THE IMPACT OF MINIMUM ENERGY EFFICIENCY STANDARDS IN THE PRIVATE RENTED SECTOR

A report for Citizens Advice

28 July 17

CONTENTS

EXECUTIVE SUMMARY

Improving dwelling energy efficiency helps meet climate change targets and leads to reduced household energy costs and healthier and happier occupants. However, there is typically lower than optimal levels of investment in energy efficiency.

Government has tried to address this under-investment by requiring landlords to ensure that their properties reach at least an E Energy Performance Certificate (EPC) rating by 2018. Currently, about 6% of private rented sector dwellings are rated below this, i.e. EPC Band F or G; or about 300,000 homes. Landlords are currently only required to do so if there is no upfront cost to them (i.e. if they are able to use government grant schemes). Given the expiration of the Green Deal, it is likely that the majority of landlords with properties rated below an EPC Band E will not be required to upgrade these homes.

The previous Government had intended to address this shortcoming. In particular, landlords could be required to pay for energy efficiency improvements in order to meet the minimum energy efficiency standards (MEES) of an EPC Band E, subject to a "cost cap".

Citizens Advice commissioned Frontier Economics to assess the impact that introducing MEES may have on tenants in the private rented sector:

- How will landlords respond to MEES in terms of rents and/or upkeep expenditure and, related, the supply of properties?
- How will these impacts weigh up against the anticipated consumer benefits in terms of reduced energy bill spend, or through increased warmth, comfort and the associated benefits?
- How these impacts will vary across different regional sub-markets?

Our approach

We have estimated the costs and benefits to tenants of energy efficiency improvements in the private rental sector. Our model includes three regional archetypes that were chosen to give a representative spread of regional and dwelling characteristics (as detailed in the report). These three archetypes are:

1. a detached house in South West;
2. a terraced house in North East; and
3. a flat in London.

We also consider wider benefits to tenants by drawing upon previous research of the benefits of household energy efficiency, such as healthier and happier occupants.

We find substantial net benefits to tenants

Implementing MEES is likely to result in significant benefits for tenants in the private rented sector in our three archetypes. These benefits would require, on average, only modest outlay by landlords.

The annual net benefits to tenants in the private rental sector range from:

- **£317 to £774 for EPC F-rated dwellings**; and
- **£501 to £1,241 for G-rated dwellings**.

These finding are based on the difference between estimated rental increases arising from the energy efficiency investment and energy cost savings[1].

Estimated rent increases

Private rental sector rents are estimated to increase by between 0% and 1.6% for EPC F homes and between 0% and 6.3% for EPC G homes (Figure 1), depending on the dwelling archetype.

- The low end of the range is the results of our econometric analysis of English Housing Survey data.
- The high end of the range is drawn from our cost pass-through analysis, which assumes that landlords are able to pass through all of the improvement costs to tenants.

Figure 1 Estimated range of rental increase by archetype

Archetype	EPC Band	Percentage rent increase	
		Low	High
Detached house in the South West	F to E	0%	0.7%
	G to E	0%	2.9%
Terraced house in the North East	F to E	0%	1.6%
	G to E	0%	6.3%
Flat in London	F to E	0%	0.5%
	G to E	0%	1.9%

Source: Frontier Economics' analysis

Note: Estimates are based on an assumed 20 year lifetime of improvements over which the landlord recovers the investment cost.

Energy cost savings

Figure 2 shows the predicted reduction in energy costs before and after accounting comfort taking[2]. The findings suggest that energy efficiency

[1] These finding assume that costs for the landlords are capped at £5,000. We have also considered alternative policy options of a £3,500 cost cap and no cost cap. Under both of these alternatives we still find significant net benefits to tenants.

[2] This estimate is done at a 'notional' level, which assumes that tenants' energy use behaviour is unchanged. As the use of notional estimates may over-estimate energy savings as it does not account for individual energy usage behaviour, we also present results in the main body that includes tenants' "comfort taking". That is, given that energy efficiency improvements reduce the cost of heating a home to a given

improvements for F and G dwellings lead to reductions in energy costs of between 23% and 38%.

Figure 2 Estimated energy cost savings

		Annual energy saving	Reduction in energy saving from comfort taking	Annual energy saving after comfort taking
Detached house in the South West	F to E	£ 774	-£ 116	£ 658
	G to E	£ 1,241	-£ 186	£ 1,055
Terraced house in the North East	F to E	£ 496	-£ 74	£ 422
	G to E	£ 944	-£ 142	£ 802
Flat in London	F to E	£ 409	-£ 61	£ 348
	G to E	£ 847	-£ 127	£ 720

Source: Frontier Economics' analysis of English Housing Survey data

Net benefit calculation

Figure 3 shows annual net benefits for tenants. (This is calculated as the difference between the annual energy cost savings and the annual rent increase.)

Figure 3 Net benefits to tenants of energy efficiency improvements

Archetype	EPC Band	Annual net "cash" benefit	
		Low	High
Detached house in the South West	F to E	£ 682	£ 774
	G to E	£ 895	£ 1,241
Terraced house in the North East	F to E	£ 404	£ 496
	G to E	£ 598	£ 944
Flat in London	F to E	£ 317	£ 409
	G to E	£ 501	£ 847

Source: Frontier Economics analysis

Wider benefits to tenants

Energy efficiency improvements also give rise to wider benefits that typically are harder to model directly. The literature on the wider benefits from more energy efficient homes shows that the wider benefits are primarily linked to:

- improved physical health;
- improved mental health; and

temperature, it is possible that following the improvements residents will use some of the savings to heat their homes to a higher temperature rather than achieving the modelled energy expenditure savings. However, this comfort taking is a benefit in itself for tenants.

- improved general well-being, in particular for children and older people.

There is, however, a trade-off between extra warmth (and the associated benefits) and energy cost savings. That is, to capture all the costs savings would mean that tenants continue to heat their homes to previous temperatures.

Impact on supply in the private rented sector

We have also considered whether MEES would reduce supply into the private rented sector due to the cost imposition on some landlords of having to make energy efficiency improvements.

The evidence suggests that the impact of MEES on the supply of homes in the private rental sector is likely to be low due to:

- the inelastic nature of supply in this sector;
- the cost imposition is relatively minor for most dwellings compared to the overall dwelling value;
- any modest increase rental prices would to some degree offset any impact arising from increased costs to landlords; and
- policy options such as cost capping or phasing could further address any supply concerns.

Summary

Our findings have a number of policy implications.

- MEES would be total welfare enhancing.
  - The costs of improvements are likely to be outweighed by energy cost savings in our archetype homes. These energy savings are likely to be significant, especially for G-rated homes. Wider health and happiness benefits are also likely to be significant. This is especially the case for tenants in fuel poverty that may currently be under-heating their homes. These benefits are likely to be direct to tenants, but also bring wider societal benefits such as savings to the NHS.
- The extent to which landlords will be able fully recoup capital cost immediately through increased rents is unclear. The evidence suggests that rents for E-rated homes are not currently significant higher than for F and G-rated homes, once other factors are controlled for. Therefore, MEES may result in a transfer from landlords to tenants, thereby having some distributional effects. However, this may be offset fully, or in part, by increases in the capital value of the dwelling.
- The evidence suggests that MEES would be unlikely to have a significant impact on the aggregate supply of homes in the private rented sector.
- There are options available to ameliorate any concerns over the supply impacts of from capital constrained landlords being unable to make the necessary improvements. This includes:

- phasing in the MEES requirements or providing a sufficient lead in time; and
- capping the maximum cost to landlords required for improvements (such as at £5,000 or £3,500).

Capping the maximum cost to landlords at £3,500 rather than £5,000 leads to results in a higher average improvement to tenants, for those whose homes are improved. This is because the average improvement cost is lower compared to a situation with a higher cost cap. However, the trade-off to this finding is that a smaller proportion of homes are improved to an EPC Band E. Under the £5,000 cap option, we estimate that 91% of F and G homes combined would be improved to a minimum EPC Band E. Under the £3,500 cap option we estimate it would be 83% of homes. In other words, approximately 2,400 fewer homes would be improved to an EPC E with a £3,500 cap compared to a £5,000 cap.

Our findings, including the proportion of homes improved, are based on the assumption that the regulations will be enforced and that landlords will comply with those regulations. If the regulations are introduced without effective enforcement, then we would not expect the regulations to have the same effect.

1 INTRODUCTION

Frontier Economics was commissioned by Citizens Advice to assess the impact that introducing minimum energy efficiency standards (MEES) may have on tenants in the private rented sector.

Improved household energy efficiency can have significant benefits such as reduced household energy costs and healthier and happier occupants. Also, from a societal perspective, improving energy efficiency can be a cost effective way of reducing harmful greenhouse gas emissions.

There is a significant body of empirical evidence that suggests increased investment in household energy efficiency improvements would be net beneficial. Despite this, the evidence suggests that there has been an underinvestment in energy efficiency in the private rental sector. For instance, the proportion of private rented sector dwelling rated F or G is higher than for owner occupiers or the social rented sector[3].

Previous research has also identified a number of potential consequences from living in poorly insulated and heated homes. For example, it is estimated that around 19 per cent of households in the private rented sector are fuel poor[4]. Damaging health impacts have also been identified as a consequence from living in poorly insulated homes. The evidence shows that occupants of warmer, better quality housing have better health outcomes, such as lower average GP visits[5].

1.1 Addressing the lack of investment in energy efficiency in the private rental sector

The previous Government sought to address the issue of underinvestment in energy efficiency standards through the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015.

These regulations required that:

- from April 2016, residential private landlords will not be able to unreasonably refuse consent to a tenant's request for energy efficiency improvements where Green Deal finance or subsidies are available to pay for them; and
- from April 2018, private domestic and non-domestic landlords will need to ensure that their properties reach at least an E EPC rating, or have installed those improvements that could be funded using available Green Deal finance or subsidies available to pay for them, before granting a tenancy to new or existing tenants[6].

These regulations, however, are likely to prove inadequate. In particular, they only require landlords to invest in improving energy efficiency standards when

3 Department for Communities and Local Government, (2016) English Housing Survey 2015 to 2016: headline report

4 DECC, 2015, Annual Fuel Poverty Statistics.

5 See, for example a summary of health improvements through investment in affordable housing in Frontier Economics, 2014, "Assessing the social and economic impact of affordable housing investment".

6 These requirements will apply to all private rented properties – including occupied properties – from April 2020 in the domestic sector (and from April 2023 in the non-domestic sector).

there is no upfront cost to them. Given the expiration of the Green Deal and the structure of ECO, we can infer that very few if any landlords with properties rated F or G will have to upgrade their properties. Therefore, without further policy action, the underinvestment in energy efficiency savings in the private rental sector is likely to persist.

1.2 Scope of the project

Before the recent election, Government was developing a proposal to address the shortcomings in the current regulations, including a “cost cap” proposal that would require landlords to pay for energy efficiency improvements in order to meet the minimum requirements, subject to cost cap of £5,000. The rationale for such a move remains.

Citizens Advice has identified gap in the current evidence base in relation to the potential impact from such a policy change.

Therefore, Citizens Advice has asked us to consider the following questions:

- How will landlords respond to Minimum Efficiency Standards in terms of rents and/or upkeep expenditure and, related, the supply of properties?
- How will these impacts weigh up against the anticipated consumer benefits in terms of reduced energy bill spend, or through increased warmth, comfort and the associated benefits?
- How these impacts will vary across different sub-markets of the England and Wales housing markets?

1.3 Structure of the report

The remainder of this report we:

- set out our framework for approaching the issue;
- establish a baseline for our analysis;
- estimate the cost of energy efficiency improvements;
- assess the impact of MEES in the private rented sector; and
- discuss the results and policy implications.

2 ANALYTICAL FRAMEWORK

This section provides an overview of our framework for considering the research questions.

We construct our analytical framework as follows.

1. We develop a **conceptual framework** that will allow us to assess the impact of MEES.
2. We develop a **quantitative model** to assess the costs and benefits to tenants from MEES.
3. We develop **three regional archetypes** to assess how the impacts of MEES may vary across different sub-markets.

2.1 Conceptual framework

In the private rental sector, tenants have little control over the decisions to invest in energy efficiency improvements. Rather, tenants must rely on landlords to make investment to improve the energy efficiency standards of dwellings.

There are a number of reasons why landlords may choose not to invest in energy efficiency improvements, even if those improvements are net beneficial:

- **Asymmetric information**: Landlords that invest in energy efficiency improvements, thereby reducing their tenants' energy costs and providing a generally warmer and more comfortable living environment, could be expected to recoup those costs through higher rents. However, the extent of those energy improvements and the degree to which they are expected to reduce energy usage is not always obvious to tenants. Until the tenants have occupied the dwelling for a period of time they typically do not have the information to estimate their average spend on energy for heating, etc. In owner-occupied homes, owners know their energy costs prior to improvements and thus have a better ability to estimate their post-improvement energy expenditure.
- **Principal-agent problem:** There are differing incentives between the landlord, who is responsible for making the energy efficiency investment decision, and the tenant or person responsible for paying energy costs which are dependent on the investment level. As such, landlords have less incentive to implement efficiency improvements when renting to a tenant than they would if the building were owner-occupied as they pay for the improvements but do not get the full benefits of lower energy costs. This problem is exacerbated by the inability of tenants to exert strong pressure on landlords if there is a limited rental supply at their price point.
- **Bounded rationality**: Both landlords and tenants have imperfect information on energy efficiency improvements and their likely payoff in terms of reduced future costs and improved living standards. Therefore they may focus on more tangible, near-term costs rather than longer-term, more uncertain savings. For the landlord, that may result in avoiding the upfront cost of improvements and losing out on potential increased rent revenue. For the

tenant, that may involve minimising monthly rental costs and forgoing possible energy bill savings.

- **Capital constraints**: For properties that would require substantive improvements to improve energy efficiency performance, homeowners and landlords may not have access to capital to make net-beneficial improvements to dwellings.

