UK Government

# RAF079/1718: Evaluation of the Domestic Private Rented Sector Minimum Energy Efficiency Standard Regulations

## Technical annex: Final impact evaluation

Department for Energy Security and Net Zero (2026)

# Contents

# Executive summary

## Introduction

This technical report covers the impact evaluation for The Energy Efficiency (Private Rented Property) (England and Wales) (Amendment) Regulations 2016, which established a minimum level of energy efficiency for privately rented property in England and Wales. The regulations for the domestic properties, which are the focus of this report, were passed by the Parliament in March 2015 and came into force for new and renewed tenancies in April 2018, and for all tenancies in April 2020. The regulations target the most inefficient properties, namely those with an Energy Performance Certificate (EPC) rate of F or G. The EPCs are certificates indicating the energy efficiency of domestic and non-domestic properties through a standard A-G labelling system with A being the most efficient properties and G the least efficient ones. The regulations require landlords of domestic properties that have an EPC rate of F or G to improve them to a minimum of E or register for an exemption, if entitled to do so. Non-compliance can result in a fine of up to £5,000 for the landlord. Local authorities in England and Wales are responsible for enforcing compliance with the regulations.

## Aims of the analysis

The impact assessment described in this report focuses on the analysis of 1) the compliance with the regulations; 2) their impact on the energy efficiency of the affected properties, as measured by the ‘Standard Assessment Procedure’ (SAP) rate included in the EPCs, the energy costs, and the CO2 emissions as measured by the ‘Environmental Impact’ (EI) rate; 3) their impact on the propensity of properties affected by regulation to apply for a second EPC when a valid certificate was in place; 4) the wider health benefits of the regulations. The analysis of compliance assesses the overall compliance with the regulations and the extent to which compliance rates differ across residential units with different characteristics, including energy efficiency changes. With regard to the impact of the regulations on energy efficiency, analysis discussed in this report allows an estimate of whether the introduction of the regulations has had an impact of the likelihood of a residential unit attaining the minimum EPC rate amongst a sub-sample of private rented sector (PRS) properties, as compared to a control group. In the case of energy efficiency and CO2 emissions, one can also assess the average increase in the SAP and EI score for the sub-sample which can be attributed to the regulations and then resulting reduction in annual energy costs and CO2 emissions. The propensity of properties affected by the regulations to apply for a second EPC is also used in this study to measure the impact on the likelihood of implementing of energy efficiency upgrades in private rental properties.

# Data sources used in the evaluation

Both the analysis of compliance and the assessment of the impact of regulations on energy efficiency heavily rely on the national EPC dataset as the main data source. EPCs have been mandated for rental properties since 1st of October 2008, with each certificate valid up to 10 years.

For the compliance analysis, all EPCs issued since the mandated year (i.e. 2008) are used for the purpose of determining eligible PRS properties. All EPCs issued after 2012 were used for identifying both the most recent and previous EPC (where available).

For the impact analysis only EPCs issued after 01/04/2016 have been used in the analysis reported here. Data on exempted properties is also used in the study, e.g. to discard these properties from the treated group when assessing the impact of the regulations on energy efficiency. In order to assess the change in the level of efficiency of residential units across time, only units with at least two EPC were used. Assessment of the policy is complicated by the fact that a number of changes in the algorithm used to produce the EPCs were introduced during the timespan used in the study affecting the SAP and EI rates for the properties being assessed. This impact manifests itself in both the properties affected by the regulations and those not being affected so that the impact cancels out when one looks at the impact of the regulations in the properties being affected, compared to those not being affected.

# Compliance with the regulations

As of August 2023, 95.7% of the 4,021,488 PRS properties with a current EPC are meeting the required standards. This is reflected in the decrease of properties rated at the lowest EPC levels, F and G, to 204,018. To achieve compliance, landlords have predominantly undertaken improvements focusing on fabric insulation and low-energy (low-e) lighting (50%), as well as a combination of fabric insulation, main heating upgrades, and low-e lighting (25%). This data underscores a gradual improvement in energy efficiency within the PRS, driven by specific retrofitting measures and a decrease in the issuance of low-rated EPCs.

# Estimates of the impact of the regulations on energy efficiency

This evaluation found that, for a sub-sample of properties with an EPC registered both before and after their introduction, the regulations have had a statistically significant impact on the energy efficiency of private rental sector properties. This has been observed both in terms of the odds of achieving an EPC rated E or above, and in terms of the increase in the SAP rate. The sub-sample of properties affected by the regulation in the EPC dataset used in this study were found to display an increase of 1.1 SAP points in their SAP rate compared to properties not affected by the regulations.

The impact of the regulations on energy efficiency was also assessed on the SAP and EI rates of the sub-sample of properties. The SAP is the only official, government approved system for assessing the energy rate for a home. Being indexed between 1 and 100, the SAP allows the comparison of energy performance of different homes. The higher the SAP rate, the higher the energy efficiency of a home. The EPC labels are created based on the underling SAP rate. The EI rate follows a similar logic and also ranges between 1 and 100, with higher rates implying lower CO2 emissions. The impact of the regulations on the energy efficiency of private rental properties in the sub-sample has been estimated to be 1.1 SAP points, while the impact on the EI rate has been estimated to be 6.9 points.

The impact of the regulations on energy costs implies an average reduction of £67 per property in annual energy costs, in the case of the properties contained in then EPC dataset used in this study. In terms of CO2 emissions, the regulations delivered average annual savings of 1,176 kg CO2 per year per property in the properties comprised in the sub-sample.

In addition, this evaluation found that the introduction of the regulations may have been a factor incentivising landlords of PRS properties in England and Wales with an F or G rated EPC to make energy efficiency improvements and apply for a second EPC within the 10 years' validity of the existing certificate. Between April 2018 and April 2020, the share of PRS properties in England and Wales that applied for a second EPC increased by 20.5 percentage point, however the equivalent share of PRS properties in Scotland only increased by 6.5 percentage points. This shows that the regulations are likely to have played a role in increasing the propensity of landlords to make energy efficiency improvements.

## Potential health impacts of the regulations

Health Impact Assessment (HIA) modelling was used to evaluate the potential health benefits of energy efficiency measures introduced under the Private Rented Sector (PRS) Minimum Energy Efficiency Standard (MEES). The objective of the analysis was to quantify the health improvements that could arise from the installation of energy efficiency measures, with a focus on reducing heating costs, enhancing thermal comfort, and potentially decreasing health-related issues and their associated costs to health services.

The HIA modelling provides an indicative estimate of the health impacts of upgrading residential properties from an EPC rating of F or G to a higher rating of E, and in some cases, to D or above. The assessment provides an estimate of the incremental health benefits relative to a baseline scenario of no improvement in EPC ratings. The benefits are considered for the population as a whole rather than for individual cases.

Using the Health Impact of Domestic Energy Efficiency Measures (HIDEEM) model, developed for DESNZ (formerly BEIS), and leveraging data from the 2017/18 English Housing Survey, the analysis estimates the impact of related MEES energy efficiency interventions on indoor environmental conditions and, consequently, the health of occupants.

The HIA modelling, spanning both short-term (5 years) and medium-term (10 years) periods, shows a modest increase in wintertime indoor temperatures, as a result of fabric and heating system measures. This improvement in temperatures is shown to correspond with a modest yet positive impact on health, as evidenced by the increase in Quality Adjusted Life Years (QALYs) - approximately 1,046 QALYs over 5 years and 2,151 QALYs over 10 years. This improvement in health is not only beneficial to the individuals within these households but also has a broader societal benefit in terms of reduced health sector spending on temperature-related diseases, estimated at around £1 million over 5 years and £2.1 million over 10 years.

The analysis highlights the potential for the regulations to contribute positively to the health and well-being of participating households. By improving indoor environmental conditions, the regulations not only enhance the comfort and living conditions of households but also contribute to a reduction in the risk of mould growth, a known factor in various respiratory and other health issues.

# 1 Introduction

## 1.1 The minimum energy efficiency standard (MEES) regulations for the private rented sector (PRS)

The 2015 amendment to the Energy Efficiency (Private Rented Property) Regulations in England and Wales sets a baseline for energy efficiency in private rental properties. This regulation applies to both residential and commercial properties, but this report concentrates on residential properties.

The regulations specific to the domestic private rented sector (PRS) apply to properties leased under certain tenancies, including assured, regulated, and domestic agricultural tenancies. The focus of the regulations is on the least energy-efficient properties, identified by Energy Performance Certificate (EPC) ratings of F or G. Under the regulations, landlords of domestic properties with an EPC rating of F or G must either upgrade their properties to at least an E rating or register for an exemption if they are eligible. The process leading to the regulations began with a consultation in 2014-2015, culminating in their passage by Parliament in March 2015.

The regulations come into force for new tenancies in April 2018 and were extended to cover all tenancies, including existing tenancies, in April 2020. Landlords with properties rated F or G have the option to seek an exemption from these regulations based on specific criteria such as ‘High cost’, ‘All improvements made’, ‘Wall insulation’, ‘Consent’, ‘Devaluation’ and ‘New landlord’. Failure to comply with the regulations can lead to a fine of up to £5,000 per property for the landlord. Local authorities in England and Wales have the responsibility of ensuring compliance with the regulations.

## 1.2 The aims of the impact evaluation

This report concentrates on evaluating compliance with the regulations and their effect on the energy efficiency of the impacted properties. This is determined by analysing the Standard Assessment Procedure (SAP) rate found in the Energy Performance Certificates (EPCs) associated with these properties. The compliance analysis is designed to gauge the overall adherence to the regulations. It specifically addresses the key evaluation question:

- **What is the proportion of landlords/properties that have complied with the regulations?**

The evaluation question regarding compliance (see further details in Chapter 3) can be approached by examining the proportion of private rental sector properties in compliance as determined through the national EPC database. The specific ownership details of a given residential unit remain unknown due to a lack of a database of landlords and therefore the EPC database is a means of potential tenancy and also the issued energy performance level. Consequently, in this evaluation, it's not feasible to make definitive judgments about the behaviour of various landlords. On a more constructive note, the analysis can explore how compliance rates vary among residential units with differing characteristics. This approach allows for addressing the following evaluation questions:

- **Under what circumstances does compliance fail to occur?**
- **What are the impacts of the regulations in the upgraded properties in terms of carbon emissions, energy usage, and cost?**

The quasi-experimental analysis in this report (see Chapter 4) evaluates the impact of the regulations on the energy efficiency of residential units. It estimates the effect of the regulations on the likelihood of a residential unit achieving at least the minimum EPC rating, compared to a control group (Scottish residential buildings). Additionally, the report describes the findings from the analysis assessing the average increase in the Standard Assessment Procedure (SAP) rate which can be attributed to the implementation of the regulations and on the Environmental Impact (EI) rates (see Chapter 4). These insights help quantify the impact of the regulations on energy costs and CO2 emissions.

The results, based on the sub-sample of PRS properties with an EPC registered both before and after the introduction of the regulations, indicate the regulations have enhanced the likelihood of properties meeting energy standards, with regulated properties being over three times more likely to achieve an E or higher EPC rating compared to unregulated ones. These properties also see an increase in SAP ratings and enjoy notable reductions in energy costs and CO2 emissions, with average annual savings of £67 and 1,176kg of CO2 per property, respectively.

This report is structured as follows:

- Chapter 2 describes the data sources and the methodology used in the evaluation to investigate the compliance with the regulations and their impact on energy efficiency, energy costs and CO2 emissions.
- Chapter 3 presents the results arising from the analysis of compliance.
- Chapter 4 presents the results related to energy efficiency, energy costs and CO2 emission.
- Chapter 5 focuses on the health impacts of the regulations, presenting both the methodology used in the analysis and the results.
- Chapter 6 concludes.

# 2 Impact evaluation methodology

The feasibility of the timelines and methodological approaches adopted in the impact evaluation were examined in two scoping analyses. To clarify, the first scoping analysis was performed in 2020 before the interim impact evaluation while the second scoping analysis was implemented in 2023 to inform the final impact evaluation discussed in this report.

## First scoping analysis

The first scoping analysis investigated: 1) the practicality of utilising the Energy Performance Certificate (EPC) datasets as the basis for sampling both the treatment and control groups in the Quasi Experimental Assessment (QEA); 2) the feasibility of matching EPC addresses to the list of exempted properties; and 3) the potential to identify privately rented properties using the data within the EPC dataset.

This scoping analysis was instrumental in refining the selection of methodological approaches for estimating the impact of the regulations on energy efficiency. This activity recommended a methodological centred on the difference-in-differences (DiD) for the first impact evaluation report. Three distinct treated groups were identified for the analysis: 'established private rental properties', 'recent private rental properties', and a cumulative group called ‘private rental properties’. The first group consists of private rental properties that were F or G before the regulations; the second group consist of properties that were F or G before the regulations but were classified as privately rented only after the regulations were introduced, while the last group is a combination of the first two. These treatment groups were chosen in the first scoping analysis to explore robustness of the impact evaluation, and asses any difference in the results based on the length of time properties were imputed to be part of the PRS market. The control group recommended by the scoping analysis comprised Scottish buildings rated F and G before the introduction of the regulations, irrespective of their tenure type.

Following these recommendations, the first impact evaluation report analysed the impact of the regulations on five variables: the Standard Assessment (SAP) score, a binary variable indicating whether a property met the minimum EPC band E standard, energy costs, which are the average costs of utilities consumed in the home, including water, gas and electricity costs as defined by Building Research Establishment (BRE), the Environmental Impact (EI) score and CO2 emissions. Results indicated a significant positive impact of the regulations on the energy efficiency, energy costs and environmental impact in private rentals, as well as CO2 emissions. However, discrepancies in property types between the treated and control groups (notably, bungalows in Scottish datasets) highlighted the need to explore whether the different composition of the treated and the control groups had any bearing on the results from the analysis, which has been tackled by using the entropy balancing method.

## Second scoping analysis

Stemming from the first impact evaluation report, a second scoping analysis was implemented to assess the appropriateness of the Scottish control group in terms of its similarity to treated groups, and the possibility of using the English Housing Survey (EHS) in the quasi-experimental element of the evaluation, as it would offer a sample representative of the English and Welsh housing stock. With regard to the former, the second scoping analysis put forward a two-step process involving balancing pre-treatment characteristics of control and treated group through the entropy balancing method (Hainmueller 2012), and implementing panel DiD regression on the adjusted dataset. The aim of the process is to weigh the units in the control group based on the composition of the treated group so that any observed effects can be more confidently attributed to the regulations.

With regard to the feasibility of using the EHS for QEA, the second scoping analysis pointed out that the structure of the EHS as a repeated cross-sectional survey, without longitudinal continuity which limited its utility for the required panel DiD analysis. Additionally, the inability to merge EHS data with the PRS Exemptions Register, due to missing identifiers like Unique Property Reference Number (UPRN) or postcode, further complicated its use in evaluating impact at the property level. Consequently, the EHS was deemed unfeasible for this specific purpose.

## Additional analysis

The importance of incorporating a two-sided analysis of the impact of the regulations became clearer during the evaluation. The DiD described in detail in Section 2.3 was deployed to measure the extent to which energy efficiency is raised, in relation to a sub-sample of properties satisfying specific requirements for having an EPC registered both before and after the introduction of the regulations. However, the regulations are likely to have affected the propensity of landlords of all affected PRS properties to make energy efficiency improvements - including those outside this sub-sample.

As it became important to complement the results from the DiD with analysis exploring the propensity for energy efficiency upgrades to be made additional scoping analysis in the final stage of the evaluation formulated the following approach:

- Identifying PRS properties which received an F or G grade ahead of the introduction of the regulations;
- Computing the share of these properties applying for a second EPC certificate while the first certificate was valid;
- Creating a baseline describing how this share evolved across time well in advance of the introduction the regulations;
- Exploring the way in which the behaviour of this share changed at key policy dates, such as the introduction of the regulations.

It was also decided to compute the share described above for a number of comparison groups to assess the extent to which any change in the behaviour of the computed share in the properties affected by the regulations could be attributed to the regulations. Properties applying for an EPC in 2013 and 2014 were selected for this analysis as they offered a 3-year span (2015, 2016 and 2017) over which they could have applied for a second EPC with relatively minor influence from the forthcoming regulations.

