Title: Consultation Stage Impact Assessment for amending the Private Rented Sector Regulations **IA No:** BEIS020(C)-19-CG **RPC Reference No: N/A** **Lead department or agency:** Department for Business, Energy and Industrial Strategy **Other departments or agencies: N/A**	Impact Assessment (IA) **Date: 15/10/2019** **Stage: Consultation** **Source of intervention: Non-Domestic** **Type of measure: Secondary legislation** **Contact for enquiries:** Shyamala Balendra-Matt / Dominic Humphrey
Summary: Intervention and Options	**RPC Opinion: N/A**

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present Value**	**Net cost to business per year** (EANDCB in 2014 prices)	**One-In, Three-Out**	**Business Impact Target Status**
£6.1bn	£8.4bn	-£361m	Not in scope	Qualifying provision

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

The non-domestic private rental market has a number of market failures that lead to underinvestment in energy efficiency. These include a split-incentive problem between landlords and tenants, and the failure of the market to address the negative impacts of carbon emissions. This underinvestment means that the sector is not delivering the carbon savings required to meet the mandated UK carbon budgets. As previous interventions have proved ineffective, the Minimum Energy Efficiency Standards were enacted in April 2018. However, since these regulations only target the lowest performing buildings in the stock, additional regulatory stimulus is needed to deliver the energy efficiency investment required in the sector.

What are the policy objectives and the intended effects?

The policy intends to drive cost-effective energy efficiency improvements in the non-domestic PRS that would not have occurred otherwise. These energy efficiency improvements will lead to reduced energy demand, as a result reducing greenhouse gases, increased business bill savings, improved air quality and greater energy security

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

Option 0) Do nothing; Option 1) Meet a minimum EPC C rating by 2030 if measures payback within 7 years; Option 2) meet a minimum EPC B rating from 2030 if measures payback within 7 years. Option 2 is the recommended option as this provides the best net benefit to society and is consistent with meeting our energy and carbon targets. This regulatory trajectory will provide an early signal for where the sector needs to be by 2030. Further balanced policy interventions are, and will continue to be, aimed at supporting landlords and tenants and building capacity and capability in the market.

Will the policy be reviewed? Yes If applicable, set review date: To be confirmed

Does implementation go beyond minimum EU requirements?		Yes		
Are any of these organisations in scope?	**Micro Yes**	**Small Yes**	**Medium Yes**	**Large Yes**

What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)	**Traded:** **-13.8**	**Non-traded:** **-30.7**

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: Date: 14th October 2019

Summary: Analysis & Evidence Policy Option 1

Description: All PRS to meet a minimum EPC Band C rating requirement by 2030 with a minimum payback of 7 years.

FULL ECONOMIC ASSESSMENT

Price Base Year 2018	PV Base Year 2018	Time Period Years 44	Net Benefit (Present Value (PV)) (£m)		
			Low: £0.9bn	High: £4.9bn	Best Estimate: £3.1bn

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price 2018)	Total Cost (Present Value)
Worst Case*	0		Optional	**£0.98bn**
Best Case	0		Optional	**£1.3bn**
Best Estimate	0		£52m	**£1.6bn**

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

Key monetised costs include: Landlords' cost of equipment and installation to meet requirements of £1.3bn, social cost of capital for landlords of £0.3bn (i.e. the opportunity cost of meeting requirements equivalent to finance cost), and compliance and familiarisation costs for landlord of £0.05bn. All costs present value (2018).

*Note worst case has lower costs than central due to assumption of reduced additionality.

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

There may be additional monitoring and enforcement costs to government of enforcing regulation on top of existing regulations, this is expected to be small. There may be a cost to landlords in terms of lost rent if there is a delay in installing the measures.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price 2018)	Total Benefit (Present Value)
Worst Case	0		Optional	**£1.9bn**
Best Case	0		Optional	**£6.2bn**
Best Estimate	0		£208m	**£4.7bn**

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

The key monetised benefits include: Energy cost savings to private leaseholders from more energy efficient technologies of £3.7bn, non-traded carbon savings of £0.6bn, traded carbon savings of £0.3bn and air quality savings of £0.1bn. All figures present value.

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

Wider benefits of energy efficiency including health and productivity have not been included. The large degree of investment in low carbon technologies is also likely to have wider economic benefits from greater jobs and spending.

Key assumptions/sensitivities/risks **Discount rate** 3.5%

We have assumed that the BEES-EPC matched sample of 900 properties is representative of the entire population of England and Wales, in terms of EPC ratings to property characteristics, the level of accuracy of this is uncertain. We have assumed that the social cost of capital is incorporated which may not be the case as these measures payback within 4 years. There is a high degree of uncertainty with how the non-domestic sector changes through time and the level of technology take-up assumed as these will vary by individual choices relevant for a particular non-domestic building to meet the requirements.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m: £-902

Costs: £52 Benefits: £232 Net: £-180	

Summary: Analysis & Evidence Policy Option 2

Description: All PRS to meet a minimum EPC Band B rating requirement by 2030 with a minimum payback of 7 years?

FULL ECONOMIC ASSESSMENT

Price Base Year 2018	PV Base Year 2018	Time Period Years 44	Net Benefit (Present Value (PV)) (£m)		
			Low: £-0.5bn	High: £11.9bn	Best Estimate: £6.1bn

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition)(Constant Price 2018)	Total Cost (Present Value)
Worst Case**	0		Optional	**£4.0bn**
Best Case	0		Optional	**£5.0bn**
Best Estimate	0		£201m	**£6.1bn**

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

Key monetised costs include: cost of equipment and installation to landlords of £4.6bn; operation and maintenance costs of £0.3bn; social cost of capital for landlords (i.e. the opportunity cost of meeting requirements equivalent to finance cost) of £1.1bn, compliance and familiarisation costs for landlords of £0.05bn.

**Note worst case has lower costs than central due to assumption of reduced additionality.

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

There may be small additional monitoring and enforcement cost to Government of enforcing regulation on top of existing regulations, this is expected to be small. There may be a cost to landlords in terms of lost rent if there is a delay in installing the measures.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition)(Constant Price 2018)	Total Benefit (Present Value)
Worst Case	0		Optional	**£3.5bn**
Best Case	0		Optional	**£16.9bn**
Best Estimate	0		£546m	**£12.2bn**

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

The key monetised benefits include: Energy cost savings to private leaseholders from more energy efficient technologies of £9.8bn, non-traded carbon savings of £2.1bn, traded carbon savings of £0.8, and air quality of £-0.4bn, which is a net cost due to some biomass systems in this scenario outstripping energy efficiency benefits of air quality.

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

Wider benefits of energy efficiency including health and productivity have not been included. The large degree of investment in low carbon technologies is also likely to have wider economic benefits from greater jobs and spending.

Key assumptions/sensitivities/risks	**Discount rate**	3.5%

We have assumed that the BEES-EPC matched sample of 900 properties is representative of the entire population of England and Wales, in terms of EPC ratings to property characteristics, the level of accuracy of this is uncertain. We have assumed that the social cost of capital is incorporated which may not be the case as these measures payback within 4 years. There is a high degree of uncertainty with how the non-domestic sector changes through time and the technology take-up assumed as these will vary by individual choices relevant for a particular non-domestic building to meet the requirements.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:	

Costs: £199	**Benefits: £560**	**Net: £-361**	**Score for Business Impact Target (qualifying £-1806**

Contents

Executive Summary

1. In April 2018, the Government introduced minimum energy efficiency standards (MEES) in the non-domestic private rented sector. The MEES used the Energy Performance Certificate (EPC) as a regulatory framework to improve the worst performing buildings. Therefore, since April 2018 properties have not been permitted to grant a new tenancy or to extend or renew an existing tenancy if their property had an EPC rating of an F or G (the EPC scale ranges from A – G). From 1 April 2023, this prohibition on leasing will also apply to continuing with an existing lease i.e. all non-domestic PRS properties will need to be at least EPC E. In the Clean Growth Strategy (CGS) the Government committed to continue to improve the energy efficiency of non-domestic privately rented buildings through this Impact Assessment and Consultation on the future trajectory of the minimum standards. Continuing to improve energy performance in this sector is essential if the UK is to help make businesses more productive and reduce carbon emissions and energy use in line with the Government's legally binding targets. These targets are essential if the UK is to meet its commitment to have net zero carbon emissions by 2050.

2. Two policy options are considered in this IA:
    - Option 1: That landlords of all non-domestic privately rented properties in England and Wales ensure their properties achieve a minimum energy efficiency standard of Energy Performance Certificate band C by 2030, provided the action required is deemed cost-effective by meeting a seven-year payback test;
    - Option 2: that landlords of all non-domestic privately rented properties in England and Wales ensure their properties achieve a minimum energy efficiency standard of Energy Performance Certificate band B by 2030, provided the action required is deemed cost-effective by meeting a seven-year payback test.
3. The market and behavioural barriers that prevented the improvement of the worst non-domestic rented buildings (that the original regulations were designed to address) still exist across the remainder of the stock. This has resulted in higher energy bills and carbon emissions than would otherwise be occurring if the market was operating efficiently. The market and behavioural barriers include:
    - Imperfect information
    - Misaligned incentives between tenant and landlord
    - Low prioritisation of energy efficiency improvement
4. Publishing this IA and Consultation now demonstrates the Government's commitment to providing time and certainty to non-domestic landlords, businesses and the energy efficiency market. Whether the PRS Regulations are strengthened in line with an EPC B or C by 2030 trajectory, landlords will have over a decade lead-in time to plan the improvement of their property or property portfolios and minimise disruption to businesses. That lead-in time, with the certainty of sustained demand we anticipate strengthened PRS regulations will create, should also encourage the energy efficiency market to grow, scale and innovate.
5. Both policy options considered have a positive Net Present Value (NPV), ranging from £3.0bn to £6.1bn for the EPC-C and EPC-B targets respectively (see table below).

Table 1: Summary CBA numbers (£bn in 2018 prices, discounted to 2018)

	Present Value Costs	Present Value Benefits	Net Present Value	EANDCB (£m), 2016 prices
Option 1: Min C 7-yr payback	£1.6	£4.7	£3.0	-£180

Option 2: Min B 7-yr payback	£6.1	£12.2	£6.1	-£361

6. The Equivalent Annual Net Direct Cost to Business (EANDCB) shows that the direct benefits outweigh the direct costs for each of the options, making the measure a 'Zero Net Cost' regulatory measure.
7. These results are consistent with the findings from the January 2015 IA that underpinned the existing regulations. The impacts are bigger in this IA because more buildings are within scope of the proposed options (analysis in this IA suggests an additional 73% more buildings are in scope compared to existing regulations across England and Wales) and the proposed standards are more stretching.
8. The main costs assessed are the capital and installation of energy efficiency measures and the social opportunity cost of this capital. The capital and installation costs fall on landlords who tend to be large organisations. The costs of these energy efficiency upgrades in this IA are more than outstripped by monetised benefits, mainly energy savings from the installed measures. This is as expected as the design of the policy brings in scope only measures that payback privately and is reflected by the positive NPVs.
9. There is a high degree of uncertainty associated with the technologies and measures that are likely to be installed given the heterogeneity of rented non-domestic building users who include commercial, public and industrial occupants. The specific technologies and measures installed will be determined by the choices relevant to making a non-domestic building meet the regulatory requirements. This analysis applies a least cost approach to determine the technology and measure take-up mix, based on our current evidence.

Section 1: Overview and Rationale

Introduction

10. This Consultation Impact Assessment (IA) on the Non-Domestic Private Rented Sector Minimum Energy Efficiency Standards (ND, PRS & MEES; respectively) follows on from the wider Government call for evidence of July 2018; *Helping businesses to improve the way they use energy*.[1]
11. The non-domestic MEES requirements were introduced on 1 April 2018 through the Energy Efficiency (Private Rented Sector) (England and Wales) Regulations 2015. These regulations set requirements for all non-domestic rented properties within scope to meet a minimum energy efficiency standard, indicated by an Energy Performance Certificate (EPC) rating of E. EPC ratings can be improved through low carbon installations or improvements to energy efficiency in respect of: heating, ventilation, air conditioning systems, lighting requirements and fabric measures that improve the insulation of a building, whether through its walls, roof or glazing options.
12. This document provides an assessment of potential impacts of amending the regulations to raise the minimum standard in 2030.

[1] Call for Evidence; *Helping businesses to improve the way they use energy:* https://www.gov.uk/government/consultations/helping-businesses-to-improve-the-way-they-use-energy-call-for-evidence

Problem under consideration

13. There are two components to the problem under consideration:

i) **Energy and Carbon:** There is a significant amount of carbon and energy reduction potential in the rented sector. The existing regulations only cover a small proportion of the market and subsequent evidence from the Buildings Energy Efficiency Survey[2] (2016) (BEES), published after the original IA for the non-domestic PRS regulations[3], finds that the rented sector represents a large proportion of the overall non-domestic buildings abatement potential required to meet the fifth carbon budget and deliver the Government's ambition to reduce business energy use by at least 20% by 2030. Delivering both of those milestones are vital for the UK to remain on track to deliver net zero carbon emissions by 2050.

ii) **Productivity improvements:** Private rented sector tenants are facing higher bills than they would if the market was functioning efficiently, as barriers like the split incentives between tenants and landlords prevent the take-up of energy efficiency installations. We anticipate tenants will make savings on their energy bills and should result in a net gain for UK businesses.

14. Existing policies do not go far enough at tackling these two issues. The current PRS regulations were intended to raise the energy efficiency of the lowest performing properties in England and Wales: the regulations only impacted approximately 18% of the non-domestic building stock. To achieve the Government's carbon and energy reduction targets, and ultimately achieve net zero by 2050, it is vital the rest of the private rented sector continues to improve. There is a substantial amount of untapped energy efficiency potential across the remainder of the rented non-domestic stock. This provides an opportunity for energy and carbon reduction.

Policy Background and Objectives

Government objectives

15. In 2017 the Government published the Industrial Strategy, with Clean Growth as one of four key challenges. Clean Growth means boosting the national income by driving and investing in low carbon growth whilst meeting national and international commitments to tackle climate change. As announced in June 2019, the ultimate objective is for the UK to have net zero carbon emissions by 2050.

16. The Clean Growth Strategy (CGS), published in 2017, outlined how the Government intends to deliver a prosperous and clean future. In the long-term, the UK will need to find solutions for a full decarbonisation pathway, including the way in which we heat our buildings and generate electricity. In the short term, energy efficiency is vital in reducing emissions because it:

- **Lowers energy bills**, helping to keep costs as low as possible for business;

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[2] BEIS analysis of BEES data: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

[3] Final Stage 2015 PRS Impact Assessment: https://www.gov.uk/government/consultations/private-rented-sector-energy-efficiency-regulations-non-domestic

- **Reduces greenhouse gas emissions**, contributing to the Government's legally binding emission reduction targets;
- Reduces energy demand, ensuring that the UK has a **secure and resilient energy system**;

17. That is why, in the CGS, the Government made a commitment to reduce business energy use by at least 20% by 2030. Of the total energy used by businesses in 2014-2015, over half came from maintaining the non-domestic building stock.[4] As 60% of non-domestic buildings are rented[5], boosting energy efficiency in the sector will be vital to delivering on the 2030 ambition.

Relevance of non-domestic MEES requirements

18. Analysis in the Clean Growth Strategy of 2017 has confirmed the large potential for energy efficiency to contribute towards meeting the above objectives. Achieving the 20% ambition will require action across all businesses. Our modelling suggests that making the improvements needed to meet this ambition is likely to be achieved by improving the energy efficiency in business buildings in both the private rented and owner-occupied sectors. The Government considers that amending the existing private rented sector MEES regulations will be the most effective way to drive wide-ranging action in the rented sector by 2030.