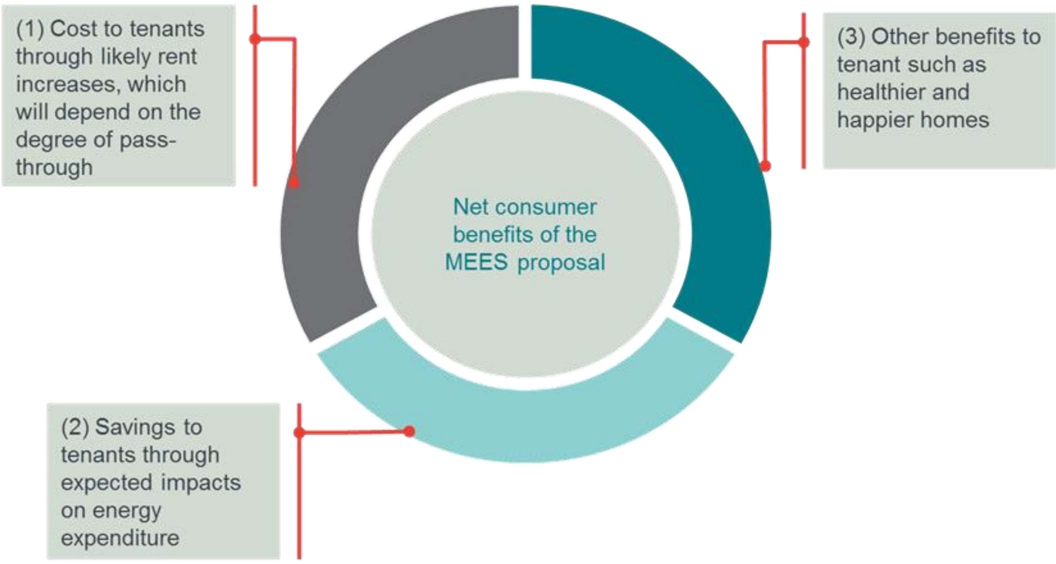
Each of the above factors has been widely noted in the past, and they have been the driving force behind many government interventions in this space, from standardising efficiency ratings, to the Green Deal and ECO.

Such impediments to energy efficiency investment would be addressed by MEES, which could require landlords to make such investments up to a minimum EPC Band E.

In light of this, our first research question how landlords will respond to MEES, including the impact on rents. Our second question then asks, how those potential impacts compare to anticipated consumer benefits in terms of reduced energy bill spend, or other associated benefits

To answer these questions, we have developed a model that estimates tenants' net benefits. This is summarised in Figure 4 and discussed in further detail below.

Figure 4 Illustration of tenants' net benefit calculation from MEES



Source: Frontier Economics

The three main aspects of the tenants' net benefit calculation are as follows.

- **Cost to tenants:** As noted above, the first part of the net benefit calculation is to consider how costs to tenants may change through increased rents. Key to this question will be to understand the extent to which:
  - tenants place a premium on EPC E compared to EPC F and G, which provides evidence for landlords' potential ability to increase rents; and

- landlords will be able to pass through increased costs to tenants through rent increases given that MEES will lead to higher costs across all EPC F and G-rated homes in the private rented sector.

We also note that it is conceivable that MEES may impact on the supply of dwellings in the private rented sector. This issue is discussed separately in Section 6.

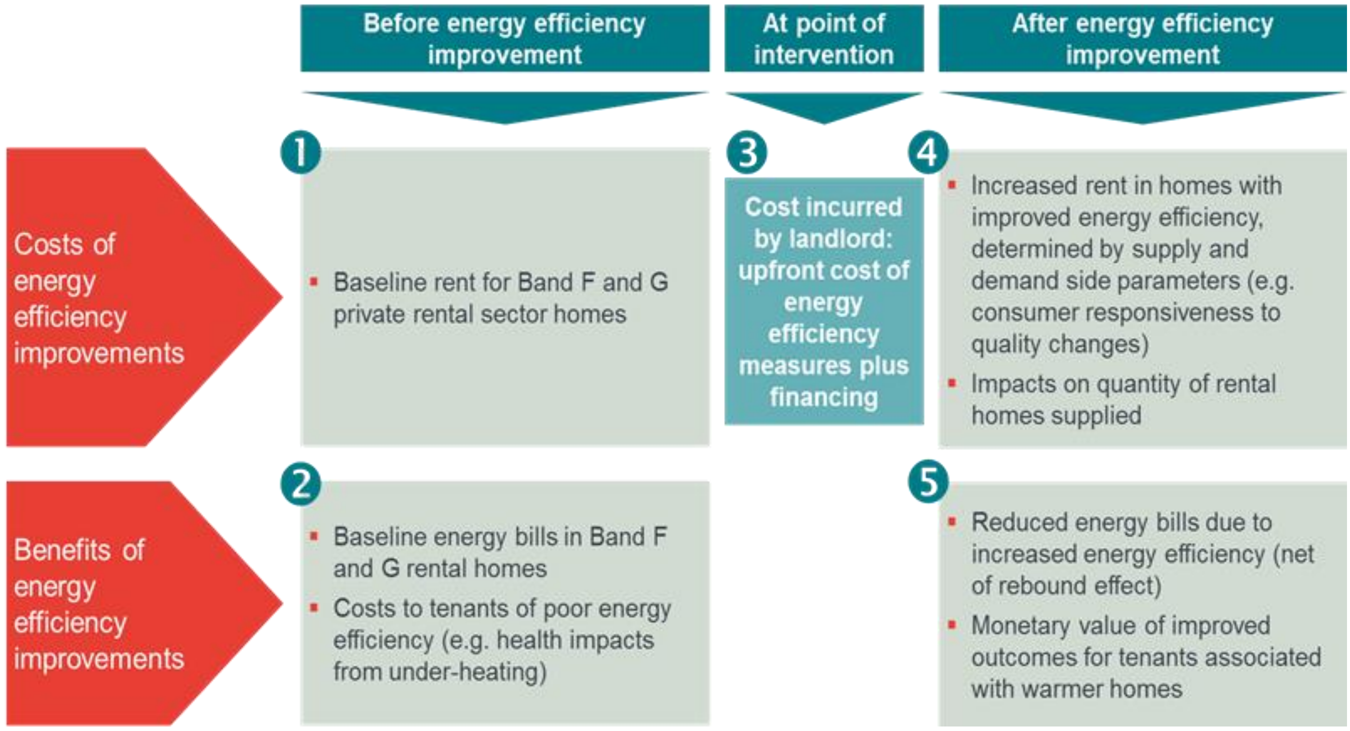
- **Energy savings:** Improved energy efficiency of homes – as measured by EPC Bands – typically leads to lower energy costs for the occupiers of the home. Therefore, a key likely benefit of MEES would be reduced annual energy costs for private rented sector tenants. Such benefits can be quantified, as discussed below, and traded off against putative increased in private rental sector rents in terms of the net "cash" benefit to tenants.
- **Other benefits**: The third part of the net benefit calculation is to incorporate wider benefits to tenants. These benefits are more qualitative in nature, as they are difficult to quantify for individual tenants. We draw previous research to show the wider benefits of household energy efficiency, such as healthier and happier occupants.

We now discuss how we quantify these benefits within our model.

2.2 Quantitative model

To estimate the costs and benefits to tenants of energy efficiency improvements in the private rental sector we have developed a quantitative model (Figure 5).

Figure 5 Summary of model for assessing MEES impact on tenants



Source: Frontier Economics

The core quantitative model has five key steps:

- **Step one – current rent**: we calculate the current average rent for EPC Band F and G dwelling in the private rented sector. These rents will then provide a baseline from which we will assess potential rent increases post energy efficiency improvements.
- **Step two – current energy costs**: We estimate average energy costs for EPC Band F and G dwelling in the private rented sector. Again, this provides a baseline from which we can calculate potential energy savings post energy efficiency improvements.
- **Step three – upgrade costs**: We consider the average cost incurred by landlords to improve dwelling from EPC Band F and G to a minimum of EPC band E. As part of this, we consider the distribution of costs as the required improvements can vary significantly across dwellings.
- **Step four – rent increase:** We estimate potential rent increases resulting from MEES. We then go on to consider how minimum energy efficiency standards may also impact on the volume of dwelling supplied in the private rented sector.
- **Step five – energy savings**: We estimate average reductions in energy costs. We do this first on a 'notional' basis (i.e. what would be the cost savings if dwelling continued to be heated to the same temperature level). We then adjust this by incorporating a 'comfort take' as part of the benefit to tenants. Effectively, we assume that they will likely heat their homes to a higher level given that their marginal cost of heating becomes lower. The issue of comfort taking is particular relevant for fuel poor, who are more likely to under-heat their homes. As outlined above, fuel poverty is a particular problem in EPC F and G banded dwellings.

We then incorporate our findings on wider benefits, such as healthier and happy tenants, which are likely to result from improved energy efficiency performance. These findings are discussed in detail in Section 6.

The final stage of the model is then to incorporate different policy design options. We discuss these policy options in detail in Section 6.

We now go on to detail how we have designed the archetypes for the model in order to ensure the most important variations across the private rented sector are included.

2.3 Archetype design

We model three archetypes to show the different impact of MEES by region and regional and dwelling characteristics. These three archetypes are:

1. **A detached house in South West**: Detached houses account for a large proportion EPC Band G dwellings, and the South West has an above average number of detached houses. The South West also has an above average number of rural properties, which are disproportionately F and G rated.
2. **A terraced house in North East:** The North East has an above average number of terraced houses, and terraced houses have a disproportionately large number of EPC Band F dwellings in the private rented sector. Also, the

North East has below average forecast population growth and has had recent low rental growth.

3. **A flat in London:** Given the characteristics of London's housing market, we consider it is important to consider London as a separate archetype. London has above average forecast population growth and has had recent large rent increases. We also note that London has an above average number of flats, and flats have a disproportionately large number of F and G dwellings in the private rented sector, despite having a lower share of F and G in total.

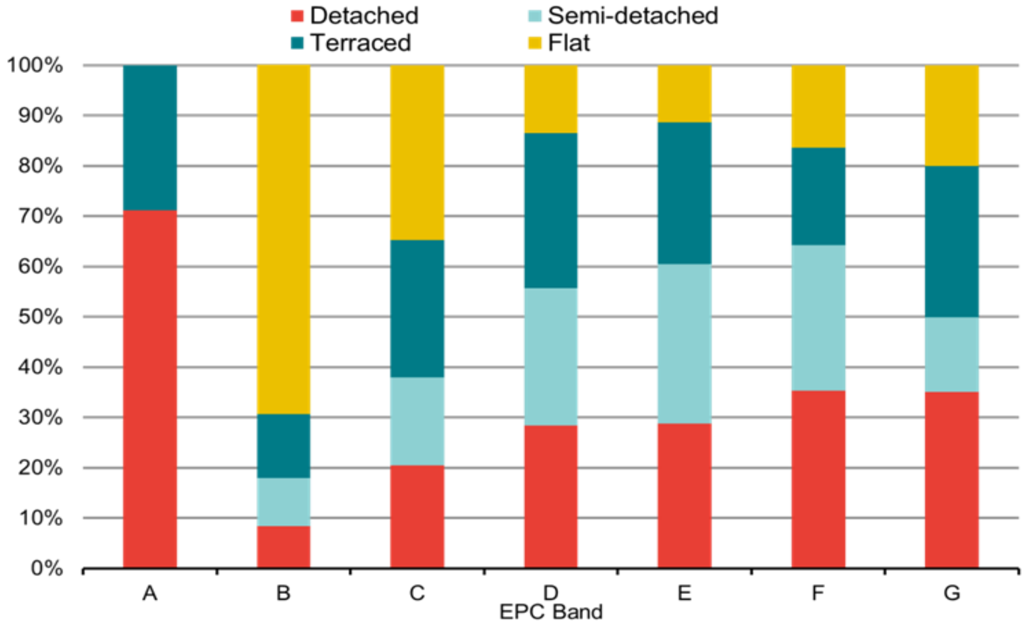
We discuss these differing factors in further detail below.

Current condition of the housing stock

About 6% of private rented sector dwellings are currently rated EPC Band F or G. However, the current condition of housing stock differs across dwelling type and area type.

In relation to dwelling type, Figure 6 shows that relatively more detached and terraced homes have the lowest energy efficiency ratings, while relatively few flats have these ratings.

Figure 6 Proportion of EPC Bands represented by each home type, England (sample data)

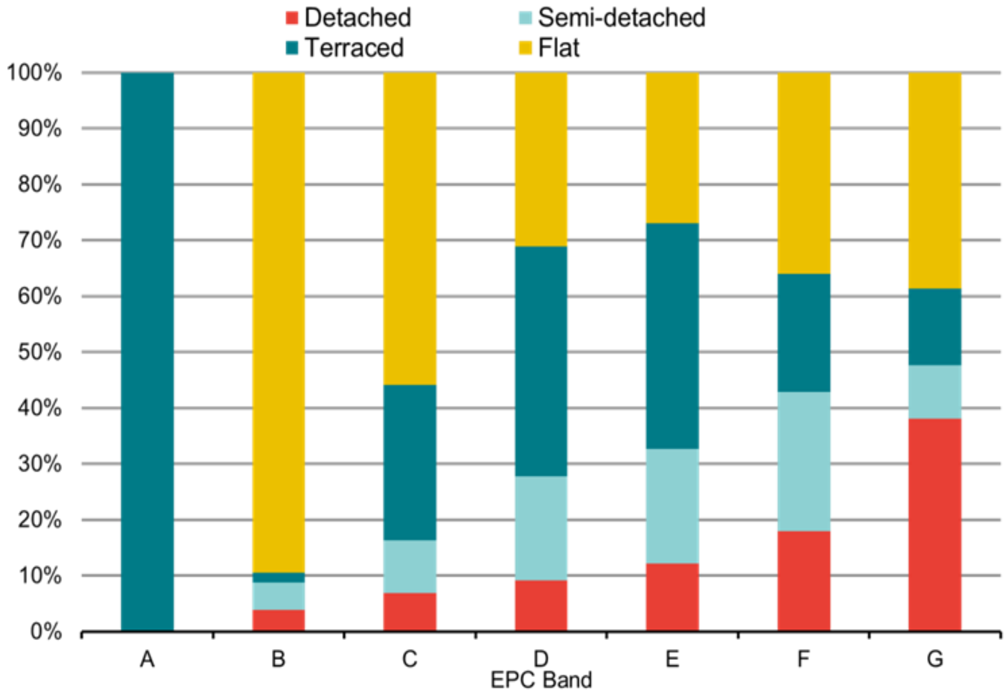


Source: Sample data reported in DECC, 2013

Note: Homes are not evenly distributed across the EPC Bands. The absolute number of homes in Bands A, B and G is relatively small.

However, the distribution of dwellings in the private rented sector is different than the housing sector more generally. In particular, tenants in the private rented sector are more likely to live in flats or terraced houses compared to owner-occupiers. Therefore, in Figure 7 we consider the proportion of dwelling by EPC band in the private rented sector only. We can see from this analysis that flats make up a larger proportion of F and G rated properties. Detached houses still account for a significant proportion. Semi-detached houses account for the smallest proportion of G-rated dwellings.

