UK[7], with an estimated 23.8 million dwellings in England.[8] Carbon emissions have high social costs such as the reduction in air quality which can lead to worse health outcomes, and the longer-term impacts of exacerbating climate change, such as increased risk of extreme weather, flooding, high temperatures, water shortages and loss of ecosystems. The UK has already made significant progress in this sector with overall emissions falling by around one fifth since 1990, despite there being a quarter more homes[9]. The overall buildings sector however remains the second largest carbon emitter behind the transport sector, with HMG's Net Zero Strategy showing that in order to meet Carbon Budget 6 targets, buildings must reduce annual emissions by more than half.[10] Improving the energy efficiency of both new and existing homes therefore represents a significant opportunity to reduce carbon emissions and support the Government in reaching its targets, whilst keeping energy costs down for consumers now and in the future.

2.3. The Heat and Buildings Strategy sets out the immediate actions and long-term signals proposed to reduce emissions from buildings. It recognises the need to do more to decarbonise the building stock by making buildings more energy efficient and by installing low-carbon heating systems. It sets out a commitment to increase standards for new-builds in the 2020s to ensure they are ready for Net Zero, including through the Future Homes Standard (FHS) from 2025 and the 2021 interim uplift to the Building Regulations.

2.4. The performance-based targets, set through the energy efficiency requirements of the Building Regulations, are an important means by which HMG can regulate for minimum energy efficiency standards and therefore reduce the carbon emissions of new and existing dwellings. The uplift to the energy efficiency requirements, as outlined in the response documents, will act as an important stepping stone towards the FHS in 2025, setting a path

[7] Department for Business, Energy & Industrial Strategy (2021), 2019 UK Greenhouse Gas Emissions, Final Figures - Data Tables, Table 5.1, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972606/final-greenhouse-gas-emissions-tables-2019.xlsx

[8] English Housing Survey 2019-2020, Headline Report (2020), https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report

[9] Department for Business, Energy & Industrial Strategy (2020), Final UK greenhouse gas emissions national statistics: 1990 to 2018, table 19, https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018

[10] Department for Business, Energy and Industrial Strategy (2021) Net Zero Strategy, https://www.gov.uk/government/publications/net-zero-strategy

towards decarbonisation of new homes and support the scaling up of low carbon technologies to decarbonise the existing stock.

# 3. Rationale for intervention

3.1. 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 domestic buildings represents a significant opportunity to reduce carbon emissions from the building stock, which is essential for the UK to meet its Climate Change Act targets[11]. Building Regulations should be used to achieve this only where it can be shown that the market would not make these changes of its own accord, or that other measures (regulatory or otherwise) are not already driving this change. The Building Regulations are the primary tool for setting standards for new homes, with there being limited evidence that new homes are being built beyond minimum standards set nationally. While there are policies in place to encourage the uptake of retrofit of the existing stock, it is necessary that the Building Regulations set minimum standards for such work.

3.2. Several market failures exist which means that, in the absence of government intervention, the market would not make the changes necessary to decarbonise homes of its own accord. In the absence of any intervention, the long lifetimes of buildings could lead to a lock-in of lower energy efficiency levels for many years to come. Uplifts to the Building Regulations can help to overcome the following market failures that act as a barrier to action:

a. **Negative Externalities:** polluters (builders and building occupiers) do not incur the true cost of the emissions they emit by heating and powering their homes. This is because the costs of increased greenhouse gas emissions and climate change such as reductions in air quality and the subsequent impacts on human health, are not reflected in the price consumers pay for fuel. The private cost consumers incur via fuel bills do not cover the full social cost of their energy use. Even if an appropriately high and sustained carbon price was applied, the mix of other market failures can act as a barrier to action. This is inconsistent with the Polluter Pays principal and hence requires government intervention to correct the market failure via uplifts to the Building Regulations. This will improve the energy efficiency of domestic buildings both at the point of construction and during the building lifetime, subsequently reducing overall energy use.

b. **Credit/Resource Constraints**: a failure to set standards at point of build can lock a dwelling into higher energy consumption. This gives consumers who do want to act limited scope to improve energy efficiency because any building work would be disruptive and expensive. A lack of capital and a reluctance to accept disruption during retrofit works can be barriers to households acting to renovate and improve existing dwellings, even if these works would be cost effective in the medium or long term. The large upfront costs of energy efficiency upgrades can also take a long time to recover given the long payback periods via lower fuel bills, hence consumers who are credit constrained may lack the ability to make the investments necessary to upgrade their homes. Using the performance-based targets set through the Building Regulations is a way to ensure new dwellings are locked into higher energy efficiency standards at the point of construction, removing the reliance on homeowners having enough capital to make the improvements themselves.

c. **Imperfect Information:** there are several information failures that can occur across the energy and housing market. First, landlords and tenants may not understand the benefits of better energy performance or what can be done to improve it. This means in the absence of any interventions, there will be a lack of incentives for consumers to make energy efficiency upgrades to their homes. For example, for existing dwellings, owners are unlikely to choose better performing windows even though this would reduce their energy bill. Second, a lack of information on potential changes in energy prices mean that home buyers, tenants and mortgage providers do not value energy efficient homes more highly than worse performing dwellings at the point of sale or rent. This effect is present in the housing market where there is limited evidence that higher energy performance results in a price premium when homeowners come to sell or rent the dwelling. Imperfect information regarding energy prices and the benefits of a more energy efficient home (e.g., improved thermal comfort, lower fuel bills, positive health and environmental outcomes) means that increased efficiency is not reflected in the market price for homes, and hence homeowners have little incentive to upgrade their properties. Hence, locking-in higher energy efficiency of homes via uplifts to the building regulations is an effective intervention in reducing tenants and homeowner's exposure to volatile energy prices by reducing their energy demand.

d. **Split incentives:** for new domestic buildings, developers have few incentives to build better performing buildings, as; they do not enjoy the benefits of lower energy bills; they do not receive the additional income from renewable technologies installed in buildings generating energy, and; they may not be able to sell a home for a premium to recover all the additional costs they accrue, despite the home being more energy efficient. In relation to existing homes, the same barriers to retrofit apply to rental properties, whereby the costs of upgrading a dwelling to make it more energy efficient fall on the landlord, but the benefits of lower energy costs and increased comfort in the home are experienced by the tenants. These misaligned incentives mean that in the absence of higher standards set through the Building Regulations, homeowners and developers may fail to make improvements to the performance of dwellings.

e. **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. Therefore, Government intervention via the Building Regulations is required to correct this under-provision of public goods by the market.

3.3. Building regulations and standards are widely recognised as an appropriate point of intervention to overcome these market failures. Action at the point of build or when relevant work is done has the advantage of 'locking in' low carbon technologies and energy efficient design, reducing overall energy demand of the building avoiding the need to retrofit in the future.

[11] The Climate Change Act 2008, http://www.legislation.gov.uk/ukdsi/2019/9780111187654/contents

# 4. Policy objectives and changes to energy efficiency standards

## Policy objectives

4.1. The UK Government has set into law a target to bring its greenhouse gas emissions to Net Zero by 2050, with the Heat and Buildings Strategy setting out the central role that decarbonising buildings must play in that. Homes currently account for 21% of total UK greenhouse gas emissions[12]. Achieving Net Zero will require significant improvements in the energy performance of both new and existing homes and decarbonisation of heating and hot water. The performance-based targets set through the Building Regulations are an important means of reducing the carbon emissions from domestic buildings and setting the right standards will ensure the Government is on track to meet its ambitious 2050 target.

4.2. Full details of the policy objectives for the new energy efficiency requirements for new and existing domestic buildings are set out in the Future Home Standard and Future Building Standard response documents. A summary of these policy objectives is provided here.

4.3. The policy objectives are:

- To reduce $CO_2$ emissions of new domestic buildings through changes to the energy efficiency requirements of the Building Regulations.
- To ensure that when relevant building work is done to existing homes, such as building an extension or replacing windows, it is done to a high standard of energy efficiency, which limits $CO_2$ emissions.
- Encourage industry to prepare for the Future Homes Standard which we propose to introduce from 2025, with a consultation set for 2023.

## Changes to standards

4.4. The Future Homes Standard and Future Buildings Standard response documents set out the details on changes to the energy efficiency requirements of the Building Regulations and associated statutory guidance for new and existing domestic buildings. The changes from current standards that are set out in the Building Regulations and in statutory guidance are outlined below.

## Uplift to the energy performance requirement for new domestic buildings

4.5. The main change to new homes is the uplift to the minimum energy performance requirements, which describe the overall energy performance targets which new homes need to achieve. As set out in Chapter 3 of the Future Homes Standard response

12 Department for Business, Energy & Industrial Strategy (2021), 2019 UK Greenhouse Gas Emissions, Final Figures, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972606/final-greenhouse-gas-emissions-tables-2019.xlsx

document[13], there were initially two options considered to uplift the energy performance requirements for 2021:

- Option 1 - 'Future Homes Fabric' would be a 20% reduction in $CO_2$ from new dwellings, compared to current standards.

- Option 2 - 'Fabric plus technology' would be a 30% reduction in $CO_2$ from new dwellings, compared to current standards.

4.6. Energy performance requirements for new dwellings are set by modelling a theoretical building, called the notional building. This notional building is the same size and shape as the building that is actually being built, but with a specification that is defined in Building Regulation guidance. This specification includes the energy efficiency of the walls, floor, roof, windows and doors and includes building services such as a gas boiler or solar panels with defined characteristics. There is a government approved calculation method for modelling the notional building and that produces the targets developers need to meet (e.g., a target carbon emission rate). This method is called the Standard Assessment Procedure (SAP). The developer can choose how to meet the targets, providing flexibility and allowing innovation. To develop options for consultation, over 100 specifications were modelled with different fabric energy efficiencies and building services. In this impact assessment we have looked at two routes to compliance (see Routes to Compliance section below).

4.7. The Government will proceed with the 'fabric plus technology', 30% reduction, option. This reduction was calculated using the specifications detailed in Table 7 using SAP 10.1. This is the chosen option because it delivers more $CO_2$ savings to support HMG's Net Zero commitments in the short-term. In addition, this option specification will encourage some homes to be built with low carbon heating from 2022, thus supporting the sector to progress towards the Future Homes Standard by developing the supply chains and skills needed for 2025.

4.8. The energy performance requirements are based on the primary energy consumption and carbon emissions from a home with:

- An increase in fabric standards
- A gas boiler
- A waste water heat recovery system
- Photovoltaic (solar) panels

The costs and benefits of introducing this standard are assessed below.

4.9. The changes to the performance standard are achievable as an interim increase to the energy efficiency standards for new homes. The increase in fabric standards can be met by developers using common materials, construction techniques and products

[13] The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings. Summary of responses received and Government response, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956094/Government_response_to_Future_Homes_Standard_consultation.pdf

readily available on the market. Solar panels are a widely available product that can be added readily to many dwelling designs. Waste water heat recovery systems are also both widely available and simple to install.

4.10. The specification for the 2021 notional building is provided in Table 7. For the full detail of the notional buildings see the Standard Assessment Procedure (SAP) version 10.2 available online at: https://www.bregroup.com/sap/sap10/.

4.11. All figures in the impact assessment are in terms of the 'Do Nothing' (Now Option 1) and the Government's chosen option of 'fabric plus technology' (Option 2).

4.12. Many of the benefits and costs come from the changes to the minimum energy efficiency standards and from homes moving to using either solar panels or heat pumps. This forms the main basis of the cost benefit analysis.

***Performance metrics to assess the energy performance of new homes***

4.13. The Government has decided on a revised package of performance metrics to ensure that a fabric first approach remains at the centre of all new homes alongside a low carbon heating system. Therefore, the following four performance metrics will be used for new homes for 2021:

- Primary energy target
- $CO_2$ emission target
- Fabric energy efficiency target
- Minimum standards for fabric and fixed building services

4.14. The 2021 uplift and the final 2021 performance metrics, combined with the level of the Fabric Energy Efficiency Standard in The Future Buildings Standard consultation, will together ensure that energy bills remain affordable. We therefore do not intend to introduce a separate affordability metric, as consulted on in the Future Homes Standard consultation, on the basis that this is no longer required and would add unnecessary complexity.

4.15. We consider the principle of a fabric-first approach to be sound. While we consulted on removing the Fabric Energy Efficiency Standard (FEES) in the Future Homes Standard consultation, we have instead retained it as a performance metric for 2021. In addition, we consulted in the Future Buildings Standards consultation on whether a full or reduced level of FEES should be implemented. We have decided to implement the full FEES standard as this provides an appropriate stepping stone as we progress to the even higher fabric standards that we expect to form the 2025 FHS specification.

***Removing the fuel factors – phasing out high carbon fossil fuels***

4.16. Fuel factors are currently used to modify the Target Emission Rate set in *Approved Document L1A 2013*; fuel factors apply to LPG, oil, solid mineral fuels and grid electricity. The Government will remove fuel factors so that any new dwelling will need

to meet the primary energy and $CO_2$ emissions equivalent to that of Policy Option 2 above.

4.17. Thus, if high carbon fossil fuels, such as oil, liquefied petroleum gas (LPG) or solid mineral fuel are to be used in new buildings, considerable mitigating measures would need to be installed to reach parity with a new gas-heated building.

4.18. Under this new policy, analysis shows that it is most likely that new homes off the gas grid will be built using heat pumps. In new homes where high carbon fossil fuels continue to be used, the mitigating measures required on the home will mean that fuel bills will be even lower than homes built to current standards.

4.19. Grid electricity now has a lower average carbon emission factor than gas, as outlined in the tables in Appendix D. Therefore, grid electricity no longer needs a fuel factor to support its use. To note, these differ from the Green Book Supplementary Guidance carbon emission factors used for appraisal purposes.

***Heat networks***

4.20. Recognising heat networks as an important part of our energy future, the Government considered the introduction of 'technology factors'. These would be applied to calculations for the target emission and primary energy rates for new dwellings where the design incorporates heat networks.

4.21. As outlined in the Future Homes Standard response document, the Government will not provide technology factors. For new dwellings connected to a new heat network, no relaxation in standards will be applied: the home will be assessed against the notional building. For new dwellings connected to an existing heat network, a second notional building will be used to set the target. This second notional building will use the actual heat network to be connected to.

4.22. In addition, new emission factors for gas Combined Gas and Heat (CHP) are now available in SAP to better reflect the carbon intensity of gas CHP.

***Futureproofing***

4.23. The full details for the future-proofing policy are set out in Chapter 3 of the Future Homes Standard response document.

4.24. Homes built under the Future Homes Standard 2025 will be future-proofed with low carbon heating and world-leading levels of energy efficiency. The 2021 uplift will ensure the delivery of high-quality homes with lower bills, also encouraging higher levels of low carbon heating to be installed now. Hence the interim uplift will act as an appropriate interim standard ahead of the full Future Homes Standard

4.25. We have introduced guidance into the 2021 draft Approved Document L, Volume 1: Dwellings to encourage new heating systems to be designed to operate at a flowrate temperature of 55°C or lower.

4.26. This will make it easier to install heat pumps or district heating in the future. In the short-term, this flow temperature will also have the additional benefit of increasing the efficiency of condensing boilers, providing an immediate energy saving to the consumer.

### *Airtightness*

4.27. The full details for airtightness testing policy for domestic buildings are set out in Chapter 5 of the Future Homes Standard response document. These include:

- limiting $CO_2$ savings associated with air-permeability levels below 3m³/m²h in naturally ventilated dwellings.
- requiring all new homes to be airtightness tested, including small dwellings
- introducing the Pulse test as an approved airtightness testing methodology with no limits on the airtightness to be measured.
- adopting CIBSE TM23 as an approved airtightness testing methodology.