## 2.1 Data sources used in the evaluation

This evaluation continued to use the data sources employed in the first impact evaluation. EPC data were sourced from the Energy Performance Certificate (EPC) registries for England and Wales, accessible at Energy Performance of Buildings Data England and Wales (opendatacommunities.org), and for Scotland, available at Home (scottishepcregister.org.uk). These registries provide detailed information on the energy performance of properties. The other source is a dataset managed by DESNZ detailing rental properties that have been granted an exemption from the regulations. These databases collectively form the foundation of the data used for the evaluation and are summarised in Table 1.

**Table 1: Summary of data sources**

| Data source | Time frame | Total number of observations | Number of observations from 2016 to 2023 | Total number of variables |
|---|---|---|---|---|
| English and Wales EPC Database | January 2008 to September 2023 | 25,034,445 | **11,546,396** | 169 |
| Scottish EPC Register | January 2014 to September 2023 | 3,156,521 | 9,054 | 498 |
| Exemptions Register | March 2017 to September 2023 | 17,005 | 7,248 | 50 |

### 2.1.1 Energy Performance Certificate data

The scoping research for assessing the impact of the regulations focused on the use of the England and Wales EPC dataset as a primary source for sampling. The EPC dataset was chosen for both the treated groups (those affected by the regulations) and the control group. The dataset used in this report encompasses EPCs issued from April 2016 until September 2023.

The first scoping study did not initially evaluate the use of the Scotland EPC dataset as a potential source for control groups due to delays in accessing this data. However, the research acknowledged that Scottish properties, which are not subject to the regulations, would ideally serve as an excellent control group, offering a comparison to the treated properties in England and Wales. The second scoping analysis further stresses the usefulness of the Scottish control group if balancing techniques were utilised to account for the difference in key characteristics of the analysed buildings.

The EPC datasets from England, Wales, and Scotland include all certificates, regardless of the reason for which they were issued such as private rental, social rental, sale, and new dwelling. The field labelled 'transaction type' was utilised to accurately identify the properties for the treated and control groups. The inclusion of this wide range of certificates in the EPC dataset provided a comprehensive pool from which to draw samples for the QEA, ensuring that the study covered a diverse range of property types and transaction scenarios.

In this study, a private rental is identified through the transaction type field in the EPC dataset. The value in this field holds irrespective of the current rental status of the building. It is therefore acknowledged that while an EPC may have been issued for a property designated as a private rental, the property may not have been rented out, e.g. due to the inability of meeting the energy efficiency requirements mandated by the regulations. Similarly, a property might have obtained an EPC as part of purchases and later be rented out without this change of tenancy being reflected in the transaction type field.

The dataset used in this analysis incorporates only residential units with at least two EPCs, one issued before the introduction of the regulations, one after. This is a key requirement for assessing the impact of the regulations on energy efficiency. In addition, only EPCs issued after April 1 2016, were considered as part of the requirement for properties to have at least one EPC before the introduction of the regulations. This decision was influenced by the desire to focus on more recent data, reflecting the current state of energy efficiency in rental properties.

However, the study faced challenges with data quality. Some residential units had an unusually high number of EPCs, which was deemed implausible. Additionally, instances were found where several EPCs were issued for the same unit on the same inspection date.

To maintain the integrity of the analysis and ensure reliability, residential units that fell into these categories – either having an implausible number of EPCs or multiple EPCs issued on the same date – were excluded from the study. This step was crucial to avoid skewed results and ensure that the analysis accurately represented genuine changes in energy efficiency over time.

The EPC dataset is built based on the Reduced Data Standard Assessment Procedure (RdSAP), a critical methodology for assessing the energy performance of existing dwellings, particularly in scenarios where a complete data set for a full Standard Assessment Procedure (SAP) is unavailable. This approach, in alignment with the Energy Performance of Buildings Directive, is specifically tailored for existing buildings and is not applicable for new constructions, which require a comprehensive SAP assessment.

The procedure for RdSAP begins with a site survey aimed at gathering a reduced data set. This data set is subsequently expanded into a full data set, adhering to rules and defaults as outlined in the SAP 2012 documentation, specifically in Appendix S19, so that the SAP calculation is performed using this expanded data set.

RdSAP applies to a variety of dwelling types, including houses, bungalows, flats, maisonettes, and park homes, and accounts for their structural variations such as detached, semi-detached, and various forms of terraced housing. It takes into consideration unique characteristics like the presence of a heat loss ground floor or a heat loss roof in these classifications. It also provides specific definitions for ‘enclosed’ dwellings commonly found in terraced housing.

The RdSAP methodology offers a streamlined yet detailed framework for evaluating the energy efficiency of existing buildings, which ensures compliance with regulatory standards despite the challenges posed by incomplete data sets. The methodology's adaptability and comprehensive nature make it a valuable tool in the realm of energy performance assessment, particularly in the context of existing residential buildings. As part of this adaptability, the RdSAP has been amended a number of times during the time period covered by the sample used in this study, i.e. from April 2016 onwards, as illustrated in the table below. The change in the RdSAP approach can be noticed in the average SAP ratings as discussed in Section 4.3.2.[1]

**Table 2: The different versions of RdSAP in use over the last 10 years**

| Time period | Version of RdSAP used to produce EPCs for existing properties |
|---|---|
| 1 Apr 2012 - 6 Dec 2014 | RdSAP 2009 v9.91 |
| 7 Dec 2014 - 18 Nov 2017 | RdSAP 2012 v9.92 |
| 19 Nov 2017 - 21 Sep 2019 | RdSAP 2012 v9.93 |
| 22 Sep 2019 - Today | RdSAP 2012 v9.94 |

[1] Tom Entwistle (2018) ‘New algorithms to calculate EPC ratings’, Landlord Zone

### 2.1.2 Exemptions Register data

In the study examining the impact of the regulations, the PRS Exemptions Register played a crucial role in identifying properties that were exempt from the requirement to improve their EPC rating to the minimum standard of E. The regulations generally mandate that rental properties must have an EPC rating of at least E, but exemptions are granted under certain circumstances.

These exemptions, however, are time limited. The study took this into account by removing properties from the treatment group if they fell within two specific criteria: first, the property had to be in bands F or G, which are below the mandated minimum EPC rating of E. Second, the property must have had a valid exemption and not have achieved an EPC rating of E or higher. This approach ensured that the treatment group only included properties that were genuinely subject to the regulations and had to comply by improving their energy efficiency to meet or exceed the E rating.

By excluding properties with valid exemptions and EPC ratings below E, the study aimed to create a more accurate and representative sample of properties impacted by the regulations. This helped in isolating the effects of the regulations on property upgrades and energy efficiency improvements, leading to more reliable and insightful findings regarding the effectiveness of the regulations.

## 2.2 Assessing compliance with the regulations

The evaluation of compliance with the regulations was aimed at understanding how effectively landlords adhered to the new energy efficiency standards. This evaluation was structured around two key questions.

The first question sought to determine what proportion of landlords or properties have complied with the regulations, which is related to the level of compliance. This aspect of the evaluation was crucial for gauging the overall effectiveness of the regulations in raising energy efficiency standards in rental properties. Compliance was defined as achieving an EPC rating of at least E by the mandated deadline of April 1 2020. This evaluation included properties that had either met the required EPC rating or had sought and secured an exemption to the regulations. By accounting for exemptions, the evaluation aimed to present a comprehensive picture of compliance, recognising that some properties were legally non-compliant but exempt from the requirements.

The second question focused on understanding the specific circumstances under which non-compliance occurred. This involved analysing various attributes of the dwellings, such as building types, performance levels, and other relevant characteristics, to identify patterns or common factors among landlords who did not meet the regulation standards. This part of the evaluation was critical in identifying potential barriers to compliance and understanding why certain properties failed to achieve the mandated energy efficiency levels. Overall, the evaluation aimed to provide a detailed understanding of the compliance landscape within the PRS, identifying both the extent of adherence to the regulations and the factors contributing to instances of non-compliance. This information is vital for policymakers and stakeholders in assessing the effectiveness of the regulations and in formulating strategies to enhance compliance and energy efficiency in the rental housing sector.

### 2.2.1 Data sources and methodological approach

For the evaluation of compliance with the PRS regulations, the scoping report identified the EPC dataset as the key source. This was used to assess the level of compliance among privately rented properties with the regulations that first came into effect on April 1 2018 for any new rental and for all rentals as of April 1 2020.

The primary method involved analysing the EPC dataset, which included all property lodgements in England and Wales as of April 2020 (for the first impact assessment) and as of August 2023 (for this final impact assessment). This approach aimed to calculate the total number of dwellings within private rentals that were compliant with the regulation, i.e., those that had achieved at least an EPC rating of E. The dataset also enabled the identification of non-compliant properties and their specific attributes, which included details like building type, age, and energy performance levels. This granular data from the EPC dataset was pivotal in understanding the characteristics of properties that failed to meet the required standards.

This dual-data approach was designed to offer a comprehensive view of the PRS landscape in terms of energy efficiency compliance. The EPC dataset provided a direct measure of compliance through actual EPC ratings, leading to a nuanced analysis of compliance and its determinants.

### 2.2.2 Limitations of the current approach

The compliance evaluation relied on a fundamental analysis of the EPC dataset. The primary objective was to calculate the number of properties in the EPC dataset, mandatory for all privately rented dwellings, that were not compliant with the regulations by the required date and did not have an approved exemption.

While conceptually straightforward, the actual determination of compliance levels posed significant challenges due to the limitations and variable quality of the data sources. The EPC dataset has known quality issues that add complexity to the evaluation process. For instance, the dataset includes the most recent EPCs for dwellings involved in private rental transactions, along with previous EPCs where available. However, anomalies such as ‘downgrades’ in EPC ratings or inconsistencies in dwelling characteristics (like differing wall types across different EPCs) were noted. These discrepancies introduced potential errors in the data, affecting the reliability of compliance assessments.

Despite these challenges, the EPC dataset was still considered the best available resource for analysing compliance and the impact of the regulations on energy efficiency. Due to the quality of the data, a margin of error was included within the analysis. This approach illustrates the complex nature of data-driven evaluations in policy research, where ideal data conditions are rare, and researchers must navigate and account for the imperfections in the available data.

Using the EPC dataset, despite its limitations, allowed for the most comprehensive and practical assessment of compliance with the regulations.

## 2.3 Assessing the impacts of the regulations on energy efficiency, energy cost and CO2 emissions

The evaluation of the impact of the regulations on energy efficiency has been conducted using a counterfactual approach. This method compared changes in a group affected by the regulations (the treated group) with changes in a group not affected by them (the control group). The Difference-in-Differences (DiD) methodology has been employed to examine different aspects of the regulations' impact on energy efficiency and environmental impact. The results from these analyses were set to contribute to a larger synthesis report, addressing several key evaluation questions including:

- the number of energy efficiency installations that were implemented in PRS properties. This analysis would provide a clear picture of the physical changes and improvements made in the properties in response to the regulations.
- the number of the energy efficiency installations which could be directly attributed to the regulations. This aspect is crucial in understanding the effectiveness of the regulations in driving changes and improvements in energy efficiency.
- the broader impacts of the energy efficient installations on carbon emissions and energy costs. This part of the analysis was aimed at assessing the overall benefits of the energy efficiency improvements from an environmental and economic standpoint.

In the QEA, the treated group consisted of properties directly subject to the regulations, while the control group included properties not affected by these regulations. This setup was crucial for establishing a valid counterfactual scenario, allowing to isolate the effects of the regulations from other factors that might influence energy efficiency. The estimation of the regulations' impact was then based on comparing the changes observed in these two groups, using the DiD methodology to provide a rigorous evaluation of the regulations' effects.

### 2.3.1 Formation of treated and control groups

**Selection of the control group**

The first scoping study assessed five control groups for use in the QEA of the regulations. These control groups were primarily based on properties not directly impacted by the regulations applicable in England and Wales. In particular, three distinct control groups were formed from the Scottish EPC dataset:

- Scottish private rentals that were F or G before regulations: This group was likely to be most similar to the treated groups, sharing the same tenure type (privately rented properties). However, the number of properties in the sample available was considered too small for robust analysis.

- Scottish Owner Occupied that were F or G before regulations: This group included residential units that were owner-occupied. Since these properties were not privately rented properties, they were considered less preferable as a control group.
- All Scottish EPC Buildings that were F or G before regulations: This group was a combination of properties from both Scottish Private Rentals and Scottish Owner Occupied. It represented a middle ground in terms of similarity to the treated groups. Due to the limitations in the size of Scottish Private Rentals Group, results were reported primarily for all Scottish EPC Buildings.

In addition, two more control groups were explored from the England and Wales EPC dataset:

- English and Wales Owner Occupied that were F or G before regulations: This group included residential units that were owner-occupied. Owner-occupied properties might not have the same motivations or financial incentives as rental properties to improve energy efficiency, which could influence the comparability of their energy performance changes. Also, since they are from the same dataset, there might be contamination issues that affect the results.
- English and Wales Social Rentals that were F or G before regulations: This group included rental units that were socially rented properties. The number of properties in this group was considered too small for robust analysis.

The first and second scoping study for evaluating the impact of the regulations concluded that properties in Scotland constituted the most suitable control group. This decision was made after considering and discarding other potential control groups, such as owner-occupied and socially rented properties in England and Wales.

The scoping report concluded that the Scottish housing stock is broadly similar to the English and Welsh housing stock, with PRS being the least efficient tenure in each country. In addition, Scottish properties would not be affected by landlords selling F and G rental properties they were unwilling to upgrade, as discussed below. The choice of the Scottish control group was also validated by assessing the parallel trend assumptions. By focusing on Scottish properties, the analysis could leverage a more consistent and comparable dataset, minimising the risks of contamination that could arise from using control groups within the same geographic and regulatory environment as the treated groups.

Control groups comprising F or G rated owner-occupied and socially rented properties in England and Wales were initially considered. However, these groups were found unsuitable, and in addition they did not meet the parallel trend assumption. This assumption is crucial in impact evaluations like DiD, requiring that, in the absence of the treatment (in this case, the regulations), the treatment and control groups would have followed similar trends over time.

Another crucial factor was the likelihood of changes in tenure over time and the potential impact of the regulations themselves. Properties in the F and G bands could be sold into other tenures if landlords were unwilling to upgrade them to meet the regulations. This potential change in tenure would contaminate any English and Welsh control group, where such tenure changes could be a direct consequence of the regulations. By choosing Scottish properties, where the regulations did not apply, the study minimised the risk of such contamination, ensuring a more accurate and reliable control group for the evaluation. Overall, these considerations led to the selection of Scottish properties as the most appropriate control group for the impact evaluation of the regulations on energy efficiency, energy costs, and CO2 emissions. This choice was aimed at ensuring the validity and reliability of the study's findings.

### Caveats related to the selected control group

Using Scottish properties as a control group in the evaluation of the regulations comes with certain caveats and limitations. These primarily relate to the differences in the energy efficiency policy environment between Scotland and England and Wales, as well as concerns about sample sizes.

In 2019 the Scottish Executive proposed the implementation of a minimum energy efficiency standard (of an EPC rating of E, as in England and Wales) from April 2020 for new and renewed tenancies and from April 2022 for all tenancies. Additionally, the regulations were planned to mandate a further increase in the minimum EPC rating to D from 2022. However, in response to the COVID-19 pandemic, the Scottish Executive announced their decision to delay the implementation of these regulations on the 15th of January 2021. However, due to the onset of the COVID -19 pandemic, this was not implemented.

The Scottish Executive proposed new timelines and targets in the Heat in Buildings Strategy report published in October 2021. The updated proposal suggested that by April 2022 all domestic PRS properties in Scotland would need to achieve an EPC rating of at least band E and that properties would need to achieve an EPC rating of C at the change of tenancy from April 2025, extended to all tenancies from April 2028. The proposals were not subsequently implemented, and a new consultation was launched in July 2023 proposing the introduction of a minimum EPC C rating standard for both new and existing tenancies from April 2028.