Rationale for intervention

19. The key market failures underpinning this proposed market intervention are stated below:

    - Misaligned incentives: the costs of installing energy efficiency measures traditionally fall on landlords, and the benefits of lower energy use and bills and a warmer property usually fall to tenants, so there is a 'misaligned' (or 'split') incentive problem in undertaking energy efficiency improvement in the building. This problem is further exacerbated by a large proportion of businesses having short tenancies[6]. This makes tenants less likely to undertake improvements, as costs may not be fully recouped within a lease length.
    - Imperfect information: in principle, in a well-functioning market, rent levels should fully reflect differences in a property's energy efficiency thus overcoming this split incentive issue. However, the presence of market failures (including imperfect information on the costs & benefits of energy efficiency measures and the negative externalities from emissions which are not fully priced into the market) mean rents may not fully reflect differences in energy efficiency. This, as well as limited understanding of the additional benefits of energy efficiency (e.g. productivity, health and bill savings) savings leaves landlords with little incentive to make energy efficiency improvements.
    - Low prioritisation of energy efficiency improvement: even in the presence of privately cost-effective measures, energy efficiency may not be taken up due to the relatively low salience of energy efficiency action relative to other economic activities/investments for the business[7]. This

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4 Business Energy Statistical Summary 2018, page 9. The remainder is industrial process. https://www.gov.uk/government/publications/business-energy-statistical-summary

5 BEIS analysis of BEES data: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

6 MSCI & BPF: https://www.msci.com/www/research-paper/uk-lease-events-review-november/0787670910

7 Mallaburn, P. (2016): https://www.theccc.org.uk/wp-content/uploads/2016/10/A-new-approach-to-non-domestic-energy-efficiency.pdf

could be due to energy bills representing a small proportion, approximately 3% for most sectors[8], of the overall costs of the business and as a result not being factored into decision making. Without sufficient demand, landlords have little incentive to make improvements to the energy efficiency of their buildings.
- Barriers to investment: the nature of energy efficiency as an investment is that it requires a capital cost upfront (which can be significant) and delivers returns over time. Access to the capital required to install a measure, or package of measures, has been cited as a further barrier to making improvements.

20. The market failures above are the same as those stated in the January 2015 non-domestic PRS regulation IA[9]. As the existing PRS regulations target the worst performing buildings (those in EPC bands F and G), which is estimated to cover less than 20% of all non-domestic properties, the market fundamentals remain the same across the remainder of the stock and the outlined market failures continue to apply. There remains significant untapped cost-effective energy saving potential: EPC evidence indicates that only 5% of non-domestic building EPC registrations in 2018 had an energy rating of below band E (i.e. an F or G energy rating)[10], down from 10% in 2017. Therefore, the majority of new registrations are outside the scope of the existing PRS regulations and further action is needed to tighten existing PRS regulations to realize the remaining available potential in the rest of the stock and meet the more ambitious goals outlined above in the government objections section.

21. Setting a clear trajectory to 2030 now should provide landlords and businesses with a long-enough lead time to plan improvements into their tenancy cycles. This early sight of a clear regulatory trajectory should also provide the certainty the energy efficiency market requires to grow, scale and innovate. However, the drawback of setting an early trajectory is that there has not been sufficient time since the implementation of the existing PRS policy to collate evidence on its impacts. To fully understand the implications of the existing PRS regulations a post implementation review is to be carried out and planned to deliver findings in 2021.

22. For more timely evidence we expect to gain further information on the impacts of the existing and proposed regulations through consultation, and via the enforcement study.[11]

Alternatives to regulation

23. As detailed in the January 2015 Impact Assessment[12], various approaches have been tried in the past to improve the energy efficiency of the PRS. However, none of the approaches could overcome the current market failures and ensure the level of improvements required across the stock to meet our energy ambitions and legally binding carbon targets therefore a regulatory approach has been adopted. Previous approaches include voluntary approaches, information services, tax breaks for landlords, and subsidies for the installation of energy efficiency measures

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[8] Business Energy Statistical Summary 2018, page 17.

[9] Final Stage 2015 PRS Impact Assessment: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401379/150202_PRS_Final_Stage_Revised_For_Publication.pdf

[10] Live tables on Energy Performance of Building Certificates: https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates; these registrations include new builds & re-registrations of existing buildings

[11] Details in Appendix C, Section B.

[12] These are contained within the Energy Act (2011) Impact Assessment https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48196/3223-EA2011-green-deal-impact-assessment.pdf (see section D).

24. As stated above, given the limited coverage of the existing PRS policy and the recent implementation of the policy in April 2018 the market fundamentals remain the same and regulation is still considered necessary to secure the significant untapped energy efficiency potential.

Section 2: Policy Proposals

Policy Proposals

25. This Impact Assessment has evaluated two potential options for strengthening the PRS Regulations. Both options aim to address the market barriers identified above to unlock the economic opportunities of low carbon growth and deliver the energy and carbon savings essential if the UK is to be net zero by 2050:

- **Option 1:** that all non-domestic privately rented buildings reach an EPC C by 1 April 2030, provided the measure or package of measures required to reach an EPC C proves cost-effective by meeting the 7-year payback test.

- **Option 2:** that all non-domestic privately rented buildings achieve a minimum energy efficiency standard of EPC B by 1 April 2030, if cost effective.

26. This policy is designed to address market failures by sending an early signal of the future PRS regulatory trajectory to landlords and businesses. This will ensure that action to improve energy efficiency, where cost effective, is taken by at least 42% (EPC C target) and up to 85% (EPC B target) of the existing stock. Setting an early trajectory will also provide the supply chain with the certainty of demand required to grow and innovate and allow enough lead in time for landlords to plan building improvement works into their tenancy cycles.

27. This policy considers what EPC band should constitute the minimum energy efficiency standard in the non-domestic private rented sector in 2030. EPC band A has not been fully modelled as it was not considered a realistic target across the majority of the stock and EPC D was not modelled as EPC C already falls short of achieving the level of energy and carbon savings required from the sector. Modelling has been carried out to understand what the impacts would be on key indicators of both policies if we extended the payback period to 10 years. In both cases such an extension of the payback period does not substantively change the NPV from the 7-year options.

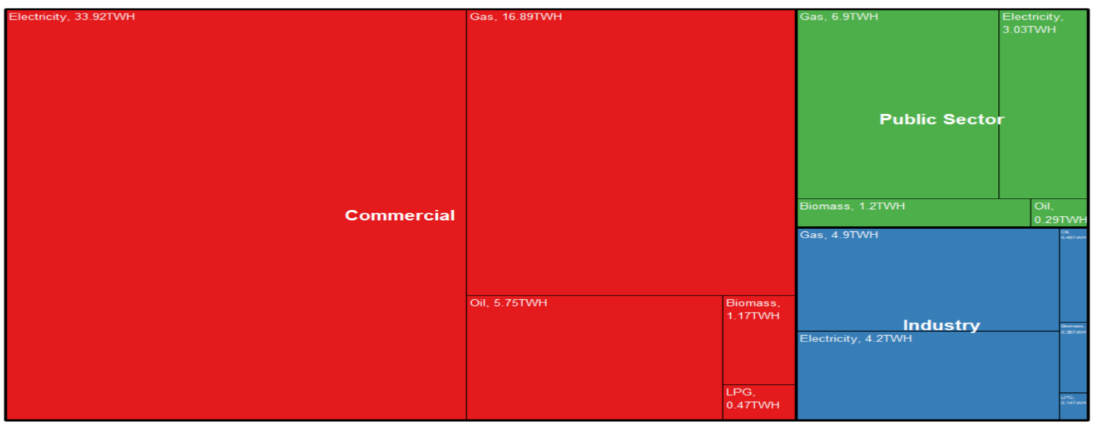
Section 3: Analysis and Impacts

28. This section provides:
    - An overview of the key market characteristics (energy, end use and EPC energy rating band distribution) of the existing population impacted by the policy;
    - Overview of analytical approach, key assumptions and counterfactual used in the IA;
    - Cost benefit analysis and EANDCB of policy options;
    - Risks & uncertainties in the analysis and sensitivity analysis of central estimates of policy options.

Existing market characteristics

29. Analysis for this IA using BEES data suggests that there are 1.1 million non-domestic rented buildings across England and Wales which consume 35% of UK energy consumption for non-domestic buildings (excluding industrial process) or 80TWh in 2015[13]. The PRS regulations will have the biggest impact on the commercial sector, representing 73% of energy use across rented buildings, with most of this being from electricity (58%), see chart below.

Figure 1: Tree Map of energy use by sector and fuel use across England and Wales, 2015



Source: *BEES (2016), non-domestic rented sector scaled to England and Wales using sub-national statistics*

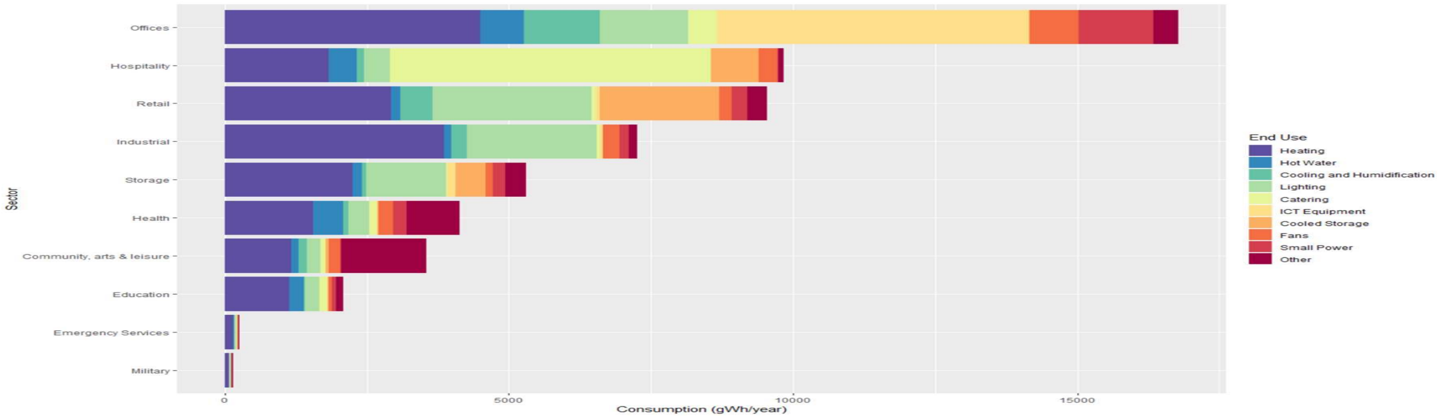
30. The four biggest building segments likely to be impacted by the regulations are: offices, industrial (excluding process), retail and hospitality, as they represent the biggest share of energy use, most of which is on heating (space and water) and lighting (see Figure 2).
31. To improve EPC ratings, measures that increase the energy efficiency are needed. These include improved heating, ventilation & air conditioning systems, lighting and fabric measures[14].

EPC registration breakdown and baseline

32. EPC ratings provide an indicator of the energy rating of a non-domestic building with G being least efficient and A being most. Figure 3 shows EPC trends through time of new non-domestic building registrations from 2008 to Q2 2018. The chart provides a rough approximation of the proportion of non-domestic rented buildings that are likely to be within scope of the regulations. Roughly 90% have an EPC of C and below, and hence fall into scope of the EPC-B target.

[13] The BEES data has been scaled using sub-national stats to reflect energy consumption for England and Wales.
[14]Measures that improve the insulation of a building, whether through its walls, roof or glazing options.

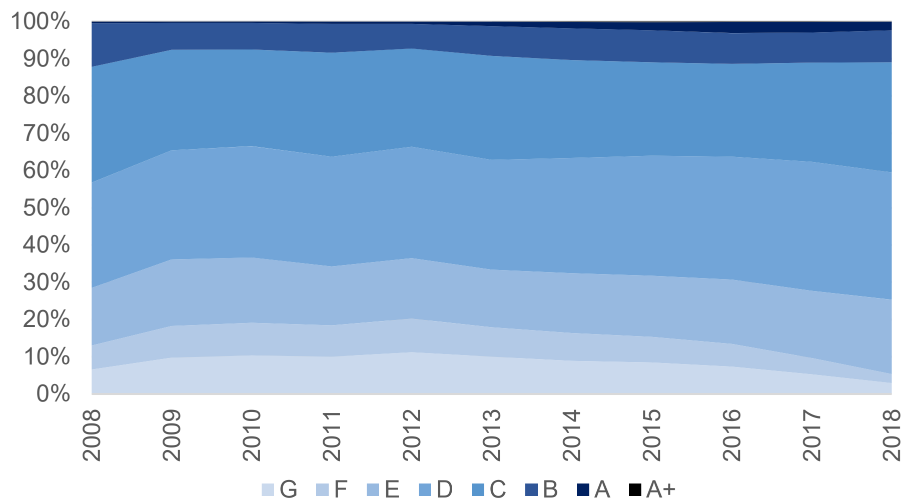
Figure 2: Energy use by sector and end use across England and Wales, 2015



Source: BEES (2016), non-domestic rented sector

33. Existing EPC regulations have already reduced the number of F and G rated properties that are newly leased. These have fallen from 20% in 2012 to 11% in 2017 from early action resulting in movement to higher bands.

Figure 3: Non-domestic EPC registrations, 2008 to Q2 2018[15]



Analytical approach

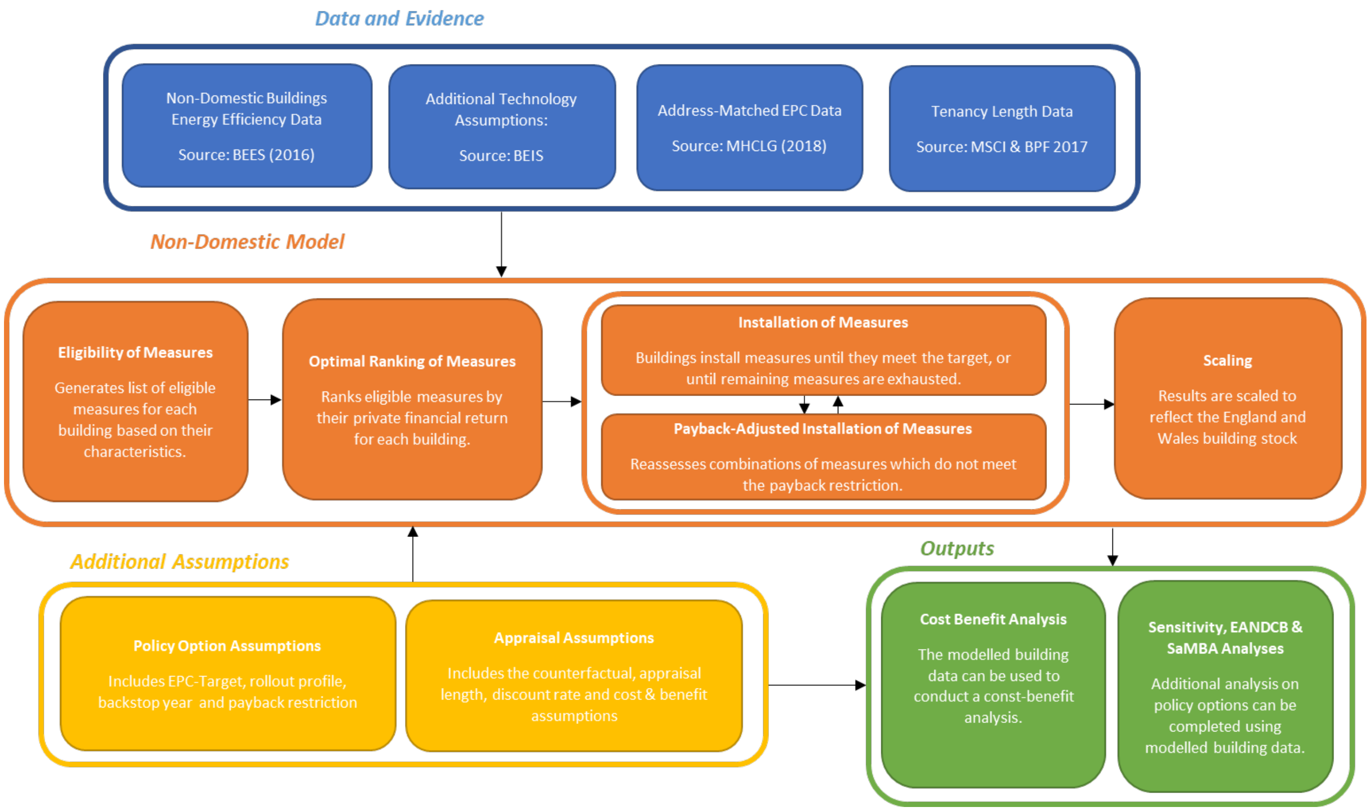
34. This section provides an overview of the analytical approach and key assumptions, followed by more detailed discussion of the approach taken towards the counterfactual, tenancy length and appraisal period.