4.28. Though we considered reflecting the uncertainty of air permeability test results in our initial proposals, based on the feedback we received through consultation and from our technical working group, we believe that reflecting uncertainty in airtightness results will add more complexity than is appropriate and would not adequately address the issue of temporary sealing.

### *Performance gap*

4.29. Approved Document guidance for the energy efficiency requirements for homes (Approved Document L1) has been rewritten to be simpler. It should be easier to understand, comply with and check against.

4.30. In addition to this, specific policies have been introduced to reduce the performance gap, which are outlined in Chapter 6 of the Future Homes Standard response document. These include:

- improving build quality by introducing guidance as part of the minimum standard within Approved Document L1.
- improving information provided to Building Control Bodies and householders by introducing a new style compliance report, called a BREL.
- improving the accuracy of as-built energy calculations by providing clearer information about the as-built specifications of new buildings to energy assessors in the form of photographic evidence.
- improving information given to the purchasers of new homes by including the version of the energy efficiency requirements the home is built to on the Energy Performance Certificate (EPC).
- improving information to householders by housebuilders providing them with a Home User Guide.

## Uplift to the energy efficiency requirements for existing domestic buildings

4.31. The full details of this policy are set out in Chapter 6 of the Future Buildings Standard response document[14]. We have improved minimum standards for when work is carried out in existing dwellings, which includes significant uplifts to the minimum standards of new elements such as walls, floors, roofs, windows, and doors. These standards apply most commonly when building an extension or replacing windows or doors.

4.32. There are also confirmed changes to uplift roof U-values which apply when a roof is being renovated; a change to minimum standards for some building services; a standard for full replacement heating systems to be designed to operate at a flowrate temperature of 55°C or lower; and; a new standard for self-regulating controls when a heating appliance is replaced.

4.33. The fabric standards have been selected because they are cost-effective uplifts that are currently achievable by industry and have a low risk of unintended consequences such as a build-up of moisture in the dwelling. Such changes are in line with our 2050 Net Zero target as our existing stock of houses are less efficient and more numerous than new buildings.

## Transitional arrangements

4.34. These changes will be implemented 6 months after regulations and statutory guidance are laid. This 6-month period is a standard period allowed for regulations to come into force, and in line with the period provided under previous iterations of the energy efficiency requirements, which provides the construction industry with time to familiarise themselves with the standard. For new homes, following consultation DLUHC consider that this remains an appropriate time period for industry to respond to these changes under the interim uplift. This follows the consultation on the vast majority of the changes in 2019 and confirmation of these changes in January 2021, essentially providing almost a year and half to prepare. Furthermore, the changes do not require a major shift in the materials used or construction practices employed today.

4.35. In addition to this, transitional arrangements are also provided, which are used to smooth the transition to new standards in the implementation of Building Regulations. These arrangements allow some building work to be done to previous standards for a specified period.

4.36. Transitional arrangements for new homes will only apply to individual buildings on which work has started within a reasonable period. Where work has not commenced on a specific building covered by the building notice, initial notice, or full plans within a reasonable period, that building will not benefit from the transitional provisions and so it would need to comply with the latest set of energy efficiency standards.

[14] The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings. Summary of responses received and Government response, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956094/Government_response_to_Future_Homes_Standard_consultation.pdf

4.37. In line with the reasonable period that was in place for the 2013 uplift in energy efficiency requirements, developers of new dwellings will have 12 months from when these regulations come into effect to commence work on each individual building.

4.38. The same transitional arrangements will apply for existing homes. They are however used less frequently because most of the work on these dwellings is started and completed within a short period of time.

# 5. Summary of impacts

5.1. A summary of the impacts considered under this Impact assessment (IA) is provided below in Table 1, relative to the counterfactual (Option 1). All figures are Net Present Values (NPV) 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.

5.2. Overall, the additional costs and benefits are largely driven by the installation of on-site renewables, which results in high upfront capital costs (and incurs maintenance and replacement costs during the building life) but delivers large energy savings primarily through reducing gas use. The overall net benefit to society of the Government's preferred option is estimated to be £4,548 million, with an equivalent annual net direct cost to business (EANDCB) of £475 million over 10 years, in 2019 prices.

5.3. For new domestic buildings the capital, transition and installation costs will be paid by business. This is split between private developers, Private Rented Sector (PRS) landlords and Housing Associations (HAs), with the majority being incurred by private developers. Private developers over the medium-long term may pass on costs to owners in the form of higher house prices, at least in areas of high demand, or development costs may become factored into land prices and therefore passed onto landowners. In the short-term however this is unlikely.

5.4. Some or all of the costs incurred by the PRS may be passed onto consumers/occupiers in the form of higher rent prices. For HAs, it is unlikely businesses will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG through HAs demanding higher grants to cover additional costs to build social rented sector accommodation.

5.5. Whilst most of the costs for any replacements or maintenance will sit with the occupier, some costs for both existing and new homes will sit with PRS landlords and HAs. PRS landlords in the short-term would absorb the cost due to rent prices being locked in by tenancy agreements. Over the longer term however, at the point of renewal, these costs could be passed on to the occupier in the form of higher rent prices.

5.6. For HAs, it is unlikely that registered social landlords will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG through HAs demanding higher grants to cover additional costs to build social rented sector accommodation.

5.7. All benefits will be experienced by the tenants in the form of lower fuel bills and by society through better air quality and reduced carbon emissions.

**Table 1: Summary of costs and benefits**

| | New dwellings | Existing dwellings |
|---|---|---|
| Transition costs (£m)<br>Energy savings (£m)<br>Incremental costs (£m) | (11.1)<br>1,734<br>(6,588) | (1.1)<br>309<br>(675) |
| Total financial benefit/(cost) (£m) | **(4,865)** | **(367)** |
| Carbon savings - non-traded (£m)<br>Carbon savings - traded (£m) | 8,497<br>32 | 866<br>- |
| Total carbon savings (£m) | 8,530 | 866 |
| Air quality savings (£m) | 351 | 34 |
| Comfort Taking | - | (1) |
| Total carbon and air quality savings | 8,848 | 899 |
| Net benefit/(cost) (£m) | **4,016** | **532** |
| Amount of gas saved (GWh) | 346,104 | 31,527 |
| Amount of electricity saved (GWh) | 4,806 | - |
| Amount of $CO_2$ saved - non-traded ($MtCO_2e$) | 64 | 6 |
| Amount of $CO_2$ saved - traded ($MtCO_2e$) | 0.1 | - |
| Cost effectiveness – non-traded (£/$tCO_2$) | 70 | 57 |
| Cost effectiveness – traded (£/$tCO_2$) | (28,957) | - |
| Present value net benefit/(cost) business (£m) [Annualised over 10 years] | **(3,999)** | **(92)** |
| **Equivalent annual direct net benefit/(cost) to business (£m)** [Annualised over 10 years] | **(465)** | **(10.7)** |

# 6. Analytical approach

## Assumptions applicable to all analysis

6.1. To assess the impact of these uplifts to the energy efficiency requirements of the Building Regulations, a cost benefit analysis has been undertaken. This Impact Assessment (IA) refines some of the assumptions used in the 2019 consultation stage IA, reflecting improvements in the evidence base following consultation and further engagement with industry, as well as most recent data.

6.2. This IA is based on the Green Book and the accompanying supplementary guidance on the valuation of energy use[15]. This IA uses updated fuel prices, the updated carbon values and the appropriate emission factors which are used for appraisal purposes.

6.3. 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.

6.4. A discount rate of 3.5% has been used for the first 30 years of the building's life and 3% for subsequent years.

6.5. Prices and estimates shown below are in 2021 base year, 2019 prices. This is with the exception of the EANDCB and Business Impact Target calculations, which is calculated using 2020 base year, 2019 prices as per official guidance.[16]

6.6. All figures in the impact assessment are in terms of the 'Do Nothing' and the final policy, option 2.

### *Appraisal time and asset life*

6.7. The appraisal period for estimating the impact of the policy is 10 years which is consistent with other IAs associated with the construction industry, including the impact assessment undertaken for changes to the energy efficiency requirements in 2013.

6.8. For the analysis of new dwellings or extensions to existing dwellings, an asset life of 60 years is 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. This helps to ensure there is a full appraisal of the 'lock in' impact of higher fabric standards. An example of this is the impact of higher wall standards, which have impacts over a long period of time, potentially the entire lifetime of the building. For building fabric insulation (external walls, floors, roofs) the assumed asset life is 60 years, except for external windows which have an assumed asset life of 30 years. This is comparable with indicative values

[15] Department for Business, Energy & Industrial Strategy (2021), Valuation of energy use and greenhouse gas emissions for appraisal, https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[16] HMG (2021), Impact Assessment Calculator User Guide, https://www.gov.uk/government/publications/impact- assessment-calculator--3

provided in Annex E of *BS EN 15459 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings*.

6.9. Gas boilers and heat pumps have assumed asset lives of 15 years, with hot water stores having a lifespan of 20 years. This is comparable with indicative values provided in CIBSE Guide M – Maintenance engineering and management. The asset lives of waste water heat recovery systems were taken to be 20 years for horizontal systems and 60 years for vertical systems.

6.10. For the analysis of existing homes, the key policies are the replacement of controlled fittings (e.g., windows) and controlled services (e.g., boilers), and the installation of self-regulating devices (e.g., thermostatic radiator valves). For these the asset life was that of the measure itself. Hence, for replacement windows for example, the costs and benefits were determined over a 30-year asset life. In this example, given the 10 years of policy being assumed, the total appraisal period for existing homes in this impact assessment is therefore 40 years, so that the full 30-year impact of a replacement in year 10 is assessed.

6.11. Only the elements of lifecycle cost that differentiated from the costs incurred in the counterfactual 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.

6.12. Replacement costs did not include replacements of components that would be expected to have a longer lifespan. For example, boiler replacements did not include the replacement of a hot water tank or the gas or water supplies. Replacement costs included an additional allowance for the labour costs of working in an existing property and for disposal of the end-of-life components; replacement is only costed if the boiler is more expensive than the counterfactual.

6.13. Consequently, the ongoing costs associated with maintenance and replacement along with the benefits from energy, air quality and carbon savings have been estimated over a 60-year period for each new building, which provides a sufficiently long period to capture the benefits of fabric ‘lock-in’. 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. Learning rates have been applied to account for reductions in costs for less mature technologies.

### *Phase-in assumptions and transitional arrangements*

6.14. For the purposes of this analysis, new build projections are used as a proxy for annual rate of new buildings in our modelling. This has been broken down between detached, semi-detached, mid-terraced houses and four storey apartment blocks. For more details, please see Appendix A.

6.15. In addition, Table 2 shows the phase-in assumptions that have been made for the numbers of new homes which will be built to the new 2021 standards as opposed to

the 2013 standard. These consider the effect of transitional arrangements and feedback from the consultation/conversations with industry. Assumptions about the lead-in, build and completion times for domestic buildings were also used to determine the profile, with the time lag expected to be 2-3 years.

6.16. Consequently, the phase-in assumptions have changed since the consultation stage IA to better reflect the above. This leads to less homes being built to standard in the first year of the policy, (now 5% as opposed to 20%), but has a faster acceleration over the subsequent years to a 100% built to standard by 2025 (as opposed to 95%).

6.17. For both new and existing homes, the regulations will come into force in June 2022. For existing domestic buildings, where work tends to be simpler and the projects smaller, it is assumed that 100% of the works are to the new standards from June 2023.

**Table 2: Phase-in assumptions (% of works captured by 2021 requirements)**

| | 2022 | 2023 | 2024 | 2025 | 2026 onwards |
|---|---|---|---|---|---|
| New domestic | 5% | 50% | 95% | 100% | 100% |
| Existing domestic | 50% | 100% | 100% | 100% | 100% |

6.18. The assessment of costs and benefits has been undertaken based on 4 building types: detached, semi-detached, mid-terrace and a 4-storey block of flats (made up of 16 1-bed single aspect and 16 2-bed corner flats). The impacts on other, taller blocks of apartments have been considered below in *Impact of FEES on high rise apartments*. This has been captured outside of the main cost benefit analysis because blocks of this type only represent a relatively small number of completions outside of London. To enable consistent target setting and comparison, the same dwelling types employed in the 2013 review of energy efficiency requirements have been used, but with some updates to reflect the Nationally Described Space Standards – as implemented for MHCLG's cost optimal analysis published in 2019[17]. The dwelling types are summarised in Table 3 below.

**Table 3: Dwelling types**

| Dwelling type | Small 1 Bed Single Aspect Apartment | Large 2 Bed Corner Apartment | Mid Terrace House | End Terrace/ Semi-detached House | Detached House |
|---|---|---|---|---|---|
| Total Floor Area (m²) | 50 | 70 | 84 | 84 | 117 |
| | Total for apartment block: 1922 | | | | |

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

***Routes to Compliance***

6.19. The 2021 energy efficiency requirements are performance-based standards requiring a 30% improvement on 2013 levels aggregated across the build-mix, based on performance-based targets for regulated primary energy, $CO_2$ emissions and fabric energy efficiency. Consequently, there are several ways in which a housebuilder can comply with the regulations. Initially, the most likely means of compliance is a specification very similar to that described in paragraph 4.6 & 4.7, which has a high level of energy efficiency, a gas boiler, solar panels and waste water heat recovery. This is the most likely means of compliance because it requires the least change from current building practices and for many housebuilders is the lowest cost solution in the short run.

6.20. The main alternative route to compliance for housebuilders is with a heat pump. This will be appealing for some to start transitioning to the Future Homes Standard and for areas that do not have a natural gas supply. For the purposes of the impact assessment and cost benefit analysis, these two routes to compliance have been modelled.

6.21. The routes to compliance profile for the central estimate in the main cost benefit modelling is as follows, and is based on both internal expertise, views of consultants and extensive engagement with industry:

**Table 4: Routes to Compliance: Central Estimate**

| Route to Compliance | 2022 | 2023 | 2024 | 2025 onwards |
|---|---|---|---|---|
| BR2021 Gas boiler and solar panels | 90% | 77% | 63% | 50% |
| BR2021 Air source heat pump (ASHP) | 10% | 23% | 37% | 50% |

Source: DLUHC and AECOM

6.22. The profile in Table 4 assumes that from 2025 onwards, the proportion of housebuilders following either route to compliance will be 50/50. Given this impact assessment is for the interim uplift, this does not consider the Future Homes Standard 2025 policy or regulation, which is likely to require that new build homes will be future proofed with low carbon heating and world leading levels of energy efficiency. However, the profile in Table 4 does assume, based on conversation with industry, that the public commitment to the Future Homes Standard will affect the choices of route to compliance before its introduction. This is in part because for larger sites that will continue to be built out when the Future Homes Standard comes into force, installing gas infrastructure becomes increasingly less profitable because it will likely be unable to be used for homes built to the Future Homes Standard.

6.23. Due to a variety of reasons, including differences in the estimated capital costs between developers (explored in the *Costs and Benefits: Improved energy efficiency requirements for new homes* section), there is some uncertainty over what proportion of housebuilders will choose which route to compliance Therefore, in addition to the central scenario that has been modelled for the main Cost Benefit Analysis, two illustrative sensitivity scenarios have been used to show the possible range in costs and benefits.