These changes in the regulatory landscape in Scotland are significant considering the use of Scottish properties as a control group in evaluating the impact of the regulations in England and Wales. The delay and subsequent revision of the Scottish regulations could influence the comparability and relevance of Scottish properties as a control group. If landlords in Scotland were influenced by the anticipation of proposed new minimum standards, their behaviour regarding energy efficiency improvements might have changed, potentially impacting the control group's characteristics. This could lead to the underestimation of the actual impact of the regulations in England and Wales, making the report's findings a conservative estimate. Also, the presence of the Scottish Home Energy Efficiency Programme, which provided additional funding to landlords for energy efficiency improvements, is not mirrored in England and Wales. This difference in available resources could lead to variations in energy efficiency measures adopted by landlords in Scotland compared to those in England and Wales, potentially influencing the behaviour of the control group.

This is also linked to the issue that the awareness of upcoming energy efficiency standards in Scotland might have influenced landlord behaviours even before their implementation. Such pre-emptive actions by Scottish landlords could partially align their practices with those motivated by the regulations in England and Wales, thereby reducing the contrast between the control and treated groups.

Finally, the available sample sizes in Scotland necessitate the inclusion of both private rental and owner-occupied properties in the control group. This requirement limits the direct comparability of the control group with the treated group, which is focused solely on privately rented dwellings. The heterogeneity introduced by combining different property types could affect the validity of the comparisons drawn between the Scottish control group and the English and Welsh treated group.

These caveats highlight the complexities and potential limitations inherent in using Scottish properties as a control group. They underscore the importance of carefully interpreting the results, considering these factors, and potentially exploring additional methods or data sources to corroborate the findings, such as entropy balancing.

### Matching EPC and Exemptions datasets

In the process of forming the treated and control groups for the evaluation of the PRS regulations, a meticulous address matching exercise was undertaken. This was necessary to align information from the PRS Exemptions Register with the entire EPC database, with the primary goal of removing properties with exemptions from the analysis.

The address matching process was based on the Levenshtein ratio, a metric used in information theory to measure the similarity between two sequences. In this context, it was applied to assess the similarity between addresses in the EPC database and those in the exemption dataset. The Levenshtein ratio is particularly useful in this setting for its ability to account for minor discrepancies in address data, such as typos or formatting differences.

Initially, a Levenshtein ratio of over 80% was considered sufficient for a positive match. This threshold was chosen as a balance between two risks: accepting erroneous matches (false positives) and discarding correct matches (false negatives). However, given the potential for significant implications of even minor address differences (such as different units in the same building), a more stringent threshold of 95% was ultimately adopted. This higher threshold aimed to ensure greater accuracy in matching, reducing the likelihood of including exempt properties in the analysis erroneously.

The address matching was conducted in a way that the addresses from the exemption dataset were compared with those in the EPC database. If a match met or exceeded the 95% Levenshtein ratio threshold, it was considered a positive match, and the property was categorised accordingly. The datasets used for the matching were the Exemptions register, which has 17,005 properties, and the unfiltered EPC database, which has 25,034,445 properties.

Using an 80% threshold the matching process gave 16,267 matches, which is very similar to the exemption's dataset total. The issue with this threshold was that many of the matched properties were false positives, meaning that since the only difference between the addresses of properties was the numeration, multiple properties inside the same apartment complex were considered all as exempt, when it was not the case. This changed when using a 95% threshold, resulting in 7,248 matching properties. One caveat of this approach is that the data for the addresses in the EPC database were not always complete, or had different formatting, which would depend on how the inspectors would write down the addresses, meaning that the quality of the data used for the matching was not optimal. A much more straightforward approach would have been to match based on UPRN, but this information was not available in the exemptions database.

The difference in results based on varying the matching threshold underscored the importance of precision in identifying exempt properties. By ensuring only non-exempt properties were included in the treated group, the evaluation aimed to accurately assess the impact of the regulations on energy efficiency, energy costs, and CO2 emissions.

### Segmentation of the treatment group

A significant challenge in this process was the potential discrepancy between the property use as registered in the EPC and its actual use. To address this issue, a set of rules was developed and tested in the scoping report to ascertain the feasibility of accurately determining the economic use of the properties. The application of these rules led to the formation of three distinct treated groups:

- Established private rental properties that were F or G before regulations: This group included residential units that had an EPC rating of F or G prior to the introduction of the regulations and were classified as privately rented both before and after the regulations came into effect. This group represents properties consistently in the private rental market that were directly impacted by the regulations.
- Recent private rental properties that were F or G before regulations: This group comprised residential units that also had an EPC rating of F or G prior to the regulations but were classified as privately rented only after the regulations were introduced, indicating a change in their economic use. These properties had a different use before the regulations and transitioned into the private rental sector post-regulation.
- Private rental properties that were F or G before regulations: The third treated group was a combination of the first two, encompassing all properties within the 'Established' and 'Recent' private rental property groups. This broader group allowed for a more comprehensive analysis of the impact of the regulations across the private rental sector.

By categorising the properties according to their status relative to the regulations, the analysis could more effectively isolate and understand the effects of the regulations on energy efficiency, energy costs, and CO2 emissions within the private rental sector.

### 2.3.2 Use of the EPC dataset

The evaluation of the impact of the regulations on energy efficiency primarily relied on the Energy Performance Certificate (EPC) register as the data source. Alternative datasets such as the English Housing Survey (EHS) were explored but discarded in the second scoping analysis. The EHS is a comprehensive survey providing detailed information on the condition and energy efficiency of housing in England. However, its structure as a repeated cross-sectional survey poses significant limitations for longitudinal analysis, as it does not track the same households and properties over time. This characteristic of the EHS rules out its direct use for evaluating the impact of the regulations using methods like Difference-in-Differences (DiD), which require at least two observations of the same property, pre- and post-implementation of the regulations. Creating a pseudo panel data by aggregating property-level data to a higher geographic level was considered as a potential workaround. However, this approach has its limitations, as it would omit important property-specific characteristics and reduce the available sample size, potentially affecting the robustness of the analysis.

Additionally, the inability to merge the EHS with the PRS Exemptions Register due to the lack of detailed property identifiers like UPRN or postcode further limits the feasibility of using EHS data for this evaluation. In conclusion, while the EHS is a valuable resource, its format and data collection methodology present significant challenges for its use in evaluating the impact of the PRS on energy efficiency at the property level. Therefore, the EPC register, despite its limitations, was considered the most robust and available data source for this interim impact evaluation.

### 2.3.3 Analytical approaches to the estimation

**Baseline approach: panel DiD**

The Difference-in-Differences (DiD) approach is a widely used statistical technique in policy analysis and econometrics, especially useful in quasi-experimental studies where treatment and control groups are not randomly assigned. This method is particularly effective in estimating the causal impact of a policy intervention by comparing changes over time between a group that is exposed to the intervention (the treated group) and a group that is not (the control group).

In cases involving multiple time periods and additional covariates, the DiD approach can be extended into a more complex regression model that includes time and group fixed effects. This generalised model allows for a more nuanced analysis that can account for other variables that might influence the outcome.

The basic formula of the generalised DiD approach is as follows:

$$y_{\{it\}} = \alpha_i + \beta x'_{\{it\}} + \delta T_{\{it\}} + \varepsilon_{\{it\}}$$

where $y_{it}$ represents the outcome variable of interest at time $t$ for unit $i$, $\delta$ is the coefficient of interest, which captures the impact of the policy and $T_{it}$ is the treatment indicator (often a binary variable, where 1 indicates the unit is part of the treated group at time $t$, and 0 otherwise). The term $x'_{\{it\}}$ represents a vector of strictly exogenous variables (including a constant) which are included to control for other factors that might influence the outcome while $\beta$ is the associated vector of parameters. The terms $\alpha_t$ are unit fixed effects, controlling for unobserved, time-invariant characteristics of each unit. Finally, $\varepsilon_{\{it\}}$ is the disturbance term, capturing the unexplained variation in the outcome.

Building upon the panel DiD approach, one can incorporate a logistic regression framework. to tackle the binary nature of the dependent variable, i.e. whether properties have achieved the necessary energy efficiency standards after the introduction of the regulations in the case of this study.

The logistic regression model is specified as follows:

$$\mathbf{log}\left(\frac{\boldsymbol{P(Y_{it})}}{\mathbf{1}-\boldsymbol{P(Y_{it})}}\right) = \boldsymbol{\alpha_i} + \boldsymbol{\beta X'_{it}} + \boldsymbol{\delta T_{it}} + \boldsymbol{\varepsilon_{it}}$$

where $\mathrm{P(Y_{it})}$ denotes the probability of the property $i$ meeting energy efficiency standards at time $t$. The unit fixed effects $\alpha_i$ are controlling for time-invariant characteristics of each property. $T_{it}$ is the treatment indicator, set to 1 if unit $i$ is subjected to the policy intervention at time $t$, and 0 otherwise, while the coefficient of interest, $\delta$, indicates the estimate effect of the policy. $X'_{it}$ represents a vector of strictly exogenous variables, with $\beta$ as the associated parameter vector. $\varepsilon_{it}$ is the error term.

The exponentiated coefficients in logistic regression, such as $e^{\delta}$ , yield odds ratios. An odds ratio greater than 1 suggests an increase in the likelihood of the outcome occurring due to the treatment, while a value less than 1 implies a decrease. The interpretation of these odds ratios facilitates an understanding of the magnitude and direction of the policy's impact on achieving energy efficiency standards.

The control variables included in the analysis were ‘total floor area’, i.e. the size of the property, and ‘main fuel type’, which is the main fuel used for heating and other energy needs such as lighting and boiling water, and built form, which is the type of structure of the building, ranging from detached and semi-detached to end terrace and enclosed end terrace. All these variables can influence the level of energy efficiency, costs and emissions, as well as their changes across time. A broader set of variables is used to create sub-samples of the treated and control groups, allowing for DiD analysis on properties with specific characteristics, therefore enabling a more detailed examination of the regulations’ impacts on different types of properties.

The essence of the DiD method is to isolate the effect of the policy by comparing the changes in outcomes over time between the treated and control groups, while controlling for other factors that might influence these changes. This method assumes that, in the absence of the treatment, the difference in outcomes between the treatment and control groups would have remained constant over time (parallel trends assumption). This assumption is crucial for the validity of the DiD approach, as any violation can lead to biased estimates.

The Difference-in-Differences (DiD) approach in this context was applied to analyse the impact of regulations on two key variables:

- The Standard Assessment Procedure (SAP) score, which is a measure of the overall energy efficiency of a residential unit. The impact of the regulations on energy costs and CO2 emissions can be inferred from the results for the SAP and the environmental impact (EI) score, respectively.
- a binary variable for EPC Band E improvement. This variable represents whether a property improved to meet the minimum standard of EPC band E (value equal to 1) or not (value equal to 0). It provides a direct measure of compliance with the regulations.

The impact of the regulations on energy costs and CO2 emissions was evaluated through their effects on the SAP (Standard Assessment Procedure) and EI (Environmental Impact) scores, respectively. Both the SAP and EI scores are key indicators in the Energy Performance Certificates (EPCs) and are directly related to energy costs and CO2 emissions. The formulae for calculating the impact on energy costs from the SAP score, and the impact on CO2 emissions from the EI score are detailed in the Building Research Establishment (BRE) report from 2014. The relationship between the SAP score and energy costs is expressed through a piecewise function that calculates energy costs based on the SAP score. This relationship is defined as follows:

$$energy\ cost\ = \begin{cases} 10^{\frac{117-SAP}{121}} & if \quad SAP < 51.2 \\ \dfrac{100-SAP}{13.95} & if \quad SAP \geq 51.2 \end{cases}$$

The SAP score is a measure of the energy efficiency of a dwelling, with higher scores indicating better energy efficiency and, consequently, lower energy costs. The EI score, on the other hand, measures the environmental impact of a dwelling, primarily in terms of CO2 emissions, with lower scores indicating lower emissions, namely

$$CO_2\ emissions\ = \begin{cases} 10^{\frac{EI-200}{-95}} & if \quad EI < 62.1 \\ \dfrac{EI-100}{-1.34} & if \quad EI \geq 62.1 \end{cases}$$

For the $CO_2$ emissions calculations, assumptions are also made on the electrical energy for heat distribution, mainly on efficiency and energy usage of heat networks.

By analysing the changes in SAP and EI scores before and after the introduction of the regulations, the study aimed to quantify the effect of the regulations on reducing energy costs and $CO_2$ emissions. This approach allows for a clear understanding of the tangible benefits of the regulations in terms of both economic savings and environmental impact.

The impact of the regulations on the SAP and EI rates is calculated based on the difference in these rates between the treated and control groups, over time. To compute the overall impact on energy costs and $CO_2$ emissions, this calculated impact (change in SAP or EI rate due to regulations) is added to the average SAP and EI rates observed in the control group after the introduction of the regulations. The resulting values (adjusted SAP and EI rates) are then used to calculate energy costs and $CO_2$ emissions, respectively. This is done by applying the relationships between SAP and energy costs, and EI and $CO_2$ emissions, as defined by BRE or other relevant standards. The final step involves comparing these calculated energy costs and $CO_2$ emissions to the values observed in the control group to quantify the impact of the regulations.

### Parallel trends assumption

The Parallel Trends Assumption is a fundamental prerequisite for the validity of Difference-in-Differences (DiD) analysis. This assumption posits that in the absence of the treatment (or policy intervention), the outcome variable of interest would have followed a similar trend over time in both the treated and control groups. This means that any differences in the outcome variable between these groups can be attributed to the treatment, rather than to other factors. The validity of the DiD methodology heavily relies on this assumption. If the parallel trends assumption does not hold, the estimated treatment effect might be biased as it could be capturing pre-existing and unrelated differences in trends between the groups, rather than the effect of the treatment.

One common approach to verify this assumption is through graphical representation. This involves plotting the trends of the outcome variable for both the treated and control groups over time, focusing on the period before the introduction of the policy (pre-treatment period). If the lines representing these trends are roughly parallel before the treatment, it suggests that the assumption holds. This case indicates that the outcome variable followed similar trajectories in both groups prior to the intervention, making it more likely that any divergence after the intervention can be attributed to the treatment. It is important to note that this method can provide only evidence supporting the assumption rather than a formal test. In fact, the assumption is fundamentally untestable since we cannot observe the counterfactual scenario, i.e. what would have happened in the absence of the treatment.

## Robustness approaches

The robustness of the results obtained from the DiD analysis was thoroughly assessed using various approaches. This is because robustness is crucial in policy evaluation studies, as it strengthens the validity and reliability of the findings. Specifically, three methods were used to assess the robustness of the results.

First, a modified DiD Approach (Bertrand et al., 2004) was utilised.[2] This approach involves simplifying the DiD analysis by using only two observations. One derived from averaging all pre-treatment period observations and the other from averaging observations after the introduction of the regulations. By reducing the data to these two aggregate points, this method aims to mitigate issues like serial correlation that can affect the standard errors in the original DiD setup. This modified DiD approach provides a different perspective on the treatment effect, checking the consistency of the results with a more aggregated data approach.

Second, DiD analysis was implemented in a number of sub-samples of the treated and control groups. This step was crucial to ascertain whether the impact of the regulations varied across different types of properties. The sub-samples were created based on the EPC variable ‘property type’ and ‘property size’ (divided into three groups: smallest, largest, and medium-sized units). Other sub-samples were considered in the analysis but could not be implemented due to constraints in the data available in the Scottish EPC dataset for variables such as ‘access to the gas grid’, ‘main fuel used for heating’ and ‘method of construction’. Analysing these sub-samples helps in understanding the differential impacts of the regulations across various property characteristics.

These varied approaches to robustness testing are essential in reinforcing the credibility of the DiD analysis. By checking the consistency of the treatment effect across different methods and sub-samples, the study ensures that the findings are not artifacts of a particular analytical approach or specific to certain types of properties.