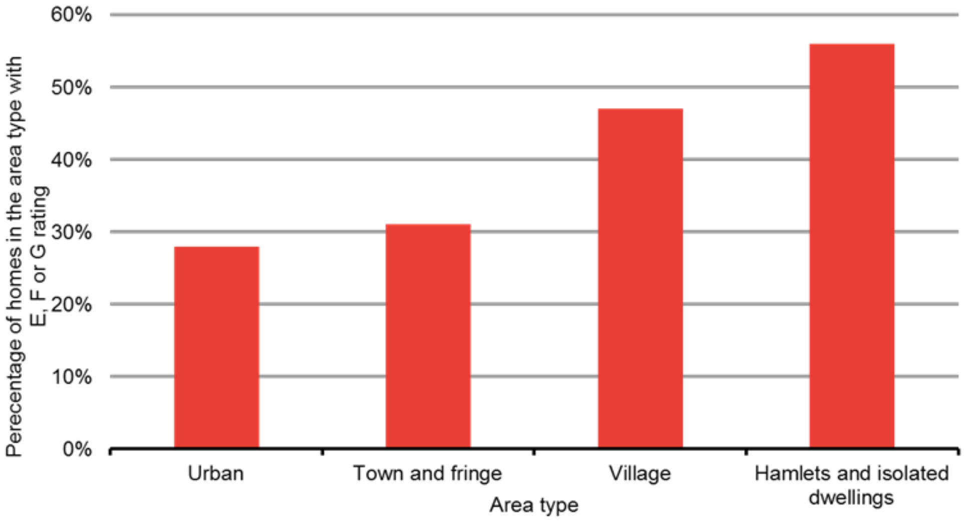
Figure 7 Proportion of EPC Bands represented by each home type in the PRS in England



Source: Sample data reported in DECC, 2013

In relation to location, the evidence shows that dwellings in less populated areas are proportionally more likely to have lower energy efficiency ratings. This is likely due to a combination of older housing stock and proportionally more detached houses. Therefore, we have incorporated into our archetype design a region (the South West) that has a relatively higher proportion of dwellings in low population areas.

Figure 8 Percentage of homes in England with a Band E, F or G EPC rating by area type

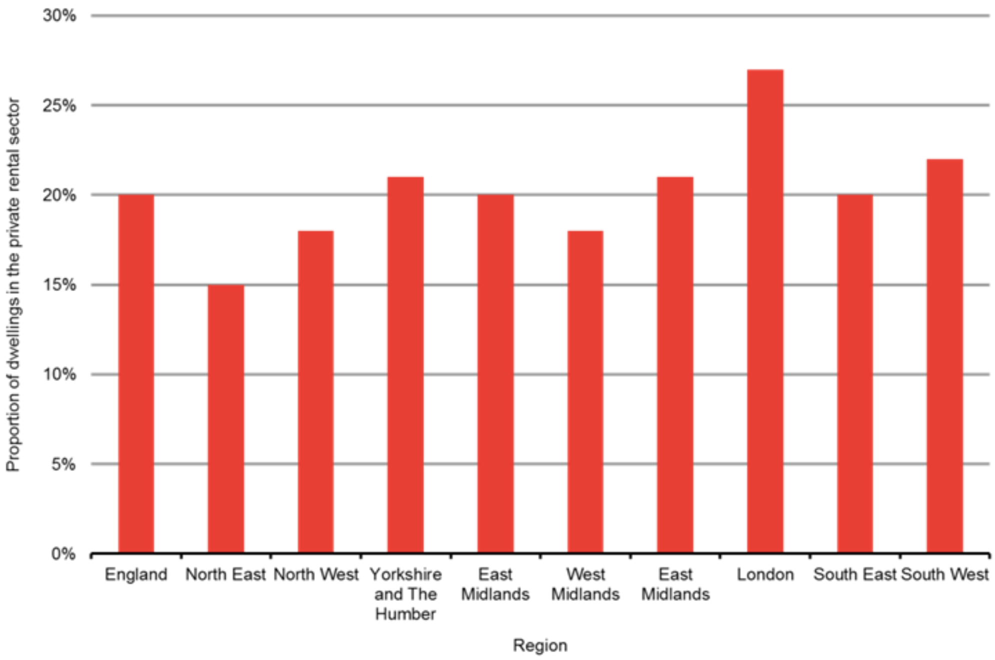


Source: Association for the Conservation of Energy, 2015; using English Housing Survey data

Regional differences

There are significant regional differences in the proportion of dwellings in the private rental sector. Figure 9 shows the proportion of dwellings by region that are in the private rented sector. London has the highest proportion of private rental sector dwellings, followed by the South West. The North East, North West and West Midlands have the lowest shares.

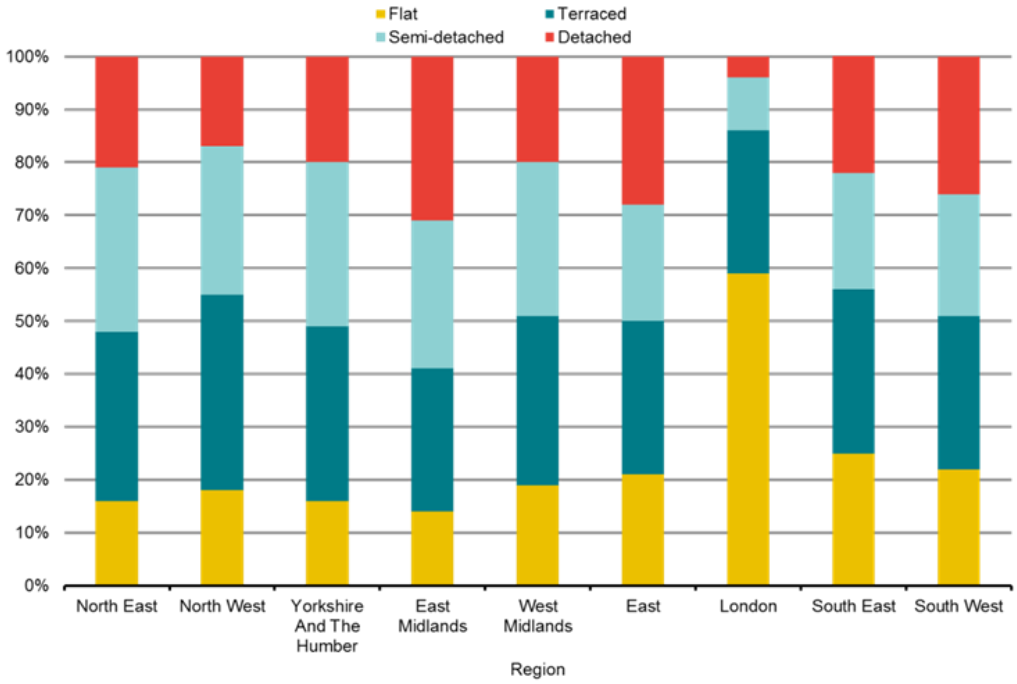
Figure 9 Proportion of private rental sector by region



Source: 2014-15 English Housing Survey data

The proportion of dwelling type also varies by region Figure 10. The North West and Yorkshire have the highest proportion of terraced houses. London's proportion of flats is more than double the national mean. The East Midlands have the highest proportion of semi- and detached-houses combined.

Figure 10 Proportion of dwelling type by region

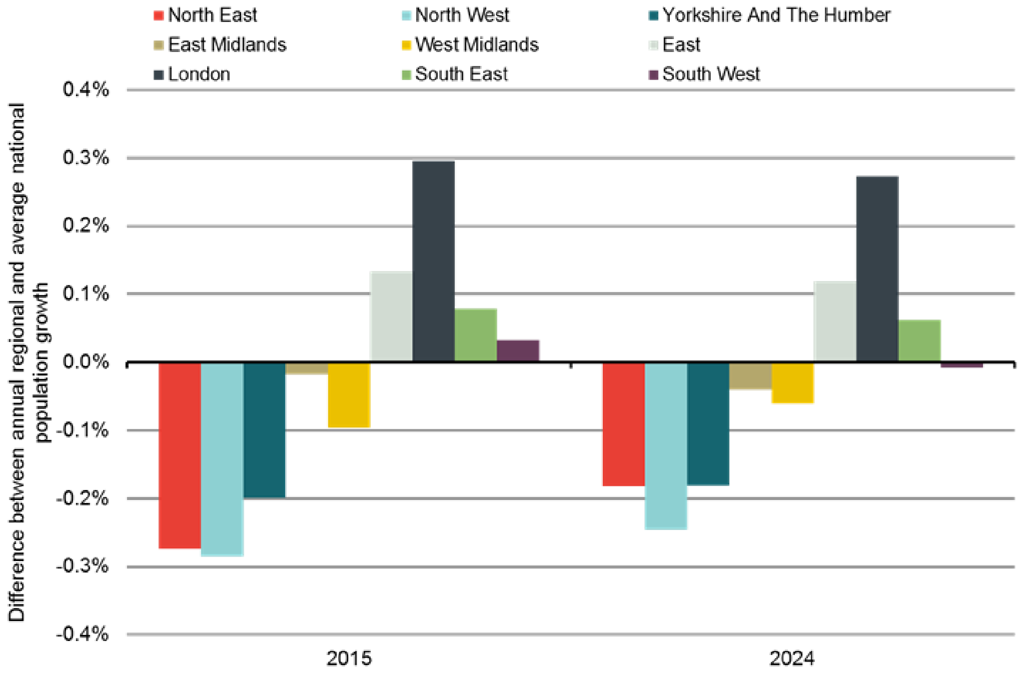


Source: 2014-15 English Housing Survey data

Future demand by region

We have also considered different macro demand characteristics across regions. Figure 11 shows the forecast population growth by region in 2015 and 2024. London's forecast population growth, in particular, is significantly above the national mean. We also note that London is likely to have more physical constraints in relation to the expanding supply of certain types of houses, which may put further upward pressure on rents. The North East, North West and Yorkshire are forecast to have population growth below the national average.

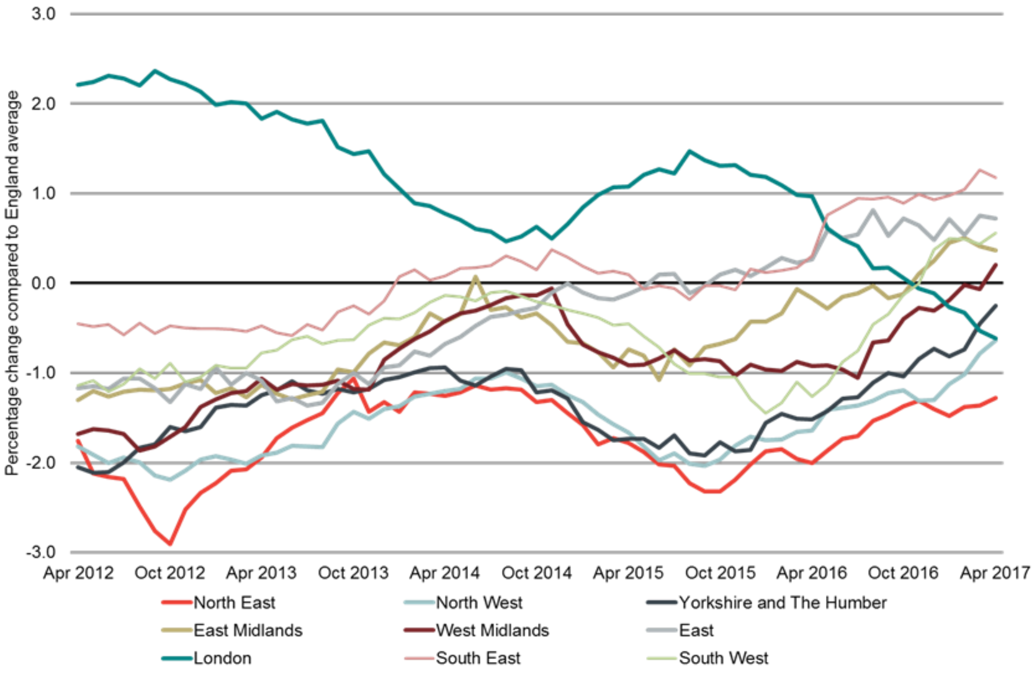
Figure 11 Forecast regional population growth relative to national mean



Source: ONS, 2014 Subnational Population Projections for Regions in England,

The evidence also shows that trends in rental growth have varied by region over the last five years (Figure 12). While rental trends have been volatile, over the last five years there has been a general North-South divide, with rental growth in the North East, North West and Yorkshire below the national average, and rental growth in London, the South East and East of England typically above the national average.

Figure 12 Growth in private rental sector rents by region



Source: ONS, Index of private housing rental prices (IPHRP) in Great Britain: Mar 2017

Therefore, in designing the model archetypes we have captured a range of regions to reflect different macro demand characteristics. These macro demand characteristics may ultimately impact the degree to which energy efficiency improvements are capitalised into house values, and/or passed through in rental increases.

3 ESTABLISHING A BASELINE FOR THE ANALYSIS

In this section, as per Step One and Step Two of our quantitative model, we estimate baseline rental costs and energy cost for EPC Band F and G dwellings.

We find that average rents are lower for EPC Band G dwellings compared to EPC Band F dwellings. We also find that detached houses have the highest rents, followed by terraced houses. lats generally have the lowest rents of the dwelling types.

Estimated annual energy costs by EPC band show that energy costs for EPC Band F homes are approximately £500 higher than EPC Band E, with G-rated homes being around £1,000 higher. Flats are found to have the lowest energy costs while detached houses have the highest energy costs across EPC ratings.

3.1 Average private sector rent for EPC Band F and G dwellings

We first use Valuation Office Agency Private Rental Market Statistics[7] to compare average rent by region[8]. As can be seen in Figure 13, rent varies considerably by region with London rents being significantly higher than other regions.

Figure 13 Average private rental sector rent by region

Region	Mean
North East	£499
East Midlands	£555
Yorkshire And The Humber	£557
North West	£563
West Midlands	£595
South West	£718
East	£750
South East	£927
London	£1,676
England	**£788**

Source: *Valuation Office Agency Private Rental Market Statistics, 2014/15*

Note: *We use 2014/15 rent data as this is the last year for which we have comparable English Housing Survey data.*

7 Valuation Office Agency, Private rental market summary statistics, England, 2014-15. (2015) https://www.gov.uk/government/statistics/private-rental-market-summary-statistics-england-2014-15

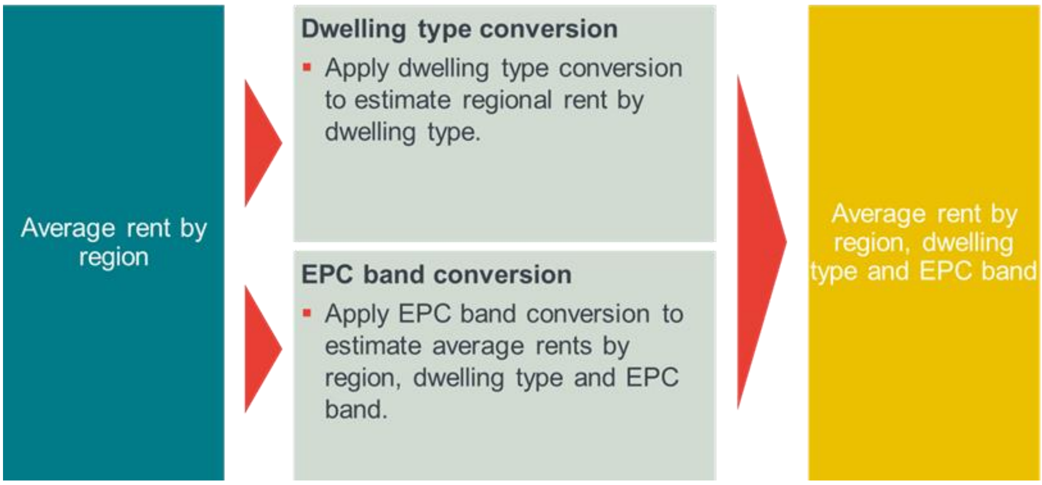
8 Valuation Office Agency rents do not control for differences in average dwelling type or size across regions.