[15] Source: Table A non-domestic EPC by asset rating, MHCLG (https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates)

Analytical and modelling approach

35. The analytical approach in this IA takes a least cost approach to achieving an EPC target, subject to constraints concerning which measures are eligible in each building, and that the measure package pays back within 7 years (see Annex C for more details). The potential technologies include: energy efficiency, cooling, ventilation, lighting and low carbon heating but exclude appliances and behavior change as these do not influence an EPC certificate. The schematic in Figure 4 below provides an overview of how our evidence and modelling combine to produce outputs for this IA.

Figure 4: Schematic of analytical approach



36. The data underpinning the modelling analysis uses an address-matched data-set using the Building Energy Efficiency Survey (BEES, 2016)[16] data on energy use and potential of properties, with their associated Energy Performance Certificate ratings (EPC). Technology assumptions are consistent with the evidence used for the Clean Growth Strategy and reflects evidence from BEES, RHI evaluations, literature review and expert judgment[17].

The table below highlights the key assumptions underpinning the analysis in this IA:

[16] This is a sample of 3,690 premises covering various non-domestic sectors across England and Wales and provided end use data by building type and abatement potential and costs from energy efficiency technologies in 2015. BEIS (2016), Building Energy efficiency Survey (BEES): https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

[17] Energy efficiency and lighting assumptions are taken from BEES. Ventilation assumptions from products policy team and heating from RHI evaluation, literature review and expert judgement consistent with assumptions used for Clean Growth Strategy.

Table 2: Key assumptions in modelling

Description	Assumption
Counterfactual (baseline) reflection of existing policies	F and G buildings have achieved minimum E rating in-line with existing regulations. Note, some may do higher than E depending on most cost-effective potential available. We have applied a sensitivity on the high cost range to cover any uncertainty in this assumption.
Deployment profile of impacted buildings	The deployment profile (or 'rollout profile') is assumed to reflect lease/tenancy length turnover, estimated using 2017 average lease length data from BPF.[18] Central estimates assume 50% of buildings comply at earliest tenancy expiration.
Buildings exempt from complying with regulations	In-line with the January 2015 IA on PRS we have assumed 10% of buildings are exempted from being able to comply for a variety of reasons including, being a listed building. New build and buildings with an EPC rating of B and above are also not assumed to be impacted.
How technologies get taken up to meet EPC rating, i.e. landlord's investment behavior	Landlords calculate which investments provide the highest value in today's money using today's fuel prices (not a projection) and undertake those measures with the highest NPV until they meet the EPC target, given the payback restriction.
Social opportunity cost of capital	A 5-year finance rate is used as a proxy for this, this is consistent with approach taken in January 2015 IA.
Appraisal period	2020-2064 to incorporate lifetime policy costs and benefits.
Hidden or 'hassle' costs to landlords	These are 10% or 15% (dependent on technology) of installation Capex and are embedded in the Capex figures based on BEES evidence.
Familiarization costs	In-line with January 2015 IA, 2 hours of landlord time is used. Assumes wage equivalent to estate agent salary.
Compliance cost to Landlords	Additional time taken to comply with regulations (i.e. demonstrate exemption or procure a new EPC after installing measures to meet the policy) are estimated given more buildings are brought in scope. Compliance times vary based on how buildings respond to the policy, with most assumed to take 2 hours.
Enforcement costs to local authorities	No additional enforcement costs estimated. Previous IA already estimated only small costs, as EPC regulations already provided enforcement infrastructure. Given both EPC regulations and previous EPC-E regulations are in place now, net impact of policy tightening should be small.
Monitoring costs to central Government	No additional costs to central government are estimated. There are expected to be no further set-

[18] For details, see the subsection on tenancy length.

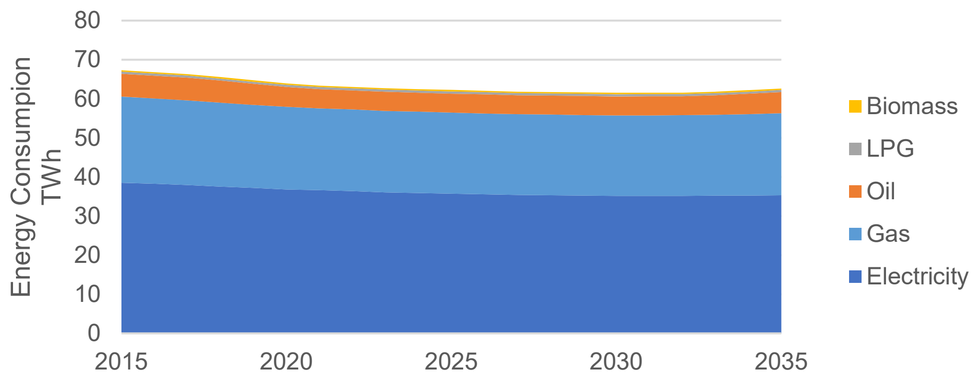
	up costs and the additional time invested in maintaining the database due to more buildings being brought into scope is expected to be small.

Counterfactual

37. This IA assumed all non-domestic buildings with an EPC rating of F and G comply with the existing regulations and achieve an EPC E by 2023.

38. Savings from existing policies[19] (detailed in annex A) are estimated using Energy Emissions Projections (2017) data.[20] In the central estimates, it is assumed these savings can be attributed to buildings meeting existing the EPC-E regulations, and by buildings out of scope of this IA (i.e. new build, buildings which have a rating of B or above, and some proportion of the 10% exempted population). The chart below shows the modelled future energy use of rented buildings (excluding new build) due to existing policies.

Figure 5: Projected energy use after existing policies, rented buildings in England and Wales



39. Sensitivity analysis is used to reflect the degree of uncertainty associated with the risk of further policy overlap (see Annex A and sensitivity analysis in Annex C section D).

Tenancy Length

40. The policy options require landlords to improve the EPC rating of their properties before they can be re-let This means the rate at which buildings respond to the policy will be largely determined by rate at which current leases expire. To model this, a deployment profile has been estimated using 2017 average lease length data from MSCI[21]. This data has been used to calculate the expected proportion of buildings which have changed lease at least once, by any given year.[22] This is then adjusted to

[19] Existing policies that are likely to have an impact of population are: Existing PRS regulations requiring meeting minimum of EPC E rating; Financial incentive from the Renewable Heat Incentive; Products policy regulations impacting lighting, boilers and ventilation and air conditioning systems. We have assumed Climate Change Levies, smart meters and Building Regulations impact energy and/or measures that are not in scope of this regulation.

[20] Updated Energy and Emissions Projections 2017: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

[21] MSCI & BPF (2017), https://www.msci.com/www/research-paper/uk-lease-events-review-november/0787670910

[22] Using the average lease length data, an estimate of the proportion of leases renewing each year was generated. This in turn provides an estimate of the cumulative proportion of buildings which have changed lease status at least once, by any given year.

account for preemptive responses to the policy, and to include the backstop year. The same method is used in the baseline and policy runs. The final rollout profile gives the proportion of buildings which are expected to have responded to the policy by a given year.

Figure 6: Modelled non-domestic deployment profile (2015-2030)

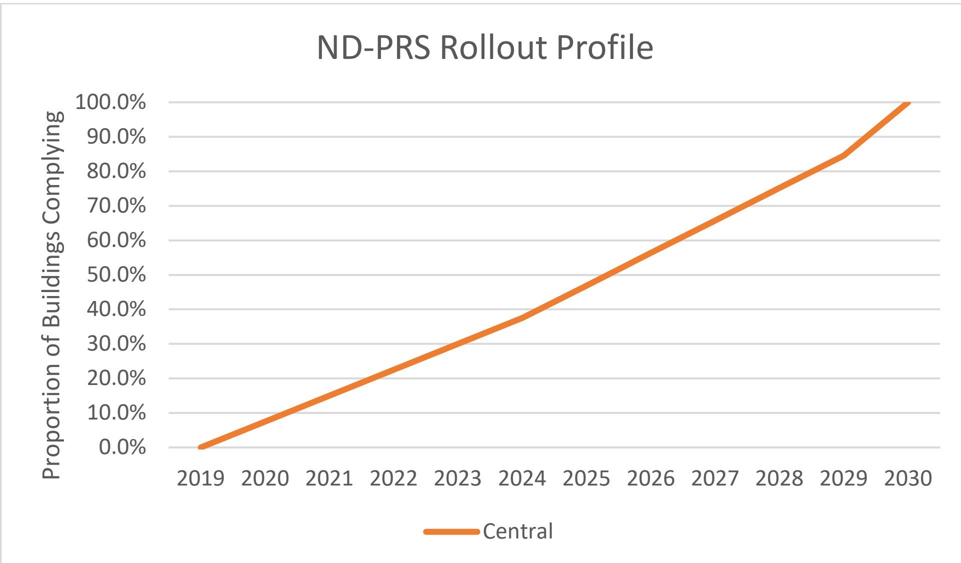
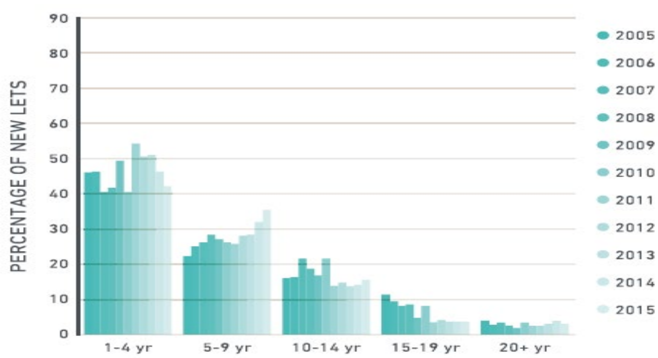


Figure 7: MSCI Proportion of leases by length (2005-2015)



Appraisal period

41. We assume an appraisal period from 2020 to 2064. While the policy period is between 2020 and 2030, the longer appraisal is necessary to capture legacy impacts of measures (mainly insulation) installed up to the backstop year (2030) where all the population is impacted by the policy.

42. To ensure the right balance between capex and the wider energy impacts of the policy are captured, we have included energy impacts over a further 25 years after the first cycle of capex installations in our modelling (2039). The 25 years reflects the average lifetime of the longest measures in the

This cumulative response distribution is assumed to being two years before the policy is implemented, in line with the preemptive responses seen before the EPC-E regulations came into effect. Additionally, it is assumed 100% of non-exempted buildings respond by the backstop year, creating a discontinuity in the final year. The calculations use unweighted average lease length data, as the policy response depends on the number of lease renewals, not the value of leases renewed.

modelling (mainly insulation including loft and cavity wall, glazing measures and some other building fabric measures[23]). More detail on the approach is discussed in the annex.

43. A shorter appraisal period would exclude some of the benefits associated with measures as a result of the policy. Costs are generally incurred earlier than the full lifetime of the benefits of measures, so a shorter appraisal period would lead to be unequal treatment of costs and benefits for the longer lifetime measures, distorting results and reducing the potential estimated benefits of the policy.

44. This approach of ensuring that the benefits are captured over the full lifetime of the measures is in line with the previous Impact Assessment on non-domestic PRS as well as Green Book Guidance[24].

[23] The full measure list is taken from BEES, see Table 4.4. of BEES technical annex: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566038/BEES_Technical_Annex_FINAL.pdf

[24] HMG, Green Book, see para 2.14: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

Cost benefit analysis (CBA)

45. This section outlines the key assumptions and results of the cost benefit analysis, as well as their implications for the policy options discussed. It also discusses the risks & uncertainties in the analysis and how these have been mitigated. Lastly, it addresses key sensitivities in the cost benefit analysis.

46. The table below summarizes the costs and benefits considered in this analysis. Annex C section B provides additional details.

Table 3: Description of monetized and non-monetized costs and benefits

	Costs	Benefits
Landlords	Monetised • Capital expenditure, covering costs of technologies installed including equipment, hidden and installation costs. • Operating expenditure of measures. • Familiarisation costs associated with understanding new regulations (estimated as if undertaken by letting agency). • Compliance costs associated with time taken demonstrating exemptions and/or compliance with regulations (estimated as if undertaken by letting agency). • Opportunity Cost of Capital forgone from other business activity. Non-monetised • Cost of forgone rent due to increase void periods during installation.	Not-monetised • Energy bill savings *during non-rented periods*. • Potential increase in property values. • Increase in tenant satisfaction and reduced void periods. • Reduction in long-term property maintenance costs. • Reduction in letting costs as property will be easier to let.
Tenants	Monetised • Capex, Opex and Hidden costs (covered in Landlord section, but potentially financed through energy bills, rent or other contractual arrangement).	Monetised • Energy bill savings during lease periods (bills not in social CBA). Not-monetised • Comfort and productivity. • Improved health. • Increase in tenant satisfaction and reduced void periods.
Letting agents	• No additional cost on top of landlord costs.	
Government	Non-monetised • Additional enforcement costs to Local Authorities and Central Government. We are undertaking a research project to improve evidence on this.	
Society as a whole	• Includes preceding costs.	Includes preceding benefits, and additionally: Monetised • Carbon emission savings • Air quality improvements • Social Value of Energy Savings Non-monetised • Increase in security of energy supply (not monetised)

		• Wider economic benefits e.g. economic growth, jobs in the green construction industry (not monetised)

47. We plan to use the consultation as an opportunity to expand and improve the assumptions underlying the currently monetized costs and benefits, as well as developing our understanding & treatment of currently un-monetised costs.

CBA Findings

48. The analysis presented in this impact assessment illustrates that the policy proposals have a significant net benefit to society, while also delivering significant carbon savings against legally binding carbon budgets and significant bill savings for tenants.