## Entropy balancing

The approach to improving the comparability of the treated and control samples involved a two-step process, focused on balancing pre-treatment characteristics and implementing panel Difference-in-Differences (DiD) regression. The rebalancing of the pre-treatment characteristics was done using the Entropy Balancing technique.

In the first step, the Entropy Balancing (EB) method, a generalisation of the propensity score matching method, is used to align the control and treated group with regard to the property type. This method was proposed by Hainmueller (2012), as a way to adjust the control group to closely match the treated group in terms of observed pre-treatment characteristics.[3] Following the balancing of the treated and control groups, the second step involves estimating the impact of the regulations using a panel DiD regression. In this phase, the weights derived from the EB

[2] Marianne Bertrand, Esther Duflo and Sendhil Mullainathan (2004). ‘How much should we trust differences-in-differences estimates?’, The Quarterly Journal of Economics, 119(1), pages 249-275.
[3] Jens Hainmueller (2012) ‘Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies’, Political Analysis, 20(1), pages 25-46.

method are applied to enhance the accuracy of the regression analysis. The panel DiD regression compares changes over time between the weighted treated and control groups, estimating the effect of the regulations on outcome variables such as energy efficiency, costs, and CO2 emissions. As indicated in the second scoping analysis, the reweighting of the control group has been implemented with regard to the property type variable.

This methodological framework integrating entropy balancing with panel DiD regression addresses the concerns related to the potential impact of the differences between the control and treated groups on the estimated impact of the regulations. Employing this combined approach serves as an additional robustness check for the baseline model, which is the principal model underpinning the evaluation. As the estimates derived from entropy-balanced models align closely with those of the baseline model, the analysis in this report predominantly relies on the latter. This is because the DiD model with fixed effects, i.e. the baseline model presented here, is the workhorse used in the literature, and because it facilitates comparison with results from the 2021 interim impact evaluation report. The baseline model, characterised by its fixed effects in the DiD framework, thus remains central to the impact evaluation process.

## 2.4 Assessing the impacts of the regulations on the likelihood of energy efficiency work

The DiD analysis was restricted to properties in the treatment and control groups that had an EPC registered both before the introduction of the regulations and a second one registered afterwards, up to August 2023. This analysis could not take into account whether the regulations had increased the propensity of landlords to make energy efficiency improvements to affected properties. In order to address this and provide a fuller understanding of impact, further analysis was conducted in the final phase of the evaluation. The analysis assessed the share of PRS dwellings in England and Wales with an F or G rated EPC prior to the introduction of the regulations which also had another EPC registered before their existing EPC had expired (EPCs are valid for 10 years). This is a strong indicator or proxy for the landlord of the property concerned having made energy efficiency improvements. Taking 2013 and 2014 as a starting point, one can compute the share of the properties applying for another EPC by any point in time while the first certificate applied for in 2013 or 2014 was still valid. Bearing in mind the cumulative nature of this metric, the computed share is non-decreasing.

The impact of the regulation could manifest as an upward inflection point around April 2018, when landlords of PRS properties in England and Wales had to meet the minimum EPC rating of E before granting a new tenancy. The pattern in the cumulative share of PRS dwelling applying for another EPC while the current one is still valid could change again in April 2020 when the remit of the regulations was extended to cover all PRS properties, regardless of whether it was covered by a new tenancy agreement or not. At that point one could hypothesise an increase in the rate of change of the computed share, if most of the PRS properties did not already apply for a new EPC in the previous two years since the regulation had come into effect. However, a decrease would be expected if a majority of PRS properties are rented on relatively short tenancies with a renewal occurring between 1pril 2018 and April

2024 or if landlords, perhaps with the help of management agencies, obtained an EPC rate E before the deadline.

One should mention here the risk of PRS properties in the F and G EPC bands exiting the PRS market, if landlords are unwilling to upgrade them to meet the regulations, as discussed in 2.3.1. In this case, the regulations would decrease the likelihood of applying for a privately rented EPC during the validity of the current F or G rate. If these properties applied for an EPC, for example to be market for sale, they would not be captured in this exercise, as only the properties with privately rented F or G rated EPC applied in 2013 or 2014 which apply for another privately rented rated EPC are considered. For the same reason, properties with F or G rated EPC issued in 2013 or 2014 entering the PRS market after the EPC was issued would not be considered in this exercise as their current EPC would not be market as private rental.

It is also helpful to compare how the share of properties in England and Wales with an F or G rated EPC applying for another EPC within the 10 years' validity of the pre-existing EPC relates to a number of comparison groups, which are not affected by the England and Wales Energy Efficiency (Private Rented Property) Regulations. There are three factors which can affect the propensity of owners to apply for an EPC when a valid one is in place: the overall regulatory environment, the rate of the valid EPC and the tenure of the property. The following comparison groups were therefore investigated to investigate the role of the overall regulatory environment, the rate of the valid EPC and the tenure of the property:

- Scottish PRS properties with an EPC rated F or G issued in 2013 or 2014
- Scottish PRS properties with an EPC rated between A and E issued in 2013 or 2014
- English and Welsh PRS properties with an EPC rated between A and E issued in 2013 or 2014
- English and Welsh owner-occupied properties with an EPC rated F or G issued in 2013 or 2014.

The first group differs from the properties targeted by the regulation only based on their geographical location: these are properties which would be affected by the regulations if they were located in England and Wales. This comparison group is affected by the caveats related to the differences in the energy efficiency policy environment between Scotland on one side, and England and Wales on the other, as explored in Section 2.3.1. As already discussed there, the Scottish Executive proposed the implementation of 1) a minimum energy efficiency standard (with an EPC E rate, as in England and Wales) from April 2020 for new and renewed tenancies and from April 2022 for all tenancies; 2) a further increase in the required minimum EPC rate to D from 2022. However, in response to the COVID-19 pandemic, the Scottish Executive first announced their decision to delay the implementation of these regulations, and later abandoned their implementation, as a consultation on a proposal for the Heat in Buildings Bill was launched in 2023. It is however possible that landlords in Scotland took pre-emptive action to increase energy efficiency, when the Scottish PRS MEES regulations were expected to be imminently introduced. It is also the case Scottish PRS properties with an EPC rated F or G did not have any specific reason to pre-emptively exit the rental market in anticipation of the regulations mandating energy efficiency improvements, as it would have been the case for F or G rated PRS properties in England and Wales.

The second comparison group, Scottish PRS properties with an EPC rated between A and E issued in 2013 or 2014, differs from the properties targeted by the regulation based on the geographical location and the category of the valid EPC. These are properties are not affected by the regulations as they are located in Scotland, like those in the previous comparison group; in addition, they have a level of energy efficiency which would have excluded them from being affected by the regulations, if they were located in the England and Wales. Considering the proposal to mandate a minimum EPC rating of D from 2022 onwards in Scotland, some of these landlords might still have had an incentive to carry out upgrade works so they can meet the requirements of the forthcoming regulations. If that was the case, one would expect the share of these properties applying for another EPC while the certificate issued in 2013 and 2014 is still valid to be similar to the share for the first comparison group described above.

The third comparison group, English and Welsh PRS properties with an EPC rated between A and E issued in 2013 or 2014, differs from the properties targeted by the regulation only based on the EPC rating. These are properties which would be affected by the regulations only if the introduced standards of energy efficiency were more stringent. The existing policy landscape in England and Wales conveyed an increasing an aspiration to improve energy performance standards in the PRS sector beyond the levels mandated in the regulations. As an example, among the key policies and proposals to improve homes, the Clean Growth Strategy published by the UK government in 2017 mentions the development of a long term trajectory to improve the energy performance standards of privately-rented homes, with the aim of upgrading as many as possible to EPC Band C by 2030 where practical, cost-effective and affordable.[4] It is however unlikely even for those fully cognisant of the government's aspirations that landlords with a PRS property rated E or above in 2013 or 2014 perceived themselves being subject to any imminent request to increase the energy efficiency before the validity of their current certificate came to an end. For this reason, one would expect English and Welsh PRS properties with an EPC rated between A and E issued in 2013 or 2014 to have very little incentive to apply for another EPC during its validity.

The fourth and final comparison group, English and Welsh owner-occupied properties with an EPC rated F or G issued in 2013 or 2014, differs from the properties targeted by the regulation only based on the tenure registered in the EPC. Assuming that the 'sale' transaction type which is registered in the EPC issued in 2013 or 2014 is reflective of these dwellings being occupied by the owner, the energy efficiency of these properties might be more proactively managed by the owner compared to a similar rented property. That is because the owner would reap any financial benefit from the bill savings arising from energy efficiency improvements. In addition, some energy efficiency upgrades have an amenity or comfort value which could incentivise the owner to carry those upgrades. It is also the case that energy efficiency improvements are generally reflected in the market value of a residential property, therefore offering an incentive to perspective sellers to carry upgrades before putting the property in the market and apply for another EPC so that those energy efficiency

[4] BEIS (2017) 'The Clean Growth Strategy', GOV.UK

improvements can be documented.[5] Finally, if the owners moved out and rented their house privately, they were required to apply for another EPC between April 2018 and 2020 if covered by a new tenancy or at the latest by April 2020 if they are covered by an established tenancy agreement. This transaction would however not be included in this comparison group as only application for a new EPC with 'sale' transaction type would be considered here.

## 2.5 Strength and limitations of the current approach

The approach adopted for analysing the impact of the regulations on energy efficiency, energy costs, environmental impact, and CO2 emissions in the current study is characterised by its comprehensive nature, integrating various methodologies and a wide range of variables, complemented by thorough robustness checks. This approach, however, comes with its own set of strengths and weaknesses.

One of the major strengths of this analysis is the use of multiple methodologies, notably Difference-in-Differences (DiD) and Entropy Balancing (EB). This dual approach enhances the robustness of the analysis, contributing significantly to the reliability of the findings. Additionally, the study's focus on a variety of variables for energy efficiency, i.e. the SAP score and a binary variable indicating if the property has an EPC with a minimum of an E rating, while the EI score and the level of CO2 emissions provide a comprehensive view of the policy's impact from different angles. The robustness of the results is further bolstered by implementing a modified version of DiD, conducting EB analysis, and modelling impacts on sub-samples, adding multiple layers of verification. Moreover, the consensus across these diverse methodologies offers valuable insights for policymakers, reinforcing the policy relevance of the study. The use of established conversion practices for SAP and EI rates, developed by BRE and widely recognised in the industry and governmental circles, also adds to the analysis's credibility.

In addition to the intrinsic limitations related to the EPC dataset discussed in Section 2.2, there are other limitations which warrant attention. First of all, with regard to the use of EPC dataset here, there is the possibility that economic use identified through the EPC field 'transaction type' might not reflect the actual use of the property. As an example, one could obtain an EPC during the purchase of a property which after the transaction is put in the market for rent and upgrade the energy efficiency when required by the regulations to a minimum of the E EPC category. This evaluation would consider this a recent rental property even though it could have been rented for a very considerable amount of time. Due to this uncertainty, it is therefore important to refer to the results for the overall rental market and see the distinction into recent and established properties as a robustness exercise.

The main limitation is however related to the difficulty in finding a suitable counterfactual. The first and second scoping study of this evaluation concluded that properties in Scotland constituted the most suitable control group. This decision was made after considering and discarding other potential control groups, such as owner-occupied and socially rented

[5] Franz Fuerst, Pat McAllister, Anupam Nanda, and Pete Wyatt (2016) 'Energy performance ratings and house prices in Wales: An empirical study', Energy Policy, 92, pp20-33.

properties in England and Wales. The choice of the Scottish control group was validated by assessing the parallel trend assumptions. Using a Scottish control group had the advantage of minimising the risks of contamination that could arise from using control groups within the same geographic and regulatory environment as the treated group.

Although the best option among those available, a Scottish control group was however exposed to the policy debate unfolding in Scotland in relation to the introduction of a policy analogous to the PRS MEES regulations implemented in England and Wales. In 2019 the Scottish Executive proposed the implementation of a minimum energy efficiency standard (with an EPC rating of E, as in England and Wales) from April 2020 for new and renewed tenancies, and from April 2022 for all tenancies. Additionally, the regulations were planned to mandate a further increase in the minimum EPC rating to D from 2022. In response to the outbreak of the COVID-19 pandemic, the policy would be postponed, as announced on the 15th of January 2021. It was then announced in October 2021 that all domestic PRS properties in Scotland would need to achieve an EPC rating of at least band E by April 2022 and an EPC rating of C at the change of tenancy from April 2025, extended to all tenancies from April 2028. However, another regulator change followed: this schedule was completely dropped, and a new consultation was launched in July 2023 proposing the introduction of a minimum EPC C rating standard for both new and existing tenancies from April 2028.

It is difficult to assess the impact of all these regulatory changes in Scotland on the validity of the Scottish properties used as control group to evaluate the impact of the regulations in England and Wales. If landlords in Scotland were influenced by the anticipation of proposed new minimum standards, their behaviour regarding energy efficiency improvements might have changed, potentially impacting the control group's characteristics. On the other hand, it is also possible that the several postponements might have led landlords to delay implementation of any required energy saving measure as long as possible. If the former effect is prevalent, it would lead to the underestimation of the impact of the regulations in England and Wales, making the report's findings a conservative estimate. If the latter effect is prevalent, the Scottish properties would represent a valid control group. Without further investigation it is difficult to assess which effect would be predominant in the population, but it is important to be fully aware of this possibility.

Another limitation related to the use of the Scottish control group is the fact that these properties were also influenced by the Scottish Home Energy Efficiency Programme, which provided additional funding to landlords for energy efficiency improvements. As this programme is not present in England and Wales, the difference in available resources could lead to variation in energy efficiency measures adopted by landlords in Scotland compared to those in England and Wales, potentially influencing the behaviour of the control group. If that was the case, one would expect the report's findings to be a conservative estimate of the impact of the regulations in England and Wales. A final limitation is related to the fact that the control group had to include Scottish properties in the PRS market and those occupied by the owners to deliver a satisfactory sample size. As the management of energy efficiency improvements is known to be more proactive in owner-occupied properties, this may impact the QEA so that the report's findings underestimate the impact of the regulations in England and Wales.

Focusing on the methodology used in this study, the DiD produced average impact of the regulations without allowing for impacts to vary according to characteristics of interest or over time. This limitation has been addressed to an extent by segmenting the treated group according to characteristics of the properties, e.g. property type. In addition, only the PRS properties with at least one EPC issued on 2016-2018 and at least another one in 2018-2023 were used in this analysis. This is because the DiD needs at least two observations for any unit of analysis, one before the intervention and one after. Two limitations arise from this requirement. Firstly, only a limited set of properties could be used in this analysis rather than the much wider set of PRS properties. Secondly, properties with at least two EPCs within the timescale for the analysis could differ from wider PRS properties. It is therefore important to bear in mind this limitation when extrapolating the result from this study to the wider set of PRS properties.

Another limitation is related to the fact that the QEA takes into account the impact of the regulations when the energy saving measures are implemented but it doesn't address the fact that the regulations may have also had an impact on the likelihood of implementing of energy efficiency upgrades. This has been addressed by implementing a complementary analysis focused on computing the impact of the regulations on the share of the properties applying for a second EPC while a valid EPC was in place. Comparison of the computed impact on properties affected by the regulations with the impact on a number of control group added confidence on imputing any change in this metric to the introduction of the regulations.

It is true that the fact that landlords of properties affected by the regulations apply or a second EPC does not necessarily convey a quantitative assessment of the impact on the policy on energy consumption, costs and CO2 emissions but on the other hand the combination of quantitative assessment through the DiD and the assessment of the propensity of landlords affected by regulation to apply for a second EPC when a valid certificate was in place provides a holistic approach delivering robust assessment of the main impacts of the regulations.

Another limitation relates to how changes in RdSAP methodology over time may influence the reported carbon savings. The impact findings indicate average savings of 1,176 kg $CO_2$ and £67 on energy bills. These carbon savings can appear proportionally larger than the bill savings when compared against average household carbon emissions and energy bills in England and Wales.[6] This may partly reflect that newer versions of RdSAP assume a lower carbon intensity for grid electricity.[7] As discussed in Section 4.1.1 of the main report, the evaluation's analysis of EPC replacement rates—defined as the percentage of properties with an EPC issued in 2013 or 2014 that obtained a new EPC between 2015 and 2023—found that properties subject to the regulations (PRS homes in England and Wales with an F or G rating) had a significantly higher replacement rate, while properties outside the scope remained unchanged. This suggests that treatment group properties are more likely to have up-to-date EPCs than those in the control group.