6.24. These are as follows:

**Table 5: Routes to Compliance: Sensitivity Analysis Scenarios**

| | Route to Compliance | 2022 | 2023 | 2024 | 2025 onwards |
|---|---|---|---|---|---|
| Scenario 1: Low ASHP Estimate | BR2021 Gas boiler and solar panels | 90% | 85% | 80% | 75% |
| | BR2021 ASHP | 10% | 15% | 20% | 25% |
| Scenario 2: High ASHP Estimate | BR2021 Gas boiler and solar panels | 90% | 70% | 50% | 30% |
| | BR2021 ASHP | 10% | 30% | 50% | 70% |

Source: DLUHC and AECOM

6.25. The full results of this sensitivity analysis can be found in Appendix B. In the low heat pump take-up scenario, costs are £2,144m and net Benefits are £5,882m, with 42.3 MtCO2e saved. In the high heat pump take-up scenario, costs are £6,616m and net benefits are £10,963 with 82 MtCO2e saved. The higher carbon savings in the high take-up scenario is because more heat pumps are used, which means gas consumption/non-traded emissions fall considerably.

### *Counterfactual*

*Energy efficiency requirements*

6.26. The modelling assumes that all new domestic buildings are presently constructed to at least the notional building specification of the current 2013 energy efficiency requirements. Some local authorities require construction to a higher standard which will reduce or negate the impact of the policy change. Moreover, a few new domestic buildings, where development started before the last uplift in energy efficient requirements and are benefitting from transitional arrangements, are constructed to older, lower standards.

*Local Authorities Approach*

6.27. The Building Regulations set energy efficiency performance standards for new dwellings at the national level. Local Authorities (LAs) however have the power to set voluntary standards beyond the national requirements through local plans. Any commitments set out in local plans by LAs are public and legal commitments. In these cases, an adjustment needs to be made to the counterfactual, as some of the costs and benefits attributed to the 2021 uplift will, instead, already be incurred due to the specific local commitments.

6.28. Consequently, DLUHC have taken forward analysis to account for this. Three groups were identified across LAs, with a stratified sample of 124 Local Plans out of a possible 333 in England taken to assess planning requirements that go further than the 2013 Building Regulations. This does not take into account how these are enforced or if some are negotiated away, but given the lack of data and evidence, the only alternative approach would be to assume that all LAs build to the 2013 Building Regulations or make an arbitrary assumption. This would lead to an underestimate of the costs and benefits in the counterfactual, and an overestimate of the impact of the 2021 uplift.

6.29. DLUHC's live data tables on housing supply[18] were then used to identify the proportion of new build homes in these LAs. The three categories are as follows:

1. **The London Plan, 35% improvement**: The Greater London Authority, through the London Plan, have set out commitments for all new housing developments to have at least a 35% reduction beyond the baseline of the 2013 energy efficiency requirements.[19] For the policy, this means that any costs or benefits are set to zero due to the London Plan going further than the 30% reduction set by the 2021 uplift.

2. **Code 4 of the Sustainable Homes Guide, 19% improvement:** The Code for Sustainable Homes (the Code) is an environmental assessment method for rating and certifying the performance of new homes. It is a standard used in the design and construction of new homes which some LAs set as a benchmark for new housing developments in local plans and remains a requirement. Some LAs did state that they went further than the 2013 standards of the Building Regulations but were neither equivalent to 35% nor 19%. To ensure a proportionate approach was taken, for the main CBA these were assumed to fall into the 19% improvement group.

3. **2013 energy efficiency requirements, 0% improvement:** This represents LAs who have no further commitments to go beyond the 2013 energy efficiency requirements.

6.30. The output of the analysis can be seen in table 6. These proportions were then applied to the whole housing stock in the main CBA.

[18] Department for Levelling Up, Housing & Communities (2021), Live tables on housing supply: net additional dwellings 2019-20, https://www.gov.uk/government/statistical-data-sets/live-tables-on-net-supply-of-housing

[19] The London Plan 2021, https://www.london.gov.uk/sites/default/files/the_london_plan_2021.pdf

**Table 6: Local Authority Counterfactual Adjustment**

| Category | Proportion of Homes in each category |
|---|---|
| 2013 energy efficiency requirements (0%) | 67% |
| Code 4 (19%) | 16% |
| The London Plan (35%) | 17% |

*Compliance*

6.31. It is known that in some new homes there is a gap between the designed and as-built performance, known as the 'performance gap'. While homes can appear to fully meet the energy performance standards through the paperwork submitted, in reality the home can fall short of these due to poor build quality. The costs and benefits of the new standards for reducing the performance gap have been discussed in the *Improved compliance and performance* section of this IA. They are not however included in the main CBA modelling, which assumes 100% compliance with the standards. 100% compliance is standard practice in estimating the impact of a regulation. However, the issues causing this gap are complex and, whilst some evidence has been produced, overall, there remains insufficient evidence to provide a sufficiently robust estimate for the size of the gap, or how widespread the problem is.

6.32. When considering the performance gap, it should be noted that the lack of evidence applies equally to the counterfactual and the 2021 proposal. This means 100% of the design performance is assumed in both cases. As a hypothetical example, if the home built to 2013 standards used 20% more regulated energy than the regulatory calculations assumed, and the home built to 2021 standards also used 20% more energy, there would still be a 30% reduction in $CO_2$ from the 2021 uplift. Where the 20% gap existed for both the policy and counterfactual, and our analysis assumes full compliance, then our analysis will underestimate the absolute carbon saved from the change. In addition, this would ignore any reductions in the gap due to the changes made to 2021 guidance and processes which provide; more information to housebuilders on how to follow the new requirements; more information for Building Control Bodies to assist building checks, and; more information for occupants to help them use their systems more effectively. This would mean there is likely to be an underestimate of the impact of the changes in 2021 energy efficiency requirements on energy savings, up to 20% in the example above. There is, however, a variety of outcomes that could lead to either an under or overestimate of the impact of the 2021 uplift, which depends on the relative performance of the counterfactual versus the 2021 proposal. Consequently, given the complexity and lack of robust evidence, DLUHC believe that a 100% compliance assumption is reasonable.

*Off-gas grid properties*

6.33. Some off-model analysis has been conducted to assess the impact on rural properties of the policy changes – see *rural impacts*. For this latter analysis the counterfactual

assumes that all rural properties, which are typically off-gas grid, use Liquid Petroleum Gas (LPG) as their main energy source and are built to 2013 standards.

# 7. Estimation of costs and benefits

## Overview

7.1. The policy changes will affect all new dwellings and when relevant building work is carried out on existing dwellings in England. The impact of the policy will be felt both at the point of new construction or building work and over the life of the building during which energy savings will be achieved. As such, the policy will have an impact on manufacturers of construction products, the construction industry and the building owners and occupants. Given the long lives of the buildings affected there is considerable uncertainty about future values. So, it is assumed that there is a ±20% uncertainty on the central estimate, with these sensitivities captured in the headline table.

7.2. To estimate the overall costs and benefits of the policy changes, we have modelled the changes in building costs, energy use and related $CO_2$ emissions using the energy efficiency requirements for 2021. This is then compared with a baseline of costs and energy use implied by the energy efficiency requirements for 2013 which are now in place, along with counterfactual adjustments to best capture current industry practice.

7.3. Some of the policies outlined above are moderate changes and are therefore not expected to have significant impacts on the costs and benefits of the policy. Consequently, it was deemed disproportionate to take forward cost benefit analysis for these changes.

7.4. The policies below are included in the impact assessment and are:

- 2021 energy efficiency requirements for new homes – see ‘Improved energy efficiency requirements for new homes’.
- Performance metrics to assess the energy performance of new homes, including primary energy, $CO_2$ and FEES – see ‘Impact of FEES on high rise apartments’ and ‘Transitional arrangements’.
- Heat networks – see ‘Changes to the calculation method for heat networks’.
- Performance gap – see ‘Improved Compliance and Performance and Administrative burdens’.
- Statutory guidance – see ‘Improved Compliance and Performance’.
- Calculation methods – see ‘Transition costs’.
- Airtightness – see ‘Airtightness for new domestic buildings’.
- Self-regulating devices – see ‘Mandating Self-Regulating Devices (SRDs) for new dwellings’ and ‘Mandating Self-Regulating Devices (SRDs) for existing dwellings’.
- Removing fuel factors – see ‘Rural impacts’.
- 2021 energy efficiency requirements for existing homes – see ‘Improved energy efficiency requirements for existing homes’.
- Transitional arrangements – see ‘Transitional arrangements’.

7.5. The policies not included and why are:

- Uplift to minimum standards for fabric in new dwellings – these are backstop values to ensure good quality building fabric, the main standards are the FEES performance metric.
- Uplift to minimum building services efficiencies in new dwellings – these are backstop values to ensure efficient building services, the main standards are the performance metrics.
- Consideration of high efficiency alternative systems – this is a reduction in guidance, no assessment is required.
- Information about Building Automation and Control Systems (BACS) – this would only affect homes with BACS, which would be very few, therefore the impacts are expected to be negligible.

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

**Improved energy efficiency requirements for new homes**

7.7. For the uplift of energy efficiency requirements for new homes, the costs and benefits have been assessed across the four building types detailed previously.

7.8. Table 7 shows the specifications assessed for each building type – the counterfactual, i.e., the current 2013 energy efficiency requirements, and the option the Government is going ahead with for the 2021 uplift in energy efficiency requirements. These are based on the notional (reference) building which is used to set the standard.

| **Table 7: Specification for each building type*** | | |
|---|---|---|
| | **2013 energy efficiency requirements** | **2021 energy efficiency requirements** |
| External Wall U-value (W/m²K) | 0.18 | 0.18 |
| Corridor Wall U-value (W/m²K) | 0.18 | 0.18 |
| Party Wall U-value (W/m²K) | 0 | 0 |
| Roof U-value (W/m²K) | **0.13** | **0.11** |
| Floor U-value (W/m²K) | 0.13 | 0.13 |
| Window U-value (W/m²K) | **1.4** | **1.2** |
| Window g-value | 0.63 | 0.63 |
| Door U-value (W/m²K) | 1.0 | 1.0 |
| y-value (W/m²K) | **Based on SAP 2012 Appendix R** | **Based on the 'Option 2' psi values in Table R2 of SAP 10.1.** |
| Ventilation System Type | Intermittent extract fans with trickle vents | |
| Air permeability (m³/h·m² at 50 Pa) | 5 | |
| Space Heating Source | Condensing gas boiler (regular for detached, combi for others) | |
| Domestic Hot Water Source | As for space heating | |
| Boiler Efficiency | 89.5% (SEDBUK) | |

| Table 7: Specification for each building type* | | |
|---|---|---|
| | **2013 energy efficiency requirements** | **2021 energy efficiency requirements** |
| Heat Emitters | **Standard radiators** | **Large (low temp) radiators** |
| Shower flow rate | 8 l/min | |
| Waste Water Heat Recovery (WWHR) | **No** | **Efficiency of 36% Utilisation of 0.98 Connected to 2 showers where present** |
| Fixed lighting capacity (lm) | 185 x TFA | |
| Lighting efficacy (lm/W) | 80 | |
| PV installation area (percentage of building foundation area) | **0%** | **40%** |
| PV assumptions | | **SE/SW facing, 45-degree pitch, no/little overshading, 6.5m$^2$/kWp, connected directly to dwelling.** |

*changes in specification in bold

7.9. The 2021 specification above in Table 7 will result in a reduction in fuel bills for householders, compared to the 2013 standard. This bill reduction was calculated using the models above in SAP 10.2 and they captured only regulated energy loads i.e., heating, hot water etc.

7.10. The analysis showed that regulated energy fuel bills in low rise apartments could reduce by around 35%, and regulated energy bills in houses could reduce by around 65%. Most of the savings are due to the introduction of solar panels.

### *Additional Capital Costs*

7.11. The increase in initial gross capital costs of achieving the new standard compared to the counterfactual are shown in Table 8. Further breakdown of the costs of the different elements is provided in Appendix C. These results show significantly higher short-term capital costs for the 2021 energy efficiency requirements relative to the baseline.

**Table 8: Additional Capital Costs for Routes to Compliance compared to Counterfactual**

| | Gas Boiler and Solar PV | AS Heat Pump |
|---|---|---|
| Detached house | £4,840 | £3,750 |
| Semi-detached house | £3,800 | £4,360 |
| Mid-Terraced house | £3,760 | £4,320 |
| Flats | £2,090 | £4,090 |
| Average (based on build mix) | £3,660 | £4,070 |

*Gross Undiscounted Costs

7.12. The changes in energy use were assessed by using SAP version 10.2. The new carbon emission and primary energy factors in SAP 10.2 were used to rebase the 2013 standard and used to calculate the 2021 standards. These carbon emission and primary energy factors are in Appendix D.

7.13. Extensive engagement was undertaken with industry to ensure capital cost estimates align with the expected industry level. From these discussions, it was agreed that in the short-term, there will be higher costs for the heat-pump route to compliance. This is principally believed to be due to an immaturity of installation supply chains and procurement processes. In addition, ongoing reductions in the variable costs of photovoltaic panel installation have been identified (i.e., the marginal cost per additional kWp installed) since the consultation cost analysis.

7.14. Consequently, costs have been revised from the consultation stage IA (see table 8 above). This has led to lower cost estimates across all house types for the gas boiler and solar PV route, whilst the estimated initial cost of the heat pump route to compliance has increased considerably.

7.15. For example, at the consultation stage it was estimated that the heat pump route to compliance would be more expensive than the 2013 counterfactual by around £3,130 for a semi-detached house and £2,780 for flats. These costs have increased for this impact assessment to £4,360 and £4,090 respectively. This has led to the difference in costs for a semi-detached house changing between the two routes to compliance, with the heat pump route going from £1,720 cheaper at consultation to it being £560 more expensive compared to the solar PV route (see table 8 above for new comparisons).

7.16. For all new homes, apart from a detached home, the initial cost of a heat pump in Table 8 is more expensive than the gas boiler and solar PV route compared to the counterfactual. This is because for a detached house using the gas boiler and solar PV route to compliance, it is assumed a more expensive hot water cylinder would be used as opposed to a combi boiler, which is used across the other dwelling types. In addition, more solar photovoltaic panels are needed for the larger house. Both issues raise the capital costs of a gas boiler and PV route, meaning a heat pump route is cheaper for a detached house compared to the counterfactual, due to the avoidance of these extra costs.

7.17. Over the longer-term, Currie & Brown estimate that the costs associated with both heat pumps and solar PV will fall, as supply chains mature and become more integrated, and learning rates take effect. For later years of the policy therefore, it is assumed that the cost of a heat pump will be around 75% of the initial cost, whilst for Solar PV they will be around 83% of the cost.

### *Gas Asset Value*

7.18. One issue raised by industry when discussing capital costs was the costs associated with the gas supply asset. The supply of utilities to a home has a capital cost attached with putting in the necessary infrastructure and any associated civil engineering works. The required works are likely to have a cost to society. On completion, this utility supply has a value as an asset, which the developer can decide to sell on to a third-party investor/supplier. The costs and sale prices of the asset will vary depending on a wide range of factors, including the size of development and how much work has been required to put in the infrastructure.

7.19. From discussion with industry, views were mixed on the expected value of the asset. Some developers reported that they could make revenue from selling on the asset over the initial capital costs, whilst some developers expected to make a loss. Speaking to utility providers, they expected that on average, the asset value would be equivalent to the initial capital costs, and therefore expected developers to recoup most or all the costs. Given the mixture of views across industry and lack of other available evidence, for the purposes of modelling it was assumed that installing the gas supply would involve little or no cost to business, as the cost is recovered on sale of the asset.