Societal impacts

49. Table 4 shows that all options provide a positive net benefit to society ranging from £3.0bn for option 1 to £6.1bn for option 2 over the appraisal period 2020 to 2064. This is associated with carbon savings of between 3.0MtCO2e (of which 1.5MtCO2e is non-traded) for option 1 and 9.2MtCO2e (of which 5.4MtCO2e is non-traded) for option 2 over the Carbon-Budget-5 (CB5: 2028-2032) period (see Table 5). The difference in NPV between Option 1 and 2 is mainly because Option 2 impacts more buildings, at an estimated 1 million buildings compared to 0.5 million in Option 1. Further, Option 2 requires higher levels of privately cost-effective energy efficiency upgrades relative to Option 1[25].

Table 4: Summary CBA numbers (£bn in 2018 prices, discounted to 2018)

	Present Value Costs	Present Value Benefits	Net Present Value
Option 1: Min C 7 yr payback	£1.6	£4.7	£3.0
Option 2: Min B 7 yr payback	£6.1	£12.2	£6.1

Table 5: Carbon savings (MtCO2e) and Energy Savings (TWh)

	MtCO2e Emissions in 2030			MtCO2e Over CB5 period			Energy savings TWh in 2030
	Traded	Non-traded	Total	Traded	Non-traded	Total	

[25] Option 2 (moving to an EPC B energy rating) impacts about 85% of the rented building population in England and Wales compared to 42% under Option 1.

Option 1: Min C 7 yr payback	0.3	0.3	0.7	1.5	1.5	3.0	4.4
Option 2: Min B 7 yr payback	0.8	1.2	2.0	3.8	5.4	9.2	12.4

50. The analysis shows that the policy options are very cost-effective at abating non-traded emissions. The cost of reducing one ton of carbon is -£283 to -£132 for options 1 and 2 respectively (see Table 6). These findings are unsurprising as the main cost components: capital and installation costs of the energy efficiency upgrades required to meet requirements of Options and the opportunity cost of capital,[26] are more than outstripped by monetized energy savings[27] and associated monetized carbon savings, see Table 6. This is because the design of the policy targets measures that privately payback, i.e. the bill savings (see Table 7), more than outstrip the cost of installations and average payback of policy options ranges from 4-5 years.

Table 6: Breakdown of CBA analysis (£bn, 2018 prices, discounted)

All Figures Present Value	Option 1: C 7-year payback	Option 2: B 7-year payback
Total Present Value Costs	**£1.6**	**£6.1**
Capital and installation costs	£1.3	£4.6
Operational costs[28]	£0.0	£0.3
Compliance + Familiarisation Costs	£0.0	£0.1
Enforcement/monitoring	£0.0	£0.0
Social cost of capital (finance cost)	£0.3	£1.1
Total Present Value Benefits	**£4.7**	**£12.2**
Energy Savings	£3.7	£9.8
Value of non-traded emissions	£0.6	£2.1
Value of traded emissions	£0.3	£0.8
Value of air quality[29]	£0.1	-£0.4
Total Net Present Value	**£3.0**	**£6.1**
Benefit to cost ratio	**2.9**	**2.0**
Lifetime non-traded carbon savings, MtCO2e	**8.7**	**30.7**
Non-traded cost effectiveness £/tCO2e	**-£283/t**	**-£132/t**

[26] The Opportunity cost of Capital represents between 21% to 25% of the capital and installation costs. These have been included in the IA as a real cost as a prudent approach. However, it can be argued that they may not be real costs as landlords would have done them if the market was operating efficiently, which this policy looks to correct, by improving the relative salience of energy efficiency, which is misaligned, *relative to* other business investment activity.

[27] Energy savings have been estimated using long run variable costs as opposed to retail values to follow Green Book guidelines. From a private perspective bill savings would be a lot higher reflecting retail energy values.

[28] Net operational costs are not zero to Option 1 but are close to zero as some technologies replace systems with higher operational costs.

[29] It should be noted that net air quality is a net benefit in Option 1 but becomes negative in Option 2 with the take up of more biomass systems which more than outstrip air quality benefits from energy efficiency technologies. This is not necessarily what would happen as this is one of many possible technology mixes, and if an alternative low carbon technology was assumed then air quality would be a net saving in both options.

51. Considering the timings of costs and benefits, the social switching value[30] for the EPC-B target is 10 years. The private switching value is 5 years. The difference is driven by the use of retail energy prices in the private calculation which are higher than the LRVC[31] energy prices used in the social calculation. The short private switching value is intuitive given the 7-year payback restriction. Further, the relatively short social switching value indicates the large magnitude of unexploited socially beneficial energy efficiency improvements in the sector, reinforcing the rationale for intervention.

52. Most costs and benefits fall on the private sector. The public sector represents about 9% of energy consumption from the buildings within scope of this IA, with about 11% of total bill savings from Option 2 attributed to the public sector.

53. Table 7 shows that the policy options are estimated to lead to substantial bill savings. Table 8 shows the key technology drivers (energy efficiency upgrades) that underpin these results.

Table 7: Private Bill Savings in 2030 from policy options, £m

	Bill savings in 2030 (£m)	Bill Savings as a proportion of total PRS Energy Bill
Option 1: C 7-year payback	£438	6.5%
Option 2: B 7-year payback	£1,159	17.3%

54. The actual final technology mix generated by the policies is uncertain due to the heterogeneity of non-domestic buildings and the wide array of choices available for each building. For simplicity, this IA chooses the most cost-effective technologies based on current best available evidence. The modelling in this IA estimates that meeting Options 1 and 2 requires replacing 33%-52% of electric heating systems, mainly with reversable heat pumps, and 5%-52% of gas boilers with a mix of low carbon heating systems. A variety of energy efficiency upgrades are also required (see Table 8), mainly lighting, controls and other energy efficiency measures. Specific case studies are included in Annex B. Additionally, alternative potential technology mixes resulting from the policy are discussed in the sections on sensitivity analysis and risks & uncertainties.

Table 8: Modelled installations of heating and energy efficiency technology by policy options

		Option 1: C 7-year payback	Option 2: B 7-year payback
Percentage change from baseline	Gas heating systems	-5%	-52%
	Electric heating systems	-33%	-52%

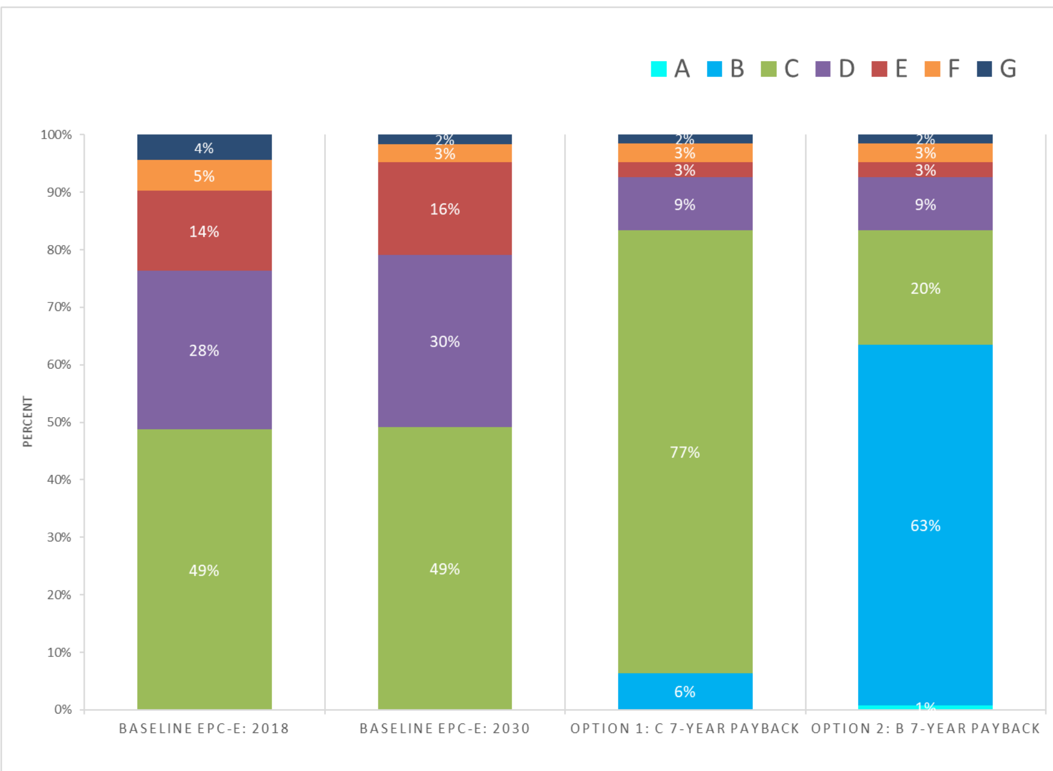
[30] Switching value is the length of time after which present value benefits exceed present value costs. The social switching value considers all monetised costs and benefits from a social perspective. The private value considers only those affecting businesses, from a private perspective.

[31] The social value uses long-run variable costs of energy, as per the Green Book recommended methodology for the social valuation of energy savings.

Additional installation numbers from baseline. Note, buildings can have more than one installation.	Low carbon heating installations[32]	160,000	540,000
	Lighting upgrades	340,000	1,100,000
	Controls	240,000	1,100,000
	Insulation and glazing	76,000	470,000
	Other energy efficiency measures	200,000	900,000
	Cooling and ventilation	16,000	28,000

55. The analysis in this IA finds that not all buildings are able to move to the higher building standards in the policy options. For Option 1, 17% of buildings are unable to reach a minimum C energy rating, whereas for Option 2 37% are unable to reach a minimum B energy rating[33]. This is likely to be because the technologies available to abate do not payback within 7 years. Figure 8 contrasts the projected 2030 EPC band distribution without intervention (baseline) against the two policy options.

Figure 8: Modelled EPC band distribution baseline versus policy options in 2030[34]



[32] Mainly gas driven and reversible heat pumps, with a small number of air source heat pumps and biomass systems. Figures rounded to two significant figures. Note, we have assumed no gas driven heat pumps in our high cost barrier range to mitigate against a technology where the supply network is less developed at present.

[33] Figure 8 generated from modelling results.

[34] Only includes in-scope properties (those beginning with an EPC rating of C or below).

Non-quantified impacts

56. The main non-quantified costs are additional enforcement and monitoring costs to Government and potential forgone rent to landlords if there are increased tenancy void periods (periods of non-occupation between tenancies) due to the time taken to undertake the installations. In-line with the January 2015 IA we have assumed these are likely to be negligible, as installations can be undertaken in existing void periods[35].

57. The main non-quantified benefits include: productivity and health benefits which the literature suggests could be substantial[36]. There are also likely to be wider employment and multiplier impacts of increasing the energy efficiency supply chain as a result of the additional demand for energy efficiency measures created by the policy. These effects are likely to have positive impacts and improve NPV estimates.

[35] This assumption is based on a study undertaken by Sweett to estimate the potential impact of the Regulations on the non-domestic PRS 'Mapping the impact of the minimum energy efficiency standards for commercial real estate' found that the forgone rent as a result of the making energy efficiency improvements in order to comply with the PRS regulations was likely to be small. http://www.greenconstructionboard.org/images/stories/Valuation_and_Demand/GCB%20630%20final%20report.pdf

[36] IEA (2014): https://www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf

Sensitivity analysis of CBA

58. Several key dimensions are identified in this sensitivity analysis. Table 9 summarises these dimensions and additional details concerning the sensitivity analysis are presented in Annex C section D. The high and low figures used throughout this IA reflect the combined impact of all these dimensions and is referred to as the multilateral sensitivity analysis. Additionally, consideration is also given to the partial impact of varying each dimension *unilaterally*.

Table 9: Sensitivity analysis key assumptions

Variable	Description	Low cost and barriers[37]	High cost and barriers
Energy Prices	Green Book Long-Run Variable Costs (LRVC) of energy have high and low alternatives for use in sensitivity which are applied here. High energy prices are used in the 'low' run, as high prices mean energy efficiency measures are more privately beneficial, so the policy is more effective. *Vice-versa* for the 'high' run.	High energy prices applied.	Low energy prices applied.
Capex costs	Capex estimates are scaled by a high and low scale factor to capture uncertainty about underlying capex costs.	Scale factor of 0.8 applied	Scale factor of 1.2 applied
Gas Heat Pump Feasibility	Gas heat pumps are a new technology, and it is possible there may be barriers to widespread deployment. Given they are an important technology in the central estimates, this sensitivity analysis considers the impact of removing them.	Gas driven heat pumps allowed (same as central estimates).	Gas driven heat pumps are excluded.
Familiarisation costs	The additional time taken to familiarise with the legislation is an assumption from the previous impact assessment, so the impact of varying it is considered. Similarly, the opportunity cost of time estimate is varied.	1 Hour £6.81 DfT estimate of value of time	2 hours £27.69 Average hourly landlord income
Compliance Costs	The additional time taken to comply with regulations, such as demonstrating exemptions or new EPCs, is an assumption so the impact of varying it is considered. Similarly, the opportunity cost of time estimate is varied.	0.5 - 1 Hour £6.81 DfT estimate of value of time	1 - 2 hours £27.69 Average hourly landlord income

[37] For this sensitivity analysis, 'high' reflects a worst-case scenario and 'low' reflects a best-case scenario.

Opportunity cost of Capital	The opportunity cost of capital depends on the foregone social return on capital that is diverted to energy efficiency measures, in lieu of their next best alternative. Central estimates use the private return on capital, as used in the model when prioritising measures. The length of time over which capital is assumed to be 'locked up' is not varied, as average paybacks are relatively stable across sensitivity runs.	3.5% The social discount rate 5 years Same as central estimates	8.5% Same as Central estimates 5 years Same as central estimates
Rollout Profile	The rate of response to the policy determines the rollout profile which is appropriate. This uncertainty is parameterised in this IA by varying the proportion of buildings who choose to comply at their first tenancy renewal, with the remainder complying at 2030. The central is 50% (of those who comply, exempted and non-compliant buildings are already excluded).	100% of buildings comply at their first tenancy end date.	0% of buildings comply at their first tenancy end date, all move at 2030.
Additionality	Other existing policies including Products Policy, Renewable Heat Incentive (RHI), Salix and the Climate Change Levy (CCL) may reduce the additionality on the policies considered.	Policy is assumed to be entirely additional (same as central estimate)	50% of in-scope savings from other policies are assumed to overlap with modelled savings.

59. In general, the values used in the sensitivity analysis reflect the extremes of the plausible range of values for each dimension. Hence, the combined effect of all the dimensions is relatively large, though, in practice, it is not expected that all dimensions would simultaneously vary in this way. In this sense, the combined effect of all the sensitivity dimensions reflects the 'best' and 'worst' case scenarios.

60. The sensitivity results for the headline CBA figures are presented in Table 10. Additional data and analysis are presented in Annex C.