[6] DESNZ 'Annual domestic energy bills', GOV.UK

[7] See: DESNZ (2024) 'Energy Company Obligation schemes: SAP and RdSAP amendments - government response', GOV.UK; & BRE 'Standard Assessment Procedure SAP 10'

Consequently, part of the observed carbon savings may reflect the cleaner grid assumption in the RdSAP methodology rather than solely the installed measures, which could explain why carbon savings appear proportionally larger than bill savings.

# 3 Compliance with the regulations

**Key points:**

- Of the 4,021,488 domestic PRS dwellings in the national EPC database, only 190,533 or 4.7% were estimated to be non-compliant as of August 2023.
- Since April 2020, the number of new EPCs issued for domestic PRS dwellings totalled 1,051,343. Only 12,237 of 1.2% of these were issued as being F or G.
- For PRS dwellings with a registered exemption, the most highly cited grounds for this were 'all relevant improvements have been made' (30%), 'consent for changes denied or subject to unreasonable conditions' (22%), or 'cost to landlord exceeds cap' (30%).
- The most common changes made by landlords to comply with the standards were concentrated on fabric insulation & low-e lighting (50%), and fabric insulation, main heating upgrade & low-e lighting (25%).

## 3.1 Introduction

Compliance with the regulations requires that all privately rented sector dwellings are at least EPC level E, unless an exemption has been granted. The purpose of this analysis is to determine the level of compliance since the introduction of the regulations. In its most simplistic form, the analysis aims to identify all compliant and stated non-compliant properties.

The EPC database provides what should be a comprehensive source of information on which to identify compliant and non-compliant properties. However, there are a number of known issues and limiting factors that act to challenge this analysis of compliance.

The main challenges of using the EPC data are quality, coverage and continuity, including:

- EPCs are known to be of varying quality, and this leads to uncertainty in both input data describing the performance features and also the EPC levels themselves. Known problems include unexpected changes in dwellings characteristics (i.e. floor area or type), 'downgrades' to stated performance features, and resulting downgrades to EPC values. This variation is commonly assigned to assessor interpretation bias and only sometimes a true change in state (e.g. an addition).
- Lack of detail in EPC data, including whether an EPC issued for private rental is still a privately rented dwelling or whether it has become subsequently owner occupied or sold; lack of a centralised and updated PRS register from which to otherwise identify properties; delays or timeliness of reporting of data.
- Lack of overall PRS data, including local authorities' PRS licensing and reporting processes; enforce and enforcement procedures.

- 'Dark' or unlicensed private rentals, or lack of EPCs when one is otherwise required, along with bad actors within the private rental market.
- The period that an EPC lasts being 10 years with no requirement for landlords to update the EPC with upgrades.

In addition, as part of the compliance analysis, there was also consideration for the broader PRS dynamics that could influence the obligation and the potential for additionality among the stock. This includes:

- Understanding the 'churn' of the PRS, i.e. the number and type of properties entering and leaving the market.
- Establishing the 'natural' rate of change in the EPC levels among PRS stock over time before, during and following the implementation of the regulations.
- Assessing the gaps in compliance reporting among PRS properties during the periods and their interaction with other energy performance requirements, i.e. the 10-year renewal of the EPC.

## 3.2 Aims, relevant periods and obstacles to ascertaining compliance

For the analysis, there are three time periods of interest for evaluating compliance:

- Before 1 April 2018, when the level of and investment in energy efficiency of PRS properties was at the discretion of the landlord.
- From 1 April 2018 to 1 April 2020, when the regulations were introduced for new and renewed tenancies.
- Finally, from 1 April 2020, when the regulations were extended to all tenancies.

The first two periods were analysed in detail in the Interim Impact evaluation report. The last period from 1 April 2020 is the main focus of this analysis.

This period is examined to both analyse compliance as of the latest data extraction of the EPCs and to provide an update on the dynamics of the PRS market and energy efficiency actions being undertaken by landlords. The dynamics and efficiency actions being considered include:

- Understanding the change in PRS in terms of the number and type of properties entering and leaving, and their EPC levels.
- Establishing the change in the EPC levels among PRS stock before and following the implementation of the regulations.
- Assessing the gaps in compliance reporting among PRS properties during the periods and their interaction with other energy performance requirements, i.e. the 10-year renewal of the EPC.

As in the first Impact Evaluation, there are several data and process-related challenges to fully determine the ‘true’ level of compliance across the PRS stock in the analysis. These include:

A lack of a centralised and updated PRS register of properties.

- Delays or timeliness of reporting of data in EPC register.
- ‘Dark’ or unlicensed private rentals.
- Properties leaving the PRS market or change of eligible tenure (i.e. converting to owner occupied).
- Local authorities’ PRS licensing and reporting processes.
- Local authorities’ enforcement of standards.
- Lack of enforcement of EPC requirements under Trading Standards.
- Quality and trustworthiness of EPCs, especially in terms of ‘transaction type’ and the actual performance level achieved.
- Lack of EPCs when one is otherwise required.
- Bad actors within the private rental market.

A report by Centre for Sustainable Energy (CSE[8]) looked at how compliance within the PRS is affected by different methods of reporting procedures and the impact on the standard. The findings of the report concluded that identifying and registering landlords within the case study councils was time intensive, but that most local authorities had developed a reporting method. However, the report noted that most local authorities were aiming to scale back the efforts around enforcement without additional financial support due to the time-intensive nature. There was, however, agreement that the data sources needed to conduct compliance were generally available.

In addition, a report by RSM[9] for the UK Committee on Fuel Poverty (CFP) described using council tax records data, HMO and licensing schemes, Land Registry data on property owners (multiple home ownership), and Tenant complaint records. However, these were for the most part not extensive or readily accessible for analysis.

[8] CSE (2022) ‘Compliance & Enforcement of the MEES in the Private Rented Sector: Pilot Study 1’
[9] RSM (2019) ‘Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector’, GOV.UK

## 3.3 Data sources

The approach to the analysis of compliance uses EPC data linked to PRS Exemption data. The EPC data analysis is supplemented with analysis of the English Housing Survey on the PRS sector conditions for the latest survey year (2020/21 and 2021/22).

The analysis comprises the following steps:

- Access the Bulk EPC lodgement data and PRS exemption register data.
- Create compliance groups using the data according to whether they are: non-compliant, compliance, exempt.
- Develop statistics on the compliance/non-compliance levels achieved (E and above), location, typology of building, date/period of compliance achieved.
- Undertake supplementary analysis on the PRS stock to characterise the energy performance of the PRS and the changes in energy efficiency features that have changed the EPC by using the English Housing Survey.

For the analysis only currently accessible data to DESNZ (i.e. EPC, Prices Paid, PRS Exemption and EHS data) is used.

## 3.4 Measuring compliance using EPC data

The selected approach to analyse compliance for the 2022/23 update is through the bulk EPC Registry data.

A download of EPC data as of August of 2023 was used and a set of exclusions were applied so that the data could be analysed. This included: selecting only EPCs with a valid building reference number and UPRN, and which had a Transaction type of ‘Rental (private)’, and which removed all ratings with an EPC of ‘I’ or an inspection date before 2007.

Using the EPC data, the following groups were established:

- Private rental properties with an EPC issued after 1 April 2020, when the PRS requirements came into effect.
- Private rental properties with a new EPC issued between 1 April 2018 and 1 April 2020, to determine the compliance during the introduction period.
- Private rental properties with an EPC issued prior to 1 April 2018 to determine the historic level of performance compliance with the regulations.
- Private rental properties with a first issued EPC since 1 April 2020, 1 April 2019 and 1 April 2018, which are used to determine the trend for compliant properties being added to the market.

- Private rental properties with an EPC issued prior to 1st April 2020 but no EPC since then, which are used to determine whether a lack of compliance or lags in reporting exists.

Using the above groups, a picture of compliance is derived from the EPC data.

## 3.5 English Housing Survey analysis

In addition to the EPC data, the analysis uses the latest available full dataset of the EHS (2020-21) to provide a broader overview of the trends of energy performance in the Private Rental Stock and other information related to tenancy and building quality. The analysis only provides an indicative understanding of the compliance and is meant to support the more granular EPC level analysis. The latest EHS data for years after 2020-21 was not available beyond the headline statistics at the time of this analysis and was therefore not used.

Within the EHS, details of household renters exist, and this includes data on tenancy type and date from which the tenancy started. Using this information, along with the assessed EPC rating within the EHS, it is possible to evaluate the length of tenancy and therefore to determine the EPCs being issued among recent rentals. It should be expected that any tenancy which began during the three periods (<2018, 2018-2020, post-2020) and the related EPC levels – all should achieve EPC E by the latest wave.

Analysing the recently available EHS provides a picture of existing EPCs composition among private rental sector that can be used to compare against the lodged EPC from the registry. EHS analysis provides insight on both energy performance and additional detailed property information not available in the EPC data. However, although the EHS is a representative sample, a caution with the EHS is that the overall sample size of the PRS in the dataset is small and therefore the uncertainty around an exact estimate of dwellings would be greater but the broad trends would be reasonable. Using the EHS is a method that provides additional evidence on compliance.

## 3.6 Findings from the EPC database on levels of compliance

The total number of dwellings identified as domestic private rental with a current lodgement in the EPC dataset with a current valid EPC was 4,021,488 as of August 2023. Note that although an EPC is valid for 10 years, and therefore any rented PRS dwellings in 2023 would expect a date of issue since 2013, this analysis excludes EPCs before 2012 in order to provide an additional year of issue. Any PRS dwelling rented presently should have an EPC issued after 2013 and any dwelling below the level E threshold and without an exemption should have been updated by April of 2020.

Table 5 shows that as of August 2023 there were 204,018 PRS dwellings with their most recent EPC marked as private rental in EPC level F and G, or 5.07%. Table 4 shows there were 13,485 F and G rated properties with a current exemption in the exemptions register data as of August 2023. This leaves 190,533 or 4.7% of all PRS dwellings with an EPC rating of F and G as August of 2023.

Compared to the interim analysis, the latest analysis shows some small differences in the proportion of dwellings in different EPC bands. However, the comparison to previous years is uncertain due to potential differences in the EPC database denominators. In April 2020 there were 3 million domestic PRS properties in the EPC database whereas in August 2023 there were 4 million. The domestic PRS sector did not expand by 1 million in the intervening years, which highlights the fact the EPC database has not (particularly in the 2020 interim analysis) been able to provide a complete picture of the energy efficiency of every property in the sector.

**Table 3: EPC ratings of PRS dwellings with an EPC as of April 2020 and August 2023**

| EPC rating | 2020 PRS dwellings Count | 2020 PRS dwellings % total | 2023 PRS dwellings Count | 2023 PRS dwellings % total |
|---|---|---|---|---|
| A | 632 | 0.01 | 841 | 0.02 |
| B | 119,667 | 4.0 | 194,067 | 4.8 |
| C | 886,111 | 29.9 | 1,358,226 | 33.8 |
| D | 1,265,199 | 42.7 | 1,613,338 | 40.1 |
| E | 564,289 | 19.0 | 650,998 | 16.2 |
| F | 97,674 | 3.3 | 156,706 | 3.9 |
| G | 31,883 | 1.1 | 47,312 | 1.2 |
| All | 2,965,455 | 100 | 4,021,488 | 100 |

Table 4 shows the status for all the exemptions recorded on the national exemptions register as of August 2023. Of the total of 16,256, 17% (2,771) were exemptions that had expired and 83% (13,485) were current valid exemptions.

**Table 4: Registered PRS exemptions as of August 2023**

| Exemption status | PRS dwellings Count | PRS dwellings % total |
|---|---|---|
| Expired exemption | 2,771 | 17 |
| Current exemption | 13,485 | 83 |

Table 5 details the calculations undertaken to estimate the number of 'non-compliant' properties using both EPC database and exemptions register data. There are 4,021,288 domestic private rental properties with a current EPC, and of these 204,018 have a current EPC rating of F or G. Exemptions have been registered for 16,256 domestic properties, of which 13,485 are current. If the number of exempted properties is subtracted from the number of F and G rated properties in the EPC database it implies there are 190,533 non-compliant properties, 4.7% of all domestic PRS properties, as of August 2023. For clarity, this does not account for any properties that have complied but not updated their EPC.

**Table 5: Estimate of non-compliance as of April 2020 and August 2023**

| | 2020 | 2023 |
|---|---|---|
| All properties in the private rental sector with a current EPC | 2,973,610 | 4,021,488 |
| Properties with a current rating of F or G | 132,841 | 204,018 |
| Properties with a current exemption | 7,855 | 13,485 |
| Estimated non-compliant properties | 124,986 | 190,533 |

Table 6 provides a more conservative alternative estimate of non-compliance just based on the number of registered exemptions that could be directly address matched to properties with a F and G rating in the EPC database. As described above, the address matching to the EPC database yielded a low match rate of 7,248. Nonetheless if the analysis is based on just these matched exemptions it implies a total of 196,770 non-compliant properties, 4.9% of all domestic PRS properties as of August 2023.

**Table 6: Alternative estimate of non-compliance as of April 2020 and August 2023**

| | 2020 | 2023 |
|---|---|---|
| All properties in the private rental sector with a current EPC | 2,973,610 | 4,021,488 |
| Properties with a current rating of F or G | 132,841 | 204,018 |
| Matched properties with a current exemption | 3,284 | 7,248 |
| Estimated non-compliant properties | 129,557 | 196,770 |

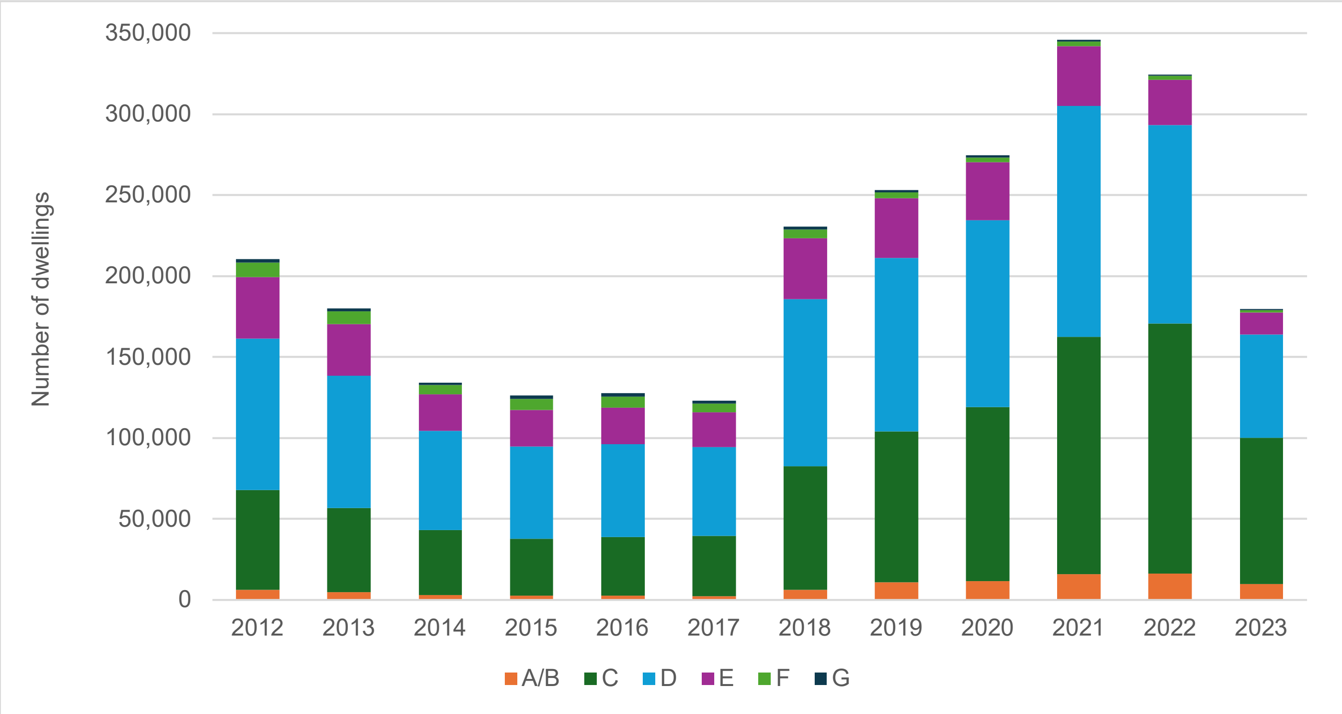
The most frequently cited reasons for an exemption (see Table 7) were that all relevant improvements had been made, the cost to the landlord exceeded the cap, that unreasonable conditions or consent was denied, wall insulation could have a negative impact. Compared to 2020, there has been a sharp decrease in the number of exemptions for reasons of no suitable funding. This is not surprising as this grounds for exemption was replaced by the cost cap exemption from April 2019.