7.20. In the case of a gas supply for a new gas heated home (gas boiler and PV route to compliance), there is a social cost attached. This is because it is expected that any costs the supplier experiences from purchasing the gas asset, will be passed on to the occupier of the home in the form of higher fuel bills. However, for homes under the heat pump route to compliance, these will no longer require a gas supply. This means there is no cost being passed on to the occupier from the gas supplier, meaning a saving to society. As homes will already be connected to an electrical supply, for the heat pump route it is expected the only change needed will be a higher capacity electrical supply. This will partially offset the savings to society in the form of higher fuel bills. For housebuilders, there will be a small increase in costs from connecting to a higher capacity electrical supply.

### *Costs and Benefits Summary*

7.21. The costs and benefits for the new 2021 standards compared to the counterfactual are shown in Table 9. The results show that the new standard results in a net benefit of £4,548m, relative to the counterfactual. The additional capital costs associated with the uplift are outweighed by the carbon and energy savings made from switching to lower forms of carbon heat.

**Table 9: Summary of results from cost benefit analysis new and existing homes – total over the appraisal period**

| | |
|---|---|
| Transition costs (£m) | (12.2) |
| Energy savings (£m) | 2,043 |
| Incremental costs (£m) | (7,263) |
| Total financial benefit/(cost) (£m) | **(5,232)** |
| Carbon savings - non-traded (£m) | 9,363 |
| Carbon savings - traded (£m) | 32 |
| Total carbon savings (£m) | 9,396 |
| Air quality savings (£m) | 385 |
| Comfort Taking (£m) | 1 |
| Net benefit/(cost) (£m) | **4,548** |
| Amount of gas saved (GWh) | 377,631 |
| Amount of electricity saved (GWh) | 4,805 |
| Amount of $CO_2$ saved - non-traded (MtCO2(e)) | **70** |
| Amount of $CO_2$ saved - traded (MtCO2(e)) | **0.1** |
| Cost effectiveness – non-traded (£/tCO2) | 127 |
| Cost effectiveness – traded (£/tCO2) | (28,957) |

Source: Currie and Brown

7.22. There are several drivers for the difference in numbers compared to the consultation stage IA, driven by changes to new homes. First, the consultation stage IA was for new homes only, whereas this IA is for both existing and new homes. Second, the consultation stage IA only used the costs of the gas boiler and solar photovoltaic panels (PV) route to compliance, with a narrative included around the expected cost of heat pumps. For this IA, two routes to compliance have been considered and there have also been some changes made to the counterfactual to best reflect the current state of the market (more details included on both in the Analytical Approach section).

7.23. Consequently, energy savings have fallen as homes being fitted with heat pumps has risen, meaning the more expensive energy source of electricity is used over gas. As more homes are now fitted with heat pumps, less are fitted with PV compared to the counterfactual. This leads to less electricity being generated, again putting a downward pressure on energy savings. Incremental costs have fallen compared to the consultation stage, due to more costs and benefits being incurred by businesses already going further than the policy. The same applies to energy savings. Overall, this leads to an increase in the total financial cost of the policy, as the reduction in energy savings is greater than the reduction in incremental costs.

7.24. Total carbon savings have increased significantly from the consultation stage IA. This is due in part to more heat pumps being used which are the lower source of carbon heat, leading to a considerable fall in non-traded emissions. Whilst traded savings have also increased compared to the counterfactual, these are lower than at consultation stage, again due to the increase in electricity consumption from heat pumps and the decrease in electricity generated from lower PV.

7.25. In addition, the government's approach to carbon valuation was updated in September 2021[20], to reflect the latest evidence, domestic and international targets, and wider context. Consequently, the values which have been used for this impact assessment are higher than those used at the consultation stage. This value change, alongside the savings in carbon made, has resulted in a significant increase in the net benefit of the policy compared to the consultation stage.

**Impact of FEES on high rise apartments**

7.26. A review was taken forward of the possible implications of applying the Fabric Energy Efficiency Standard (FEES) target on high-rise apartment blocks, in terms of potential issues for compliance with the 2021 requirements . This included consideration of how this might impact on the feasibility of meeting the FEES target in terms of technical ability and cost, also considering the government's ban on combustible materials in and on the external walls of high-rise buildings.

7.27. Overall, the analysis suggested that it would be possible to comply with the 2021 full FEES target. The change in FEES target in 2021 might drive curtain walled apartment block designs towards triple glazing, with a higher performance than is currently typically specified and an associated cost increase. The difference in specification compared to current practice would be expected to be less in areas such as London where Local Planning Authorities already set targets which go beyond 2013 requirements.

**Changes to the calculation method for heat networks**

7.28. We investigated how new dwellings connected to district heat networks could comply with the 2021 standards.

7.29. For the analysis a 'block of flats' was modelled, as described in 6.18, that was selected as being the most representative core model for new dwellings which are connected to district heat networks. This block of flats used the Gas CHP heat network specification in Table 10 below and the 2021 fabric, natural ventilation, wastewater heat recovery, and PV specification, all in Table 7 above.

7.30. This was then modified to produce four options, to see whether they would comply with the 2021 target emission rate and primary energy rate. These options were:

- An 'advanced fabric' case, using specifications from the 2021 consultation ('option 1').
- An 'advanced fabric plus MVHR' case, as above but with MVHR added.
- A 'reduced distribution losses' case, taking a lower value informed by discussions with BEIS which assumed network losses of 20%.
- A 'heat pump' case which combines a heat pump with gas CHP and gas boilers. See Table 10 for heating specification.

[20] HMG (2021), Valuing GHG Emissions in policy appraisal, https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal

**Table 10: Specifications for district heating network modelling**

| | Gas CHP | Heat pump and Gas CHP |
|---|---|---|
| Space Heating Source 1 | Gas CHP | Gas CHP |
| Gas CHP efficiency | Heat eff 43%, Power eff 38% | Heat eff 43%, Power eff 38% |
| Heat to power ratio | 1.13 | 1.13 |
| Gas CHP fraction of heat supplied | 0.75 | 0.50 |
| Space Heating Source 2 | Gas Boilers | Gas Boilers |
| Gas boiler efficiency (SEDBUK) | 91.0% | |
| Gas boilers fraction of heat supplied | 0.25 | 0.10 |
| Space Heating Source 3 | - | Heat Pump |
| Heat pump fraction of heat supplied | - | 0.40 |
| Heat pump efficiency | - | 340% |
| Domestic Hot Water Source | As for space heating | As for space heating |
| Hot water details | HIU | HIU |
| Distribution loss factor assumptions | 1.5 | 1.5 |
| Community heating charging system/controls (where applicable) | Charging system linked to use of community heating, programmer and TRVs | Charging system linked to use of community heating, programmer and TRVs |
| Emitters | Radiators | Radiators |
| Electricity tariff | Standard | Standard |
| No. of showers | 2 except for small flat (1) | 2 except for small flat (1) |
| Shower flow rate (l/min) | 8 | 8 |
| No. of baths | 1 | 1 |
| WWHR present | Yes | Yes |

7.31. The primary energy factors (PEFs) and carbon emission factors (CEFs) for electricity generated by gas CHP are those in SAP 10.2 and can be seen in Appendix D.

7.32. The ‘advanced fabric + MHVR’, ‘reduced distribution losses’ and the ‘heat pump’ cases all complied with the 2021 Dwelling Primary Energy Rate (DPER) and Dwelling Emission Rate (DER). Therefore, there are practical means of complying when building new gas CHP heat networks, and often when connecting to existing gas CHP heat networks.

### *Futureproofing*

7.33. Included within the section above *Costs and Benefits: Improved energy efficiency requirements for new homes* are the costs and benefits of installing larger emitters with lower flow temperatures now. The benefits for the future have not been fully captured. The cost benefit analysis uses gas boilers as the replacement for gas boilers. It is, however, likely that in the future heat pumps will be installed as a replacement for gas boilers. The larger emitters will have the benefit to consumers in the future of not

requiring replacement, therefore saving consumers money, reducing waste, reducing disruption and hence making it more likely low carbon heat will be installed.

**Costs and Benefits: Airtightness for new domestic buildings**

7.34. There are two policy changes: 100% testing and carbon capping.

***100% testing***

7.35. The counterfactual is the number of homes that currently have an airtightness test for compliance purposes. This has been determined through the total number of airtightness tests undertaken on new homes[21], corrected for (reduced by) additional testing based on unpublished data from BSRIA e.g., due to testing during the construction process or additional testing when a home fails their initial test. This was then divided by the number of new build dwellings[22]. This was analysed over the period from April 2016 to March 2018. The results show an average percentage of new build dwellings tested each year of 86%.

7.36. Once 100% testing is introduced, the additional number of new build dwellings to be tested each year is therefore 14%. Some homes fail tests and will be retested. Based on current fail and retest rates in BSRIA data, the number of additional tests to be undertaken is therefore estimated to be around 16.6%.

7.37. Based on data by BSRIA, the cost of each test is on average £64 for volume housebuilders. Hence, the cost of extending air-permeability testing to 100% of new build UK properties will therefore be the number of homes constructed x 16.6% x £64.

7.38. The benefit is expected to be gained from the improvement of the air-permeability of those dwellings that are not currently tested. It is assumed, for the purpose of this analysis, that 100% testing could improve the air-permeability of the currently untested dwellings that would otherwise fail the initial test and require additional works to pass. It is assumed that airtightness testing will not impact on those homes that are currently untested but would be expected to pass the test first time. The benefit will be the fuel savings and reduced fuel bills that result from that improvement.

7.39. The number of dwellings that will benefit from a reduced air-permeability is therefore the number of homes constructed x 14% (number of homes not currently tested) x 10.08% (unpublished BSRIA estimate of the percentage of homes that currently fail their first airtightness test i.e., the airtightness test result is poorer than their design air permeability).

7.40. The energy saving per benefitted dwelling was determined using the SAP version 10.2 for the semi-detached house, used elsewhere in the new domestic modelling (the

[21] DCLG (2016), Airtightness testing Scheme Statistics: England and Wales, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/714057/180605_Air_Tightness_Testing__Master_Stats__April_2016_to_March_2018.pdf

[22] Ministry of Housing, Communities and Local Government (2019), Table 213 and 214: permanent dwellings started and completed by tenure England and Wales (quarterly), https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building.

results from the semi-detached home were assumed on average to be representative of the building stock). Unpublished data from BSRIA shows that the typical design air permeability target is 5m³/m²h @ 50 Pa and on average failed tests (i.e., their first airtightness test) had an air-permeability that was 1.4m³/m²h @ 50 Pa poorer than the design air-permeability. Hence, it's assumed the benefit from testing is associated with a reduction in air permeability from 6.4m³/m²h @ 50 Pa to 5m³/m²h @ 50 Pa. The results from SAP show a reduced energy consumption of 172kWh/year.

7.41. The overall costs and benefits for 100% sample testing, compared with continuation of the existing 2013 standards, are shown in Table 11. There is a net cost of this policy.

**Table 11: Summary of results from cost benefit analysis (100% sample testing)**

| | |
|---|---|
| Energy savings (£m)<br>Incremental costs (£m) | 1.4<br>(10.1) |
| Total financial benefit/(cost) (£m) | **(8.7)** |
| Carbon savings - non-traded (£m)<br>Carbon savings - traded (£m) | 4.2<br>- |
| Total carbon savings (£m) | 4.2 |
| Air quality savings (£m) | 0.2 |
| Net benefit/(cost) (£m) | **(4.3)** |
| Amount of gas saved (GWh) | 170.4 |
| Amount of electricity saved (GWh) | - |
| Amount of $CO_2$ saved - non-traded (MtCO2(e)) | 0.03 |
| Amount of $CO_2$ saved - traded (MtCO2(e)) | - |
| Cost effectiveness – non-traded (£/tCO2) | 173 |
| Cost effectiveness – traded (£/tCO2) | - |

***Carbon emissions capping***

7.42. This change involves capping carbon emissions savings, associated with an air-permeability below 3m³/m²h @ 50 Pa, in naturally ventilated dwellings. The purpose of this would be to discourage the construction of overly airtight, naturally ventilated dwellings that could lead to poor ventilation and indoor air quality.

7.43. Data received from BSRIA confirms that this policy change has an impact of around 2% on naturally ventilated dwellings because they have a design air permeability of below 3$m^3/m^2$h @50 Pa.

7.44. The developer would still need to be compliant with the overall heat performance standards. Hence, the cost associated with this change is already captured within the costs of the improved standard.

**Improved Compliance and Performance**

7.45. The main cost benefit analysis assumes 100% compliance. It is known however that in some new homes, there is a gap between the designed and as-built performance of

new buildings, known as the ‘performance gap’. The cause is sometimes poor build quality leading to non-compliance with the standards.

7.46. To ensure housebuilders comply with the standards and to reduce the performance gap, guidance and processes have been improved to provide more information to housebuilders on how to follow the new energy efficiency requirements. These improvements are detailed below:

Simpler guidance: Approved Document guidance for the energy efficiency requirements has been rewritten to be simpler. It should be easier to understand, comply with and check against.

Build quality guidance: This new guidance in the Approved Document provides more detail on how to limit thermal bridges and ensure good airtightness. The new guidance is in-line with good practice and should already be followed as a minimum if we are assuming full compliance with building fabric standards. The guidance also provides Building Control information on key aspects to check.

Compliance Report (BREL): A single style of compliance report is to be produced by calculation software, the BREL. The commercial Standard Assessment Procedure (SAP) software each produce their own versions of a compliance report. Standardisation of the reports is to ensure that Building Control always receive the same high-quality information to check.

Photographic evidence: Photographs of each home are to be taken by the developer at specified points during construction and provided to Building Control, SAP assessors and the homeowner. This is to improve the accuracy of energy calculations and to provide assurance that the SAP energy models reflect the as-built dwellings.

Energy efficiency requirements version: The version of the energy efficiency requirements which a home is built to is to be included on the Energy Performance Certificate (EPC). This is to improve information given to the purchasers of new homes.

Home User Guides: Regulations 39 and 40 of the Building Regulations require that information about the use of fuel and power is provided to the owner of the building. Within the current Approved Documents, there is already guidance that the features of the home should be explained to the user. The new guidance makes it clear to developers that the explanation should be in plain English and, to further aid occupiers, the information will be in a single document (the Home User Guide). A Home User Guide template has been provided to help developers: https://www.gov.uk/government/publications/home-user-guide-template.

***Costs***

7.47. Of the changes in guidance, many of these are considered to already be the minimum expected in complying with the energy efficiency standards of the Building Regulations. Therefore, these should create no extra costs for housebuilders compared to the 2013 standards. Many of the original costs from first issuing guidance

will have been captured in previous Impact Assessments (IAs) for the energy efficiency requirements of the Building Regulations. A summary of the expected impacts, which are not captured in the cost benefit analysis, is below:

a. **Simpler guidance**: It is assumed that there is no net cost associated with the simpler guidance as housebuilders and other professions are already required to read guidance. There will be additional time to become familiar with the new Approved Document, however this is balanced by reduced time to apply the simpler guidance.

b. **Build Quality Guidance and Home User Guides**: The costs of for these two changes have not been included in the cost benefit analysis as full compliance with the Building Regulations is assumed. Therefore, no extra cost is created over the minimum standard today and many of the original costs from first issuing guidance will have been captured in previous IAs:

    i. Building quality guidance: there will be some initial costs associated with adapting to a new way of working but the costs of following the new practices are not significantly greater than current practice.

    ii. Home User Guides: there will be initial costs associated with adopting the Home User Guide template, but developers can then simply adapt the Guide for future schemes which should result in a similar or reduced cost to current practice.

c. **Compliance report**: The information on the BREL is already captured through the normal data input to SAP. Hence, there should be little, or no cost borne by the developer or SAP assessor.

d. **Energy efficiency requirements version**: Whilst this is a new ask, there should be minimal or no costs to the EPC assessor or the EPC software provider. This has been designed into the EPC schema by the government.