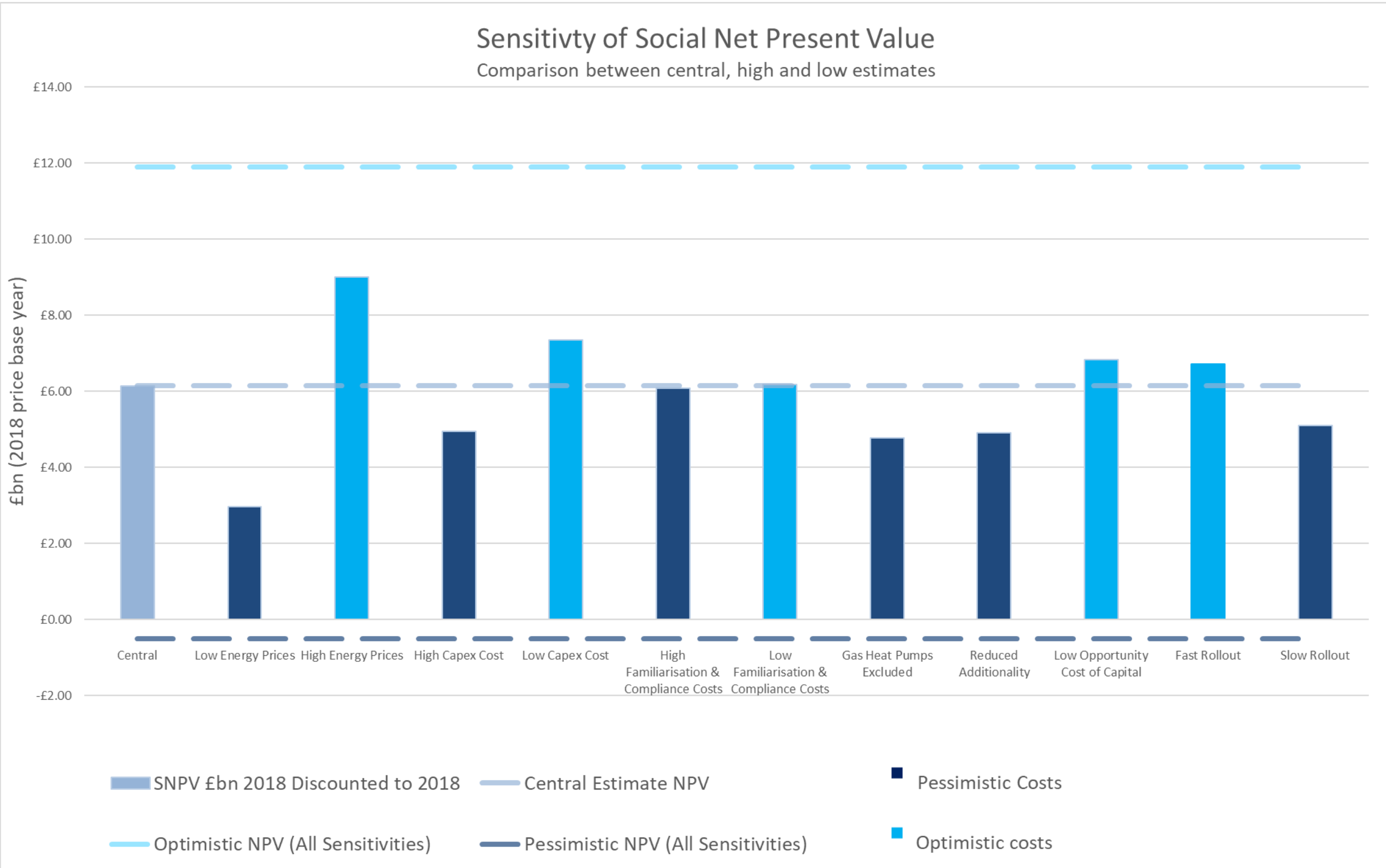
Table 10: Sensitivity analysis headline impacts on NPV (£bn 2018, discounted to 2018)

		Net present value £bn 2018
Option 1: C 7-year payback	High cost and barriers	**£0.9**
	Central	£3.0
	Low cost	**£4.9**
Option 2: B 7-year payback	High cost and barriers	**£-0.5**
	Central	£6.1
	Low cost	**£11.9**

61. Table 10 shows that the NPV ranges from £0.9bn to £4.9bn for Option 1 and £-0.5bn to £11.9bn for Option 2. Following on from the assumptions in Table 9, Figure 9 shows the main variables that influence the NPV. For the high cost and barriers range several worst-case factors contribute towards

it, including: low energy prices, the reduction additionality to reflect risks of further policy overlaps, the removal of gas driven heat pumps, and high capital costs that are 20% more expensive than the central case. These assumptions may overstate the costs and barriers faced but provide a prudent range for this IA.

Figure 9: Impact on NPV of sensitivity assumptions for Option 2 (£bn 2018, discounted to 2018)



62. The estimates in Figure 9 were calculated for an EPC-B policy with a 7-year payback and a 2030 backstop. Individually, the dimension with the greatest impact on NPV is high/low energy prices. This is because prices have effects at multiple levels of the modelling,[38] affecting both the technologies which are installed and the value of the energy savings they produce. The next most impactful

[38] For example, low prices will mean the payback lengths on all measures are increased, as bill savings are lower. This will reduce the number of measures which are eligible for installation under the payback restriction. Secondly, the *relative* private returns on measures may also change, which could change the measures than get installed. Thirdly, the differences between the low/central/high prices are larger for oil and gas, than for electricity. This introduces another change in the relative efficacy of different technologies, affecting the fuel switching incentive. Lastly, the lower energy prices also directly affect the social cost benefit analysis, with the social value of energy savings being lower when prevailing prices are low. (This is implicit in the Green Book Supplementary Guidance long run variable cost figures (LRVC) which are used for the social impact monetisation of energy savings.) This directly reduces the net present value.

dimensions are the high/low capital cost assumptions, the exclusion of gas heat pumps and the more pessimistic additionality assumption. All three individually reduce NPV by £100m-£150m. Further discussion of these dimensions is left to the annex.

63. The other notable aspect of the chart is that the combined effect of the sensitivity dimensions is large relative to their individual effects. This is because of the way the sensitivity dimensions interact when they are implemented together and is discussed in the annex.

64. Overall, the main conclusion of the sensitivity analysis is that both policy options offer potential net social gains. In the worst-case scenario, the energy efficiency (and emissions reductions) of an ambitious policy may be delivered with net zero social impact, with potential net private benefits still expected given the policy only targets measures which pay back promptly.

Equivalent Net Direct Cost to Business (EANDCB)[39]

65. The direct costs and benefits considered fall within the same appraisal period as the main analysis (2020 to 2064). This analysis finds the direct benefits outweigh the direct costs for each of the options, making the measure a 'Zero Net Cost' regulatory measure. This is unsurprising given the policy only targets measures which privately pay back. The large private gains implied by the EANDCB also provide support for the rationale for intervention. Namely, there is large, unexploited scope for privately beneficial energy efficiency improvements in the non-domestic buildings stock. This finding is also consistent with the existing non-domestic PRS IA for the minimum E regulation, but with a higher benefit to cost differential, as expected given the larger population impacted.

Table 11: EANDCB disaggregated costs and benefits (£m 2016 prices, discounted to 2017)

EANDCB (£m 2016 prices, discounted to 2017)	Option 1: C 7-year payback	Option 2: B 7-year payback
Capex £m 2016	£51.0	£184.4
Opex £m 2016	-£0.8	£12.3
Compliance & Familiarisation Costs £m 2016	£1.9	£2.1
Costs £m (to business)	**£52.2**	**£198.8**
Total Bill savings £m 2016	£232.6	£560.1
Benefits £m (social)	**£232.6**	**£560.1**
EANDCB	**-£180.4**	**-£361.2**

66. It should be noted; the costs and benefits are expected to accrue to different subsets of the business population. The direct costs are expected to be incurred largely by landlords, mostly in the form of

[39] EANDCB figures include capex (including hassle factor), opex and compliance/familiarisation costs. The benefits included are bill savings. EANDCB has been calculated *excluding* public sector bill savings, so only includes commercial and industrial sector savings. Costs incurred on buildings rented by the public sector *are* included, as without data on cost pass-through from landlords to tenants, we make the conservative assumption that the costs are entirely incurred by landlords, so are counted in the EANDCB calculation.

capital expenditure, while the direct benefits are expected to go to renters in the form of bill savings. Since both are predominantly businesses, they are both included in the EANDCB calculation. The final distribution of costs and benefits will depend on the extent to which rents increase, but given this is a transfer, it has no impact on the EANDCB analysis.

Small and Micro Business Assessment (SaMBA)

67. There are two groups of business impacted in this IA, landlords and tenants. The direct costs of the regulation are expected to fall on landlords. The table below from the British Property Federation (2017)[40] provides a breakdown of investors who own properties in the UK by value, this suggests that most landlords (at least 76%) tend to be large businesses (i.e. overseas investors, listed companies and real estate investment trusts, UK insurance companies and pension funds).

Table 12: Commercial property ownership in the UK 2016

	£bn in 2016
UK insurance companies and pension funds	£79
Overseas investors	£139
UK collective investment schemes	£79
UK REITS & listed prop companies	£74
UK unlisted prop companies and UK private individuals	£72
UK traditional estates / charities	£23
UK other	£20
Total value of buildings in investment portfolio	£486

Source: British Property Foundation

68. While most landlords are large organizations most bill savings tend to fall on SME and micro businesses, see Table 13 below from our modelling results.[41] Further evidence will be collected about impacts on small and micro sized businesses through-out the consultation.

Table 13: Estimated proportion of Bill savings in 2030 by organization size

	Micro	SME	Large	Other (Undefined from BEES sample and public sector buildings)
Option 1: C 7-year payback	31%	28%	32%	9%

[40] British Property Foundation (2017), Property Data Report 2017: https://www.bpf.org.uk/sites/default/files/resources/PIA-Property-Data-Report-2017.PDF

[41] Costs are similarly distributed. 25% of capex costs are incurred in buildings with micro business tenants, and 31% for SMEs in the EPC-B policy.

Option 2: B 7-year payback	23%	25%	38%	14%

Risks and uncertainty

69. The key risks and uncertainties in relation to the analysis presented in this IA are:

- There is a high degree of uncertainty around the types of technologies that are likely to be taken up given the heterogeneity of the non-domestic buildings population and the choice of measures available. For simplicity we have assumed measures that are eligible and are cost effective based on our best evidence. In the case of gas driven heat pumps, which are taken up in the central estimate, the supply chain is less well developed than for other technologies. To account for this, the high cost and barrier estimate in the sensitivity analysis assumes no gas driven heat pumps can be installed.
- There is a high degree of uncertainty about the make-up of existing systems installed across non-domestic buildings. The evidence in this IA draws heavily from BEES assumptions about non-domestic building energy use and potential. Additionally, further eligibility criteria have been established by BEIS engineering experts to mitigate against technologies being installed in specific modelled building archetypes.
- The evidence base for heating and cooling technologies is less developed than the energy efficiency assumptions taken from BEES. BEIS has commissioned an external research project to ascertain this information to feed into the Final Stage IA.
- There is a risk that existing policies may overlap with the central estimate in this IA. The risk is expected to be small as the counterfactual covers this, but a sensitivity run has been done in the high cost and barrier range to reflect this.
- The matched EPC sample of BEES properties is small, about ~900 cases of buildings. This isn't a major concern in this IA as the 'end use' and 'abatement potential' data (that underlie much of the analysis) are based on the full BEES sample, which has been extensively quality assured. Additionally, results are scaled to reflect the energy consumption of England and Wales using sub-national UK statistics.
- The exact calculation to estimate an energy rating for the EPC is based on individual non-domestic building characteristics which cannot be replicated given the large volume of information required. This IA applies a simplified approach to model energy ratings that has been agreed with experts in BEIS and MHCLG.
- An additional area of uncertainty is the potential for a change to the methodology underpinning non-domestic EPCs.[42] For example, a change in the emission factors or any other number of elements underpinning the non-domestic EPC could alter the EPC distribution of non-domestic buildings and impact the coverage of the policy. To better understand the scale of this potential change we have carried out indicative analysis. This suggested that if emission factors were updated in line with the continuing decarbonisation of the electricity grid, the EPC bands for a few illustrative buildings would not change substantially. There remains uncertainty about how the full distribution could be impacted. If there are changes to the methodology underpinning the EPC we will, where feasible, reflect this in any future analysis in order to capture the impact this has on the policy.
- Finally, the response rate to the policy is another element of uncertainty. The mechanism of the policy operates by guiding expectations about the standards necessary over medium/long time horizons. It is currently unknown how landlords will respond to this, which is why the sensitivity analysis included extremes of both early and late compliance. It is also not known how this

[42] Link to further detail on SBEM (including introductions to EPC's, SBEM and reference buildings). BRE's website is also a useful source of information.

mechanism will affect enforcement. We aim to address of these questions via consultation and the enforcement study.

Annex A: Counterfactual and policy overlaps

70. The table below describes the existing policies that we have identified that may overlap to some degree with the energy savings available that this IA looks to unlock.

Table 14: Existing policies and how we have accounted for them in the IA

Existing Policy	Description	Approach
Existing PRS regulation	From April 2018 rented properties will have a minimum EPC of E and all tenancies from April 2023, from energy efficiency measures with 7-year payback.	Fully accounted for. Counterfactual model run assumes minimum EPC-E rating target.
Products Policy	The EU Eco-design Directive and the Energy Labelling Framework Regulation set minimum performance and information requirements for energy using products (i.e. lighting, boilers, air con units) placed to take the least efficient products off the market.	Accounted for through overlaps with meeting E regulations. Assume remainder of savings accounted from buildings that are not within scope of this IA (i.e. new build, B and above bands and some element of the 10% exempted buildings). Sensitivity analysis shows the extent of uncertainty with this.
Renewable Heat Incentive (RHI)	Provides financial incentives to increase the uptake of renewable heat by businesses, the public sector and non-profit organizations.	As above.
Salix	Provides interest-free loans in England to public sector organizations for energy efficiency schemes.	As above.
Climate Change Levy (CCL)	Levied on the supply of energy to business and public sector consumers. The main rates of CCL are set by fuel and are intended to incentivize businesses to reduce their energy consumption.	Assume 100% of CCL savings are out of scope as they are likely to reduce appliances and behavior change predominantly.

71. This IA captures impacts of existing policies in the central estimates by modelling buildings to a minimum EPC rating of E and above. We assume that further existing policy savings are captured by populations out of scope of this IA which include: new builds (which, in particular, reflect building regulations and product standards), buildings who have a rating of B and above (specifically product standards) and some element of the 10% of exempted building (which we have assumed may also be implicated by product standards in particular). It should be noted that this IA only looks at ‘regulated’ energy that influences an EPC. Unregulated energy use like appliances and catering are not in scope of this IA and may be impacted by existing policies.

72. The table below shows case studies of buildings modelled in the IA, in terms of what they had to install to move from an EPC E energy rating to a C or B and the associated additional cost, bill savings and the implied private payback period.

Table 15: Case studies from modelled building stock

Building Type	Floor area m^2	EPC Improvement	Installation measures required and additional capital costs (includes installation and hassle costs)	Bill reduction in 2030	Private payback years
Office, pre 1900 construction, small	157	E to C	Gas heat pump and 1 lighting upgrade Cost = £3,871	£818	4.7
		E to B	Gas heat pump; 1 lighting upgrade; other controls; other thermal efficiency Cost = £4,668	£1,002	4.7
Retail, small shop, construction 1940to1985, small	139	E to C	Reversable air to air heat pump and 1 lighting upgrade Cost = £2,118	£501	4.2
		E to B	Reversable air to air heat pump and 2x lighting upgrades Cost = £2,139	£545	3.9
Retail, small shop, construction age unknown	218	E to C	Reversable air to air heat pump for heating and cooling and 1 lighting upgrade Cost = £3,976	£1,744	2.3
		E to B	Reversable air to air heat pump for heating and cooling; 2x lighting upgrades; thermal controls; and other controls Cost = £5,828	£2,135	2.7

Annex C: Analytical approach

A: Modelling approach:

73. The model underpinning this IA uses an address-matched population of the BEES sample of ~3700 buildings, which provides evidence on building characteristics and potential for non-domestic properties, with the non-domestic Energy Performance Certificate (EPC) database published by MHCLG. This is then scaled using sub-national energy stats to provide energy use for England and Wales[43]. A subset of ~900 of the original BEES sample, which were addressed-matched, is then used to link building characteristics with an EPC rating.