As noted in the previous chapter, we model three archetypes, namely:

- a detached house in South West;
- a terraced House in North East; and
- a flat in London.

For each of these archetypes we estimate baseline rents for EPC Band F and G dwellings, as summarised in Figure 14 and discussed in further detail below.

Figure 14 Baseline rents for EPC Band F and G dwellings



Source: Frontier Economics

To do this, we first estimate **average regional rents by dwelling type**. As Valuation Office Agency data is only available by region and not by dwelling type, we use English Housing Survey data for 2014-2015 to estimate rent by dwelling type. This is done by calculating the proportional difference between the average rent for each dwelling type and the national average rent. For each dwelling type, we then apply this proportion to the average rent by region to estimate regional rent by dwelling type.

We then estimate **average regional rents for EPC Bands F and G**. Valuation Office Agency data is not available by EPC band so again we use English Housing Survey 2014-2015 data to estimate rent by EPC band. As with the dwelling type calculation, this is done by calculating the proportional difference in average rent by EPC band and the national average rent. This proportion is then applied to the Valuation Office Agency data to estimate regional rent by EPC band.

Figure 15 shows our estimated average monthly rents by region, dwelling type and EPC band. Baseline rents for our three archetypes are highlighted in blue.

We find that average rents are lower for EPC Band G dwellings compared to EPC Band F dwellings. However, this does not yet control for other factors that may impact the level of rent, such as number of bedrooms or age of the property. We also find that detached houses have the highest rents, followed by terraced houses. Flats generally have the lowest rents of the dwelling types.

Figure 15 Average monthly private rental sector rent by region, dwelling-type and EPC rating

	Terraced		Detached		Flat	
	F	G	F	G	F	G
England	**£ 756**	**£ 728**	**£ 1129**	**£ 1086**	**£ 754**	**£ 726**
North East	£479	£461	£715	£688	£478	£459
East Midlands	£533	£512	£795	£765	£531	£511
Yorkshire And The Humber	£535	£514	£798	£767	£533	£513
North West	£540	£520	£807	£776	£539	£518
West Midlands	£571	£549	£852	£820	£570	£548
South West	£689	£663	£1,029	£989	£687	£661
East	£720	£692	£1,074	£1,033	£718	£691
South East	£890	£856	£1,328	£1,277	£888	£854
London	£1,609	£1,547	£2,401	£2,309	£1,605	£1,543

Source: *Frontier Economics analysis based on Valuation Office Agency Private Rental Market Statistics (2014/15) and English Housing Survey data (2014/15)*

3.2 Average energy costs for EPC Band F and G dwellings

To establish baseline energy costs, we estimate annual **energy costs by EPC band** using English Housing Survey data. Using the English Housing Survey's Fuel Poverty dataset we group observations by dwelling type and EPC rating and calculate the average energy cost for each sub-sample, as shown in Figure 16 below.

Energy costs are generally higher for dwellings with lower EPC ratings. EPC band F homes have annual energy costs of about £500 higher than EPC Band E, with G-rated homes being about £1,000 higher.[9] Flats have lower energy costs than other dwelling types while detached houses have the highest energy costs across EPC ratings.

[9] Our findings are broadly consistent with previous research by Association for the Conservation of Energy (ACE). ACE previously considered energy costs by EPC band, but not by dwelling type and not constrained only to the private rental sector. ACE found an average energy cost of £2,670 for G-rated properties, £2,140 for F-rated properties, and £1,640 for E-rated properties. Our results are re broadly in line with those previously found, albeit slightly lower than those found by Citizens Advice and ACE. "Private renters in poor quality homes face £1,000 higher costs to heat their homes" Citizens Advice (2016) https://www.citizensadvice.org.uk/about-us/how-citizens-advice-works/media/press-releases/private-renters-in-poor-quality-homes-face-1000-higher-costs-to-heat-their-homes/

Figure 16 Average annual energy cost by EPC rating

	Terraced	Detached	Flat	Average[10]
England average	**£1,371**	**£1,696**	**£1,019**	**£1,316**
E-rated	£1,564	£1,786	£1,362	£1,573
F-rated	£2,060	£2,560	£1,771	£2,077
G-rated	£2,508	£3,027	£2,209	£2,560

Source: English Housing Survey Fuel Poverty dataset, 2014/15

3.3 Summary of EPC Band F and G private sector rents and energy costs

Bringing together our results for EPC Band F and G private sector rents and energy costs, Figure 17 summarises both measures for our three archetypes.

Figure 17 EPC Band F and G private sector rents and energy costs

Archetype	Annual rent		Annual energy costs	
	F	G	F	G
South West detached house	£12,343	£11,871	£2,560	£3,027
North East terraced House	£5,748	£5,529	£2,060	£2,508
London flat	£19,256	£18,519	£1,771	£2,209

Source: Frontier Economics analysis

10 Note the average also includes semi-detached houses.

4 COST OF ENERGY EFFICIENCY IMPROVEMENTS

The next step in our approach is to estimate costs to landlords of making energy efficiency improvements. Specifically, we consider the average cost to improve an EPC Band F or G dwelling to an EPC Band E dwelling.

4.1 Average cost of energy efficiency improvements by EPC Band

There are a wide range of improvements that are typically undertaken to improve energy efficiency performance. The exact improvements made to reach an E will be determined by the individual characteristics of a dwelling, value for money from the improvements, and any other landlord preferences.

Figure 18 shows estimates for upfront costs of common energy efficiency measures. The average lifetime of these measures is 28 years.

Figure 18 Estimated upfront costs of common energy efficiency measures

Energy efficiency measure	Upfront cost range		Lifetime (years)
	Low	High	
Cavity wall insulation	£500	£1,500	42
Draught proofing	£80	£120	10
External wall insulation	£4,000	£14,000	36
Heating controls	£ 350	£450	12
High performance doors (per door)	£ 500	£500	30
Gas-fired condensing boilers	£2,200	£3,000	12
Internal wall insulation	£4,000	£14,000	36
Loft insulation	£100	£350	42
Replacement glazing	£3,300	£6,500	20
Roof insulation (flat roof)	£ 850	£1,500	20
Secondary glazing	£1,000	£1,500	20
Under-floor insulation	£800	£1,200	42
Cavity wall insulation	£500	£1,500	42

Source: "Information for the Supply Chain Green Deal Measures" DECC (2013)

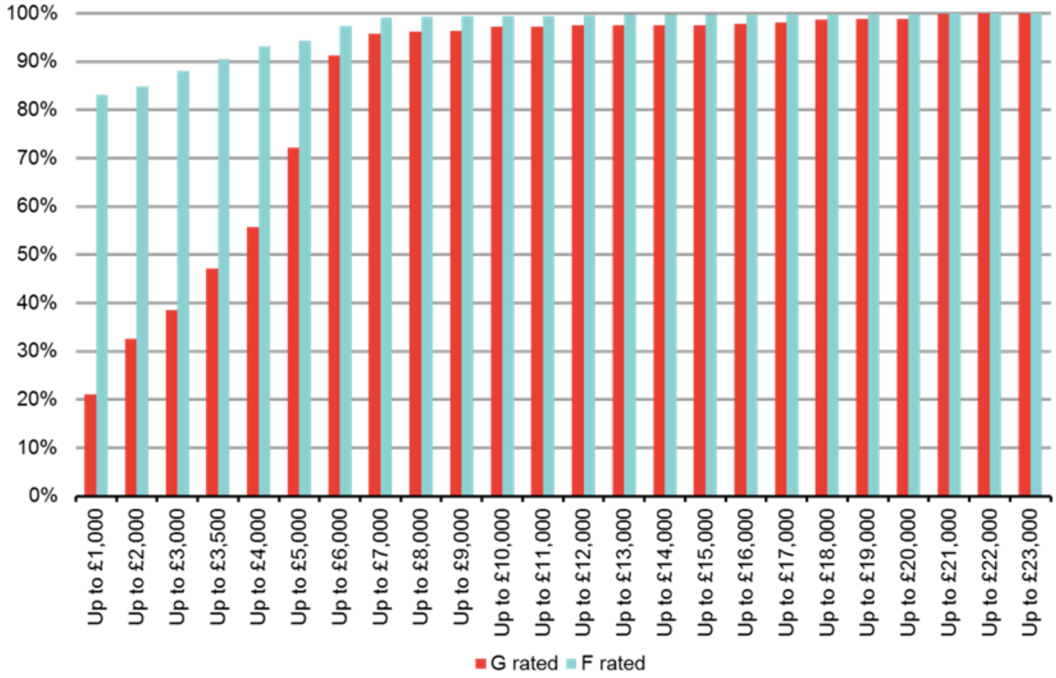
Parity Projects has previously estimated the average minimum cost required to improve a Band F or G home to an E rating[11]. They did this by applying options modelling to a representative sample of over 3000 F and G rated dwellings. Applicable measures for each dwelling are added in order of cost effectiveness, resulting in required investment estimates for each dwelling.

Using this method, Parity Projects found that the average costs were:

- F to E: £943
- G to E: £3,773

We adopt these average cost estimates into our model. However, these average figures mask the distribution of estimated improvement costs across dwellings (as seen in Figure 19). For example, over 80% of F-rated dwelling could be improved to EPC Band E for under £1,000, while only 20% of G-rated dwellings could be improved to an EPC Band E for this level of cost. However, there are proportionally more EPC Band F dwellings than EPC Band G dwellings. Nearly 80% of EPC Band F and G dwellings combined could be improved to an E rating for under £3,000.

Figure 19 Proportion of dwellings improved by cost band



Source: Frontier Economics' analysis of Parity Projects (2014) "Analysis for WWF and UK-GBC: achieving minimum EPC standards in housing data summary".

To account for this distribution, we also estimate average improvement costs only for dwellings which can be brought to an E standard within an investment limit of £5,000. We assume that all dwellings which can reach an E rating for £5,000 or less must undertake the improvements and those which exceed this threshold are required to make a minimum investment of £5,000.

[11] "Analysis for WWF and UK-GBC: achieving minimum EPC standards in housing," Parity Projects (2014)

Under a £5,000 cap policy, the average cost of improvement is lowered to £837 for F to E properties and £3,162 for G to E properties. This is because the outlier properties with very high improvement costs are capped at £5,000. With this £5,000 investment cap, approximately 94% of F rated dwellings and 72% of G rated dwellings can be improved to an E rating, with the remainder of homes receiving only partial improvements.

Figure 20 shows the average cost of improvement and proportion of dwellings which would reach an E rating under various potential policy options. There is a clear trade-off between the required level of investment and the number of dwellings which will reach an E rating. Our main discussion of results will focus on the case where investment is capped at £5,000, with the no cost cap and £3,500 cap policy options discussed in more detail Section 6.

Figure 20 Average improvement costs and outcomes of policy options

		No cost cap	£5,000 policy cap	£3,500 policy cap
F to E	Average cost of improvement	£943	£ 837	£ 734
	Proportion of dwellings reaching EPC E rating	100%	94%	91%
G to E	Average cost of improvement	£ 3,773	£ 3,162	£2,558
	Proportion of dwellings reaching EPC E rating	100%	72%	47%
F and G to E	Cumulative proportion of dwellings reaching EPC E rating	100%	91%	83%

Source: *Frontier Economics' analysis of Parity Projects (2014) "Analysis for WWF and UK-GBC: achieving minimum EPC standards in housing data summary".*

Due to data availability constraints, we are unable to break these average costs down further by dwelling type. The Parity Projects research, however, suggests that dwelling size does not typically have a large impact on the improvement costs required to meet an EPC Band E. This is because measures such as replacing boilers have similar costs across property types. If we were to look to increase the EPC rating to higher than an E, the difference in improvement costs between flats and houses would become more significant as measures such as wall insulation and window glazing are more dependent on dwelling type and size. Although, we note that some flats are also extremely costly to upgrade to higher EPC bands given their construction design and age.

4.2 Conclusions on improvement costs

The average cost of improving an EPC Band F to an EPC Band E ranges from £734 to £943, dependent on the policy option chosen. The average cost of improving an EPC Band G to an E ranges from £2,558 to £3,773 depending on the chosen policy cost cap. The cost distribution has a long tail of more expensive properties to improve, particularly G rated properties, which will face improvement costs higher than these averages.

5 IMPACT OF ENERGY EFFICIENCY STANDARDS IN THE PRIVATE RENTED SECTOR

In this section we estimate the likely impact of energy efficiency standards on rent and energy costs in the private rented sector.

5.1 Impact on private sector rent

As discussed in Section 2, there are two reasons why MEES may impact on private sector rents, namely

- If tenants place a premium on EPC E dwellings compared to EPC F and G dwellings (i.e. increased demand); and
- if higher costs to all landlords of EPC F and G-rated dwellings in the private rented sector allow landlords to pass through a portion of these costs to tenants through rent increases (i.e. increased supply costs).

We use three methods to estimate the rent impact from energy efficiency improvements.

1. **Literature review**, including:
   - evidence of how EPC ratings impact house prices in England and Wales; and
   - evidence of how energy efficiency ratings impact rental prices and houses prices in other jurisdictions.
2. **Econometric estimation** of how EPC Bands currently impact private sector rent.
3. **Cost pass-through analysis** as a cross-check against our econometric analysis, we assess the potential for landlords to pass through improvement costs, and how that would impact on private sector rents.

5.1.1 Literature review

The academic literature looking at the effect of energy efficiency rating on the housing market usually focuses on how EPC ratings are priced into property values, rather than the impact on rental prices. In particular, to our knowledge, there are no previous studies for the UK or England that have specifically investigated the impact of EPC ratings on private sector rents.