7.48. Given that the above guidance is being made simpler to follow compared to 2013 guidance and are already considered to be part of the minimum standard, the only extra costs incurred by housebuilders is the new additional standard of providing photographic evidence. This is an on-going cost for developers which has been estimated below and included in the cost benefit analysis. There are four components to the cost:

a) **Photo taking:** Appendix B of Approved Document L Volume 1 schedules the photos required per dwelling as part of reporting evidence of compliance. The quantity of photographs required per dwelling is not specific. It is assumed, on average, that approximately 30 photos will need to be taken per dwelling to satisfy the specification. The time needed to take a photo of the quality specified is expected to be no more than 30 seconds per photo. Thus, on average, the total time needed for taking all photos per dwelling is expected to be around 15 minutes.

b) **Photo management:** The photo specification in Appendix B of the Approved Document includes naming conventions for each photo such that each can be indexed for ease of reference later. A coding system is provided in Appendix B that includes the plot construction reference number and a code for the detail being photographed.

Many SME and major developers use cloud document storage platforms for the management, storage and sharing of project documents, such as drawings, specifications, inspection records, etc. which can be accessed by the client, design, and construction team as authorised by the site administrator. These platforms already facilitate photo management and storage options.

Discussions with one of the major platform providers used in the construction sector has identified that their platform could easily be developed to accommodate a downloadable app onto phones/tablets that could link to a client portal. The app could be developed to provide a menu containing the schedule of photos listed in Appendix B such that the user selects the detail from the menu at the time of taking the photo. The photo can then be automatically named and uploaded to the appropriate folder without further user interaction.

As many developers already use these platforms, which are billed monthly or annually (typically between £600 and 800 annually per company, not per development), any additional cost associated with photo uploading, renaming and storage is expected to be incorporated within the existing fees for these packages. Hence, the costs to the developer per development for photo management will be very small if not negligible. As such, costs are not included in this assessment as the cloud platforms are already widely used.

c) **Training and QA:** Additional time will be needed to instruct site personnel about their responsibilities for the taking of photos and the conventions for uploading them. These instructions could be given as part of site induction training, which already takes place in compliance with CDM regulations. It is expected that the training per person for site photos would be an additional 10 minutes within the induction session. In addition, for the cloud platforms, the downloading and use of an integrated app would be around a further 10 minutes (i.e., 20 minutes total). It is expected that the time allocation for training will reduce once construction site personnel become familiar with the standards.

For this assessment, a development size of 50 dwellings is used, and it is assumed that between 40 and 50 trade operatives would need to be trained. This also results in a total time of up to 20 minutes training per operative per dwelling.

Additional time may be necessary for a site manager (or person with their authority) to conduct QA audits to ensure photos are being taken and stored correctly. The amount of time needed would likely vary according to the size of the development and the associated number of trade personnel. For this assessment, it is expected that the QA process will be on a sample basis, i.e., not checking every photo in every dwelling. On

this basis, it is assumed that the QA would cover up to 50% of photos taken and should also take no longer than 30 seconds per photo. For a development size of 50 homes, the total number of photos to be reviewed would be 750, which equates to 7-8 minutes per dwelling. This time estimate is rounded to 10 minutes per dwelling. Time allocation to account for mitigating a QA audit failure is not included in the assessment as there is greater benefit in the photo/QA process identifying a defect.

d) **Shared access to photos:** Access to the photos will need to be afforded to both building control inspectors and the SAP assessors.

An advantage of the cloud platform is that both the SAP assessor and BCB would simply need a user login to the portal to grant access to the photo folders (or other folders if authorised). This would eliminate any time needed for the developer to send photos. Hence, time for this task is not included in this assessment.

A summary of the time allocation for photos is set out in Table 12:

**Table 12: Time needed for photos and file management per dwelling**

| Photo-taking | File management | Training | QA | Distribution to BCB/SAP assessor | Total time per dwelling |
|---|---|---|---|---|---|
| 15 min | * | 20 min | 10 min | * | 45 min |

* denotes automatic process (no time allocated)

The training costs will be reduced over time as the industry gets more familiar with the approach, but some training costs have been retained to account for the continuing need for new trade operatives to be upskilled, any changes to the software package etc. The following is assumed:

- Year 1: 100% of training costs incurred
- Year 2: 75% of training costs incurred
- Year 3: 50% of training costs incurred
- Year 4 onwards: 25% of training costs incurred

Based on a typical hourly rate of £34 for a site manager, it is estimated that these time costs would result in approximately £26 per home in year one, falling to £6.50 per year from year four onwards.

***Benefits***

7.49. Benefits have not been included in the main assessment of costs and benefits, as it is assumed that there is 100% compliance, in line with other impact assessments.

7.50. It is known however that in some new homes, there is a gap between the designed and as-built performance of new buildings. The size of this gap is very uncertain, with no data sources immediately available to correctly quantify the issue (See Compliance section for more details). Consequently, AECOM took forward some sensitivity analysis to provide an indicative estimate of the benefits. These are the potential

benefits gained from increasing compliance in the housebuilding industry from a clearer set of compliance package measures. To do so, AECOM focussed on improvements to build quality.

7.51. For the baseline, an example semi-detached dwelling was modelled in SAP using the 2021 notional building specifications. Four scenarios were then modelled to evaluate the impact of possible deviations from the designed building. These were based on site observations of circumstances where junctions and interfaces may not have included the specified amount of insulation, or where insulation is missing, displaced or poorly installed – these are all issues that the building quality guidance is intended to address.

7.52. The analysis suggests that the gas consumption increases by approximately 15-20% and carbon emissions increase by approximately 20% by applying what is reasonably representative defects likely to occur. The impact will vary in practice depending on the actual build quality and the exact nature of the defects. This equates to an average of £52 per home per year.

**Costs and benefits: Improved energy efficiency requirements for existing homes**

7.53. The changes for existing homes have been split into fabric changes and building services changes. The section on fabric includes changes to the standards of:

- new thermal elements (usually extensions).
- renovated thermal elements.
- replacement of controlled fittings (windows and doors).

7.54. The section on building services includes changes to the standards of:

- efficiencies of replacement building services.
- heating systems to be designed to run at 55°C when they are being fully replaced (larger radiators).
- installation of self-regulating devices (usually thermostatic radiators valves).

***Improved fabric standards in existing homes***

7.55. For the uplift to fabric standards for existing homes, only the costs and benefits of the improved standards for new thermal elements and the replacement of controlled fittings have been quantified. For this analysis, it is assumed that most new thermal elements in existing homes are being built to no better than the existing minimum standard. It is however assumed that 73% of replacement-controlled fittings are already meeting the new, improved, standard[23].

7.56. The standard is being raised for the renovation of pitched roofs where insulation is between the rafters and for flat roofs or roofs with integral insulation. This is improved to a U-value of 0.16 W/m$^2$K, which is the current minimum standard for pitched roofs

[23] Based on evidence of window ratings in circulation provided to DLUHC.

with insulation at ceiling level. It is likely to only have a small effect on the usability of a loft space e.g., resulting in an additional 10-15mm of insulation below the rafters for pitched roofs. The cost impacts have not been fully quantified because this increase in insulation thickness will have very little cost implication, particularly where most of the cost of the work is due to labour. Therefore, it was not deemed proportionate to cost.

7.57. **New thermal elements.** The analysis is based on the impact to the construction of extensions. There are approximately 135,000 extensions a year[24] which will be impacted. The change to strengthen minimum performance standards are 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.

7.58. **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[25]. The change is to strengthen standards to a U-value of 1.4 W/m$^2$K for both windows and doors.

7.59. The energy saving benefits of these policy changes were determined using SAP version 10.1[26] for an 84m$^2$ semi-detached house (the results from the semi-detached home were assumed on average to be representative of the building stock[27,28]).

- **New thermal elements:** the analysis modelled an extension of 20m$^2$, this has been estimated to be a common extension size[29]. 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.

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

[24] DLUHC estimate based on previous energy efficiency requirements impact assessments and planning data
[25] Based on data reported by Competent Person Schemes
[26] BRE, SAP 10, https://www.bregroup.com/sap/sap10/
[27] The semi-detached model represents both the semi-detached and end of terrace build forms. Based on the 2019 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.
[28] The fabric values for the baseline semi-detached home reflect new build standards from ADL 1995.
[29] 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.

7.61. Table 13 shows the results of this analysis. The policy changes result in a net benefit of £308m for raising the standards for new thermal elements and a net benefit of £123m for raising the standards for replacement windows and doors.

**Table 13: Summary of results from cost benefit analysis (improved fabric standards for existing dwellings only)**

| | New thermal elements | Replacement of controlled fittings | Total |
|---|---|---|---|
| Training and dissemination costs (£m) | | | 1 |
| Energy savings (£m) | 162 | 63 | 225 |
| Incremental costs (£m) | (362) | (113) | (475) |
| **Total financial benefit/(cost) (£m)** | **(200)** | **(49)** | (250) |
| Carbon savings - non-traded (£m) | 489 | 167 | 655 |
| Carbon savings - traded (£m) | - | - | - |
| **Total carbon savings (£m)** | **489** | **167** | 655 |
| Air quality savings (£m) | 20 | 6 | 26 |
| Comfort taking (£m) | - | (1) | (1) |
| **Net benefit/(cost) (£m)** | **308** | **123** | 431 |
| Amount of gas saved (GWh) | 19,780 | 5,435 | 25,215 |
| 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 (£/$tCO_2$) | 85 | 124 | (50) |
| Cost effectiveness – traded (£/$tCO_2$) | - | - | |

***Improved building services standards in existing homes***

7.62. The standards for most replacement services have not been improved beyond those currently included in the existing guidance or product standards. Most of those that have been improved represent only a small number of replacements each year, for example heat pumps, and therefore the impacts have not been quantified as it was not considered proportionate. The exception to this is regular (not combination) oil boilers where the new efficiency standard has been expressed as 91% ErP, and the existing standard is 88% SEDBUK. There is not a linear relationship between the two methods, with the standard sometimes being slightly higher and sometimes slightly lower. The method of expressing the standard does not result in a significant uplift in standards. It is also likely this does not represent most of the oil boiler replacement market; most replacements are assumed to be combination boilers.

7.63. The new standards will require heating systems to be designed to run at 55°C when they are being fully replaced. This work is significantly less common than either boiler replacement or individual radiator replacement when one fails and is estimated by industry to only represent 1.2% of total boiler replacements. This type of work would also lead to larger radiators being fitted, which is expected to only carry a small extra cost. Not needing to replace radiators again when low carbon heat is installed is a

benefit but has not been quantified. Given the small number of homes affected and the magnitude of costs for larger radiators, it was deemed disproportionate to take forward cost benefit analysis.

7.64. Self-regulating devices (SRD) should now 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. The most common approach to compliance with the new SRD standard would be to install a room thermostat in one location (e.g., the main living room) and install a thermostatic radiator value (TRV) on all radiators in other rooms (except for the radiators where the room thermostat is placed).

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

7.66. 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 the energy efficiency requirements. Hence, there will be an impact of making this practice part of the minimum standard.

*Number of homes affected*

7.67. There are approximately 1,700,000 replacement gas boilers per year in the UK[30].

7.68. Table 14 shows that English homes comprise 83% of the UK stock. Hence, this results in ~1,412,000 replacement gas boilers in England per year.

7.69. In 2019, 88.2% of dwellings in England were on gas as their main heating supply and 3.3% were on oil. The number of oil boilers in the English housing stock is therefore 3.7% of the number of gas boilers.[31]. Assuming the same asset life of both boiler types, this results in 52,825 replacement oil boilers in England per year.

7.70. Hence, in total, it is estimated that there are 1,465,000 (gas and oil) boiler replacements per year.

[30] 2019, HICC data
[31] English Housing Survey, 2019

**Table 14: Existing housing stock**

| | |
|---|---|
| England | 23,778,000 [32] |
| Scotland | 2,605,000 [33] |
| Wales | 1,431,000 [34] |
| Northern Ireland | 799,000 [35] |
| **Total UK** | **28,619,000** |
| **Proportion in England** | **83%** |

7.71. 86% of dwellings already have at least one TRVs present[36]. Given that the English Housing Survey does not differentiate between the number of TRVs identified in a home upon surveying, and there is no other available data, for the purposes of this analysis a central estimate of 50:50 was taken 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. The final 14% of dwellings have no TRVs present.

7.72. Applying these proportions to the number of gas boiler replacements, homes with TRVs can be presented as three groups as follows:

- Group 1 (TRVs present in all rooms): 43% of all homes; ~630,000 homes per year.
- Group 2 (TRVs present in habitable rooms only): 43% of all homes; ~630,000 homes per year.
- Group 3 (TRVs present in no rooms): 14% of all homes; ~208,000 homes per year.

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

*Counterfactual*

It is assumed:

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

7.75. Data from the English Housing Survey shows that 3,497,000 [37] installed at least one TRV over the last 5 years, equalling an annual five-year average of 699,000 homes. This figure is assumed as the annual yearly increase going forward, hence it is assumed that 699,000 homes will put TRVs on either radiators in habitable rooms or radiators in all rooms when they have their boiler replaced.

[32] Ministry of Housing, Communities and Local Government (2020), English Housing Survey 2019 to 2020: headline report: https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report
[33] Scottish Government, 2019, Housing statistics 2019: key trends summary, https://www.gov.scot/publications/housing-statistics-scotland-2019-key-trends-summary/
[34] Welsh Government, 2019, Housing stock data https://statswales.gov.wales/Catalogue/Housing/Dwelling-Stock-Estimates/dwellingstockestimates-by-localauthority-tenure
[35] Department of Finance- NI, 2019, Annual housing stock statistics, https://www.finance-ni.gov.uk/publications/annual-housing-stock-statistics
[36] 2019, EHS Data

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

7.76. Based on the number of dwellings with TRVs, there is a 75:25 split between installations in Group 2 and 3 homes. It is assumed that all of these will move into Group 1 by fitting TRVs in all rooms, which is standard industry practice.

7.77. Consequently, out of the 1,465,000 replacement boilers a year, it is expected that 1,328,000 of these will already be installing TRVs in all rooms in the counterfactual. This leaves 137,000 homes affected by the policy change, split between Group 2 and 3. The results are as follows:

**Table 15: Number of buildings with TRVs that fall into the counterfactual and policy**

| Homes with TRVs in no. of rooms | No. of replacement boilers by group | Of which are new dwellings moving into Group 1 | Numbers affected by Policy |
|---|---|---|---|
| **Group 1: All rooms** | 628,562 | - | - |
| **Group 2:Some rooms** | 628,562 | 525,425 | 103,137 |
| **Group 3: No Rooms** | 208,128 | 173,978 | 34,151 |
| **Total** | **1,465,253** | **699,402** | **137,288** |

*Benefits*

7.78. An 84m$^2$ semi-detached house was modelled using SAP version 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[38].

7.79. The 2016 BEIS consultation impact assessment for Boiler Plus[39] 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%[40]. In practice, there is limited robust evidence for the level of energy savings from TRVs[41] and there is expected to be significant variation in the achievable savings depending on consumer engagement with their control system. However, given the data limitations, the BEIS central estimate was used for the analysis.