74. The model estimates the impact on the EPC rating of applying measures from BEES and heating and cooling assumptions produced for the Clean Growth Strategy. The SBEM methodology used for calculating real world EPC bands is not replicated[44]. To estimate the impact of abatement measures on EPC band the modelling in this IA assumes that a proportional decrease in emissions produces an equivalent decrease in SBEM score (e.g. halving emissions halves the score)[45]. This has been approved as a sensible approximation by BEIS statisticians and MHCLG. Therefore, the model should produce plausible estimates of impact on EPC ratings.

75. The potential impacts of energy efficiency (building fabric) improvements and changes of heating and cooling appliances (including fuel switching and low-carbon technologies such as various heat pumps and biomass) are considered. These will affect the energy consumption, emissions, fuel bills and, where applicable, EPC rating of the building stock. Microgeneration renewables, heat networks and load-shifting technologies are not in scope. In addition, new build is out of scope.

76. Measures are installed based on their cost-effectiveness when considered in isolation. Energy savings by buildings considers the package of energy efficiency measures installed rather than energy savings by measures in isolation to avoid double counting of energy savings attributed to individual installations within buildings. Measures are installed until the target EPC rating is reached or there are no more eligible and mutually-compatible options available. Each modelled building installs all its measures each year with a deployment profile determining what proportion of buildings deploy each year based on lease length.

B: Description of key costs and benefits and their treatment in this IA

77. **Capital Expenditure (Capex):** This is the largest individual cost of amending the regulations. Installing energy efficiency and heat measures involves an upfront capital investment to pay for the technologies and their installation. When measures reach the end of their lifetime and need to be replaced or undergo substantial maintenance, it is assumed some of the capex is incurred again. These costs are assumed to fall on landlords.

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[43] BEIS (2018), Total final energy consumption at regional and local authority level: https://www.gov.uk/government/statistical-data-sets/total-final-energy-consumption-at-regional-and-local-authority-level

[44] This is because the BEES abatement estimated potential from energy efficiency is not correlated with current EPC rating as the assumptions and methods underpinning the BEES current energy/emissions estimates and the abatement potential estimates are largely independent, and the latter is much better understood with the technology input assumptions validated by BEIS experts.

[45] Specifically we estimate a Change in SBEM rating to follow the following formula:
New SBEM = Original SBEM * post-abatement regulated emissions (i.e. after abatement potential) / pre-abatement regulated emissions
Where "Original" means the completely unmodified building (i.e. the actual EPC score from the EPC database), not the building as it was before the most recent installation(s).

78. Energy Efficiency technology assumptions are taken from BEES, with low carbon heating and cooling technologies based on expert judgement reflecting a review of the literature and RHI evaluation data. The evidence on heating and cooling technologies is less developed and we are currently undertaking a research study to inform the next stage assessment for this IA. The latter is intended to feed into the next stage of this assessment.

79. For the purposes of this IA, it is assumed the real cost of measures is constant. In reality, competition and technological improvements may reduce the cost of some technologies. Alternatively, constraints on the expansion of supply may mean their prices increase as a result of increased demand. It is not feasible to estimate these hypothetical changes in prices over the time frame of the IA, so a constant real cost is assumed.

80. The regulations only require installation of measure packages that meet the payback restriction (the length of time it takes for the associated bill savings to cover the capex cost). In line with the existing regulations, the payback restriction is 7 years. Annex D presents analysis on the impact of extending this to 10 years.

81. **Operating Expenditure (Opex):** This is the cost associated with maintaining and operating measures over their lifetime. It is estimated based on the value of the capex of a measure, with adjustments made based on technological assumptions. Since it is derived from capex, the same assumption about constant real costs applies to opex also.

82. Evidence underpinning opex assumptions are the same as the capex assumptions above.

83. **Opportunity cost of Capital:** Supplementary guidance to the Green Book on valuing energy use and greenhouse gas emissions[46] advises that "the costs of private financing would generally be considered to be a real social cost". This is because financing costs may affect private sector allocation decisions. When capital is tied up in a specific project, alternative profitable use of such capital is ruled out and there is a foregone social benefit. Finance costs have been included in this impact assessment, ensuring consistency with guidance, and mirroring assumptions used in the January 2015 Private Rented Sector Impact Assessment, where a social interest rate of 8.5%[47] applied over 5 years is used. The 5-year period is assumed to reflect a typical loan length which is marginally higher than the average payback lifetime of measures in this IA.

84. **Hidden costs:** These are costs associated with researching and procuring measures, and other costs associated with the purchasing and installation process outside those captured by capex. Hassle costs are modelled as varying depending on which measures are installed, and also the scale of the installation. Hence, each measure has a hassle factor (10% to 15%), and this is applied to the capex. For example, maintenance, controls, behavioural measures, awareness and optimisation solutions generally have lower hassle factors of 10%, and more intensive measures have 15%. The assumptions underpinning these are from BEES.

[46] Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[47] 146. The Committee on Climate Change have previously undertaken research on the appropriate means of estimating the opportunity cost of capital where private funds are used to achieve social aims. They found that the appropriate opportunity cost for business financing of social aims was in the region of 7% to 10%. We use the mid-point of this range, 8.5%, as the assumed private interest rate assumption. The CCC report is available here: http://archive.theccc.org.uk/aws/Time%20prefernce,%20costs%20of%20capital%20and%20hiddencosts.pdf

85. Additionally, higher capex assumptions are applied in the high cost sensitivity analysis to reflect additional issues associated with installation of heating technologies, based on evidence gathered for the CGS.

86. **Familiarisation costs:** The costs associated with familiarising with the new regulations are treated as being time costs. In keeping with previous impact assessments, it is assumed this will take two hours for non-domestic buildings. Given these regulations exclusively affect non-domestic buildings, it has been assumed much of the compliance work will be undertaken by real estate professionals, so the central estimates use the average wage of this group, rather than that of landlords as in previous IAs. The central wage estimate is £13.23. It uses the average weekly earnings of estate agent professions (ONS data)[48] to get the initial wage data. This is used to calculate a yearly income, which is then corrected for income tax, and scaled down to an hourly figure by using data on the average weekly hours worked (LFS data)[49]. The impact of using other estimates of wage rates is considered in the sensitivity analysis.

87. This IA uses the modelled number of buildings in scope, which is derived from BEES[50]. It is assumed each building requires an individual to familiarise with the regulations. This is analogous to assuming that non-domestic landlords have an average portfolio size of 1. This is a more conservative assumption than used in the previous impact assessment because of the lack of evidence on the number of landlords in the non-domestic rented sector across England and Wales.

88. **Compliance costs:** These capture the costs associated with using a regulatory measure as opposed to other alternatives. They include the costs to landlords associated with demonstrating exemptions, either due to explicit exemption (such as heritage status) or implicit exemption (due to the payback restriction precluding sufficient investment to meet the policy). It also includes an estimate of the time taken to acquire a new EPC for those buildings which comply with the policy in full.[51] These calculations use the same wage assumptions as the familiarisation costs calculation.

89. The estimated compliance time for a building depends which of three categories it falls in to:

A. Affected buildings (buildings which install measures due to the policy)
B. Assumed exempted buildings (buildings which are exempted by assumption)
C. Other exempted buildings (buildings that already meet the target *or* are exempt due to the payback restriction)

90. In the central estimates, it is assumed affected buildings take two hours to comply with regulations. This mostly comprises the time taken to demonstrate a new EPC. For buildings which are exempt by

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[48] ONS data, Average weekly non-seasonally adjusted salary (Sep17-Sep18) for Real Estate Activities from the Monthly Wages and Salaries Survey: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/averageweeklyearningsbyindustryearn03

[49] ONS Labour Force Survey weekly hours worked (2018): https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/actualweeklyhoursworkednotseasonallyadjustedhour01nsa

[50] BEIS (2016), Building Energy efficiency Survey (BEES) https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

[51] Landlords are not required to obtain a new EPC to demonstrate compliance, though this is expected to be the easiest way for a landlord to demonstrate that they have complied with the Regulations. (Page 19 ND MEES Guidance https://www.gov.uk/government/publications/the-private-rented-property-minimum-standard-landlord-guidance-documents)

assumption (such as heritage properties) it is assumed to be 1 hour capturing only the time to demonstrate their pre-determined exempt status to local authorities.

91. For those who are otherwise exempted it is assumed to be 1 hour. This group consists of two types of building. Ideally, those buildings who already meet the regulations would be expected to take 0 hours (as they need take no action), and those who are exempt due to being unable to install any measures would take longer. However, as we are unable to distinguish between the two groups in our modelling, we have used a conservative assumption that all of this group take one hour.

92. **Enforcement costs:** The cost to local authorities of enforcing this policy are expected to largely comprise the additional time costs associated with processing complaints, exemptions and possible legal challenges, due to the greater number of buildings in scope. However, they are not monetised here for several reasons. Firstly, as discussed in the original IA, the infrastructure associated with delivering and measuring EPCs already exists and so is not a cost of this policy. Secondly, the original IA already covers the initial setup cost and operational cost of the enforcement mechanism. Hence, the additional impact of this policy is only to bring more buildings into scope, so is expected to be small.

93. Additionally, work is soon to begin on an enforcement study to understand the costs associated with enforcement in more detail. The original impact assessment estimated enforcement costs based on consultation responses which detailed the expected resource intensity of enforcing the policy. However, these consultation responses are now out of date, and were referring to the domestic and non-domestic sectors simultaneously. Therefore, the enforcement study and responses garnered through further consultation will be used to improve enforcement cost estimates for the final stage impact assessment.

94. **Monitoring costs:** These costs are incurred by central government to monitor the policy. In the original impact assessment, this primarily comprised the development of a bespoke IT system and database to track temporary exemptions, and the staffing costs required to operate and maintain the database. The setup costs are already covered in the original IA, and it is assumed they do not need to be incurred again for this policy. Given the operating costs were considered to be small from the outset in the original IA, the additional cost of recording more exemptions due to this policy are expected to be small, so are not monetised.

C: Appraisal Period:

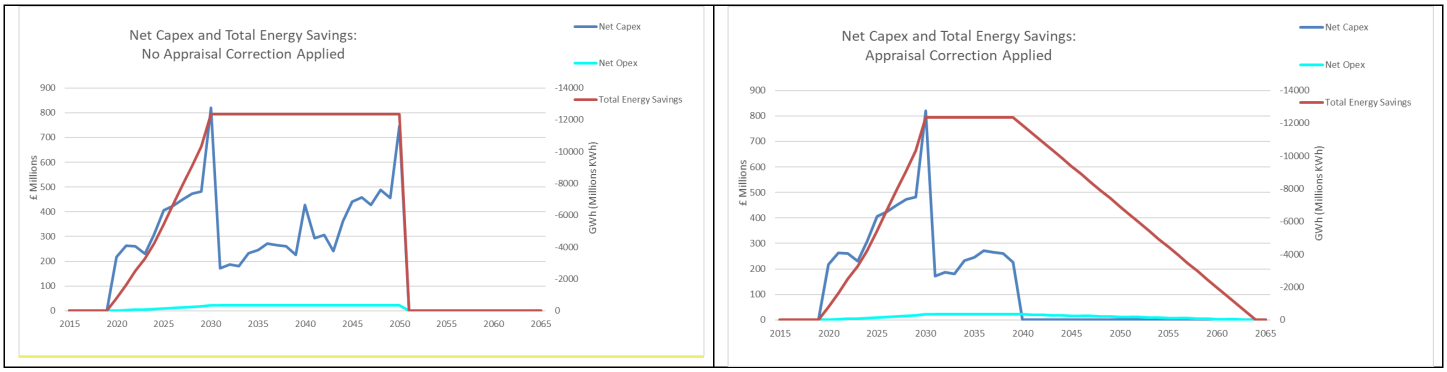
95. As noted in the main body of the IA, the appraisal period runs from 2020 to 2064. Though the policy period is only from 2020-2030, a longer appraisal period is necessary to reflect the fact that the benefits of measures (primarily energy savings) are accrued for many years after their installation. Using a shorter appraisal period would overestimate net costs, by failing to include the benefits associated with the capital expenditure.

96. Determining an appropriate appraisal period is complicated by the fact that the modelling approach incorporates both the cost of newly installed measures, and the re-installation of measures which have expired. Hence, to accurately capture benefits and costs, an appraisal correction is applied. This ensures that only the costs of one set of measures are included. Similarly, it also ensures that only energy savings associated with the full lifetime of this one set of measures are included. In this way, the problem of overestimating costs is resolved.

97. The appraisal correction uses a clearly identifiable cycle in the capex estimates, which ends in 2039. The appraisal adjustment sets capex to zero after this point, capturing a single set of measures. To ensure the appropriate energy savings are attributed to this capital expenditure, energy impacts over a further 25 years are included. This reflects the average lifetime of the longest measures in the modelling.[52] Energy savings (and opex) are set to decline linearly from their 2039 peak to 2064, in order to reflect the expiration of the measures currently in place in 2039.

98. The combined impact of these two corrections can be seen by contrasting graphs in figure 10.[53]

Figure 10: Appraisal Period Correction



D: Sensitivity Dimensions

99. Sensitivity has been carried out on the following variables.

100. **Energy Prices:** High and low energy prices are taken from Green Book Supplementary guidance tables for energy saving evaluation[54]. High/low prices have two effects. Firstly, prices affect the payback period of measures, as the capex is invariant on prevailing energy prices, but bill savings vary. Secondly, the value of those energy savings depends on the prevailing prices, so a given energy savings has a different value depending on the prevailing price. This applies both to the social valuation using long run variable costs (LRVC) of energy, and the private effect, which uses retail prices.

101. Low prices are used in the high (worst case) scenario, as low prices reduce the number of measures which payback, and also reduces the social value of energy savings. High prices are used in the low (best case) scenario for analogous reasons.

102. **Familiarisation costs & Compliance Costs:** The time taken to familiarise and comply with the regulations are based on the original impact assessment. The high/low wages are based on the range implied by different, reasonable methods of estimating the opportunity cost of time.

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[52] This is mainly loft insulation, cavity wall insulation, glazing measures and other building fabric measures. The full measure list is taken from BEES, see Table 4.4. of BEES technical annex: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566038/BEES_Technical_Annex_FINAL.pdf

[53] These figures show the correction when applied to an EPC-B policy with a 7-year payback restriction and a 2030 backstop.

[54] Green Book Supplementary Guidance (2018) https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

103. The high estimate of £27.69 is an estimate of average hourly landlord income. This is calculated from Council of Mortgage Lenders data[55] on the average yearly income of landlords. This is then corrected for income tax and scaled to an hourly wage using the same average weekly hours worked (from the LFS data)[56] used in the central familiarisation & compliance estimates.

104. The low estimate of £6.81 is the Department for Transport's estimate of the value of time.[57]

105. **Capex costs:** A +/- 20% factor is applied to capex and opex in the high/low scenarios respectively, reflecting uncertainty in capex and opex estimates at the level of technologies. Error factors in BEES[58] range from 10%-20%, so 20% was applied across the board as a conservative estimate of the impact of varying these costs.