Therefore, we present below the findings from:

1. studies looking at the effect of EPC rating on property prices in England, Wales, GB or the UK; and
2. studies looking at the effect of EPC ratings on sales and rental prices outside the UK.

These papers usually use transaction data and estimate the difference in prices between dwellings with different EPC ratings, holding constant a set of observable characteristics pertaining to the property and area type.

- **The effect of EPC ratings on property prices in England and Wales:** For both England[12] and Wales[13], Fuerst et al find that EPC bands have a statistically significant effect on house prices.
  - For England, E-rated dwellings had an average sale price of 6.6% more than G-rated dwellings, and F-rated dwellings 6% more than G-rated dwellings. This implies that E-rated dwellings are only 0.6% more expensive than F-rated dwellings.
  - For Wales, the reference band is EPC D and the price discount for F-rated and G-rated dwellings is 4.7% and 7.2% respectively.
  - In Wales the authors identified the set of buy-to-let dwellings where the EPC certificate was issued for the purpose of marketing the dwelling on the private rental market. For that subsample, they find no price discount associated with a rating lower than D, while there is still a price premium associated with a higher rating. This suggests that EPC ratings may be a less important feature in determining rental prices in the private rental market.
- **The effect of EPC ratings on property prices and rental prices outside the UK:** When property prices and rental prices are analysed in the same study, energy efficiency ratings are consistently found to positively impact property prices more than rental prices.
  - In Ireland, Hyland et al (2013)[14] find a 2.7% rental discount for F and G-rated dwellings compared to D-rated dwellings. In contrast, for sales, the discount is 5.6%, twice as high.
  - In Austria, a study by the European Commission[15] estimates a price premium of 8% in the sales market and 4.4% in the lettings market for each one-notch improvement in the energy efficiency rating.
  - In France, the same study finds a price premium of 4.3% in Marseille and 3.2% in Lille for each one-notch improvement in the sales market – there is no data available for the rental market. Interestingly, the effect is different depending on the dwelling type and on the city: for Marseille, the effect is driven by flats and there is no effect on house prices, while for Lille the effect is driven by houses and the effect on flats is much smaller. It could suggest that for houses, energy efficiency enjoys a greater premium in the city more dependent on energy for heating.

Overall, this literature review suggests that EPC ratings have a relatively limited impact on rental prices. In general, previous studies find that EPC Bands impact

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12 Fuerst et al, 2016 Is Energy Efficiency Priced in the Housing Market? Some Evidence from the United Kingdom, University of Cambridge (Working Paper)

13 Fuerst et al, 2016, Energy Performance and House Prices in Wales: an Empirical Study, University of Cambridge Working Paper Series

14 Hyland et al, 2013, The Value of Domestic Building Energy Efficiency – Evidence from Ireland, University of Oxford Discussion Paper Series

15 European Commission, 2013, Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries

rental price less than property prices; with an average impact of about half or less. As an illustration, if a similar disparity between the impact of EPC Bands on rental prices and property prices exist in England and Wales, then given the above findings this would equate to a premium for E-rated dwelling of between 0.3% and 3.3% above F and G-rated properties.

5.1.2 Econometric assessment of rent differentials

Our next step is to econometrically assess whether EPC ratings are associated with a differential in private sector rents. Like previous studies, we estimate the difference in prices between dwellings with different EPC ratings, holding constant a set of observable characteristics pertaining to the property and area type.

Data

To estimate the relationship between EPC rating and rent, we use data from the English Housing Survey spanning four consecutive years (2011-2015).

It is worth noting that this data differs from the data used in the studies outlined in the previous section:

- **Sample housing data versus transaction data:** The literature usually relies on transaction data retrieved from commercial platforms or public sources, which contain an exhaustive list of all the property for sales or rent in a given jurisdiction at a given time. In contrast, the English Housing Survey is a survey conducted every year in England, gathering data on a sample of dwellings. While the transaction datasets used in the literature typically have hundreds of thousands of observations, our sample has around 4,000 privately rented dwellings. This difference in sample size means that our estimations are in general less precise than in the literature, although our rich set of controls partly compensates for the smaller sample size.
- **Properties for rent to new tenants versus long-term tenants:** Rental prices from transaction data reflect current market prices, while our sample is comprised of existing tenancy agreements (including those held by long-term tenants). There are pros and cons from the two different approaches. Transaction data gives a more accurate picture of the market today, and the price a tenant would face if entering a new agreement. However, including existing tenants may be more reflective of the sector if, for example, it were the case that long-term tenants pay a lower rent as private landlords fail to fully adjust rents every year based on market prices.
- **Advertised EPC rating versus EPC rating estimated by a surveyor:** In many jurisdictions, advertising the EPC rating of listed properties for sale or rent became mandatory in the past 10 years. It means that in the papers using transaction data, both the landlord and potential tenants have information on the energy efficiency performance of the dwelling for rent. In contrast, in the English Housing Survey the EPC rating is estimated by a surveyor conducting the physical part of the survey, without the tenant being necessarily aware of this rating. As a result, what we estimate does not reflect

how much more tenants are willing to pay to live in a more energy-efficient dwelling, but rather how much more tenants living in a more energy efficient dwelling *actually* pay compared to tenants living in a less energy-efficient dwelling.

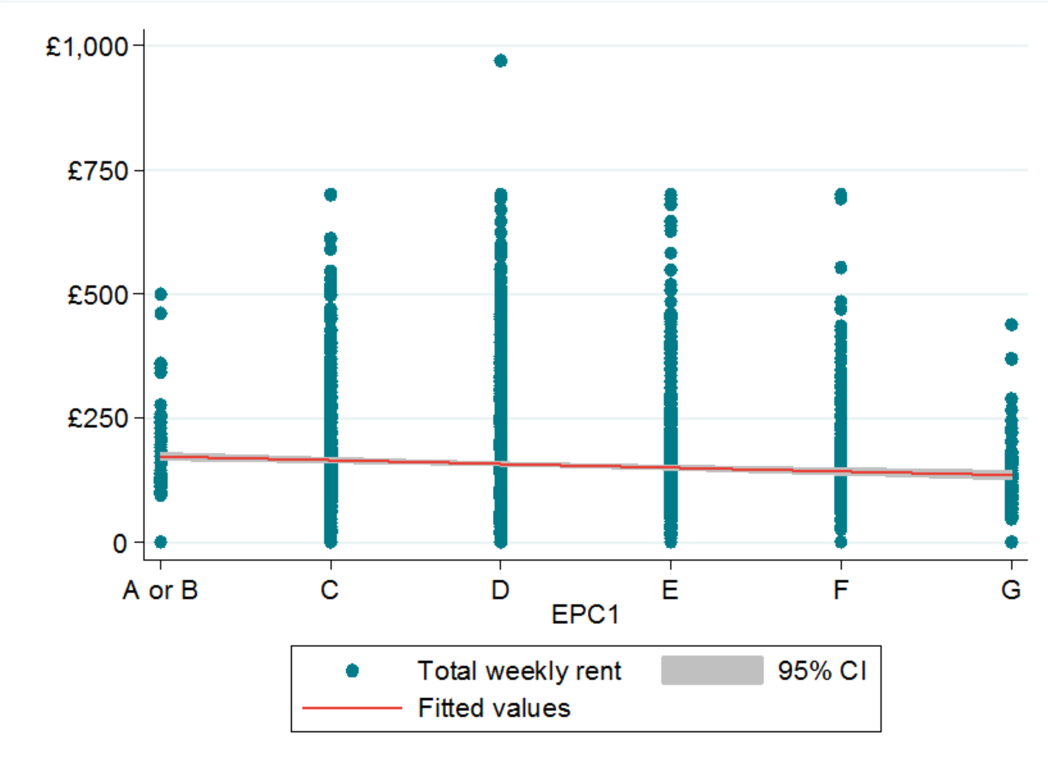
- **Extensive set of control variables versus basic controls for area and property characteristics:** The English Housing Survey data has detailed information about the dwelling's characteristics which are not available in typical transaction data. For example, it indicates the age of the dwelling, which is sometimes absent from transaction data. This variable influences both rental prices and EPC rating as more recent dwellings are usually better insulated. It is therefore an important factor to control for when estimating the effect of EPC rating on rents. This gives an advantage to our data compared to some transaction data.

While our results are broadly comparable to those from the literature, the above differences in approaches and data suggest that the results should not be compared directly.

High-level assessment of relationship between EPC and private sector rent

As a first step, we plot the relationship between EPC and rent (Figure 21). We see that there is a small positive correlation between EPC rating and rent: the higher the EPC rating, the higher the rent. However, this analysis does not control for other factors that may also impact on rent. To generate more robust estimates we control for property-specific and area-specific characteristics in the next section.

Figure 21 Relationship between weekly rent and EPC rating



Source: Frontier Economics using English Housing Survey data

Note: The sample contains all the privately rented dwellings subject to a market rent from the 2013/2014 and 2011/2012 English Housing Survey Physical Surveys

Regression analysis

We then perform a regression analysis, which allows us to control for property-specific and area-specific characteristics likely to affect both the distribution of EPC ratings and rents. Our model is a standard "hedonic price regression model", in that it tries to explain rental prices by a set of observable components, namely:

- the location of the dwelling: Including geographic region, whether the dwelling is located in an urban or rural area;
- the characteristics of the property: Including the size of the dwelling, number of bedrooms, dwelling type, dwelling age, etc; and,
- the energy efficiency rating.

More detail on the econometric model can be found in the appendix, and in the rest of this section we focus on the results of the analysis.

The effect of energy efficiency on rental prices can be estimated using two different variables:

- **EPC bands**, ranging from A to G (A and B are grouped together in the data); and

- the standard assessment procedure (**SAP score)**, which is a score between 0 and 100 where 0 is the least energy-efficient dwelling and 100 is the most energy-efficient.

The correspondence between EPC bands and SAP score is set out Figure 22.

Figure 22 Correspondence between EPC rating and SAP score

EPC Band	Corresponding SAP score
A/B	80.5 < SAP ≤ 100
C	68.5 < SAP ≤ 80.5
D	54.5 < SAP ≤ 68.5
E	38.5 < SAP ≤ 54.5
F	20.5 < SAP ≤ 38.5
G	0 < SAP ≤ 20.5

Source: Frontier Economics using English Housing Survey data

In the results below, we focus on the results using the SAP score as, given the sample size, this model produces stronger results than using individual EPC Band.

We have estimated separate models for houses and for flats. We use the housing model for our archetypes of a detached house in the South West and a terraced house in the North East. For our London flat archetype, we also include an interaction variable that isolates the price effect of an increase in SAP score when the dwelling is located in London[16].

In each model, we find that the coefficient of the SAP score – i.e. the percentage change in rental price for a unit change in the SAP score – is not statistically different from zero. That is, we cannot determine whether rents for EPC Band E dwellings have statistically significant higher rents than F or G rated dwellings, once other factors are controlled for[17]. (These results are discussed in further detail in the appendix). Therefore, according to this analysis, the evidence suggests that increased energy efficiency ratings as a result of MEES would not necessarily lead to an increase in private rental sector prices.

5.1.3 Cost pass-through assessment

As noted above, our econometric analysis suggests that rents for E-rated homes are not currently statistically significantly different tor F and G-rated homes, once other factors are controlled for. However, a regulatory MEES, which increases costs across an entire sub-segment of the sector, may result in the costs of those improvements being passed through to tenants over time.

Therefore, we also assess the potential for landlords to pass through energy efficiency improvement costs, and how that would impact private sector rents.

To estimate the upper limit for rent impact from cost pass-through, we estimate the potential impact on rent from landlords passing through increased costs to

[16] This is because the effect found for flats as an average effect across all regions of England may differ to London given that London may exhibit different pricing patterns compared to flats elsewhere.

[17] We have similar findings when EPC Bands are used rather than SAP scores.

consumers. To maximise the prospect of passing through costs, landlords are expected to do so in a way that limits the impact on demand. That is, landlords would not recover in a "lump sum" charge to tenants but spread the cost recovery over the lifetime of the energy efficiency improvement. If landlords tried to recover costs over a shorter time period, this would mean larger rent impacts, which tenants would not be willing to pay for: If tenants were willing to pay above the cost for these improvements, then landlords would have already made them.

To estimate the expected rent impact from cost pass-through, we first calculate the total costs of energy efficiency improvements that need to be recouped, based on the time period and discount rate. . Once we have calculated the annual amount to be recovered, we then estimate, based on the market structure, the proportion which would be passed through to tenants through increased rent.

As discussed above, we estimated the average upgrade costs of £837 to move F and £3,162 to move G rated properties to an E rating. For modelling purposes we assume that landlords do not face capital constraints, though we will discuss these constraints further in Section 7. As such, the return on investment required is based on the opportunity costs of funds, which we estimate at 9% based on the Bank of England average interest rate from UK monetary financial institutions on personal loans to households. We estimate the average lifetime of 20 years for energy efficiency improvements based on lifetimes reported by DECC (2013), as shown above in Figure 18[18].

After using the above factors to determine the effective annual cost increase to landlords, we assess the ability of landlords to increase rents to recover these costs. The level of cost pass-through is dependent on whether a cost shock is firm or industry-specific, the nature of competition, and the curvature of supply and demand curves. In a perfectly competitive market, firm specific cost changes are fully absorbed by the firm with no scope for pass through.[19] Once the cost change applies to the industry rather than to an individual firm, cost pass-through is possible. In this analysis we consider the industry to be all EPC Band F and G properties, in which case a regulated MEES is an industry wide cost change. In reality F and G-rated properties are to some extent a subset of the wider private renal sector. Cost pass-through is therefore possible and we look further at market characteristics to estimate a pass-through level.

First, we assess how the level of competition affects the level of cost pass-through.

In a monopoly market where firms face constant marginal costs, the level of pass-through is equal to the ratio of the slope of the demand curve and the slope of the marginal revenue curve. Assuming that demand is linear – that is, a

18 We note that some common measures, such as draught proofing and gas-fired condensing boliers have shorter life spans – 10 years and 20 years respectively – while other common measures such as loft insulation have much longer life spans – i.e. 42 years. We consider that 20 years represents a reasonable average lifetime for energy efficiency improvements.

19 Yde, Paul L. and Michael G. Vita, "Merger Efficiencies: Reconsidering the 'Passing-On' Requirement," Antitrust Law Journal. (1996)

constant relationship between a change of price and change in demand – the cost pass through is 50%.[20] [21]

Under perfect competition, a cost increase will shift the supply curve upward by the amount of the increase. The level of cost pass-through is then dependent on the relative elasticities of supply and demand. Cost pass-through can be as high as 100% in the extreme case where either supply is perfectly elastic (a horizontal line) or demand is perfectly inelastic (a vertical line).[20] In other situations, pass-through will be less than 100%. The pass-through rate increases as demand becomes more inelastic and as supply becomes more elastic. It also changes depending on the curvature of the demand curve. If demand becomes more sensitive to price as the price increases (i.e. the curve is concave to the origin) the level of cost pass-through is lower. Alternatively, if demand is convex to the origin, the level of cost pass-through is higher.[22]

Based on this, we undertake an analysis for both a 50% and a 100% cost pass-through rate. The true pass-through rate is likely to lie somewhere in the middle of this range, as discussed below. We find that a cost pass-through rate of 50% implies rent increases between 0.2% and 3.2% for F and G properties moving to an E rating. Under 100% cost pass-through, rents increase by between 0.3% and 6.3%.