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

[39] Department for Business, Energy and Industrial Strategy (2016), Heat in Buildings - The Future of Heat, Consultation outcome, https://www.gov.uk/government/consultations/heat-in-buildings-the-future-of-heat

[40] 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

[41] Lomas, Kevin; Haines, Victoria; Beizaee, Arash (2016), Heating controls scoping review project. Loughborough University, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/573888/Final_Report_-_Heating_Controls_Scoping_Review_Project.pdf

7.80. The space heating savings are shown in Table 11 for each Group 2 and 3 home based on the central estimate.

**Table 16: 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<br><br>(This accounts for the fraction of non-habitable floor area in the home) |

*Costs*

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

7.82. Table 17 shows the results of this analysis. The SRD policy leads to a £162m net benefit under the central estimate. The costs of larger radiators are also included in the table.

**Table 17: Summary of results from cost benefit analysis (SRDs and larger radiators in existing dwellings)**

| | SRDs | Larger Radiators | Total |
|---|---|---|---|
| Energy savings (£m) | 84.0 | - | 84 |
| Incremental costs (£m) | (141) | (59) | (200) |
| **Total financial benefit/(cost) (£m)** | (57) | **(59)** | (116) |
| Carbon savings - non-traded (£m) | 210 | - | 210 |
| Carbon savings - traded (£m) | - | - | - |
| **Total carbon savings (£m)** | 210 | **-** | 210 |
| Air quality savings (£m) | 7.9 | - | 7.9 |
| **Net benefit/(cost) (£m)** | 162 | **(59)** | 102 |
| Amount of gas saved (GWh) | 6,313 | - | 6,312.8 |
| Amount of electricity saved (GWh) | - | - | - |
| Amount of $CO_2$ saved - non-traded ($MtCO_2(e)$) | 1.2 | - | 1.2 |
| Amount of $CO_2$ saved - traded ($MtCO_2(e)$) | - | - | - |

## Training

7.83. There are transition costs incurred by businesses to familiarise their employees with the new technical requirements. The overarching methodology has not changed (e.g., businesses will continue to use SAP to assess compliance for new homes). Furthermore, the higher standards that will come into force are progressive i.e., the majority should be able to be met through straightforward amendments to current practices, rather than radical changes in the way new buildings are constructed.

7.84. It is assumed that training is necessary for developers and associated professional services to design the buildings to the new standards and procure the appropriate building components, for the supply chain to be ready to meet this demand and for building control to assess the building applications and work.

7.85. The familiarisation costs that are likely to occur have been estimated by Adroit Economics through the following process:

- Types of business/organisation that will be affected were identified. These included energy consultants, SAP assessors, contractors, architects, engineers, energy modellers and building control.
- Types of familiarisation activity were identified. These included preparing training course material, self-study, CPD, and formal training courses.
- Consultation was undertaken with a small sample of these businesses and/or representatives of these businesses/organisations, to identify the time/cost likely to be incurred.

- The costs were then scaled up across the industry based on the number of businesses/organisations.

7.86. Table 18 shows the estimated average familiarisation time (in hours) for each type of affected business/organisation.

**Table 18: average familiarisation time (hrs) for each type of affected business**

| | Energy Consultant | SAP Assessor | Main Contractor/ Developer | Architect | Engineer - other | Engineer - energy modeller | Building Control |
|---|---|---|---|---|---|---|---|
| New energy efficiency requirements | 22.5 | 15 | 7.5 | 2.5 | 2.5 | 20 | 26.25 |
| SAP | 26.25 | 7.5 | 0 | 0 | 0 | 2 | 0 |
| Performance Gap | 2 | 0 | 0 | 2.5 | 2.5 | 8 | 26.25 |
| Airtightness | 2 | 0 | 3.75 | 0 | 0 | 12 | 0 |

7.87. In addition to the time for familiarisation, it is anticipated that some of the changes will also involve attendance at a 1-day training course. The cost of the training course has been included at an estimated £250 per day, with 50% of the courses being delivered at no cost by industry bodies. The analysis assumes that the following changes will involve 1 day training courses:

i. energy modellers to become familiar with the changes to energy efficiency requirements
ii. Building Control to become familiar with the changes to energy efficiency requirements
iii. SAP assessors to become familiar with the change to SAP
iv. Building Control to become familiar with Performance Gap.

7.88. Table 19 shows the estimated number of businesses/organisations that will need to become familiar with the changes:

**Table 19: Estimated number of businesses that will need to familiarise themselves with the changes**

| | Energy Consultant | SAP Assessor | Main Contractor/ Developer | Architect | Engineer – other | Engineer – energy modeller | Building Control |
|---|---|---|---|---|---|---|---|
| Numbers of organisations | 3,085 | 3,427 | 465 | 13,105 | 12,592 | 380 | 400 |

7.89. Table 20 shows total estimate familiarisation costs for new and existing dwellings:

**Table 20: Transitional training cost to business by measure**

| | New Dwellings | Existing Dwellings |
|---|---|---|
| Energy efficiency requirements guidance | £4,541,316.8 | £1,135,329.2 |
| Performance gap guidance | £2,445,222 | - |
| Performance gap – establish new processes | £896,776 | - |
| SAP | £3,323,997 | - |
| Airtightness | £346,897 | - |
| **Total** | **£11,055,609.25** | **£1,135,329.2** |

7.90. Using the HMT GDP deflator, this means that the estimated transitional costs in 2019 price year and 2021 base year is **£12.2 million.**

7.91. Please note 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 standards.

**Transitional arrangements**

7.92. The 2021 regulations and statutory guidance will apply to all buildings that have not commenced development within 12 months of the regulations coming into force. The one-year transition period will therefore mean some existing consents will need to be amended so they can be built out in compliance with the 2021 regulations. This is due to the impact of FEES and solar panels or heat pumps dependent on the route to compliance. Quod consultants have led analysis to estimate the costs for amending existing consents for dwellings.

7.93. Analysis suggests that 9,385 consents will need to be amended. This accounts for planning consents typically having a lifetime of 3 years from the date permission was granted until development must commence and may then take several years for all the buildings to start on larger schemes. This excludes London consents as London Plan requirements are more than 2021 energy efficiency requirements.

7.94. The changes to comply with 2021 energy efficiency requirements are expected to require an amendment to existing consents, with the most appropriate route being at the discretion of the planning authority. A Non-Material Amendment (S96a) would be appropriate for most scenarios which would cost approximately £1634. A Minor Material Amendment (S73) may be required for buildings in conservation areas, where the roofscape may be considered to contribute to the character and appearance of the area (relevant for the addition of photovoltaic panels) and this would cost approximately £2474. The costs account for both a planning fee and professional fees.

7.95. Assuming 5% of the consents will require a S73 due to being in a conservation area, or due to other local sensitivities assessed by the Council, this comes to a total of £15,728,738.

**Comfort taking**

7.96. Comfort taking is when a reduction in heating bills leads to some householders choosing to heat their homes to higher temperatures. It was considered whether comfort taking should be included in the models for new and existing homes.

7.97. We have adopted the approach taken in the Green Deal impact assessment 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).

7.98. 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.

7.99. The most appropriate approach to take for comfort taking in new homes was unclear. Since people in different situations are unlikely to perceive the same value of comfort, it is not reasonable to assume the same level of comfort taking for existing and new homes. The counterfactual for the new homes analysis is a 2013 standard which is already a much more energy efficient standard than for a typical existing home. It is much less likely that there would be substantial further comfort taking from this uplift because consumers are unlikely to perceive this relatively small difference in standards. Furthermore, given the lack of empirical data available, applying any other assumption other than no comfort taking would effectively involve the imposition of an arbitrary assumption and any analysis to develop an estimate of comfort taking would not be proportionate. Therefore, no comfort taking has been applied to new dwellings.

# 8. Business impacts

### Equivalent Annual Net Direct Cost to Business (EANDCB)

8.1. The changes to the energy efficiency requirements of the Building Regulations for new and existing homes will result in increased costs to business of £475m per year over the 10-year policy period, with the expected EANDCB for PRS landlords £90m and £86m for Housing Associations. As per the HMG's official impact assessment Calculator, the EANDCB has been calculated in 2019 prices, 2020 PV base year.

8.2. The direct costs determined to be in scope of the EANDCB are transition costs, upfront capital costs, installation costs, some maintenance costs and some replacement costs for existing homes. Most of these costs are the capital costs incurred by developers.

8.3. The 10-year policy appraisal period was used in line with Green Book Guidance. This captures the majority ( over 90%) of costs incurred by business from the regulation uplift, as many of the bigger costs, particularly capital and installation, occur in the first 10 years of the policy. However, this does mean that any replacement or maintenance costs incurred in the following 60 years will not be included in the EANDCB calculation.

8.4. The alternative approach would be to include all costs but calculate the EANDCB over 70 years rather than 10. This would bring the EANDCB down substantially as the costs are spread over a much longer time horizon, which could potentially be misleading given that most of the costs happen in the first 10 years of the policy. Furthermore, the only replacement and maintenance costs that would be incurred by business would be for those homes that are either in the Private Rented Sector or owned by Housing Associations (amounting to less than 10% of the overall costs). The remaining costs would fall to the occupiers of the home. Due to this, and to remain consistent with Green Book guidance, it was therefore decided to still appraise the EANDCB over the 10-year policy period.

8.5. There are no direct benefits to business of the new requirements, as the benefits of greater energy savings will be experienced by the occupants, whilst reduced carbon emissions and improved air quality are societal benefits.

**Table 21: EANDCB and Business Net Present Value (£m)**

| | |
|---|---|
| EANDCB | (475) |
| Business Net Present Value | (4,091) |
| Score against the Business Impact Target | (2,376) |

### Capital, Transition and Installation Costs for New Homes

8.4. For new domestic buildings the capital, transition and installation costs will be paid by business. This is split between private developers, Private Rented Sector (PRS) landlords and Housing Associations (HAs), with the majority being incurred by private

developers. Using English Housing Survey (EHS) data on new build completions by tenure, it is estimated that 19% of costs will sit with PRS landlords and 18% will sit with HAs. Private developers over the longer term may pass on costs to owners in the form of higher house prices, at least in areas of high demand. Over the medium-long term, development costs may become factored into the land prices and therefore passed onto landowners, however in the short-term this is unlikely.

8.5. Some or all of the costs incurred by PRS may be passed onto consumers/occupiers in the form of higher rent prices. For HAs, it is unlikely businesses will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG through HAs demanding higher grants to cover additional costs to build social rented sector accommodation.

8.6. All benefits will be experienced by the tenants in the form of lower fuel bills and by society through better air quality and reduced carbon emissions.

**Maintenance and Replacement Costs**

*New Homes*

8.7. Whilst most of the costs for any replacements or maintenance will sit with the occupier, some costs will sit with PRS landlords and HAs. For Maintenance costs of a new home, costs occurring in the first 10 years of the policy for PRS and HA will be included. No replacement costs for new homes have been included in this calculation, as none of these costs will occur in the first 10 years (see paragraph 8.3 and 8.4).

8.8. For the PRS it is likely that these costs could be passed on to the occupier in the form of higher rent prices. For HAs, it is unlikely businesses will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG through HAs demanding higher grants to cover additional costs to build social rented sector accommodation.

8.9. All benefits will be experienced by the tenant in the form of lower fuel bills and by society through better air quality and reduced carbon emissions.

**Table 22: EANDCB and Business Net Present Value for New Homes (£m)**

| | |
|---|---|
| EANDCB | (465) |
| Business Net Present Value | (3,999) |
| Score against the Business Impact Target | (2,323) |

*Existing Homes*

8.10. For Existing Homes, all costs incurred will be for the replacement and maintenance of windows, doors, extensions and radiators with self-regulating devices over the 10-year appraisal period. Any replacement or maintenance costs after the 10-year period have not been included in this calculation (see paragraph 8.3 and 8.4). Again, whilst the

majority of costs will sit with the occupier, some costs will be incurred by PRS landlords and HAs.

8.11. The EHS Headline report[42] was used to identify the tenure splits of the existing housing stock. In 2019-20 the PRS accounted for 19% of the existing stock, with HAs accounting for 10%. The remaining 71% was made up of the non-business sectors of Owner Occupiers (64%) and Local Authorities (7%).

8.12. On extensions, there is very limited evidence on the number of extensions by housing sector. Consequently, DLUHC spoke with planning and development consultants to get expert views. Consultants concluded that extensions were almost exclusively carried out by the Owner Occupier sector. Consequently, it is assumed that no costs associated with extensions are incurred by the PRS or HAs. For the remaining elements, it is estimated that the PRS landlords will incur an EANDCB of £7.0m, with HAs having an EANDCB of £3.7m. This equals a total EANDCB for existing dwellings of £10.7m. Landlords may have already accounted for these costs in the form of higher rent prices. If they have not, then in the short-term they would absorb the cost due to rent prices being locked in by tenancy agreements. However, over the longer term, at the point of renewal, these costs could be passed on to the occupier.

8.13. For HAs, it is unlikely businesses will be able to pass on the costs due to social rented sector rent levels being set by HMG. In this case, costs may be passed onto HMG through HAs demanding higher grants to cover additional costs to build social rented sector accommodation.

8.14. All benefits will be experienced by the tenant in the form of lower fuel bills and by society through better air quality and reduced carbon emissions.

**Table 23: EANDCB and Business Net Present Value for Existing Homes (£m)**

| | |
|---|---|
| EANDCB | (10.7) |
| Business Net Present Value | (91.9) |
| Score against the Business Impact Target | (53.4) |

## Small and Micro Business Assessment (SaMBA)

8.16. Small and micro businesses (SMBs) in the housing sector principally comprises developers/constructors, architects, and other technical specialists. Some small and micro businesses in the manufacturing sector will also be affected by the new standards, in particular windows and door manufacturers.

8.17. The number of small (10-49 employees) and micro (0-91 employees) businesses in the affected sectors are detailed below. These figures are from the ONS UK Business Counts dataset, broken down by employment band and 5-digit SIC code[43] rounded to

[42] English Housing Survey, December 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945013/2019-20_EHS_Headline_Report.pdf

[43] The consensus at the ONS is that the 3 digit SIC code is the optimum level in terms of sample size and confidence in estimates. However, given this assessment is specifically about the construction of domestic buildings, this requires a more specific SIC code hence the reason for using SIC 5.

the nearest 5. For builders and developers, 99.5% of the 82,010 enterprises are small or micro businesses. For architectural practices 99% of the 13,105 businesses are small or micro businesses.

**Table 24: Number of Small and Micro Businesses in scope of the regulation changes**

| Business (5-digit SIC code) | Micro businesses | Small businesses | Total number of businesses | SMBs as % of total |
|---|---|---|---|---|
| Builders and developers | 78,650 | 2,955 | 82,010 | 99.5% |
| Architects | 12,030 | 900 | 13,105 | 99% |

8.18. For windows and door manufacturers it is not possible to identify the exact number or proportions of SMBs in the sector from published statistics because of categorisation issues. Within the ONS 5-digit SIC code classification:

- Manufacture of timber windows and doors is included in the wider SIC 5 category of builders' carpentry and joinery – 98% of the 6,195 enterprises in this sector are SMBs;
- Manufacturer of plastic windows and doors are included within the wider SIC 5 category of manufacture of builders' ware of plastics – 88% of the 1,410 enterprises in this sector are SMBs;
- Manufacture of metal windows and doors have their own specific SIC 5 category – 93% of the 1,150 enterprises in this category are SMBs;
- Based on the statistics above, it is likely that over 90% of the enterprises in the window and door manufacturing sector are small or micro.