106. The adjustment to capex (and opex) is applied *after* the modelling, when theoretically it should be applied before. Adjusting the capex on measures could change the measures which are installed, something not captured by just scaling the post-hoc capex and opex data. However, there are two reasons to expect this will have little impact. Firstly, given all measures are scaled by the same factor, the relative ordering of measures[59] will likely remain unaltered. Secondly, though it is possible that more measures might now come in over the payback threshold, given the relatively small impact of extending the payback threshold from 7 to 10 years, it is not expected that this assumption will be impactful. This is because most measures pay back in under 5 years, so the impact of scaling up costs by 20% is unlikely to push many measures over the threshold, and where they do, there would be substitution to other measures, mitigating the impact further.

107. **Opportunity cost of capital:** Consideration is given to the impact of reducing the opportunity cost of capital estimate. In particular, the central estimate uses the private financing cost to proxy the social cost. Hence, the interest rate is arguably too high, as it reflects an estimate of private borrowing costs. In the low (best case) sensitivity run an interest rate of 3.5% is used to reflect the implied social cost of foregone capital expenditure. This is in line with the social discount rate as opposed to the private cost of financing said investment.

108. **Gas Heat Pumps:** An important dimension of the sensitivity analysis is the role of gas heat pumps. In the EPC-B run they are a key technology, with large-scale installations (around 20% of buildings in scope). However, they are also a relatively new technology, so it is possible barriers exist to their widespread deployment, such as lack of information on the part of landlords or builders. For this reason, the 'worst case' scenario excludes gas heat pump installations. This also acts as a general indication of the sensitivity of the results to the removal of a key technology, since gas heat pumps are one of the most impactful technologies. The implications of this sensitivity for the key results is discussed at the end of Annex C subsection E.

109. **Additionality:** The central estimates are deemed to account for additionality satisfactorily with the counterfactual EPC-E run. To account for the possibility of lower additionality, the high cost (worst

[55] Council of Mortgage Lenders, A profile of UK Landlords (2016): https://www.cml.org.uk/news/cml-research/the-profile-of-uk-private/the-profile-of-uk-private-landlords-08.05.17.pdf

[56] ONS Labour Force Survey weekly hours worked (2018): https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/actualweeklyhoursworkednotseasonallyadjustedhour01nsa

[57] DfT, Values of Time and Vehicle Operating Costs, TAG Unit 3.5.6: www.dft.gov.uk/webtag/documents/expert/pdf/U3_5_6-Jan-2014.pdf

[58] BEES data

[59] In terms of myopic NPV, which is the criteria used to prioritize installations.

case scenario) estimate attributes some of the modelled energy savings to other policies in the non-domestic PRS sector.[60] The details of these data are summarized in Table 14 in annex A. The net energy savings are then reduced in line with these estimated savings.

110. The additionality sensitivity also accounts for the costs of those installations. This is done because, intuitively, if some energy savings are excluded due to additionality concerns, then the cost of delivering those energy savings should also be excluded. This is done by finding the *proportion* of modelled energy savings which are non-additional and scaling the capex and opex by the same factor.[61] I.e., if 10% of energy savings are removed by the more stringent additionality assumption, capex and opex will be scaled by 0.9.

111. **Rollout:** In contrast to the existing regulations, the options presented here only require landlords to meet the new target *by* 2030, rather than at the end of their existing tenancy. Hence, the rate at which buildings respond will be related to expected rate of tenancy turnover, but will also depend on the propensity of landlords to comply at these earlier opportunities, rather than waiting until the deadline. We expect this earlier compliance to happen relatively frequently, as the existing natural void periods between tenancies afford the cheapest opportunity for landlords to undertake any work required to comply with the regulations. In addition, the regulations only require the undertaking of privately beneficial investment, increasing the likelihood of early compliance.

112. To model this, a deployment profile has been estimated using 2017 average lease length data from MSCI. This data has been used to calculate the expected proportion of buildings which have changed lease at least once, by any given year. It is then assumed 50% of buildings comply at this point, with the remainder assumed to comply at 2030. This 50% applies to those buildings we expect to comply, excluding exempted and non-compliant buildings. This is then adjusted to account for preemptive responses to the policy. The same method is used in the baseline and policy runs. The final rollout profile gives the proportion of buildings which are expected to have responded to the policy by a given year.

113. The uncertainty around the response rate has been bounded by logical extremes, as there are no data that could be used as a guide for estimating compliance rates for a policy mechanism of this kind. For the lower bound, we assumed the (highly conservative) limiting case where all buildings respond at the 2030 deadline, with no early compliance. Though we do not believe this is a realistic outcome, it does reflect the limiting case scenario, and hence is useful, particularly as this worst case scenario does not fundamentally undermine the policy. For the upper bound, we assume ‘perfectly rational’ compliance, whereby all buildings respond at the first tenancy turnover. This is not the diametric opposite of the lower bound, which would assume full compliance in 2021, as this is an untenable assumption. Hence, the sensitivities are asymmetric, with the lower bound more conservative than the upper bound is optimistic. This help mitigate optimism bias, as well as reflecting the greater risk of slow compliance *vis* faster compliance.

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[60] Data on the energy savings delivered by other policies are taken from the energy and emissions projections data. These savings are given yearly and are disaggregated by sector (public/commercial/industrial) and by fuel type. These energy savings are then scaled by the rollout profile to give the estimate of the total in-scope energy savings delivered by other policies which overlap with the net savings implied in the model. These savings are then scaled by an additionality factor of 50%. This assumes 50% of aforementioned savings from other policies are deemed to be ‘overlapping’ with the modelled energy savings from this IA.

[61] This is done by adding up the savings from other policies and finding the ratio between these savings and the modelled savings giving the proportion of modelled savings which are eliminated due to additionality. If this proportion is ‘x’, capex (and opex) are scaled by (1-x). So if 30% of energy savings are subtracted away, then capex and opex are scaled down by 0.7, so 30% of capex and opex are removed as well.

E: Sensitivity Results:

114. Turning to the results, a number of further insights are worth noting. In particular, the lower relative volatility of costs *vis-à-vis* benefits is discussed in more detail. Additional details are given on the unilateral sensitivity, as well as the impact of the sensitivity on the private financial case.

Table 16: Sensitivity results of key CBA figures (£bn 2018, discounted to 2018)

		PVC £bn 2018	PVB £bn 2018	**NPV £bn 2018**
C 7-year payback	High cost and barriers	£1.0	£1.9	**£0.9**
	Central	£1.6	£4.7	**£3.0**
	Low cost and barriers	£1.3	£6.2	**£4.9**
B 7-year payback	High cost and barriers	£4.0	£3.4	**-£0.5**
	Central	£6.1	£12.2	**£6.1**
	Low cost and barriers	£4.9	£16.9	**£11.9**

115. Beginning with the multilateral sensitivity, Table 16 shows the key high-level CBA figures, as well as the present value of costs and benefits individually. It can be seen that most of the changes in NPV between the high/central/low estimates are driven by changes in the magnitude of benefits. This is mainly driven by high/low energy prices (as discussed in the main body of the IA).

116. The observation that costs are less variable than benefits is driven by the nature of the policy. In particular, by necessitating a particular EPC band, the capex required to meet the policy can remain high, even as benefits fall, driving down the benefits per unit cost. This happens because the point where measures stop being installed is determined by when sufficient energy efficiency gains have been made (provided they do not violate the payback restriction), *not* the marginal private/social value of those measures.

117. Additionally, it is noteworthy that costs are seen to *fall* in the pessimistic case. This is due to the more stringent additionality assumption, which attributes a greater proportion of the benefits *and* costs to other policies. If this assumption were not included, it is expected that the costs would be higher, and benefits would be smaller than the central estimate.

Table 17: Sensitivity results of key emissions figures

		MtCO2e Emissions in 2030			MtCO2e Over CB5 period			Energy Saved
		Traded	Non-traded	Total	Traded	Non-traded	Total	Total 2030 TWh
C 7 year payback	High cost and barriers	-0.3	-0.2	-0.4	-0.6	-0.5	-1.1	-2.9
	Central	-0.3	-0.3	-0.7	-1.5	-1.5	-3.0	-4.4
	Low cost and barriers	-0.3	-0.3	-0.7	-1.6	-1.6	-3.3	-4.4
B 7 year payback	High cost and barriers	-0.7	-0.8	-1.5	-1.7	-2.5	-4.2	-8.8
	Central	-0.8	-1.2	-2.0	-3.8	-5.4	-9.2	-12.4

	Low cost and barriers	-0.8	-1.2	-2.0	-4.1	-6.0	-10.1	-12.7

118. Table 17 shows the high and low emissions savings under sensitivity. It corroborates the key conclusion drawn above: even though there are falling benefits per unit cost, there are still similar absolute levels of energy efficiency gains. This is reflected in the emissions savings, as well as the total energy use in 2030.

119. In particular, comparing the central estimate with the optimistic estimate, the energy and emissions savings are very similar, despite the NPV and BCR figure being significantly different. This is because the policy is delivering a similar profile of EPC bands, and a similar set of measure packages across these runs. The differences are driven by the higher benefits of delivering those measures in terms of the value of the energy savings.

120. Similarly, the pessimistic energy and emissions savings are more similar to the central estimates than the NPV or BCR figures. Further, to the extent that they are different, this is driven by the more stringent additionality assumption, which strips out a significant proportion of the modelled savings. Hence, the savings due to the policy look smaller than in the central/optimistic scenarios, but if the additionality assumption were removed, they would look similar. In this case, any remaining differences between the NPV and BCR would be mostly explained by the higher cost, and lower benefit of delivering the set of measure packages, analogous to the optimistic case.

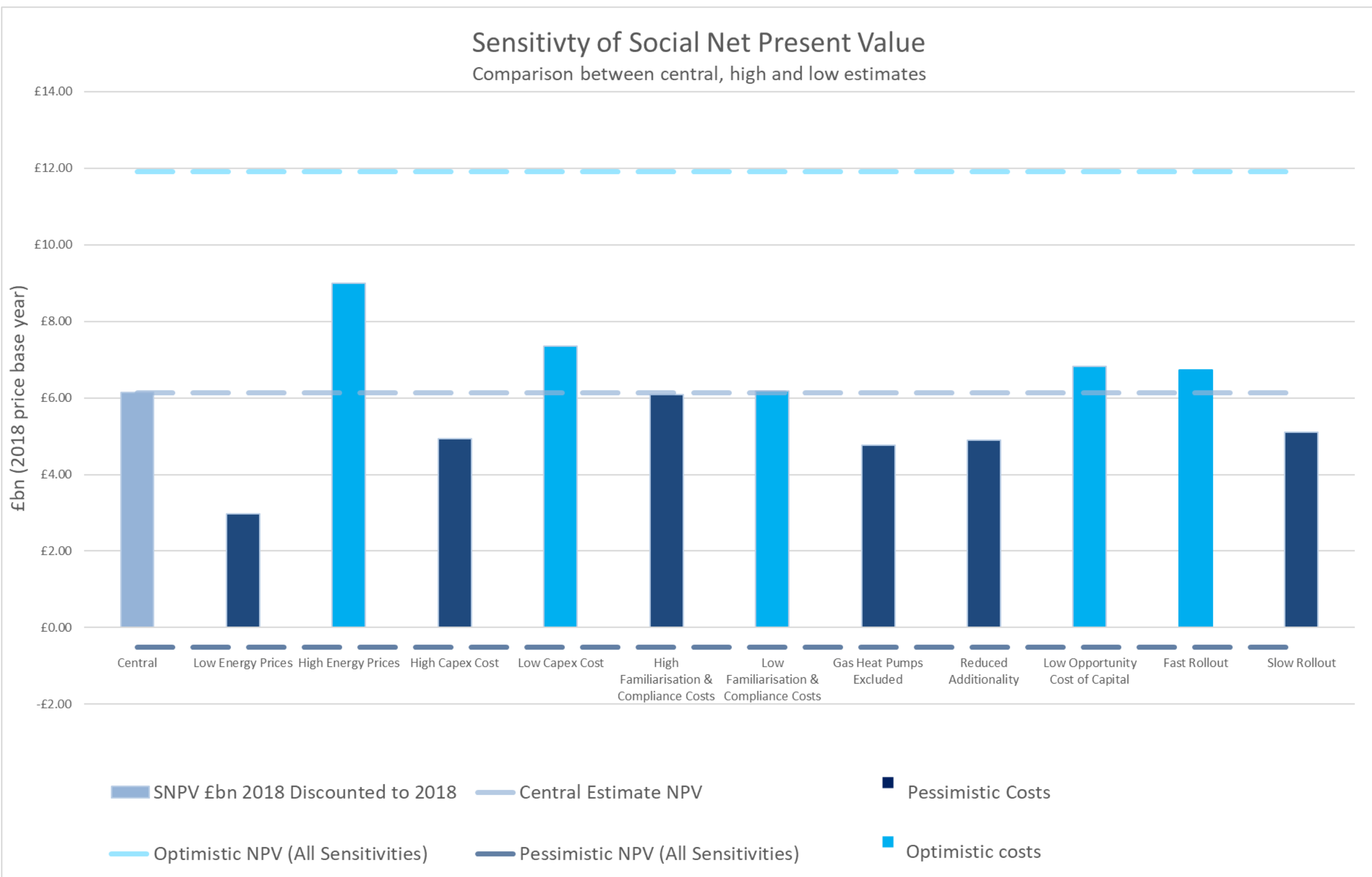
Table 18: Sensitivity results of disaggregated CBA figures (£bn 2018, discounted to 2018)

	C 7-year payback			B 7 Year payback		
	High Costs and Barriers	Central	Low Costs and Barriers	High Costs and Barriers	Central	Low Costs and Barriers
Total Present Value Costs	**£1.0**	**£1.6**	**£1.3**	**£4.0**	**£6.1**	**£4.9**
Capital and installation costs	£0.7	£1.3	£1.2	£2.8	£4.6	£4.2
Operational costs	£0.0	£0.0	£0.0	£0.3	£0.3	£0.3
Compliance + Familiarisation Costs	£0.1	£0.0	£0.0	£0.1	£0.1	£0.0
Enforcement/monitoring	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Social cost of capital (finance cost)	£0.2	£0.3	£0.1	£0.7	£1.1	£0.4
Total Present Value Benefits	**£1.9**	**£4.7**	**£6.2**	**£3.4**	**£12.2**	**£16.9**
Energy Savings	£1.6	£3.7	£4.6	£4.6	£9.8	£12.4
Value of non-traded emission savings	£0.1	£0.6	£1.0	£0.7	£2.1	£3.6
Value of traded emission savings	£0.1	£0.3	£0.5	£0.2	£0.8	£1.3
Value of air quality savings	£0.0	£0.1	£0.1	-£2.1	-£0.4	-£0.4
Total Net Present Value	**£0.9**	**£3.0**	**£4.9**	**-£0.5**	**£6.1**	**£11.9**
Benefit to cost ratio	**1.9**	**2.9**	**4.9**	**0.9**	**2.0**	**3.4**
Lifetime non-traded carbon savings, MtCO2e	**4.1**	**£8.7**	**9.7**	**19.3**	**30.7**	**35.2**
Non-traded cost effectiveness £/ton	**-181**	**-283**	**-407**	**61**	**-132**	**-236**

121. Table 18 gives a disaggregated breakdown of the costs and benefits (present value) under sensitivity. Consistent with the analysis thus far, capex and the opportunity cost of capital are the most volatile costs. In terms of benefits, the largest absolute change is the value of energy savings, however the value of non-traded emissions savings undergoes one of the largest proportionate changes. This is due to changes in the fuel switching incentive caused by changes in the relative prices of different fuels.