Figure 23 shows the percentage rent increase for each of our three archetypes based on both a 100% and 50% cost pass-through. Areas such as London which face higher starting rents will face smaller percentage increases. Alternatively, the impact of the cost pass-through will be higher in areas such as the North East with lower starting rents.

Figure 23 Estimated private sector rent increase based on cost pass-through analysis

		Detached house in the South West	Terraced house in the North East	Flat in London
100% cost pass-through	F to E	0.7%	1.6%	0.5%
	G to E	2.9%	6.3%	1.9%
50% cost-pass through	F to E	0.4%	0.8%	0.2%
	G to E	1.5%	3.1%	0.9%

Source: Frontier Economics' analysis

Because the private rental sector is made up of many landlords (suppliers) and many tenants (consumers), its market structure could be better characterised by perfect competition than monopoly. Additionally, demand in private rental sector is relatively inelastic which indicates a higher cost pass-through. For the purposes of this analysis, we assume 100% cost pass-through for our net benefit calculations, noting that this is the high-end of our estimated range.

20 Based on the fact that with linear demand curves, the slope of the marginal revenue curve is twice as steep as the slope of the demand curve.

21 Bulow, Jeremy I. and Paul Pfleiderer, "A Note on the Effects of Cost Changes on Prices," Journal of Political Economy 91, Issue 1 (1983)

22 RBB Economics, "Cost pass-through: theory, measurement, and potential policy implications, A Report prepared for the Office of Fair Trading" (2014)

5.1.4 Conclusions on rental impact

Bringing together the above evidence, we estimate the range of rental impacts from MEES in our three archetype models. The lower end of our range is drawn from our econometric results, which suggest that at present there are not current rent premiums for EPC Band E homes in our three archetypes compared to F and G-rated homes. As noted above, this is the lowest end of the range as these findings were based on the current market situation. Regulated MEES would impose a cost on landlords of all EPC Band F and G homes, which may be passed through to tenants to some degree, therefore leading to higher rents in the future. Our high range is drawn from our cost pass-through analysis. Again, we consider this is likely to be at the high end of the range because, if current tenants in EPC Band F and G homes do not place a significant premium on living in an EPC Band E home, then it is unlikely that landlords would be able to pass through more than the cost of the energy efficiency improvements. In fact, it is possible that landlords may not be able to pass through all of these costs (at least initially) especially in areas where there is little growth and excess housing stock.

Figure 24 Estimated range of private sector rental increase by archetype

Archetype	EPC Band	Percentage rent increase	
		Low	High
Detached house in the South West	F to E	0%	0.7%
	G to E	0%	2.9%
Terraced house in the North East	F to E	0%	1.6%
	G to E	0%	6.3%
Flat in London	F to E	0%	0.5%
	G to E	0%	1.9%

Source: Frontier Economics' analysis

Note: Estimates are based on an assumed 20 year lifetime of improvements over which the landlord recovers the investment cost.

5.2 Impact on energy costs

In this section we estimate the impact of improved energy ratings on household energy costs. To do this, we estimate the notional energy use for our archetype homes if they were E-rated, and compare these estimates to our previous estimates for F and G-rated home.

As discussed in Section 3.2, the English Housing Survey provides notional values for household fuel expenditure based on the BRE's Domestic Energy Model (BREDEM 2012). We use this data to generate estimates of annual energy expenditure by EPC band. We then calculate the expected reduction in energy costs from moving from an EPC rating F to E as the difference between the average energy cost in an E-rated dwelling and the average energy cost in an

F-rated dwelling. The same is done to calculate the expected reduction in energy costs from upgrading a G to an E rating.

However, the use of notional estimates rather than actual values may lead to overestimates of energy savings as notional values do not account for individual energy usage behaviour. Households living in fuel poverty tend to under-heat their homes due to budget constraints and high heating costs. Given that energy efficiency improvements reduce the cost of heating a home to a given temperature, it is possible that following the improvements residents will use some of the savings to heat their homes to a higher temperature rather than achieving the modelled energy expenditure savings. This behavioural impact on cost savings is known as 'comfort taking.'

The level to which comfort taking reduces the predicted energy cost savings is influenced by the fuel poverty status of tenants. In line with previous findings, we assume that comfort taking leads to a 15% decrease in predicted energy cost savings for the general population[23]. If we were to focus only on tenants currently living in fuel poverty this decrease would be larger, with DECC finding a decrease as large as 40% of predicted values for tenants in "hard to treat homes in income deprived areas[24]." For the purposes of our analysis we assume a comfort take of 15% in the private rented sector, but note that this comfort take is in itself a benefit of improved energy efficiency.

Figure 25 shows the predicted reduction in energy costs before and after accounting comfort taking.

Figure 25 Energy cost savings before and after comfort taking applied

		Annual energy saving	Reduction in energy saving from comfort taking	Annual energy saving after comfort taking
Detached house in the South West	F to E	£ 774	-£ 116	£ 658
	G to E	£ 1,241	-£ 186	£ 1,055
Terraced house in the North East	F to E	£ 496	-£ 74	£ 422
	G to E	£ 944	-£ 142	£ 802
Flat in London	F to E	£ 409	-£ 61	£ 348
	G to E	£ 847	-£ 127	£ 720

Source: Frontier Economic analysis

Conclusions on energy cost impact

We find that energy efficiency improvements for F and G-rated homes lead to reductions in energy costs of between 23%-38% before accounting for comfort taking. Because these estimates are based on notional values, we account for comfort taking in our model which leads to estimated reductions in energy costs between 20%-33%.

[23] Final Stage Impact Assessment for the Green Deal and Energy Company Obligation, DECC (2012)

[24] Impact Assessment of proposals for implementation of the Community Energy Saving Programme (CESP), DECC (2009)

6 NET BENEFIT CALCULATION FOR TENANTS

The use of multiple methods in calculating the impact of energy efficiency improvements on rental costs allows us to present a range of possible net benefit outcomes for tenants – calculated as the difference between the annual energy bill savings and the annual rent increase.

Our econometric results indicate that there has been no significant rental discount associated with F or G–rated homes. Therefore, using this method we find no rent increase to tenants associated with the energy efficiency improvements. With no rent increase tenants get to keep all of the savings in energy costs, providing the upper bound on the net benefit range.

Because our econometric results are based on historical data from a period when energy efficiency improvements were voluntary, they may not be reflective of the current market. Now that all landlords are compelled to improve their dwellings, they may collectively increase rents to reflect these costs. In this scenario, we would expect a maximum cost pass-through of 100% in a competitive market. Therefore our second method accounts for the situation in which the landlord recovers 100% of the improvement costs through increased rent. This method provides the lower bound of the net benefits to consumers range.

Figure 26 below shows the range of net cash benefits to tenants before accounting for comfort taking. These are the benefits that would accrue to tenants if they were to continue heating their homes to the same temperature after the energy improvements have been undertaken.

Figure 26 Net benefits to tenants of energy efficiency improvements

Archetype	EPC Band	Annual net “cash” benefit	
		Low	High
Detached house in the South West	F to E	£ 682	£ 774
	G to E	£ 895	£ 1,241
Terraced house in the North East	F to E	£ 404	£ 496
	G to E	£ 598	£ 944
Flat in London	F to E	£ 317	£ 409
	G to E	£ 501	£ 847

Source: Frontier Economics analysis

Figure 27 shows the net benefits to tenants after accounting for comfort taking. As discussed above, comfort taking refers to tenants increasing the temperature to which they heat their homes as a result of lower energy costs after improvements have been made. Assuming a 15% decrease in estimated annual energy cost savings, we still find a positive range of net benefits to tenants.

Figure 27 Net benefits to tenants after comfort taking

Archetype	EPC Band	Annual net "cash" benefit	
		Low	High
Detached house in the South West	F to E	£ 566	£ 658
	G to E	£ 709	£ 1,055
Terraced house in the North East	F to E	£ 330	£ 422
	G to E	£ 456	£ 802
Flat in London	F to E	£ 256	£ 348
	G to E	£ 374	£ 720

Source: Frontier Economics analysis

Although comfort taking reduces the estimated annual energy cost savings for tenants, the increased heat in the home provides its own non-cash benefits. The difference between the net benefits to tenants with and without the comfort take is a reflection on the value that tenants place on these additional benefits. These benefits can include:

- Improved physical health;
- Improved mental health;
- Improved general well-being, especially for children and older people.

These benefits are discussed in further detail in Annex B.

7 DISCUSSION OF RESULTS AND POLICY IMPLICATIONS

Our findings suggest that regulations requiring MEES would be, on average, beneficial for private sector tenants in our three archetypes.

Currently, about 6% of private rented sector dwellings are rated below EPC band E; or about 300,000 homes. Tenants of these homes would stand to benefit from such a policy change.

Our findings suggest that the benefits would be largest for tenants for EPC Band G homes. This is because improvements to these homes result in significant savings in energy costs. Tenants of these dwelling are also likely to have larger benefits in relation to healthier and more comfortable homes, especially the fuel poor who are most at risk from under heated homes.

As outlined in Section 1, a significant proportion of tenants living in EPC Band F and G homes are fuel poor. For instance, in 2014, 28.5 per cent of G-rated homes were classed as fuel poor, compared to 19 per cent of E-rated properties and only 2.5 per cent of properties rated C and above[25]. This is primarily driven by the additional heating costs in homes with poor energy efficiency performance.

7.1 Policy options

As noted, our analysis is based on the assumption that MEES regulations would require all landlords to improve their properties to at least an EPC Band E, but that the costs would be capped at £5,000.

Potential other policy options include:

- no cost cap; and
- a cost cap of £3,500.

Therefore, we have considered the implications of these policy options on our findings.

Using these three scenarios, we update our net benefit analysis from Section 5, as summarised below in Figure 28. Note that the policy options only impact our findings at the low end of the net benefit range[26]. As can be seen, the average benefit for tenants in each archetype increases as the cost cap is lowered. This is because the average improvement cost is lower compared to a situation without a cost cap. The trade-off to this finding is that a smaller proportion of homes are improved to an EPC Band E. Under the £5,000 cap options, we estimate that 91% of F and G homes combined would be improved to a minimum EPC Band E. Under the £3,500 cap option we estimate it would be 83% of homes.[27] In other

[25] DECC, 2016, Annual Fuel Poverty Statistics Report

[26] This is because at the high end of the range we assume that there is no impact on rental prices, and therefore the benefit is determined by the average energy savings only. However, while high-end benefit estimates do not change, the number if tenants benefiting will change in each scenario.

[27] Note that the other homes would receive improvements – up to the value of the cost cap – but these improvements would not be sufficient to reach an EPC Band E.

words, approximately 2,400 fewer homes would be improved to an EPC E with a £3,500 cap compared to a £5,000 cap.

Figure 28 Estimated net benefits for tenants by policy scenario

		No cap	£5,000 cap	£3,500 cap
Detached house in the South West	F to E	£671	£ 682	£694
	G to E	£832	£ 895	£961
Terraced house in the North East	F to E	£393	£ 404	£416
	G to E	£535	£ 598	£664
Flat in London	F to E	£306	£ 317	£329
	G to E	£438	£ 501	£567

Source: *Frontier Economics' analysis*

7.2 Impact on supply in private rented sector

We have also considered the potential impact of MEES on the supply of properties in the private rented sector. That is, we consider whether MEES may reduce supply into the private rented sector due to the cost imposition on some landlords of having to make energy efficiency improvements. If supply were to reduce materially, then the impact of lower supply may need to be traded off against the benefits of improved quality in relation to more energy efficient home.

In general, the empirical evidence suggests that the total housing supply is inelastic[28]. That is, the volumes of houses supplied are not very sensitive to changes in price. The UK market has also been found to be less elastic than other markets, such as the USA or Australia[29], perhaps driven by regulatory constraints to the supply of housing.

Previous studies have also found that construction costs have no significant impact on the overall supply of new houses into a market[30]. This is because other market dynamics, such as changes in demand, are likely to be the main driver of changes in the supply of new houses.

However, most of the existing literature relates to the supply of the housing market as a whole, or the supply of new houses into the market. There is less empirical evidence available that relates specifically to the private rented sector.

Nevertheless, there are a number of reasons why MEES may have a limited impact on the aggregate supply of homes in the private rented sector.

- Any impact of MEES on the supply of homes in the private rented sector would likely only be relevant to the existing housing stock. That is because new builds are typically already compliant with the MEES due to modern building regulations and constructions techniques.

[28] Barker, Kate.(2004). "Review of housing supply: Delivering stability: Securing our future housing needs." HM Treasury, London (2004).

[29] Ball, Michael, Geoffrey Meen, and Christian Nygaard.(2009) "Housing supply price elasticities revisited: Evidence from international, national, local and company data." Journal of Housing Economics.

[30] Ball, Michael, Geoffrey Meen, and Christian Nygaard. .(2009) "Housing supply price elasticities revisited: Evidence from international, national, local and company data." Journal of Housing Economics.

- MEES could impose a relatively small capital cost imposition on landlords. As discussed above/below, this cost imposition may be capped at, say, £5,000. This represents a relatively small amount of the total value of a property. For instance, it is 2.4% of the average UK house sale price in 2016.
- Even if landlords incurred cost up to the cap of £5,000 and were unable to pass any of this through to tenants, this would only negatively impact gross yields by between 0.02% and 0.05% for F-rated dwellings, and 0.05% and 0.17% for G-rated dwellings.[31]
- Improved dwelling quality may impact renters' willingness to pay, therefore increasing rent prices, which may **increase** the supply of homes in the private rented sector. As discussed in Section 5, we find that the MEES is likely to have a relatively modest impact on rents in the private rental sector. Therefore, while landlords are likely to be able to recover some of their costs through increased rents, there is unlikely to be a significant increase in demand driving additional supply.
- We note that while MEES may not lead to substantially higher **rental prices**, the improvements in energy efficiency would likely impact on **house values** to a greater extent (as discussed in Section 5). Therefore, improvements in energy efficiency arising from MEES may be capitalised into house values, which landlords would capture in the long-term value of their asset, meaning the incentive to leave the market is dampened further.