### Table 7: Grounds for registered exemptions as of April 2020 and August 2023

| Grounds for exemption | Exemptions in 2020 Count | Exemptions in 2020 % total | Exemptions in 2023 Count | Exemptions in 2023 % total |
|---|---|---|---|---|
| All relevant improvements have been made | 2,226 | 28.3 | 5,198 | 38.5 |
| Consent denied | 1,263 | 16.1 | 2,868 | 21.3 |
| Cost to landlord exceeds cap | 940 | 12.0 | 3,582 | 26.6 |
| Devaluation of more than 5% | 23 | 0.3 | 38 | 0.3 |
| New landlord | 62 | 0.8 | 361 | 2.7 |
| No suitable funding | 2,732 | 34.8 | 223 | 1.7 |
| Wall insulation would have a negative impact | 609 | 7.8 | 1,215 | 9.0 |
| All | 7,855 | 100 | 13,485 | 100 |

In order to provide a further perspective on levels of compliance, the analysis also looked specifically at the ratings of new EPCs being issued in each year before and after the introduction of the regulations. Figure 1 shows all EPCs issued since 2012. Over time, F and G ratings represent an increasing small minority all new EPCs. From April 2020 – when the regulations came into force for all types of tenancy – the number of EPCs issued for the PRS totalled 1,051,343. Of these, only 12,237 or 1.2% were in the F and G bands.

### Figure 1: New EPCs issued for PRS dwellings from 2012 to 2023




Note: data for 2023 is up to August 2023 only, not the full year

Considering only F and G EPCs issued since April 2018, the majority of the types of dwellings these were issued for were mid-terraced dwellings (42%), followed by semi-detached (26%), end-terraced (18%), detached (10%), enclosed end/mid-terraces (5%). The analysis also shows that 80% of all issued F and G EPCs were for dwellings built before 1950 and 44% were issued among pre-1900 constructed dwellings.

**Figure 2: EPCs issued for PRS dwellings by dwelling type since April 2018**

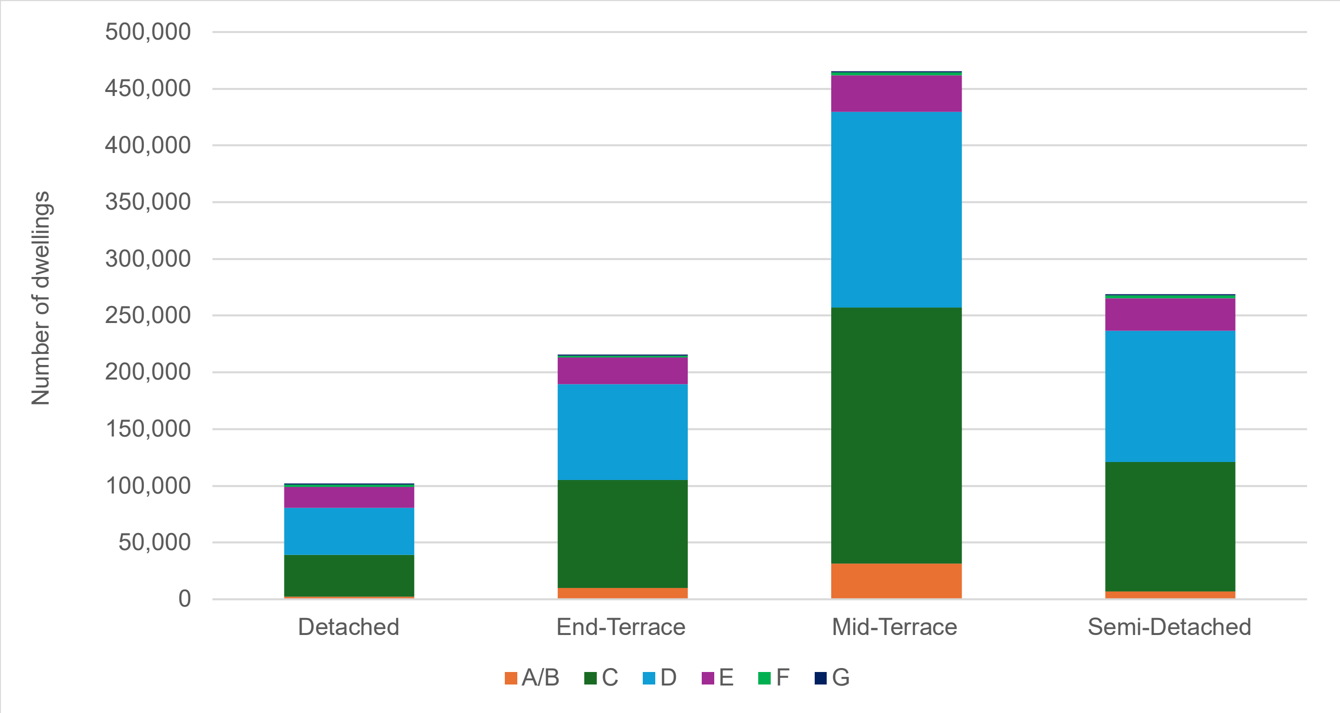
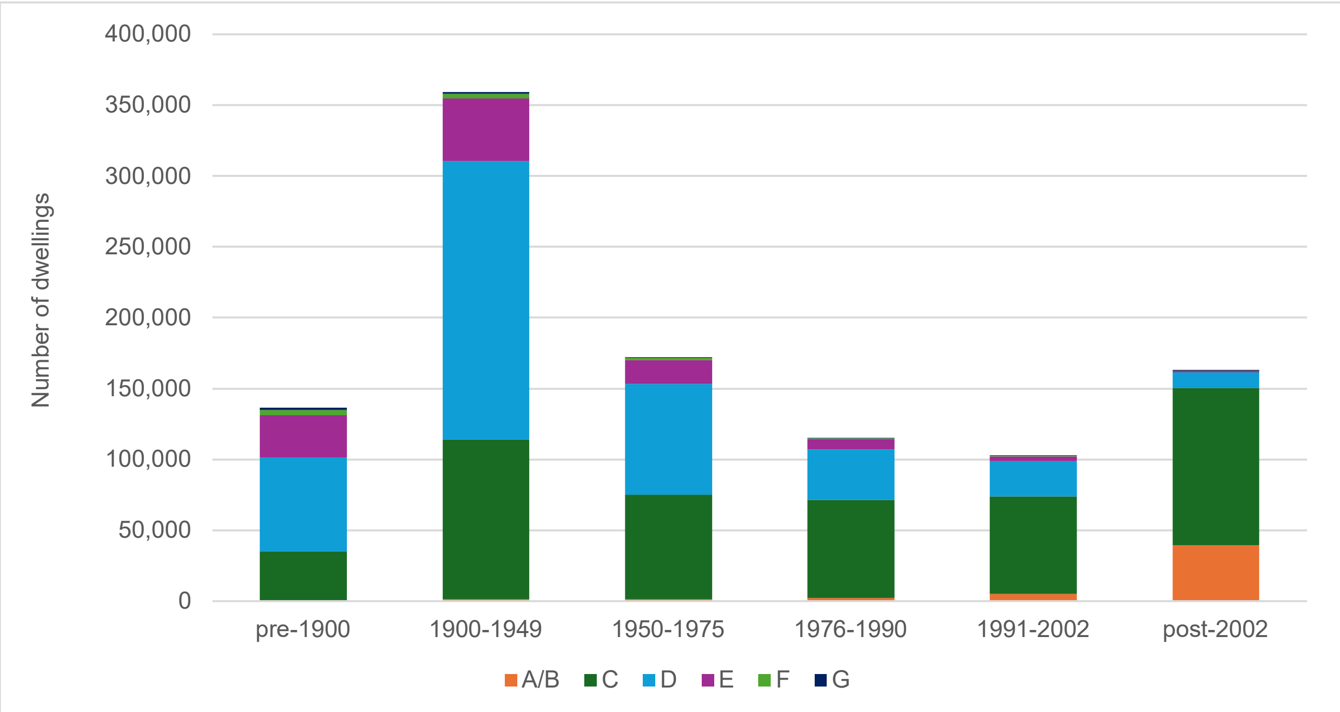



**Figure 3: EPCs issued for PRS dwellings by construction age since April 2018**



The analysis also shows that the frequency of getting a new EPC amongst previous F and G properties is 6.9 years, about 2 years shorter than the frequency for previous E and above properties (see Table 8).

**Table 8: Years between previous and current EPC for all PRS dwellings issued since 2012**

| Previous EPC rating | N | Mean | Median |
|---|---|---|---|
| A/B | 32,793 | 9.77 | 10.12 |
| C | 128,614 | 9.32 | 10.08 |
| D | 159,004 | 8.87 | 10.04 |
| E | 89,019 | 8.75 | 10.02 |
| F | 52,666 | 6.85 | 7.91 |
| G | 14,942 | 6.94 | 8.06 |
| All | 477,038 | 8.75 | 10.02 |

Table 9 shows the top elements that have changed between the previous and current EPC for PRS dwellings that had improved their rating between the previous and current EPC. Insulation seems to be the primary means of achieving improvements in EPC rating, more so than improvements in heating systems or windows.

**Table 9: Change in energy performance elements between previous and current EPC for non-exempt PRS dwellings that experienced an increase in EPC value**

| Changes in performance features | All PRS dwellings Count | All PRS dwellings % total | Previous F & G PRS dwellings Count | Previous F & G PRS dwellings % total |
|---|---|---|---|---|
| Fabric insulation & low-e lighting | 201,399 | 66.4 | 35,189 | 50.5 |
| Fabric insulation | 32,999 | 10.9 | 6,767 | 9.7 |
| Fabric insulation, main heating upgrade & low-e lighting | 32,346 | 10.7 | 17,717 | 25.4 |
| Low-e lighting | 24,111 | 8.0 | 3,463 | 5.0 |
| Fabric insulation & main heating upgrade | 6,285 | 2.1 | 3,179 | 4.6 |
| Main heating upgrade & low-e lighting | 3,670 | 1.2 | 2,078 | 3.0 |
| Main heating upgrade | 2,390 | 0.8 | 1,290 | 1.9 |

Note: fabric insulation includes loft insulation, wall insulation, floor insulation and window upgrades; heat upgrades include new condensing boilers (standard and combi).

## 3.7 Findings from the EHS on levels of compliance

The EHS is considered the definitive standard, outside the Valuation Office Agency, for describing the English dwelling stock. By comparing aspects of the above analysis to the EHS it is possible to cross-validate some of the trends observed in the EPC database data. Comparing the EPC database to the EHS on available collected variables shows that the EHS PRS stock and the EPC PRS database shows they are broadly similar.

The latest EHS data available for the analysis was from the 2020-2021 EHS so it was not possible to make a direct time-equivalent comparison. It also only represents English PRS properties and not Welsh PRS properties.

Although comprehensive comparison is not possible due to the sample differences and limited number of EPC variables, the EHS database does have broadly comparable characteristics in terms of EPC bands. According to the EHS 2020-21 there were 4,246,740 PRS dwellings in England, of which 184,065 (4.3%) were estimated to be in EPC band F and G. The above EPC-based analysis shows that as of August 2023, 5.1% or 204,018 English and Welsh PRS dwellings were in bands F and G.

**Table 10: EPCs of PRS dwellings in EHS 2020-21 and EPC database 2023**

| EPC band | EHS 2020-21 | EPC 2023 |
|---|---:|---:|
| A/B | 2% | 5% |
| C | 39% | 34% |
| D | 44% | 40% |
| E | 10% | 16% |
| F | 3% | 4% |
| G | 1% | 1% |
| All | 100 | 100 |

In addition, comparing the EPC database to the EHS for dwelling size and dwelling type (Table 11) shows that there are slightly more dwellings of a smaller size (<50m2) and a higher proportion of flats in the EPC database.

**Table 11: Building size and type of PRS dwellings in EHS 2020-21 and EPC 2023**

| | EHS 2020-21 | EPC 2023 |
|---|---|---|
| **Total Floor Area:** | | |
| <50m2 | 17% | 19% |
| 50-69m2 | 33% | 31% |
| 70-89m2 | 29% | 27% |
| 90-109m2 | 12% | 12% |
| >110m2 | 10% | 11% |
| **Dwelling Type:** | | |
| Bungalow | 5% | 4% |
| Detached house | 7% | 6% |
| Flat | 39% | 46% |
| Semi-detached house | 16% | 15% |
| Terraced house | 33% | 29% |
| All | 100% | 100% |

# 4 Impact of the regulations on energy efficiency

**Key points:**

- The introduction of the regulations is estimated to have increased the propensity of landlords with F or G rated properties to make energy efficiency improvements.
- As a consequence of the regulations, affected properties are much more likely to meet the required level of energy efficiency, with the odds of achieving the required an EPC rated E or above being at least 3.5 times the level observed in the control group.
- The introduction of the regulations delivered increased energy efficiency (about 1 point in the SAP metric included in the Energy Performance certificates), reduced energy costs (by an average of £67 per year per affected property) and $CO_2$ emissions (by an average of 1,176kg $CO_2$ per year per affected property).
- The impact of the regulations was found to be higher in the first couple of years after their implementation. Since then, properties not affected by the regulations have caught up to some extent with the progress made by the rental properties affected by the regulations.

## 4.1 Introduction

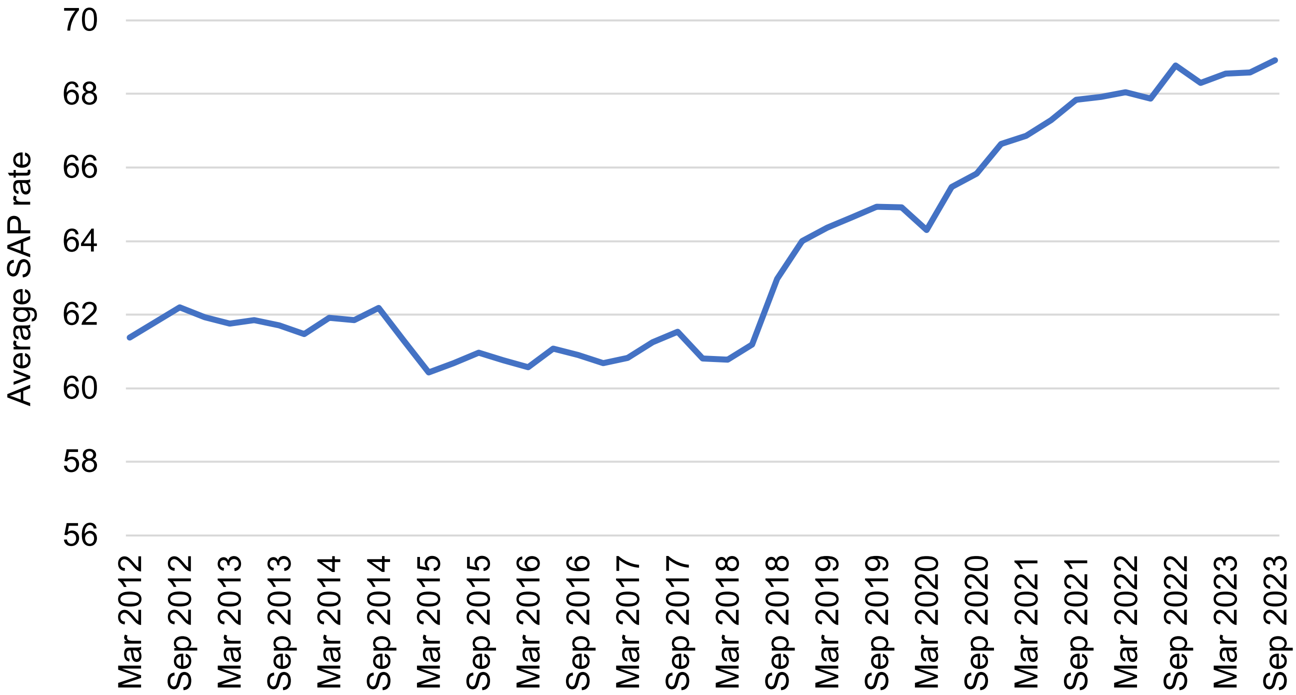
This chapter discusses the results assessing the impact on the regulation on the propensity for energy efficiency upgrades to be made to PRS properties in scope of the regulations, and the estimated impacts on energy efficiency, energy cost, and $CO_2$ emissions based on a sub-sample of properties that had an F or G rated EPC registered before the regulations were introduced and a second EPC registered afterwards, up to August 2023.