122. **Unilateral sensitivity:** Turning to unilateral sensitivities, there are a number of general points, followed by a more detailed examination of the rollout sensitivity, and the role of gas heat pumps. Figure 9 is reproduced for reference (labelled Figure 11). One notable aspect of the chart is that the combined effect of the sensitivity dimensions is large relative to their individual effects. This is because of the way the sensitivity dimensions interact when they are implemented together.

Figure 11: Impact on NPV of sensitivity assumptions for Option 2 (£bn 2018, discounted to 2018)[62]



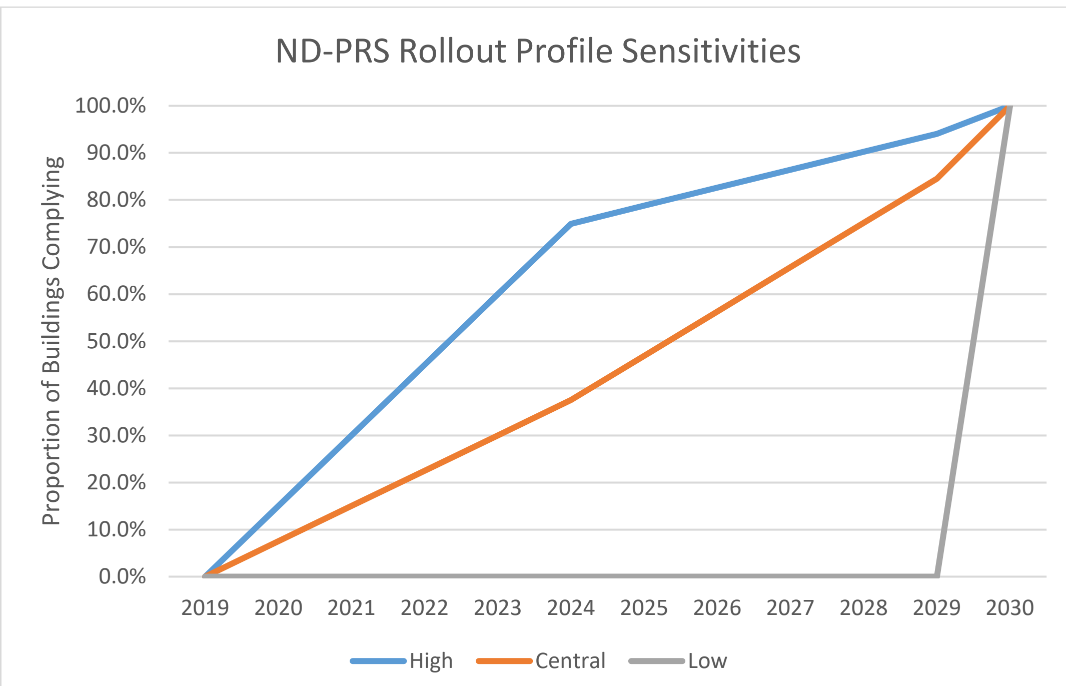
123. For example, in the pessimistic case, several sensitivities tend to drive down the return on capex and mutually reinforce each other. Firstly, low energy prices reduce the NPV but the capital expenditure remains relatively high for reasons discussed previously. Secondly, removing gas heat pumps also necessitates greater capital expenditure (on less effective measures) because it removes a cost-

62 Reproduction of Figure 9.

effective technology. Thirdly, the capex inflation factor exacerbates both impacts on capex, and fourthly this higher capex then increases the opportunity cost of capital. Hence, the interaction of these four sensitivities, in particular, explains the extreme value of the pessimistic NPV estimate.[63]

124. **Rollout Profile:** One of the key sensitivities was the assumptions about the response rate to the policy. Given we have limited evidence for understanding when buildings will choose to respond before the 2030 backstop, we chose to use a wide sensitivity. The 'fast' rollout assumes 100% of landlords comply at their first tenancy break. I.e, they respond to the policy as if it behaved like the existing regulations. The 'slow' rollout assumes 0% of landlords comply at the end of their first tenancy, and all of them wait until 2030. The central case assumed 50% comply at the end of their first tenancy. This sensitivity is asymmetric, with a conservative bias, as is visible in figure 12. This asymmetry is intentional. The 'fast' rollout does not include landlords complying *before* tenancies end, as it was deemed the earliest plausible point of compliance would be the next available void period. However, the downside risk is considered at its logical extreme; 100% of compliance occurring in 2030. This is to reflect that we do not know *a priori* what the minimum level of early compliance might be, and any such assumption would be difficult to justify, so we examine the lower bound.

Figure 12: High and low response-rate rollout profiles



125. Table 19 shows the impact of varying the response rate. As expected, NPV over the appraisal period is increased with earlier compliance and reduced by later compliance. This is predominantly because earlier compliance results in more years of savings in the appraisal period, because expiring technologies are assumed to be reinstalled up to 2039. Interestingly though, the central case has

[63] A Similar story can be told for the optimistic estimate. High energy prices create large social gains, given some level of capex, as well as bringing more measures within the scope of the payback period. The lower interest rate in the social cost of capital estimate further reduces the costs associated with the capital expenditure. Lastly, the capital cost deflation factor then amplifies both of these mechanisms.

slightly higher non-traded savings than the high. This is because early movers face different prevailing fuel prices, changing their fuel switching incentives. In the modelling, later movers tend to comply by abating more non-traded intensive fuels than earlier movers, resulting in higher non-traded savings over CB5, despite the lower compliance in years 2028 & 2029. As expected, the slowest rollout sees reduced carbon savings as here 0% of buildings comply in 2028 & 2029. This is knowingly unrealistic, as it is implausible that contracts would be signed in 2029 without complying with the regulations. However, since this is the lower bound it is encouraging that CB5 NT savings only fall by less than 30%, even with this punitively conservative assumption.

Table 19: Summary of key figures from fast/slow rollout sensitivity

	NPV (£bn 2018)	NT MtCO2e Over CB5
Central	£6.1	-5.4
Fast Rollout	£6.7	-5.3
Slow Rollout	£5.1	-3.8

126. **Gas heat pumps:** Lastly on the unilateral sensitivity analysis, additional details are presented on the impact of removing gas-driven heat pumps from the analysis. This is explored for an EPC-B target.

Table 20: Summary of key figures excluding gas heat pumps (£bn 2018, discounted to 2018)

Key Figures	Net Present Value	Total Bill savings CB5 (2028-2032)
B-7 No Gas Heat Pumps	£4.8	£5.1
B-7	£6.1	£5.3
Change	-£1.38	-£0.20
% Change	-22%	-4%

127. Table 20 shows that a substantial amount of the 'worst case' impact can be attributed to the removal of this one technology. Net present value falls by 21%, though there are still considerable net social gains. This is expected as removing gas driven heat pumps forces the installation of more marginal measures which deliver lower energy savings per unit cost.

128. However, total bill savings only fall 3.4%. Hence, though gas heat pumps are important for the delivery of social benefit (they contribute a lot of emissions reduction at relatively low cost), similar gains from energy efficiency are made without them. This is consistent with the previous findings of the sensitivity analysis, regarding the relative stability of energy & carbon savings *vis-à-vis* costs & benefits. In this case, the nature of the policy means that even if the most optimal technology is

removed, other measures are expected to still be installed to deliver the energy efficiency gains, but at lower marginal private/social benefit.

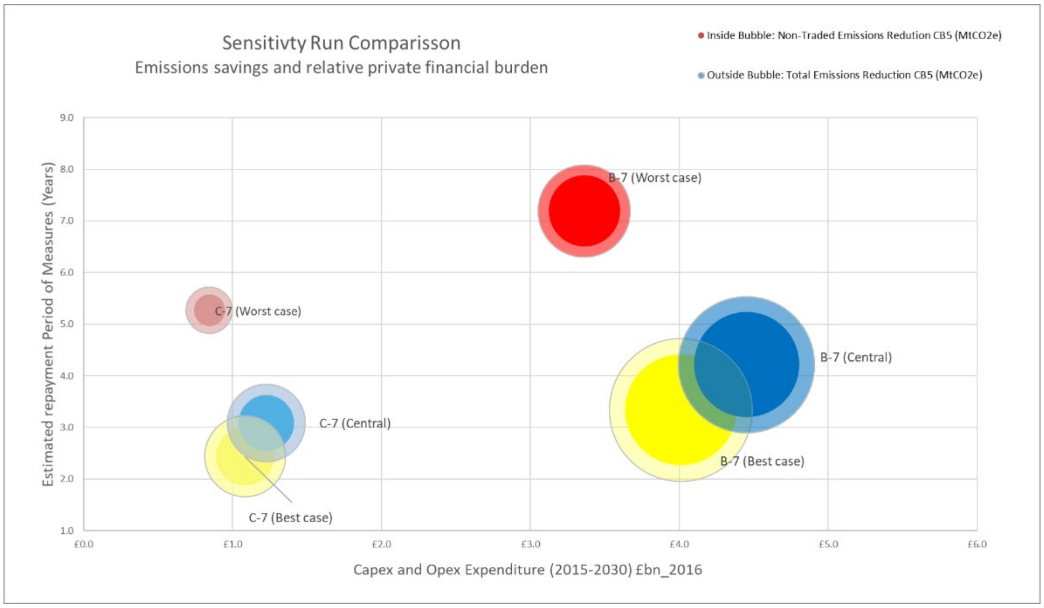
Table 21: Modelled installation numbers given exclusion of gas heat pumps

Difference between central and no-GHP technologies for EPC-B target	Net Installation Difference at 2030 (000's)	% Change
Insulation	141,000	48%
Glazing	224,000	125%
Thermal Controls	227,000	39%
Other Controls	185,000	32%
Lighting	13,000	1%
Behaviour and Awareness	0	0%
Heating Upgrade/Maintenance	57,000	22%
Cooling and Ventilation Upgrade/Maintenance	3,000	12%
Other Thermal Efficiency	282,000	42%
Other Energy Efficiency	0	0%
Electric Heat Pumps	3,000	501%
Reversible Heat Pumps	2,000	1%
Gas Heat Pumps	-349,000	-100%
Hybrid Heat Pumps	0	N/A
Biomass Boilers	6,000	173%
CHP	0	N/A

129. Table 21 shows the change in *net* installations between the central estimate and the estimate excluding gas heat pumps. It shows that there is no single technology which replaces gas driven heat pumps. Instead, almost all technologies see an increase. This is important for two reasons. Firstly, it implies the results are robust to the removal of specific technologies because there is a reasonable degree of substitutability between technologies. Secondly, it is an encouraging sense-check for the modelling, as it shows that different buildings have different responses to shocks to the available technologies. This implies the model captures the heterogeneity of the non-domestic space.

130. Finally, the prior analysis already considers the social impact of the policies. However, it is also useful to explicitly consider the private financial burden required to deliver the emissions savings, and how this behaves under sensitivity.

Figure 13: Private Financial Burden (Capex and Estimated Payback Times)



131. Figure 13 compares the change in CB5 emissions savings against two measures of private financial burden. It shows the capital (and operational) expenditures on the X-axis and the approximate repayment period on the Y-axis[64], capturing two proxies for the private financial burden. Moving 'up and right' on the chart means an increase in the private financial burden. The size of the outer bubble is the total emissions, and the inner bubble is the non-traded emissions.

132. Considering the central estimates, the difference between the EPC-C and EPC-B policies is as expected. Private financial burden is higher in both dimensions, but there is a large increase in the magnitude of emissions savings.

133. Considering the sensitivity figures, in both the EPC-C and EPC-B runs the optimistic case delivers comparable (slightly higher) emission savings to the central estimate, but at considerably lower private financial burden. This is largely due to the higher bill savings and the optimistic capex deflation factor. The pessimistic scenario also has lower capex, but this is due to the assumption of reduced additionality, not 'lower costs'. On the other hand, the pessimistic scenario has a much longer estimated payback period. This is the combined effect of lower energy prices reducing bill savings and the removal of gas driven heat pumps which is a key cost-effective technology. Lastly, it also delivers smaller emissions savings (due largely to the reduced additionality).

134. In terms of magnitude though, it can clearly be seen that the difference between EPC-C and EPC-B is much larger than that between the high and low estimates. The lowest estimated emissions savings from the EPC-B policy are considerably larger than the largest estimated savings from the EPC-C policy.

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[64] Approximate repayment period is estimated by taking the *total* capex and opex to 2030 (undiscounted) and dividing it by the bill savings in 2030, to give a proxy for the number of years of bill savings needed to repay the capital outlay.

Annex D: Extending the payback period

135. This IA has focused on increasing the stringency of the EPC target. However, achieving this requires investment in more capital-intensive measures, which may have longer payback periods. Hence, this analysis considers the effect of increasing the payback restriction, in this case from 7 to 10 years. This will bring more measures into scope and will increase the viability of measures with long lifetimes that may pay back more slowly.

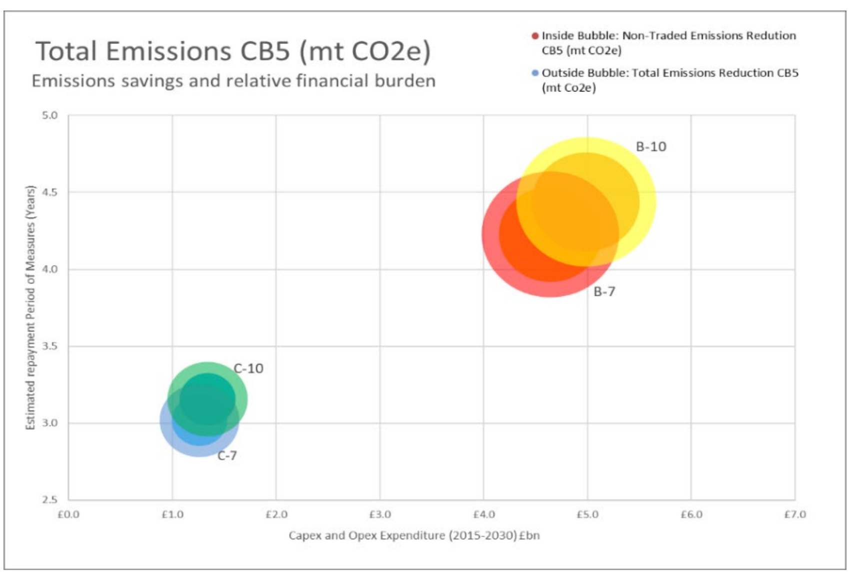
136. Table 22 contrasts the headline results in the 7 and 10-year options. The extension of the payback period makes negligible difference to the NPV for either target. Similarly, emission and energy savings are almost identical in the EPC-C case, and only slightly higher for EPC-B.

Table 22: Summary results for payback period extension

	NPV (£bn)	Total MtCO2e Over CB5	Energy savings TWh in 2030
C 7-year payback	£3.0	3.0	4.4
C 10-year payback	£3.0	3.0	4.4
B 7-year payback	£6.1	9.2	12.4
B 10-year payback	£6.2	9.6	12.9

137. This small net social impact obscures an increase in private financial burden. Figure 14 uses the same axes as Figure 13 (in annex C) to capture private financial burden.[65] Going from an EPC-C to an EPC-B target increases the private financial burden but delivers compensating emissions savings. Extending the payback restriction also somewhat increases private financial burden, but with comparatively negligible additional emissions savings. Overall, this analysis does not support extending the payback period on social or private grounds. The small additional contribution to the government's emissions reduction targets are insufficient to justify the additional private burden.

Figure 14: Private burden of payback period extension



[65] As before, the approximate repayment period uses *total* capex and opex to 2030 (undiscounted) and the bill savings in 2030, to give a proxy for the number of years of bill savings needed to repay the capital outlay.