Capital constraints have previously been cited as a barrier to energy efficiency improvements. If capital constraints impact on landlords' ability to meet MEES, then it is conceivable that some may choose to leave the market, thereby reducing the overall supply of homes in the private rented sector. We consider that the impact of this could be limited as:

- the cost imposition is relatively small;
- landlords are unlikely to leave the market due to the opportunity cost of lost rent; and
- leaving the market would therefore likely entail selling the property. If a landlord did sell a property, the property would only leave the private rented sector if it was purchased by an owner-occupier. As the private rental sector is increasing as a proportion of the housing stock[32], this suggests that if a landlord did sell a property it may stay within the private rental sector.

Overall, the evidence suggests that the impact of MEES on the supply of homes in the private rental sector is likely to be low. The cost imposition is relatively minor for most dwellings. Also, any modest increase in rental prices may to some degree offset any impact arising from increased costs to landlords. There also appears to be a number of policy options which would further ameliorate any impact on the volume of homes supplied in the private rented sector. These options include the following:

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[31] We calculated this using 2015/16 average rental prices for each of our regions from the Valuations Office Agency and average property prices from the Office of National Statistics, and assume that the £5,000 cost of the energy efficiency is spread over 20 years with a discount rate of 9%.

[32] ONS, 2016, UK Perspectives 2016: Housing and home ownership in the UK

- **Cap on improvement costs**: For example, it has been suggested that landlords costs may be capped at £5,000 in relation to complying with the MEES.
- **Phasing of MEES**: For example, there may be a lead in time before landlords need to comply with the MEES, Therefore, landlords' capital constraints would not be as acute compared to a situation without a sufficient lead in period.

7.3 Implications of our findings for policy design

Our findings have a number of potential impacts for policy design.

- Our analysis suggests that MEES would be total welfare enhancing.
  - The costs of improvements are likely to be outweighed by energy savings costs in our archetype homes. These energy savings are likely to be significant, especially for G-rated homes. Larger detached houses are also likely to see more significant savings.
  - Wider health and happiness benefits are also likely to be significant. This is especially the case for fuel poor homes that may currently be under heating their homes. These benefits are likely to be direct to tenants, but also wider societal benefits such as savings to the NHS.
- However, the extent that landlords will be able fully recoup upfront capital cost immediately through increased rents is unclear. The evidence suggests that rents for E-rated homes are not currently significant higher than for F and G-rated homes, once other factors are controlled for. Therefore, MEES may result in a transfer from landlords to tenants – thereby having some distributional effects
- The evidence suggests that MEES would be unlikely to have a significant distortionary impact on the aggregate supply of homes in the private rented sector. Although, some marginal homes may exit the private rented sector.
- To ameliorate the impact on overall supply from capital constrained landlords being unable to make the necessary improvements consideration could be given to:
  - capping the maximum cost to landlords required for improvements (such as at £5,000 or £3,500); and
  - phasing in the MEES requirements or providing a sufficient lead in time.

We note that our analysis has been undertaken on historical data. Given that energy efficiency may be becoming more prominent in tenants' decisions making over time, consideration could be given to updating this research in the future.

Also, as noted above, we have considered a MEES of EPC Band E. However, future consideration could be given to an improved minimum standard, such as D and C, which would lead to greater energy cost and other savings, although these would have to be weighed against likely higher home improvement costs.

ANNEX A TECHNICAL ANNEX OF ECONOMETRIC ANALYSIS

Our econometric analysis tests whether EPC ratings are associated with a differential in private sector rents. Like previous studies, we use a hedonic price regression and estimate the difference in prices between dwellings with different EPC ratings, holding constant a set of observable characteristics pertaining to the area type, the property characteristics and time.

The data

We use data from the English Housing Survey spanning four consecutive years (2011-2015)[33]. We obtain a sample of 4,889 privately rented dwellings, of which 3,764 pay a market rent. We use this subsample of tenants paying a market rent as our core sample in the rest of the analysis.

The model

The general form of the equation estimated with the econometric model is as follows:

$\text{Log(rent)}=\beta\text{*EE variable}+ \sum\gamma_k\text{*(location controls)}_k + \sum\delta_i \text{*(property characteristics)}_i +\sum\alpha_j \text{*(time controls)}_j + u$

Where:

- Log(rent) is the logarithm of the private sector rent, excluding costs. We use logs as this makes the coefficients results easy to interpret. For example, a one unit change in the number of bedrooms equals a x% change in rental prices;
- Each coefficient (e.g. ß, γ) gives the percentage change in private sector rent from a one unit change in the independent variable (e.g. EPC rating);
- The energy efficiency variable is the main variable of interest as it is its relation to private sector rent that we are testing. We use both EPC rating (A-G) and SAP score (0-100);
- The location controls include:
  - The nine English regions;
  - The type of area: urban/town and fringe/village/hamlets and isolated dwellings;
  - The neighbourhood's IMD (Index of Multiple Deprivation) decile;
  - The appearance of the area as rated by the surveyor: satisfactory/with some problems/poor; and

[33] More specifically, we use the Physical survey of the EHS 2011/12 and the EHS 2013/2014. The EHS Physical Survey always groups together data from 2 consecutive years, hence the combined dataset spans 4 years. More detail on the data used can be found on the UK Data service website:: https://discover.ukdataservice.ac.uk/series/?sn=200010

- The property characteristics include:
  - The dwelling type: small/medium terraced house/semi-detached house/detached house/bungalow/converted flat/ low rise purpose built flat/ high rise purpose built flat
  - The dwelling age;
  - The number of bedrooms;
  - The surface of the dwelling; and
- The time controls include:
  - The length of residency; and
  - The year of the survey.
- u is the error term which contains everything we cannot control for.

We estimate this equation for two different samples:

1. All the privately rented houses subject to a market rent.
2. All the privately rented flats subject to a market rent.

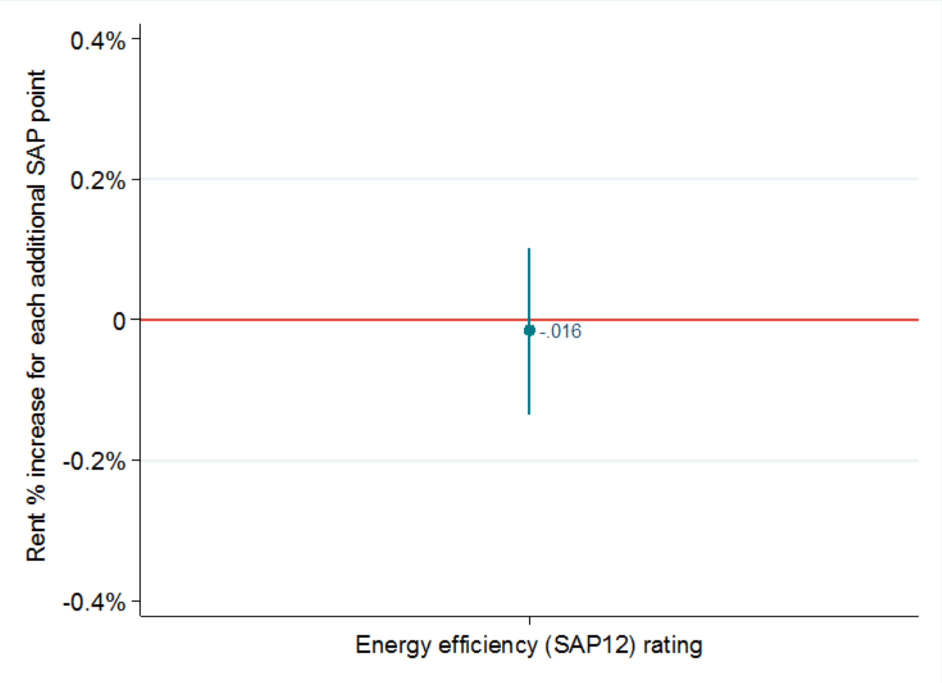
In addition, we estimate an equation for flats where the SAP score effect can vary with the flat location, more specifically whether the flat is in London or not. Indeed, there are good reasons to believe that flats located in London may exhibit different pricing patterns compared to flats elsewhere. The equation estimated is as follows:

$$\text{Log(rent)} = \beta^* \text{ EE variable*london} + \sum \gamma_k \text{*(location controls)}_k + \sum \delta_i \text{*(property characteristics)}_i + u$$

The results

Figure 29 presents the magnitude (blue dot) and 95% confidence interval (blue line) of the estimated coefficient for the rent increase of houses. It shows that for houses, holding everything else constant, an additional SAP point is not associated with a higher rent.

Figure 29 Rent percent increase for each additional SAP point, houses only



Source: Frontier Economics using EHS data

The results differ when we estimate the same equation for flats, as shown in Figure 30 below. These results suggest, with a 95% confidence interval, that there is a significant positive effect of increasing SAP score on rents, and this effect is estimated to be 0.18% holding everything else constant.

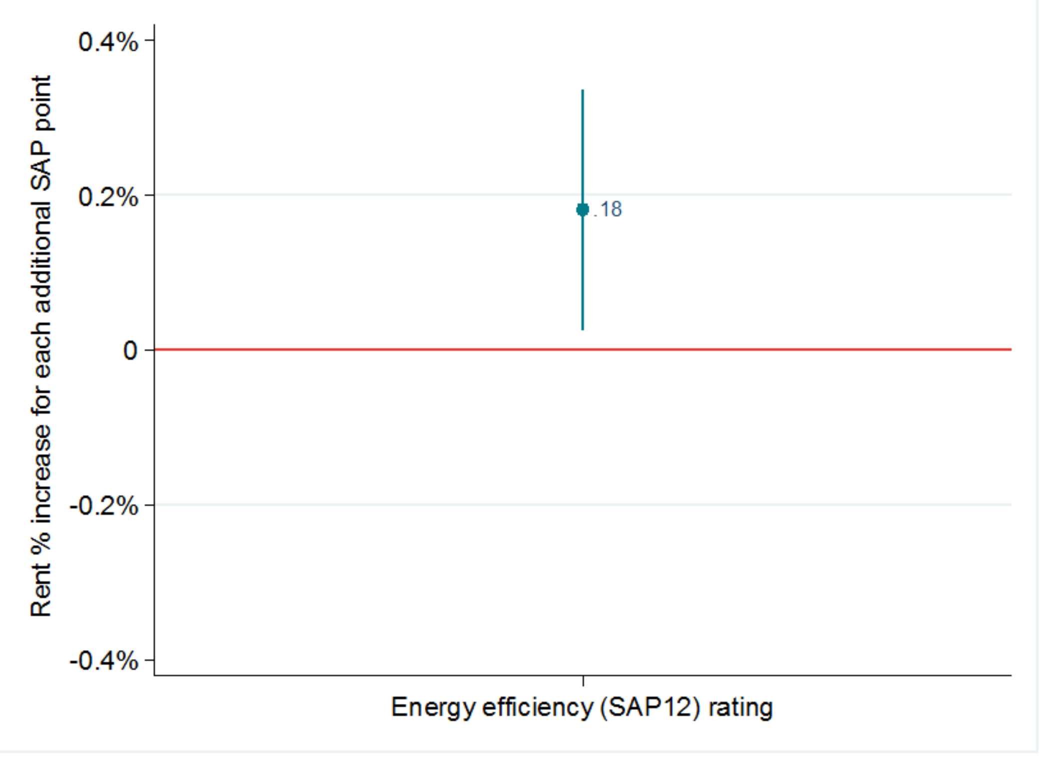
As an average E-rated flat has a SAP score of 48, an average F-rated flat a SAP score of 32, and an average G-rated flat a SAP score of 12, his implies a 3.2% discount for a F-rated dwelling compared to a E-rated dwelling, and a 7.4% discount for a G-rated dwelling compared to an E-rated dwelling.

Turning to the second equation, Figure 31 shows the effect of an increase in the SAP score for an average flat located in London decomposed into 1) to the left, the mere % price effect of an increase in SAP score, and 2) the additional % price effect of an increase in SAP score **when the dwelling is located in London.** These two effects are added together when considering a flat in London, which in this case gives a total effect not significantly different from zero. This means that the effect found in Figure 35 is driven by a 0-effect for London flats, and an effect of 0.24% for non-London flats.

This result is not surprising compared to previous findings. Indeed, in a DECC report looking at sales prices in England and Wales, Fuerst et al (2013) find that the effect of EPC rating is much higher in the North than in London and the South and mention two possible explanations:

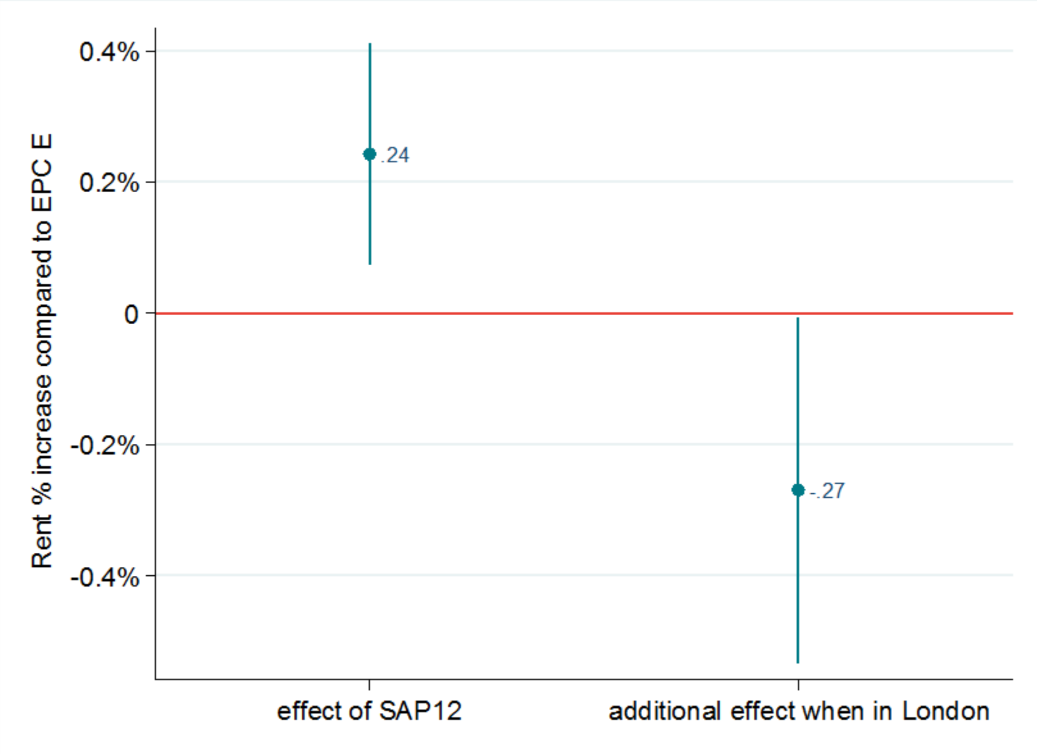
- The capitalisation of a fixed amount of annual energy savings makes for a smaller fraction of the total rental value in high-rent regions compared to lower-rent regions.
- The shortage in housing supply in London may make people more concerned about important characteristics like location within London rather than energy efficiency characteristics.