The impact of the regulations on the propensity for energy efficiency upgrades to be made is explored by computing the share of PRS properties with an F or G rated EPC issued in 2013 and 2014, which apply for another privately rented EPC by any point in time within the 10 years' validity of the existing certificate, as discussed in Section 2.4. This metric has been computed for PRS properties in England and Wales with an F or G rated EPC issued in 2013 and 2014 and for four comparison groups: 1) Scottish PRS properties with an EPC rated F or G issued in 2013 or 2014; 2) Scottish PRS properties with an EPC rated between A and E issued in 2013 or 2014; 3) English and Welsh PRS properties with an EPC rated between A and E issued in 2013 or 2014; 4) English and Welsh owner-occupied properties with an EPC rated F or G issued in 2013 or 2014.

The evaluation of the impact of the regulations on energy efficiency levels of the PRS properties, energy cost and CO2 emissions is based on the DiD methodology. This approach involves analysing two key variables of interest and conducting a robustness analysis through modified DiD methods and segmentation of the treated group. The DiD method has also been applied to environmental impact ratings. From the results of the DID analysis, the impact of the regulations on energy costs and CO2 emissions has been computed. This comprehensive set of evidence confirms expected impacts of the regulations on the energy efficiency and environmental ratings of the affected properties with consequent impacts on cost savings and CO2 emissions.

Before presenting the results of the analysis, it is helpful to explore how the overall level of energy efficiency has evolved in the PRS sector, as recorded in the national EPC dataset. As shown in Figure 4, the average of the SAP rate of EPC issued in any specific quarter for PRS properties in England and Wales has fluctuated around the value of 61 for at least six years before increasing in 2018, shortly after the introduction of the regulations. As the increasing trend has continued since then before slowing down somewhat in 2022, this cursory analysis provides initial evidence that the average efficiency of PRS properties has increased in correspondence of the introduction of the regulations.

**Figure 4: Average quarterly average SAP rate for the properties in the Private Rented Sector**

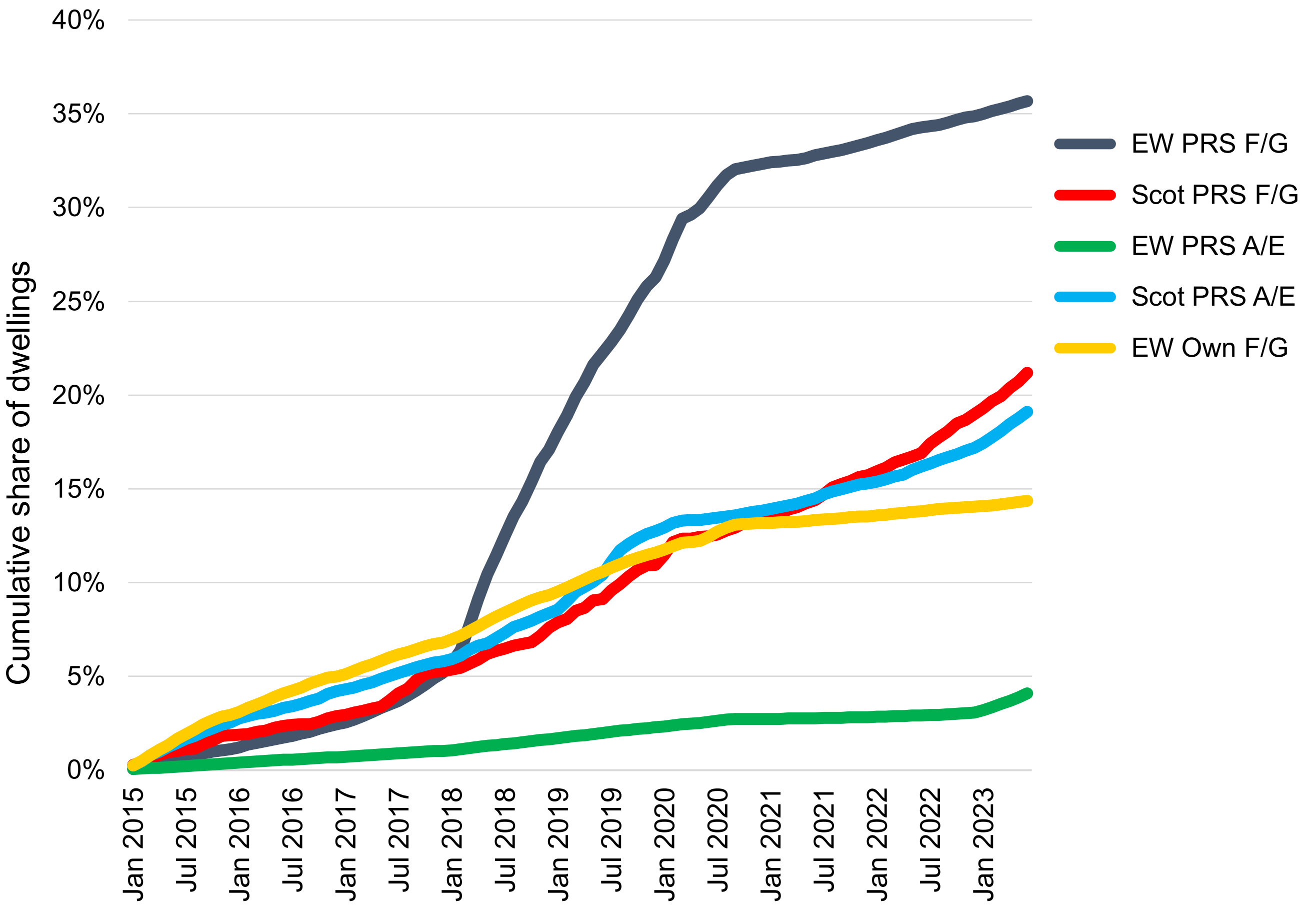


## 4.2 Findings on the impact of the regulations on the propensity for energy efficiency upgrades

The findings of this work indicates that the introduction of the regulations seems to have been a factor incentivising landlords of PRS dwellings in England and Wales with an F or G rated EPC to apply for a second privately rented EPC within the 10 years' validity of the existing certificate.

As shown in Figure 5, in the case of PRS dwellings in England and Wales with an F or G rated valid EPC, labelled 'EW PRS F/G in the figure', there is a clear change in the slope of the curve describing the number of properties applying for second EPC near the introduction of the regulations in April 2018.

**Figure 5: Cumulative share of dwellings with an EPC issued in 2013 and 2014 applying for a second EPC for properties affected by the regulations and 4 comparison groups**




Note: 'EW PRS F/G' indicates English/Welsh PRS properties with an F/G EPC; 'Scot PRS F/G' indicates Scottish PRS properties with an F/G EPC; 'EW PRS A/E' indicates English/Welsh PRS properties with an A-E EPC; 'Scot PRS A/E' indicates Scottish PRS properties with an A-E EPC issued in 2013 – 2014, 'EW Own F/G' indicates English/Welsh owner-occupied properties with an F/G EPC.

Until then, the share of the F or G rated PRS properties in England and Wales applying for a second PEC is remarkably similar to the share of the properties in Scotland, labelled ‘Scot PRS F/G’ in the figure. This offers an indirect confirmation of the suitability of this comparison group. For the first three years, i.e. from January 2015 to December 2017, the computed share of the properties in the two countries in Figure 5 are virtually identical: 5.2% in England Wales and 5.3% in Scotland. By the end of May, barely two months after the regulations had come into effect, the share of the PRS properties with F or G rated EPC issued in 2013 or 2014 applying for a second EPC has doubled to 10.5% in England and Wales, while it has gone up by only 1 percentage point in Scotland to 6.2%. In the following two years, from April 2018 to April 2020, 0.9% of the PRS properties in England and Wales with a F or G rated EPC issued in 2013 or 2014 applied for another EPC every month. That is more than treble the percentage in Scotland, and six times the value in England and Wales up to December 2017. Between April 2018 and April 2020, the computed share in Figure 5 increases by 20.5 percentage points in England and Wales but by only 6.5 percentage points in Scotland. After April 2020 when all PRS properties in England and Wales were mandated to comply with the policy, the share of the PRS properties in England and Wales applying every month for a second EPC after being issued an F or G rated EPC in 2013 or 2014 reverts to values similar to those observed before the introduction of the regulations. No change takes place in Scotland: after April 2020 the share of the PRS properties applying for a second EPC remains at levels similar to those in the previous 24 months.

This analysis confirms that the pattern of the share of the properties applying for a second EPC in the case of the dwellings affected by the regulations is radically different from the other comparison groups considered in this study. It also confirms that PRS properties in England and Wales with an EPC rated above E issued in 2013 or 2014 faced very little incentive to apply for a second EPC. As their level of energy efficiency is relatively high, these landlords were unlikely to be at risk of being mandated any action to increase the energy efficiency before the validity of their current certificate came to an end, which decreased their incentive to apply for a second EPC during the validity of the current certificate. The share of PRS properties in England and Wales with an EPC rated above E issued in 2013 or 2014 in Figure 5, labelled ‘EW PRS A/E’, applying for a second EPC up to 2017 is a fifth of the share of the properties affected by the regulations: 1% against 5%. The introduction of the regulations has no marked impact on this comparison group: between April 2018 and April 2020, the computed share goes up by 1.3 percentage points against an increase of 20.5 percentage points in the properties affected by the regulations.

The analysis presented here confirms that owner-occupied properties in England and Wales with an EPC rated F or G issued in 2013 or 2014 were more likely to apply for a second EPC until the introduction of the regulations. In December 2016, the computed share in Figure 5, labelled ‘EW Own F/G’ is 5%, more than double the value of the share for the properties affected by the regulations. This is attributed to the fact that the owners living in their properties can directly benefit from the bill savings arising from energy efficiency improvements, as well as any amenity or comfort value. It is also possible that these owners improved energy efficiency immediately before putting the property on the market to increase the potential sale price. As the introduction of the regulations approaches, however, the gap between the computed shares for owner-occupied properties in England and Wales with an EPC rated F or G issued in 2013 or 2014 and those affected by the regulations narrows until the share of the PRS properties in England and Wales with a F or G rated EPC issued in 2013 or 2014 applying for a second EPC becomes higher in March 2018, just before the policy came into force. Between April 2018 and April 2020, the value for ‘EW Own F/G’ in Figure 5 goes up by 4.5 percentage point against an increase of 20.5 percentage points in the properties affected by the regulations.

Finally, the share of Scottish PRS properties with an EPC rated above E issued in 2013 or 2014 applying for a second certificate is surprisingly high in Figure 5, as indicated by the line labelled ‘Scot PRS A/E’. As expected, the computed share is much higher than the value for the PRS properties in England Wales with a similar rating. This is because a proposal to mandate a minimum EPC rating of D from 2022 had been discussed in Scotland which might have influenced landlords of properties with an E certificate to take pre-emptive action. The share for Scottish PRS properties with an EPC rated between A and E is however higher than for the Scottish PRS properties with a F or G rated EPC which should have faced higher incentives to apply for a second EPC. It is also higher than the properties covered by the regulations in England and Wales before the regulations came into force. As the regulations should be affected by much less regulatory uncertainty than the proposal discussed in Scotland, one would have expected a stronger impact compared to the Scottish proposal, even before their introduction. While relative high value of the share of the Scottish PRS properties with an EPC rated above E issued in 2013 or 2014 applying for a second certificate may deserve additional investigation, it seems that the regulations quickly made up for the initial difference. The gap between the share for these properties and those affected by the regulations in England and Wales narrows until the latter becomes higher in February 2018, just before the policy came into force. In the 24 months between April 2018 and April 2020, the value for ‘Scot PRS A/E’ in Figure 5 goes up by 6.7 percentage point against an increase of 20.5 percentage points in the properties affected by the regulations.

## 4.3 Sample used in the analysis of the level of energy efficiency of the PRS properties, energy cost and CO2 emissions

As discussed in Section 2.1.1, this analysis uses only properties:

- With at least two EPCs, one of which is issued between 2016 and April 2018, i.e. before the introduction of the regulations, and one after; and
- With the EPC issued before the introduction of the regulations being either F or G rated.

The findings in this report are obtained by using the three treated groups selected in the first scoping study, and used in the 2020 impact evaluation report, namely: recent private rental properties, established private rental, and all private rental properties. Established rentals are long-standing privately rented properties with EPC ratings of F or G before the regulations, offering insights into how existing rentals adapt to new energy efficiency standards. Recent rentals, in contrast, entered the private rental market post-regulation, also with EPC ratings of F or G prior to it. They highlight the response of newly classified rental properties to the regulatory demands for energy efficiency. The 'all private rentals' classification is just the sum of the two first groups.

The control group used in the 2020 impact evaluation report is also used here: Scottish properties meeting the two EPC criteria set out above. However, these properties include both owner-occupiers and PRS, limiting their reliability as a counterfactual. Treated and control groups are further discussed in Section 2.3.1.

Table 12 details the number of observations for different types of rental properties during the period 2016-2023, which are used in the DiD analysis. One can notice that the volume of data available for any treated group in the period between April 2016 and March 2020 is much higher than the data available for the period starting in April 2020.[10] In the case of the overall private rental category, 48,079 observations are available for the former period while only 10,192 for the latter. This is supportive of the assumption that the great majority of the landlords affected by the regulations took action before the deadline of April 2020. In addition, one can notice that the recent rentals treated group has a higher number of observations compared to the established rentals. In the period between April 2016 and April 2020, there are about twice the number of recent rentals than established rentals although the ratio decreases to 1.3 in the period starting in April 2020.

**Table 12: Number of observations in the three treated groups (all private rentals, recent rentals, and established rentals) and the control group used in the DiD analysis**

| Category | After April 2016 and before April 2020 | After April 2020 |
|---|---:|---:|
| Recent private rentals | 32,532 | 5,765 |
| Established private rentals | 15,547 | 4,427 |
| All private rentals | 48,079 | 10,192 |
| Control group | 12,968 | 3,134 |

The descriptive statistics for the control group are discussed in some detail in Section 2.3.1. The bulk of the data is from the period between April 2016 and March 2020, as it occurs for the treated groups. The smaller size of the control group, compared to the treatment groups, confirms results from the first impact evaluation report.

[10] As tax years are used, each period in the table starts in April.