***Impact on small and micro businesses***

8.19. Adroit Economics were commissioned to consult with key stakeholders from the sectors mentioned above to explore the extent to which SMBs would be disproportionately affected by the changes to the energy efficiency requirements, as set out in the response document. A summary of the findings from these discussions with industry are below:

1) **Small builders/developers:** from Adroit's consultation, they concluded that the changes will have almost no material additional impact on SMBs. The reason for this is twofold. First, for contracting activities it is typical for small developers to work on a procurement basis with the necessary technical work taken on by others, hence the builder will buy in the necessary expertise and pass on the cost. Second, for development activities SMBs typically offer small numbers of bespoke homes, which are already built to a higher specification and are routinely designed from scratch. Therefore, while the impact of new standards on absolute build costs for a smaller developer may be higher than those for a larger business, this does not necessarily mean they will be affected more significantly. This is because their starting cost base is likely to be higher and other elements of their business model will differ.

2) **Small architects:** from Adroit's consultation there were mixed views on the likely impact, but any disproportionate additional impact on SMBs is likely to be marginal. Any additional impact on smaller firms may be the result of smaller firms being unable to host all the software or undertake all the calculations in house, meaning more may have to be subcontracted out to external specialists. Familiarisation costs are expected to be similar, irrespective of size of practice. In fact, smaller practices often rely more on informal information transfer and so they may require *fewer* training days than larger firms. Moreover, smaller firms are often seen as being 'nimbler' when reacting to changes in legislation and therefore may be able to implement changes in their practices more easily and at less relative cost that some larger firms.

3) **Small timber window and door manufacturers:** Adroit undertook consultations with four small windows and door manufacturers, which highlighted that there is likely to be a significant additional impact on SMBs because of the changes in standards. From the four consultations it appears that changes in standards are likely to have a significant impact on some smaller manufacturers relative to larger ones. This is due to the strong likelihood of having to:

    a. Product redesign: larger businesses are likely to have a larger product range and some of these existing products are likely to meet the new standards. In contrast, many small businesses will not have existing products that will meet the standards and will therefore have to produce more new products to meet the new standards. This will require product design/redesign, thus incurring costs (R&D, design and testing/certification costs). These costs for small firms will vary significantly, from minor to major costs, depending on the extent of the existing product range and the manufacturing processes that they use. A small proportion are likely to face very significant costs.

    b. Retooling: in some cases, retooling may also be required where small firms' existing tools are not sufficiently flexibly to accommodate the design changes required (for example where the thickness of doors or windows will be required to increase). The requirement for increased thickness was felt to be the result of a combination of the changes to energy efficiency requirements (plus other changes to building regulations in areas of fire and security). Large businesses will be able to exploit economies of scale and hence can afford to retool more easily, benefitting from wholesale prices for new machinery.

    c. Delay in time to market: the time involved in developing new products plus testing and certification (for which there is a reported backlog because of a reduced number of test houses due to EU departure arrangements and an increase in fire safety testing), would mean that small firms needing to develop new products to meet the standards would be out of the market

until new products were developed, which in some cases (based on the reported R&D time) could be over a year.

d. Cost recovery capital: cost recovery will generally tend to take longer for small firms than larger firms because of the formers' smaller volume of sales

e. Cost recovery period: moreover, it was felt that the impact of the costs above on profitability and viability are likely to be exacerbated. This is due to the short payback/cost recovery period from anticipated additional changes, and consequent costs arising, because of the Future Homes Standard.

8.20. To quantify the possible disproportionate impacts on the profitability and viability of window and doors SMB manufacturers, significant in-depth analysis and research would need to be undertaken. Given the small number of manufacturers, this was considered disproportionate. From the consultations, however, it is clear that retooling and redesign costs could be considerable, and the proportion of annual turnover that these costs represent is likely to be larger for SMBs than for larger firms. Some potential unit costs below are included. All costs are indicative costs from consultation with industry and have not been included in the CBA:

- There are a total of 600 small manufacturers of timber products used in buildings, although not all of them will be making windows or doors;

- The majority of window/door manufacturers may have to redesign products. Consultees, suggested that for most the cost is likely to be relatively small, within a range of £2,000 to £5,000 per product, but that a minority will incur significantly greater costs for new equipment etc.;

- The driver for new equipment will be a change in the thickness of either doors or window frames;

- The requirement of additional thickness is the result not just of the energy efficiency requirements, but it was suggested that regulations relating to fire safety and security would also have an impact on this – so for some it's potentially the cumulative impact of various changes happening at the same time;

- The consultees did not however provide a clear indication of what the new equipment/ retooling costs would be, other than that they would be significant;

- One large manufacturer suggested a cost of up to £500,000 to develop a new product.

8.21. An additional point raised was that for those incurring significant costs, there would be limited time to recover the costs before further changes and costs were required to meet the future homes standard.

***Mitigating the impact on small and micro businesses***

8.22. The industry-led Future Homes Hub is a key tool in supporting SMBs to understand and meet the new regulations. With the support and input of government (DLUHC, BEIS, Defra and Homes England) the Hub will support industry by coordinating pilot developments and prototypes, identifying technical and operational solutions, carrying out research and analysis into delivery challenges and producing technical guidance. Of particular use to SMBs will be the specialist guidance that the Hub will produce, which will focus on the practical ways in which SMBs can meet the regulations.

8.23. We are asking for better information to be given to householders in the form of a Home User Guide, this is described in *Improved Compliance and Performance*. We are mitigating the impact on small and micro businesses by providing a professionally written, free to access template on gov.uk.

8.24. Through extensive engagement with the window industry, we found that the increased standard for window replacements in existing dwellings could impact some small wooden window manufacturers significantly. This is because some wooden window manufacturers do not have windows in their product range that could meet the standard. They are also more likely to be smaller businesses than businesses that manufacture uPVC and aluminium windows. For this reason, we are providing an extra year's transition to these window manufacturers to allow them a slower adjustment and spread any costs over a longer timeline.

***Rationale for non-exclusion of small and micro businesses from the regulations***

8.25. SMBs make up ~99% of the number of businesses involved in domestic building works in the construction sector (see Table 24 above). Given this, an exemption from regulation changes would be inappropriate as it would prevent the policy objectives of the regulatory changes from being achieved, which could pose a legal risk for the Government. The primary objective of these changes is to improve the energy performance of new domestic buildings, therefore reducing carbon emissions and the impact of new homes on climate change. This is essential if the Government is to achieve its legally binding Carbon Budget 6 targets and wider Net Zero ambition. Additionally, the construction industry is made up of businesses of all types and sizes working together. Applying and policing differing construction standards to some businesses and not to others would be impracticable. For example, manufacturers would have to operate additional production lines. This could further increase the additional impact on small windows and doors manufacturers, and so an exemption to small and micro developers could exacerbate the impact on manufacturers.

8.26. Furthermore, given that uplifts to the Building Regulations have historically happened every few years, regulatory changes such as the ones set out in this impact assessment are fully embedded in the construction industry. Most businesses are therefore aware of and would be expecting the increase in standards, hence an exemption for SMBs is not

required and there is no precedent to exempt SMBs from uplifts to the Building Regulations.

8.27. Given the number of ways in which SMBs may be disproportionately affected by the changes, the Government plans to work with industry to help mitigate the effects on small businesses. These mitigations are outlined below.

# 9. Other wider impacts

9.1. The impact assessment has set out the direct costs to businesses and society, such as capital, replacement and maintenance costs, as well as setting out the wider societal benefits, such as lower fuel bills, better air quality and lower emissions. There are, however, several considerations that may be indirectly affected by the uplift in standards, or indeed indirectly effect the potential impacts of the Building Regulations. These are explored below.

**Economic and financial impacts**

***Competition***

9.2. The principal markets affected by the 2021 policy are the markets for the development of new domestic buildings and the refurbishment of existing domestic buildings, along with the supply chains to produce construction materials used in those developments.

9.3. As a result of higher standards for new buildings from 2021, building developers would have to comply with the more stringent targets and as a result would see costs rise. The increased costs are expected to affect developers with similar house designs and developments in similar ways. Therefore, any competitive effects in the market for building development are likely to be negligible.

9.4. The 2021 uplift in energy efficiency requirements assumes some improvement in fabric and services specifications. If fabric energy efficiency had been improved in isolation, this could have given manufacturers of products which impact on fabric performance (insulation, windows) an advantage over those involved in manufacturing and supplying building services (e.g., boilers, lighting); however, this is not the case. Furthermore, flexibility is provided in a way that developers can meet the higher performance standards, which should ensure that no single product or manufacturer can dominate any part of the market.

***Innovation***

9.5. Particularly with respect to raising the energy efficiency requirements for new homes, 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.

9.6. The standards are likely to result in an increased use of low/ 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 in the main cost benefit analysis.

***International Trade***

9.7. The more stringent energy efficiency standards for 2021 are set out in the Approved Guidance standards for a range of products across the new and existing stock, including windows and doors, boilers, solar PV and Heat pumps. Performance based standards are set through the Approved Document guidance, which does not mandate the specific technologies or products to be used. Therefore, HMG is not required to notify the World trade Organization.

9.8. However, given that many businesses will decide to follow the Approved guidance, this decision could lead to an increase in costs where the suggested standard is set above the current market level, leading to businesses needing to produce more efficient products. If these firms are unable to absorb the costs and are actively engaged in international trade, then this could lead to exports falling as these goods become less competitive. However, this depends on a wide range of factors, including whether the market is predominantly domestic or international, if England has a comparative advantage/disadvantage in these goods, the required standards overseas and the price of goods on the international market.

9.9. There could also be some indirect economic impacts, particularly by encouraging innovation. If product innovation occurs, particularly in lower carbon forms of heat, this could lead to the development of new products and higher demand in clean growth/ renewable markets. If there is global demand for these goods then businesses will be incentivised to sell their products abroad, thus increasing international trade. This could also lead to benefits for key UK sectors, such as manufacturing, if innovation takes place in a market where the UK holds a comparative advantage.

***Housing supply***

9.10. DLUHC has completed national viability analysis of this policy on housing supply. The analysis takes an average approach to viability and attempts to understand the total impact across national supply. Given the cost increase arising from the policy, it is expected that where developers cannot absorb these costs or pass them onto landowners, there might be some negative viability impact on housing supply.

9.11. Areas in London and the south might be expected to be able to cope better with cost impacts given the large gap between development cost and sale prices when compared with areas with lower sale prices, for example in the North West of England. Brownfield sites with high redamation cost are also expected to be a less viable from cost increase arising from the policy.

9.12. Given the relatively short lead time before this change is introduced, it is expected that developers would not have fully factored in these costs into sites and therefore will have to absorb the cost onto their own balance sheet. As such, the short-term impact on housing supply viability may be slightly more volatile, but evidence would suggest that the system is sufficiently robust to be able to absorb these costs in other ways. In the

medium term, more Section 106 (developer contribution) renegotiation or affordable housing reductions may occur to offset these costs.

9.13. In the short-term it is unlikely that house prices will be able to fully absorb the cost increase arising from this policy as broader market drivers are likely to dominate. However, as we move to the long-term, we are likely to see developers offsetting higher costs through higher sales prices in areas of high demand.

***Health and well-being impacts***

9.14. There are potentially beneficial improvements in health and quality of life from the effect of increased energy efficiency on thermal comfort. This has not been included in the CBA. It is important 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 new requirements and guidance to reduce the risk of overheating in new homes.

***COVID-19***

9.15. COVID-19 has had several implications for the construction industry. First, housing supply has been impacted by COVID-19, with the total number of new completions in 2020 being significantly lower than in previous years. This was due to a near total shutdown of the construction industry in March 2020 as the pandemic hit, with border restrictions limiting the transportation of key construction materials. However, many of the impacts from COVID-19 are expected to be short lived, with long-term contraction not expected. It is therefore reasonable to assume that, as the economy bounces back, there should be no additional impact on housing supply in the longer term. As the total appraisal period for this IA is 70 years (accounting for the policy period and building life), COVID-19 impacts are not included in this analysis.

9.16. Second, because of the pandemic more people are working from home. This may place a greater value on the importance of energy efficient and warm homes as they have spent more time indoors and will have needed to heat their home more frequently in the day. This means that there could be additional health and wellbeing benefits because of the 2021 changes, as more people will be benefiting from the improved thermal comfort in their homes, also exacerbating the importance of higher energy efficiency measures in the reduction of fuel bills.

***Rural impacts***

9.17. Assessing rural impacts means determining whether the impacts on rural areas will be different to those for urban areas, and whether there are specific local or regional effects.

9.18. As described in section 4, the Government will remove fuel factors that are currently in Approved Document L1A 2013. These factors provide some relief in the target applicable to new dwellings that are off the gas grid, principally those in rural areas. The fuel factor

means that if the chosen heating fuel is more carbon intensive than gas (such as oil or LPG), the carbon emissions target is increased, making it less demanding. This is not consistent with the Government's plans to phase out high carbon fossil fuels and wider climate ambitions such as decarbonising the building stock.

9.19. Without the fuel factor, any new building will have to meet primary energy and $CO_2$ emissions equivalent to that of the new energy efficiency requirements. This means builders will have to build to higher, and more expensive, fabric and/or services standards.

9.20. Due to the changes in carbon emission factors described previously, electricity use is now less carbon intensive than gas, as outlined in Appendix D. Therefore, the fuel factor has also been removed for electricity. This change has no impact on rural homes adopting an electric heated solution.

9.21. A home built to 2013 energy efficiency requirements with an LPG boiler was modelled. This model used the 2013 notional building but with a roof U-value of 0.11 $W/m^2K$, window U-values of 1.2 $W/m^2K$ and a 90.1% efficient LPG boiler (SEDBUK) instead of natural gas. All models in the rural analysis used the detached house type, as this is the most prevalent in rural areas. The LPG boiler efficiency was selected as being towards the higher end of current LPG boilers in the PCDB but not the highest, and fabric improvements were prioritised over PV.

9.22. Analysis of the extra cost for off gas grid properties to comply with the new standards can be seen in Table 25 below. This suggests that there is not a substantive cost difference between retaining or removing the fuel factor in practice, when complying with the 2021 target by adopting low carbon heat source, such as an air source heat pump.

9.23. It will be challenging in either case to comply with the 2021 targets using LPG or oil as fuels - the design specifications in Table 7 will not be sufficient as the amount of PV likely to comply would exceed the roof area available (although it may be possible to comply with more expensive and efficient PV panels than assumed in the specification).

9.24. A lower cost option is likely to be to change to a low carbon heat source, such as an air source heat pump. Analysis shows that it is therefore likely that most new homes built off the gas grid will be built using low carbon heating. From discussion with industry, there are many new homes off the gas grid are already being constructed with heat pumps instead of using oil or LPG.

**Table 25: Costs to comply with 2021 energy efficiency requirements for off-gas grid properties**

| | 2013 requirements (with LPG) | 2021 requirements (with heat pump) |
|---|---|---|
| Total build cost | £172,131 | £172,996 |
| Extra cost over the baseline | £0 | £865 |

Source: Currie & Brown

## Environmental impacts

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

## Administrative burdens

9.26. Administrative burdens are identified as the costs to businesses of requirements and standards to provide information.