Figure 30 Rent percent increase for each additional SAP point, flats only



Source: Frontier Economics using EHS data

Figure 31 Rent percent increase for each additional SAP point, flat in London



Source: Frontier Economics using EHS data

Figure 32 shows the three regression tables, displaying not only the coefficient associated with the energy efficiency rating, but also the coefficients associated with the control variables. For each categorical variable, one of the values is ”base” category and the coefficient associated with the other values reflects the relative percentage difference in price between the base category value and the other values. For example, the coefficient associated with the North West region estimates the relative price different for an average dwelling located in the North West compared to the North East (which is the ”base” category).

Figure 32 Energy efficiency impact on PRS regression output

	(1)	(2)	(3)
DEPENDENT VARIABLE	log (rent)	log (rent)	log (rent)
SAMPLE	houses only	flats only	flats only
CORRESPONDING FIGURE	Figure 34	Figure 35	Figure 36
Energy efficiency (SAP12) rating	**-0.000159**	**0.00181****	**0.00242*****
	(0.000602)	(0.000794)	(0.000859)
Dwelling is in London = 1			1.029***
			(0.0966)
sap12 rating * dwelling is in London			**-0.00270****
			(0.00134)
Location controls			

Region = North East	base	base	base
Region = North West	0.0398	0.122**	0.122**
	(0.0243)	(0.0489)	(0.0488)
Region = Yorkshire and the Humber	-0.00154	0.0735	0.0729
	(0.0259)	(0.0520)	(0.0521)
Region = East Midlands	0.00527	0.00804	0.00917
	(0.0269)	(0.0633)	(0.0634)
Region = West Midlands	0.0985***	0.158***	0.159***
	(0.0256)	(0.0555)	(0.0555)
Region = East	0.238***	0.349***	0.350***
	(0.0280)	(0.0479)	(0.0479)
Region = London	0.839***	0.859***	
	(0.0298)	(0.0456)	
Region = South East	0.421***	0.438***	0.440***
	(0.0280)	(0.0484)	(0.0484)
Region = South West	0.212***	0.278***	0.279***
	(0.0284)	(0.0484)	(0.0484)
Rurality - morphology = urban	base	base	base
Rurality - morphology = town and fringe	-0.107***	-0.136***	-0.134***
	(0.0208)	(0.0339)	(0.0338)
Rurality - morphology = village	-0.104***	-0.00618	-0.00362
	(0.0279)	(0.0717)	(0.0714)
Rurality - morphology = hamlets and isolated dwellings	-0.0540	-0.102	-0.0975
	(0.0382)	(0.129)	(0.126)
1st IMD 2010 decile (most deprived)	base	base	base
2nd IMD 2010 decile	0.0254	0.00406	0.00538
	(0.0225)	(0.0299)	(0.0300)
3rd IMD 2010 decile	0.0977***	0.00630	0.00585
	(0.0252)	(0.0323)	(0.0324)
4th IMD 2010 decile	0.135***	0.0528*	0.0556*
	(0.0258)	(0.0314)	(0.0314)
5th IMD 2010 decile	0.122***	0.0522	0.0535
	(0.0275)	(0.0330)	(0.0332)
6th IMD 2010 decile	0.137***	0.0614*	0.0600*
	(0.0309)	(0.0358)	(0.0359)
7th IMD 2010 decile	0.178***	0.0791*	0.0811*
	(0.0267)	(0.0429)	(0.0428)
8th IMD 2010 decile	0.178***	0.106***	0.105***
	(0.0271)	(0.0394)	(0.0398)
9th IMD 2010 decile	0.230***	0.0954**	0.0942**
	(0.0322)	(0.0388)	(0.0386)
10th IMD 2010 decile (least deprived)	0.291***	0.172***	0.171***
	(0.0298)	(0.0386)	(0.0387)
Appearance of area = 1, satisfactory	base	base	base
Appearance of area = 2, some problems	-0.0295*	-0.0677***	-0.0684***
	(0.0169)	(0.0215)	(0.0214)
Appearance of area = 3, poor	-0.0616*	-0.0797	-0.0754

	(0.0340)	(0.0508)	(0.0507)
Property characteristics			
Small terraced house	base	base	base
Medium/large terraced house	0.00295		
	(0.0183)		
Semi-detached house	0.0122		
	(0.0172)		
Detached house	0.0826***		
	(0.0288)		
Bungalow	0.0669**		
	(0.0283)		
Converted flat		base	base
Purpose built flat, low rise		0.0839**	0.0835**
		(0.0331)	(0.0329)
Purpose built flat, high rise		0.245***	0.254***
		(0.0457)	(0.0454)
Dwelling age = pre 1850	base	base	base
Dwelling age = 1850 to 1899	-0.0369	0.0390	0.0305
	(0.0396)	(0.0645)	(0.0643)
Dwelling age = 1900 to 1918	-0.0530	-0.0577	-0.0630
	(0.0409)	(0.0675)	(0.0671)
Dwelling age = 1919 to 1944	-0.0343	-0.0768	-0.0878
	(0.0415)	(0.0681)	(0.0679)
Dwelling age = 1945 to 1964	-0.0212	-0.148**	-0.154**
	(0.0411)	(0.0712)	(0.0709)
Dwelling age = 1965 to 1974	-0.0348	-0.130*	-0.136*
	(0.0433)	(0.0707)	(0.0704)
Dwelling age = 1975 to 1980	-0.0212	-0.119*	-0.121*
	(0.0466)	(0.0720)	(0.0716)
Dwelling age = 1981 to 1990	-0.0412	-0.134*	-0.140*
	(0.0440)	(0.0754)	(0.0750)
Dwelling age = 9, post 1990	0.0280	-0.0693	-0.0767
	(0.0407)	(0.0711)	(0.0709)
1 bedroom	base	base	base
2 bedrooms	0.306***	0.188***	0.187***
	(0.0436)	(0.0237)	(0.0235)
3 bedrooms	0.407***	0.289***	0.285***
	(0.0474)	(0.0497)	(0.0493)
4 bedrooms	0.613***	0.345**	0.338*
	(0.0580)	(0.174)	(0.175)
5 bedrooms	0.771***	0.936***	0.925***
	(0.0895)	(0.244)	(0.242)
6 bedrooms	0.481***	1.531***	1.522***
	(0.164)	(0.0919)	(0.0915)
7 bedrooms	0.365***		
	(0.0656)		
8 bedrooms	1.781***		
	(0.0856)		
Useable floor area (sqm)	0.00125**	0.00153*	0.00162*

	*		
	(0.000424)	(0.000932)	(0.000923)
Time controls			
Length of residence = less than one year	base	base	base
Length of residence = one year	-0.0266*	-0.0167	-0.0167
	(0.0159)	(0.0224)	(0.0224)
Length of residence = two years	-0.0562***	-0.0357	-0.0392
	(0.0183)	(0.0256)	(0.0255)
Length of residence = 3-4 years	-0.0663***	-0.0376	-0.0375
	(0.0174)	(0.0257)	(0.0256)
Length of residence = 5-9 years	-0.110***	-0.116***	-0.116***
	(0.0196)	(0.0258)	(0.0258)
Length of residence = 10-19 years	-0.193***	-0.191***	-0.191***
	(0.0315)	(0.0492)	(0.0494)
Length of residence = 20-29 years	-0.254**	-0.303***	-0.308***
	(0.101)	(0.103)	(0.103)
Length of residence = 30+ years	-0.463***	-0.344**	-0.345**
	(0.0658)	(0.159)	(0.158)
year surveyed= 2011/12	base	base	base
year surveyed= 2012/13	-0.00207	-0.0117	-0.0112
	(0.0171)	(0.0239)	(0.0239)
year surveyed= 2013/14	0.0627***	0.0116	0.0122
	(0.0169)	(0.0223)	(0.0223)
year surveyed= 2014/15	0.0714***	0.0587***	0.0610***
	(0.0156)	(0.0194)	(0.0194)
Constant	4.257***	4.271***	4.234***
	(0.0710)	(0.0956)	(0.0977)
Observations	2,383	1,357	1,357
R-squared	0.616	0.627	0.628

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Frontier Economics using EHS data

Note: The coefficients in red and bold are the ones reported in Figures 29, 30 and 31

ANNEX B WIDER BENEFITS

Our quantitative analysis estimates the financial impacts on tenants from energy efficiency standards – namely energy cost savings and increased rents. However, it is also important to consider wider impacts on tenants. These benefits typically cannot be modelled directly, although the difference between the net benefits with and without the comfort take are a reflection on how tenants value these wider benefits.

We have drawn upon the existing literature to identify potential tenant benefits from more energy efficient homes. These wider benefits are primarily linked to improved physical and mental health as well as general well-being.

A.1 Evidence on physical health impacts

As evidenced in Figure 2, Section 1, those that live in poorly insulated homes are more likely to be in fuel poverty. Fuel poverty is in turn linked to lower temperatures at home, especially during the winter heating season[34]. There is a strong body of evidence linking under-heating to health issues. In particular, cold homes can lead to cardiovascular and respiratory diseases, as shown in the Hills Poverty Review[35].

COLD HOMES CAN LEAD TO CARDIOVASCULAR AND RESPIRATORY PROBLEMS

Exposure to cold temperatures can have negative impacts on health, primarily for older people and the very young. Health impacts caused by exposure to cold tend to relate to cardiovascular and respiratory problems. Low temperatures are also associated with diminished resistance to infections and the incidence of damp and mould in the home, which are associated with respiratory problems."

(Hills, John, 2011, "Fuel poverty: the problem and its measurement", CASEreport, 69. DECC)

These problems result in excess deaths in winter each year. In England and Wales around 30,000 more people die in winter than in the summer, of which over 80% are over the age of 75[36]. According to ACE[37], about one third of these excess winter deaths can be attributed to the cold (ACE, 2015). This could explain why historically, excess winter deaths have been higher in England and Wales compared to countries in continental Europe and Scandinavia, despite the UK's relatively mild winters. (Wilkinson 2001).

These health benefits could be monetised in terms of the avoided costs to the NHS, as done in previous research[38]. However, these benefits overlap with the

[34] DECC, 2016, "ECO: Help to Heat – Transitioning to a New Fuel Poverty Focused Obligation, consultation stage impact assessment"

[35] Hills, John, 2011, "Fuel poverty: the problem and its measurement", CASE report, 69. DECC

[36] ONS 2015

[37] ACE, 2015, "The Cold Man of Europe"

[38] Frontier Economics, 2014, "Assessing the social and economic impact of affordable housing investment"

energy cost savings benefits. Those households living in poorly insulated homes, who tend to under heat their homes and suffer from cold temperatures, would have lower energy savings benefits accruing from an EPC upgrade, and more health benefits. On the other hand, the households living in poorly insulated homes who tend to keep their homes warm despite high energy costs would have higher benefits in terms of energy savings and lower health benefits. Given this overlap there is a risk of double counting if health benefits are monetised and added to the monetary benefits from energy saving.

A.2 Evidence on mental health impacts

Living in a poorly insulated home can also affect mental well-being: evidence show that living in cold and damp housing contributes to a variety of different mental health stressors, including persistent worry about debt and affordability, thermal discomfort, and worry about the consequences of cold and damp for health.

In addition, a meta-study summarizing research on the impact of energy efficiency improvement on mental health reports that 16 out of 25 studies find a positive association between the two[39].

A.3 Evidence on general well-being impacts

Survey data from the Office for National Statistics indicates a correlation between satisfaction with living accommodation and life satisfaction, although causality is difficult to establish. Of those who report a low satisfaction with their accommodation, nearly half also report a low satisfaction with their life[40]. This relationship underlines the importance of improving dwelling quality, for example through energy efficiency improvements.

While all tenants can benefit from increased satisfaction with living accommodation, the well-being of children and older people is particularly impacted.

Children

Energy efficiency improvements have the ability to improve children's school performance. The first path through which it can impact school performance is through decreasing absenteeism. A study in New Zealand found that children living in homes where energy efficiency improvements have been made take 15% fewer days away from the classroom than the control group who had no measures installed[41]. Additionally, studies of children with asthma have shown that improved heating and ventilation in the home lead to reduced asthma related school absences in the winter[42]. If the time a child needs to take off school due to illnesses related to living in cold or damp conditions decreases after

[39] Lidell & Guiney,2015, "Living in a cold and damp home: frameworks for understanding impacts on mental well-being", Public Health

[40] Frontier Economics "Assessing the social and economic impact of affordable housing investment" (2014)

[41] Liddell, C. "The impact of Fuel Poverty on Children" University of Ulster (2011)

[42] Housing and Health Research Programme, "More effective home heating reduces school absences for children with asthma," (2009)

improvements are made there may be significant positive effects on children's long-term educational attainment.

Secondly, children and young adult's learning can be negatively impacted if they do not have a warm and comfortable place to do school work. The National Centre for Social Research found that 10% of children who have lived in inadequately heated housing for 3-5 years reported that they do not have a quiet place in the home to do their homework, compared to only 4% for children who do not face heating issues at home[43]. If energy efficiency improvements allow families to affordably heat more rooms of the home, this effectively increases the space available to the family. This can provide more comfortable spaces for homework and other activities[44]. Because of the long-term impact of cold homes on children's educational attainment and chances of success a preventative approach is needed.

Lastly, by making fuel costs more affordable, a "heat or eat" situation can be avoided. A 2011 survey undertaken by Save the Children found that 45% of respondent families considered rationing food in winter in order to pay their energy costs[45]. They also find that 59% of respondent parents are being forced to cut back on other essentials in order to afford their winter energy costs. By reducing the burden of energy costs, energy efficiency improvements can help to eliminate these difficult choices and lead to positive well-being impacts for both adults and children.

Older people

As discussed above, older people are particularly vulnerable to the physical health risks associated with living in cold homes. This can be worsened by self-imposed social isolation resulting from a reluctance to invite friends and family into their home due to embarrassment about cold temperatures or mould. Energy efficiency improvements can alleviate these issues and increase an individual's pride in their home, enabling vulnerable groups such as the elderly to maintain a higher level of social integration.

[43] Barnes M et al, "The Dynamics of Bad Housing: The Impacts of Bad Housing on the Living Standards of Children" National Centre for Social Research (2008)

[44] Downey, F et al, "Capturing the "multiple benefits" of energy efficiency in practice: the UK example" Energy Saving Trust (2015)

[45] "Rising Energy Costs: The Impact on Low-Income Families," Save the Children (2011)

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