9.27. The Approved Document introduces new standards for the developer to provide information to both a Building Control Body and to the householder. The information being provided to each is a new style compliance report: The Building Regulations England Part L report (BREL), and photographic evidence. From discussions with industry, we understand that many developers already have photographic evidence of the building work of interest. A compliance report is already produced from SAP software, the extra detail required is believed to be little extra burden. There may be costs associated with collating, emailing and printing; but these are believed to be minimal, in the order of <£10 per dwelling. The benefits of improved compliance would likely outweigh the costs significantly.

# 10. Equalities assessment

10.1 Under the Equalities Act 2010, all public authorities are required to have due regard to the need to:

a. Eliminate unlawful discrimination, harassment and victimisation and other conduct prohibited by the Act.
b. Advance equality of opportunity between people who share a protected characteristic and those who do not.
c. Foster good relations between people who share a protected characteristic and those who do not.

10.2 This means there is a statutory duty to consider the impacts of the policy changes in this impact assessment on people with the protected characteristics of age, disability, gender reassignment, marriage or civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation.

10.3 Throughout the development of the policies in this impact assessment, the Government has assessed the potential impact on those with protected characteristics. Various processes and sources have helped to inform this assessment, including extensive engagement with a wide range of stakeholders and a review of all the correspondence that has been received in relation to the proposals. The responses to the two-stage consultation on the policies were also carefully analysed to identify specific concerns which were raised about any disproportionate impact the policies may have on individuals because of a protected characteristic.

10.4 Where appropriate, policies have been amended and mitigating measures put in place. The assessment has concluded that there is no evidence that the final policies covered by this impact assessment will have a disproportionately negative impact on individuals with protected characteristics.

# 11. Monitoring and evaluation

11.1. A full technical consultation on the Future Homes Standard (FHS) is planned for spring 2023, which will provide proposals for the technical detail and associated draft guidance of the Future Homes Standard. Ahead of the full consultation, there will be a period of extensive stakeholder engagement which will help to inform the consultation proposals.

11.2. The period of stakeholder engagement will include working with industry, such as the Future Homes Hub, to monitor and evaluate the implementation of the 2021 uplift, with a focus on understanding the impact that the uplift is having and the way in which it is being implemented. This engagement and evaluation will allow us to develop proposals for the next version of the energy efficiency requirements: The Future Homes Standard. The feedback that is received from consultees will be carefully analysed and the lessons that are learnt will be incorporated into the final policy of the Future Homes Standard.

11.3. A statutory review clause to monitor and evaluate the impacts of the policy after 5 years has not been included in the 2021 uplift since the policy is due to be monitored and reviewed in advance of that anyway, with the technical consultation of the FHS planned in 2023. Additionally, most of the changes are being implemented via changed to the Approved Documents rather than through regulations, and hence no statutory review clause is required.

# Appendix A – Net Completions Projection

Below is the independent analysis conducted by Adroit Economics of the number of new domestic dwelling completions in England between 2022-2032, broken down by building type. This is used in the cost benefit modelling to assess the impact of changes to the energy efficiency requirements of the Building Regulations.

These estimates of new build completions are produced by an independent consortium, based on their analysis of a range of data sources that show recent trends in dwelling completions, coupled with economic projections. They are indicative, should be used for appraisal purposes only and do not represent an official forecast of changes in housing supply.

| | **2022-23** | **2023-24** | **2024-25** | **2025-26** | **2026-27** | **2027-28** | **2028-29** | **2029-30** | **2030-31** | **2031-32** |
|---|---|---|---|---|---|---|---|---|---|---|
| Detached house* | 74,254 | 75,739 | 77,254 | 78,799 | 80,375 | 81,179 | 81,990 | 82,810 | 83,639 | 84,475 |
| Semi-detached | 56,253 | 57,378 | 58,526 | 59,696 | 60,890 | 61,499 | 62,114 | 62,735 | 63,363 | 63,996 |
| Terraced | 31,502 | 32,132 | 32,774 | 33,430 | 34,098 | 34,439 | 34,784 | 35,132 | 35,483 | 35,838 |
| Flats | 63,003 | 64,263 | 65,549 | 66,860 | 68,197 | 68,879 | 69,568 | 70,263 | 70,966 | 71,676 |
| **Total** | **225,012** | **229,512** | **234,102** | **238,785** | **243,560** | **245,996** | **248,456** | **250,940** | **253,450** | **255,984** |

*Bungalows have been included in the detached house category

Source: Adroit Economics

Please note, these projections are not an estimate of ‘net additions’, which is the figure usually used to calculate changes in housing supply. They do not account for change of use or conversions, which are a significant element of net addition but is outside the remit of this impact assessment; nor does it capture the impact of policy interventions that could increase industry’s capacity to build new houses.

Although the range of available data sources provides a reasonable basis to estimate future trends, there inevitably are uncertainties and hence the projections should be treated with caution. Figures in the projections above do not take account of the impacts of COVID-19 on housebuilding, hence are likely to be inflated.

# Appendix B – Sensitivity Analysis

## Carbon Values Sensitivity Analysis

Sensitivity analysis was taking forward using the higher and lower estimates of carbon values, using Table 3 in the Green Book Supplementary Guidance (see below):

| Table B1: Green Book Carbon Values (£/tco2e) | | | |
|---|---|---|---|
| **Year** | **Low** | **Central** | **High** |
| **2022** | 124 | 248 | 373 |
| **2023** | 126 | 252 | 378 |
| **2024** | 128 | 256 | 384 |
| **2025** | 130 | 260 | 390 |
| **2026** | 132 | 264 | 396 |
| **2027** | 134 | 268 | 402 |
| **2028** | 136 | 272 | 408 |
| **2029** | 138 | 276 | 414 |
| **2030** | 140 | 280 | 420 |
| **2031** | 142 | 285 | 427 |

The results for new and existing dwellings are as follows:

**Table B2: New Carbon Value Estimates for New Dwellings**

| **New Dwellings** | Low | Central | High |
|---|---|---|---|
| Transition costs (£m) | (11.1) | (11.1) | (11.1) |
| Energy savings (£m) | 1,734 | 1,734 | 1,734 |
| Incremental costs (£m) | (6,588) | (6,588) | (6,588) |
| Total financial benefit/(cost) (£m) | **(4,865)** | **(4,865)** | **(4,865)** |
| Carbon savings - non-traded (£m) | 4,249 | 8,497 | 12,746 |
| Carbon savings - traded (£m) | 16 | 32 | 49 |
| Total carbon savings (£m) | **4,265** | **8,530** | **12,794** |
| Air quality savings (£m) | 351 | 351 | 351 |
| Comfort Taking | - | - | - |
| Total carbon and air quality savings | 4,616 | 8,848 | 13,146 |
| Net benefit/(cost) (£m) | **(249)** | **4,016** | **8,281** |
| Amount of gas saved (GWh) | 346,104 | 346,104 | 346,104 |
| Amount of electricity saved (GWh) | 4,806 | 4,806 | 4,806 |
| Amount of $CO_2$ saved - non-traded ($MtCO_2e$) | 64 | 64 | 64 |
| Amount of $CO_2$ saved - traded ($MtCO_2e$) | 0.1 | 0.1 | 0.1 |

**Table B3: New Carbon Value Estimates for Existing Dwellings**

| **Existing Dwellings** | Low | Central | High |
|---|---|---|---|
| Transition costs (£m) | (1.1) | (1.1) | (1.1) |
| Energy savings (£m) | 309 | 309 | 309 |
| Incremental costs (£m) | (675) | (675) | (675) |
| Total financial benefit/(cost) (£m) | **(367)** | **(367)** | **(367)** |
| Carbon savings - non-traded (£m) | 433 | 866 | 1,088 |
| Carbon savings - traded (£m) | - | - | - |
| Total carbon savings (£m) | **433** | **866** | **1,088** |
| Air quality savings (£m) | **34** | 34 | 34 |
| Comfort Taking | (1) | (1) | (1) |
| Total carbon and air quality savings | 467 | 899 | 1,122 |
| Net benefit/(cost) (£m) | **100** | **532** | **756** |
| Amount of gas saved (GWh) | 31,527 | 31,527 | 31,527 |
| Amount of electricity saved (GWh) | **-** | - | - |

| | | | |
|---|---|---|---|
| Amount of $CO_2$ saved - non-traded ($MtCO_2e$) | **6** | **6** | **6** |
| Amount of $CO_2$ saved - traded ($MtCO_2e$) | - | - | - |

## Routes to Compliance Sensitivity Analysis

As described in chapter 4, the 2021 energy efficiency requirements are performance-based standards requiring a 30% improvement on 2013 levels aggregated across the build-mix, based on performance-based targets for primary energy, $CO_2$ emissions and fabric energy efficiency. Consequently, there are several ways in which a housebuilder can comply with the regulations. The most likely means of compliance is the specification described in paragraph 4.6 & 4.7 which has a high level of energy efficiency, a gas boiler, solar panels and waste water heat recovery. The main alternative means of compliance for housebuilders is with a heat pump.

Given the uncertainty over what proportion of housebuilders will choose which route to compliance, in addition to the central scenario that has been modelled for the main cost benefit Analysis, two illustrative sensitivity scenarios have been used to show the possible range in costs and benefits. A comparison of the costs and benefits of the overall policy changes, based on a low, central and high heat pump take up scenario can be seen in the table below.

In the low heat pump take-up scenario, costs are £2,144m and net Benefits are £5,882m, with 42.3 MtCO2e saved. In the high heat pump take-up scenario, costs are £6,616m and net benefits are £10,963 with 82 MtCO2e saved. The higher carbon savings in the high option is because more heat pumps are used, which means gas consumption/non-traded emissions fall considerably.

**Table B4: Scenario Analysis for Routes to Compliance**

| | Low | Central | High |
|---|---|---|---|
| Transition costs (£m) | (11.1) | (11.1) | (11.1) |
| Energy savings (£m) | 3,820 | 1,711 | 25 |
| Incremental costs (£m) | (5,953) | (6,574) | (6,630) |
| Total financial benefit/(cost) (£m) | **(2,144)** | **(4,874)** | **(6,616)** |
| Carbon savings - non-traded (£m) | 5,561 | 8,673 | 11,243 |
| Carbon savings - traded (£m) | 421 | 31 | (280) |
| Total carbon savings (£m) | **5,882** | **8,705** | **10,963** |
| Air quality savings (£m) | 329 | 347 | 362 |
| Total carbon and air quality savings | **6,211** | **9,052** | **11,325** |
| Net benefit/(cost) (£m) | **4,066** | **4,178** | **4,709** |
| Amount of gas saved (GWh) | 206,983 | 342,588 | 451,073 |
| Amount of electricity saved (GWh) | 98,429 | 4,631 | (70,407) |
| Amount of $CO_2$ saved - non-traded ($MtCO_2e$) | 40 | 64 | 84 |
| Amount of $CO_2$ saved - traded ($MtCO_2e$) | 2.3 | 0.1 | (1.6) |
| Cost effectiveness – non-traded (£/$tCO_2$) | 35 | 70 | 78 |
| Cost effectiveness – traded (£/$tCO_2$) | (1,610) | (31,325) | 3,171 |

# Appendix C – Cost Breakdown

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 2019[44] that might be incurred by a housebuilder completing more than 1,000 homes per year using traditional (i.e., masonry) construction methods. The analysis assumes reasonably efficient supply chain, design development and construction processes but recognises that delivery of technologies such as heat pumps are still to be fully developed due to relatively low historic deployment levels. 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 housing product. These variations in design, location and delivery method could result in a cost range of +/- c.30% or more. Notwithstanding these variations, the proportional uplifts associated with moving from one specification to another are likely to be similar across different market segments [45].

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 home 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.

44 Cost analysis was reviewed in Summer 2021 and some elements updated to reflect changes in market rates and new information. Changes principally affected the variable costs of photovoltaic panels, higher performance glazing and heat pumps.

45 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 C.1** includes details of the cost information used for each specification option, including any variations between building type, costs are only shown for those specifications that vary between the considered specification options. These do not include expected learning rates.

**Table C.1: Cost data for fabric elements that vary between the selected specifications for new domestic buildings**

| Element | Specification | Unit | New cost (£ per unit) |
|---|---|---|---|
| External Wall – plasterboard, blockwork, mineral wool brick, lintels, ties and cavity trays/closers | 0.18 W/m².K | m² | £221 |
| Ground / Exposed Floor | 0.13 W/m².K | m² | £153 |
| Roof – mineral wool insulation at joist level | 0.13 W/m².K | m² | £185 |
| | 0.11 W/m².K | m² | £187 |
| Windows uPVC | 1.4 W/m².K | m² glazed area[46] | £265 |
| | 1.2 W/m².K | m² glazed area | £300 |
| Waste-Water Heat Recovery | Vertical pipe system (houses and upper floor flats) | Nr | £400 |
| | Tray system (ground floor flats) | Nr | £1200 |
| Radiators (installed but excluding heating pipework) | Standard | Nr | £60 |
| | Sized for low temperature heating | Nr | £90 |
| Roof mounted - photovoltaic panels | Fixed costs for systems <4kWp | Per installation | £1,100 |
| | Variable costs for systems <4kWp | Per kWp installed | £600 |
| | Variable costs for systems >4kWp | Per kWp installed | £1,100 |
| Heating plant | Gas boiler system and hot water cylinder (detached home) | Nr | £2,360 |
| | Gas boiler combi (other house types) | Nr | £1,110-£1,310 |
| | Air Source Heat Pump (5kW) including hot water cylinder | Nr | £5,750 |
| Gas connection | 10 or more homes | Nr | £988[47] |
| Enhanced power supply | Additional 1.5 kVa capacity to support use of heat pump | Nr | £85 |

46 Typical glazed area taken as around 65% of the window opening based on research undertaken on overheating by MHCLG.
47 The cost of a gas connection is included within the overall societal cost benefit analysis but is excluded from cost to business calculations (see para 7.47 onwards)

**Table C.2** includes details of the cost information used for 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 C.2: Cost data for elements that vary between the selected specifications for domestic extensions**

| Element | Specification | Unit | Cost (£ per unit) |
|---|---|---|---|
| Domestic external wall – brickwork external leaf and mineral wool insulation | 0.28 W/m².K | m² (ele2ment) | £189 |
| | 0.18 W/m².K | | £194 |
| 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 |
| Windows | 1.6 W/m².K | | £230 |
| | 1.4 W/m².K | | £240 |
| Doors (partially / unglazed) – composite only | 1.8 W/m².K | | £830 |
| | 1.4 W/m².K | | £850 |

# Appendix D – Primary energy and carbon factors

The below tables contain the calculated primary energy and $CO_2$ emission factors used to develop the 2021 energy efficiency requirements; these can also be found in SAP 10.2. To note these are different to the carbon emission factors found in Green Book Supplementary Guidance, which are used for appraisal purposes.

**Table D.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 grid, PV** | 0.715 | 0.697 | 0.645 | 0.567 | 0.478 | 0.389 | 0.330 | 0.336 | 0.405 | 0.513 | 0.623 | 0.718 |

*Source: SAP 10.2, Table 12e*

**Table D.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 |
| **Electricity produced by Gas CHP** | 2.149 |

*Source: SAP 10.2, Table 12*

**Table D.3: Carbon emission factors for electricity used in the analysis [kg$CO_2$e/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 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: SAP 10.2, Table 12d*

**Table D.4: Carbon emission factors for other fuels used in the analysis [kg$CO_2$e/kWh]**

| | CEF |
|---|---|
| **Mains gas** | 0.210 |
| **LPG** | 0.241 |
| **Heating oil** | 0.298 |
| **Electricity produced by Gas CHP** | 0.348 |

*Source: SAP 10.2, Table 12*