## 4.4 Findings on overall impacts on energy efficiency, energy cost and CO2 emissions to date

### 4.4.1 Impacts of the regulation on the likelihood of achieving EPC band E or above

DiD analysis using a logistic functional form was used to quantify the regulations' effect on the likelihood of properties achieving the required energy efficiency standards. The logistic function is chosen to take into account the binary nature of the dependent variable, as explained in further detail in Section 2.3.3[11]. The DiD analysis was based on a sub-sample of properties in the treatment and control group that had an F or G rated EPC registered before the regulations and a second EPC registered after their introduction up to August 2023.

The results, as detailed in Table 13, indicate that the regulations have significantly increased the probability of meeting the new energy efficiency standards. The table contains the coefficients, the odds ratios related to the baseline model (including fixed effects), the entropy balanced model that reweights the control group for greater comparability with the treatment group, and the model with control variables (including total floor area, built form and fuel type) but excluding fixed effects.

Notably, the estimated coefficients are remarkably consistent across different treated groups, including private, recent private, and established private rental properties. The coefficient for recent private rental properties is marginally higher than that for established private rental properties, with the coefficient for the broader category of private rental properties (including both types of properties) falling in between.

Furthermore, this consistency persists across the various estimated models. As the difference between the estimates from the entropy balanced and the baseline model are small, one can conclude that the relationship between property status (private rental, recent private rental, established private rental) and the likelihood of EPC improvements arising from the regulations is stable and not heavily contingent on the shares of different property types included in the treated and the control groups. Consequently, the policy implications drawn from the baseline model remain valid and reliable, even after accounting for potential imbalances in property types.

[11] The binary variable is defined as 'property improved to minimum standard of EPC band E'. In other words, if the property has been improved to meet an EPC rated E or above, the value of this variable is 1 while the value is 0 if the EPC band E has not been reached.

The coefficients in Table 13 enable the calculation of the odds ratios, also in the table, which compare the odds of achieving EPC band E in the treated properties against those in the control group.[12] This analysis reveals a substantial impact of the regulations on meeting the energy efficiency threshold. Specifically, the odd ratios for the treated group range from 3.19 higher than for the control group in the case of recent private rental properties to 3.56 higher for established private rental properties in the case of the baseline model.

The comparison of results in Table 13 with those from the first impact evaluation report reveals a decrease in the strength of the impact of the regulations on the likelihood of PRS properties achieving at least a band E EPC. In the first report, the coefficients in the baseline model ranged between 2.34 and 2.62, indicating a stronger likelihood of achieving a minimum of an EPC band E. Conversely, the coefficients range between 1.16 and 1.27 in Table 13, suggesting a less pronounced effect of the regulations on energy efficiency improvements. The difference in the value of the coefficients translates into the computed odds ratios: the first impact evaluation report's ratios were between 10.33 and 13.78 in the baseline model, against values between 3.19 and 3.56 in Table 13. Consistency in the value of the coefficients and related odds ratios is observed across different models and treated groups in both reports.

**Table 13: Results for the likelihood of a property being improved to a minimum standard of EPC band E relative to the control group[13]**

| Category | Baseline model | Entropy balanced | Model with control variables |
|---|---|---|---|
| All private rentals (N = 67,325) | | | |
| Coefficients | 1.26** | 1.28** | 1.17** |
| Odds ratio | 3.53 | 3.61 | 3.22 |
| Pseudo R2 | 0.47 | 0.32 | 0.69 |
| Recent private rentals (N = 59,671) | | | |
| Coefficients | 1.27** | 1.29** | 1.12** |
| Odds ratio | 3.56 | 3.64 | 3.06 |
| Pseudo R2 | 0.38 | 0.29 | 0.60 |
| Established private rentals (N = 16,708) | | | |
| Coefficients | 1.16** | 1.18** | 1.08** |
| Odds ratio | 3.19 | 3.26 | 2.94 |
| Pseudo R2 | 0.50 | 0.27 | 0.57 |

[12] The odds, calculated as the ratio of the probability of success (reaching EPC band E) to the probability of failure (not reaching EPC band E), vary from 0 to infinity.
[13] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

### 4.4.2 Impacts of the regulations on the SAP rate

A DiD analysis within a linear model framework was conducted to quantitatively assess the regulations' impact on the Standard Assessment Procedure (SAP) rate. This approach simplifies interpretation of the regression coefficients as they directly indicate the increment in the SAP rate attributable to the regulations, after accounting for changes observed in the control group unaffected by the policy. It does this by comparing the average change in SAP scoring over the period in England and Wales, with that occurring over the same time period in Scotland.

As detailed in Table 14, three models were examined. These include the baseline model with fixed effects, the entropy balanced model that reweights the control group for greater comparability with the treatment group, and the model with control variables incorporating total floor area, built form and fuel type but excluding fixed effects. The results in the table show the difference in the impact of the regulations across the three treated groups considered in this study. SAP rates for recent private rentals have increased by between 1.8 and 2.1 points, depending on the model, while for established private rentals they have decreased between 2.8 to 3.0 points. All private rentals (which comprises both recent and established rentals) displays an intermediate effect, with an increase between 1.1 to 1.3 points.

When comparing different models, the baseline and the entropy balanced models yielded similar results. The entropy balanced model shows a marginally higher impact on recent private rentals, but the difference is small, i.e. 2.1 compared to 1.8. For established private rentals, the difference between the two models is even smaller, a decrease equal to 2.8 compared to 2.9. These negative coefficients suggest a smaller increase in SAP rate for English and Welsh established properties relative to Scottish properties. The similarity between the entropy and baseline model carries through to the private rentals category, which comprises both recent and established rentals: the impact of the regulations is estimated to be an increase in the SAP equal to 1.1 points according to the baseline model and 1.3 points according to the entropy balanced model. This consistency suggests that the composition differences between the treated and control groups had a limited impact on the outcomes.

**Table 14: Results for the impact of the regulations on the SAP rate in the case of the three treated groups assessed in this study relative to the control group**[14]

| Treated | Baseline | Entropy balanced | Model with control variables |
|---|---|---|---|
| All private rentals (N = 67,325) | | | |
| Coefficients | 1.1** | 1.3** | 1.1** |
| R2 | 0.31 | 0.22 | 0.31 |
| Recent private rentals (N = 59,671) | | | |
| Coefficients | 1.8** | 2.1** | 1.8** |
| R2 | 0.24 | 0.19 | 0.27 |
| Established Private Rentals (N = 16, 708) | | | |
| Coefficients | -2.9** | -2.8** | -3.0** |
| R2 | 0.35 | 0.20 | 0.37 |

Confirming the results for the likelihood of achieving an EPC band E or higher, the comparison between the results above and those from the first impact evaluation report points at a difference in the estimated impact of the regulations on the SAP rate. In the first report, the impact on recent private rental properties was estimated to range between 8.0 and 10.0 SAP points, compared to the estimated impact ranging between 1.8 and 2.1 points in Table 14. The impact on established private rentals was smaller but still positive in the first impact evaluation report (between 1.3 and 3.0 points) while it has become negative in Table 14, with estimates ranging between a reduction of 2.8 and 3.0 points. Finally, the impact on the overall private rentals (including both established and recent properties) was estimated to range between 5.1 and 5.2 in the first impact evaluation report compared to values ranging between 1.1 and 1.3 points in Table 14.

## Robustness approaches

The findings on the impact of the regulations on the SAP rate are further supported by the robustness approaches described in Section 2.3.3. Specifically, Table 15 presents the impact on the SAP rate using the methodology in Bertrand et al. (2004), while Table 16 presents estimated impact across sub-samples of the treated and control groups.

[14] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

### Results from Bertrand et al (2004) approach

The methodology in Bertrand et al. (2004) addresses potential issues of serial correlation in the variable of interest. The estimation of this model utilises a dataset comprising the same properties as the models in Section 4.3.2. After calculating an average of the EPCs before and after the policy implementation for each unit in the dataset, a linear model is estimated using only two data points for each property. The results from the first impact evaluation report, based on data from 2016 to 2020, delivered positive impacts on the SAP rates across the three treated groups used in the analysis: between 6.0 and 6.2 SAP points for private rental properties, 9.2 and 8.2 for recent private rentals, and 2.4 and 4.1 for established private rentals. The current analysis, extending the dataset to 2023, paints a more complex picture. The impact is still positive for recent private rentals, with both coefficients being 1.8, and the broader category of private rentals with estimates between 1.0 and 1.1. On the other hand, coefficients for established private rental properties exhibit a negative coefficient between -3.0 and -2.9.

**Table 15: Results for the impact of the regulations on SAP rate for the treated groups assessed in this study relative to the control group from the estimation of the DiD approach allowing for potential serial correlation in the variables[15]**

| Treated | Baseline | Model with Control Variables |
|---|---|---|
| All private rentals (N = 58,732) | | |
| Coefficient | 1.1** | 1.0** |
| R2 | 0.32 | 0.34 |
| Recent private rentals (N = 52,535) | | |
| Coefficient | 1.8** | 1.8** |
| R2 | 0.26 | 0.28 |
| Established private rentals (N = 15,836) | | |
| Coefficient | -3.0** | -2.9** |
| R2 | 0.34 | 0.37 |

[15] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

In the model not accounting for serial correlation in Table 14, the coefficients for all private rentals, recent private rentals, and established private rentals were estimated to be 1.1, 1.8, and -2.9, respectively, by the baseline model. Results from the model incorporating tackling serial correlation presented in Table 15 deliver almost identical coefficients: 1.1 for private rentals, 1.8 for recent private rentals, and -3.0 for established private rentals in the case of baseline model. The consistency between the results in Table 14 and Table 15 extends to the model with control variables, therefore confirming that potential serial correlation does not appear to be a concern in the case of the models estimated in this study.

### Results across property types

The effect of the regulations on SAP scores is further validated by applying the baseline model and the model with controls to various sub-samples within the treated and control groups used in this study. This subdivision is particularly insightful for two reasons: first, it helps us understand the factors associated with the change in EPC values following the introduction of the regulations; and second, it aids in identifying the reasons behind the distinct policy impacts on recent versus established private rental properties.

Table 16 sheds light on the impact of regulations by property type. It consistently shows a smaller impact on flats compared to houses across all treated groups. Bungalows generally have positive impacts, particularly in recent rental properties (2.5 and 4.1). This difference might be due to inherent characteristics of these property types or differences in their responses to regulatory changes. There is also a clear contrast between the impacts on established and recent rental properties. As an example, flats in the established rental case experience a decrease of about 4.0 SAP points, whereas flats in the recent rental category a more moderate decrease of 2.8 SAP points. The impact on property size (Small, Medium, Large) varies across treated groups but larger properties generally show stronger impact of the regulations. This may reflect the impact being stronger in the case of houses compared to flats, the former having a bigger size than the latter.

Estimated coefficients of the regulations are consistently negative across the subgroups comprised in the established rental properties which, means that the change in the energy efficiency in these properties is smaller than the change observed in the control group. The change is positive, except for the flat subcategory, in the case of recent private rentals. This might be explained by established rentals being older properties characterised by less advanced construction standards or difficulties in upgrading these buildings to meet new regulations. On the other hand, recent rentals might reflect relatively modern properties which have been more easily brought up to the required standard. Overall, the estimates in Table 16 confirm that the difference in the estimated impact of the regulations across treated groups in are not due to specific property types or properties of a specific size.

**Table 16: Results for the impact of the regulations on SAP rate across sub-samples of the treated and control groups assessed in this study relative to the control group[16]**

| | Baseline | Model with control variables |
|---|---|---|
| **All private rentals** | | |
| House (N = 33,580) | | |
| Coefficient | 3.4** | 0.9 |
| R2 | 0.32 | 0.52 |
| Bungalow (N = 5,314) | | |
| Coefficient | 2.2** | 2.6** |
| R2 | 0.28 | 0.36 |
| Flat (N= 28,408) | | |
| Coefficient | -2.9** | -3.0** |
| R2 | 0.30 | 0.30 |
| Small (N = 22,441) | | |
| Coefficient | -0.4 | -0.2 |
| R2 | 0.30 | 0.41 |
| Medium (N = 22,440) | | |
| Coefficient | -0.1 | 0.6 |
| R2 | 0.33 | 0.50 |
| Large (N = 22,440) | | |
| Coefficient | 2.7** | 1.3** |
| R2 | 0.29 | 0.45 |
| Traditional construction (N = 55,886) | | |
| Coefficient | 1.2** | 1.2** |
| R2 | 0.33 | 0.51 |
| Non-traditional construction (N = 2,431) | | |
| Coefficient | 1.0** | 0.9 |
| R2 | 0.27 | 0.35 |
| **Recent rentals** | | |
| House (N = 30,238) | | |
| Coefficient | 3.8** | 1.3 |
| R2 | 0.28 | 0.49 |
| Bungalow (N = 4,840) | | |
| Coefficient | 2.5** | 4.1** |
| R2 | 0.25 | 0.34 |

[16] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

| | Baseline | Model with control variables |
|---|---|---|
| Flat (N = 24571) | | |
| Coefficient | -2.8** | -2.9** |
| R2 | 0.19 | 0.19 |
| Medium (N = 19,889) | | |
| Coefficient | 0.3 | 1.8** |
| R2 | 0.27 | 0.47 |
| Large (N = 19,889) | | |
| Coefficient | 3.1** | 2.5** |
| R2 | 0.25 | 0.42 |
| Traditional construction (N = 49,500) | | |
| Coefficient | 1.5** | 0.9** |
| R2 | 0.27 | 0.47 |
| Non- traditional construction (N = | | |
| Coefficient | 0.7** | 0.7 |
| R2 | 0.14 | 0.25 |
| **Established rentals** | | |
| House (N = 7,264) | | |
| Coefficient | -2.8** | -3.1** |
| R2 | 0.30 | 0.32 |
| Bungalow (N = 2,298) | | |
| Coefficient | -0.7 | -3.4** |
| R2 | 0.24 | 0.25 |
| Flat (N= 7,124) | | |
| Coefficient | -4.0** | -4.0** |
| R2 | 0.46 | 0.466 |
| Small (N = 5,569) | | |
| Coefficient | -2.2** | -2.6** |
| R2 | 0.44 | 0.46 |
| Medium (N = 5,568) | | |
| Coefficient | -4.2** | -4.1** |
| R2 | 0.37 | 0.39 |
| Large (N = 5,568) | | |
| Coefficient | -2.6** | -4.5** |
| R2 | 0.25 | 0.27 |

Comparison between the results Table 16 and those in the first impact evaluation report indicates that a reduction in the intensity of the impact has occurred across property types, size and method of constructions. As an example, in the case of houses within private rental properties, estimated impact in the first evaluation report ranged between 7.8 and 11.5 compared to a range between 0.9 and 3.4 in Table 16. Confirming results from this study, the first evaluation report concluded that the impact of the regulation is positively correlated to the size of the properties. As an example, in the case of the baseline model estimated impact of the regulations on small, medium and large private rental properties was reported to be 1.2, 8.2 and 9.2 SAP points, respectively compared to -0.4, -0.1 and 2.7 in Table 16. With regard to the method of construction, the baseline model delivered an estimated impact of the regulations in private rental properties equal to 7.1 and 6.1 for private rental properties which are traditionally built and non-traditionally built, respectively. The same model delivers an estimated impact of 1.2 and 1.0 for those properties, as shown in Table 16.

### 4.4.3 Impacts of the regulations on energy costs

The assessment of the regulations' effect on energy costs is based on the relationship between the SAP (Standard Assessment Procedure) rate and the anticipated energy consumption within homes, as outlined in Section 2.3. However, there are two important considerations regarding these findings: Firstly, the results do not account for 'in-use factors' such as the increased comfort levels that residents might choose; in addition, the savings arising from any specific technology over time might degrade as part of the normal wear and tear of the technical kit. As a result, these findings might overestimate the actual impact of the regulations compared to their actual impact. Secondly, the energy cost findings are calculated using the prices from 2023, while the first report used 2012 prices, resulting in an underestimate of the actual cost savings as prices are higher than those observed in 2012. Therefore, the comparison between reports should be treated with caution.

**Table 17: Computed impact of the regulations on average yearly energy cost per property based on the impact on energy efficiency (as measured by the SAP) in Table 14**

| Treated | Baseline | Model with control variables |
|---|---:|---:|
| All private rental | -£67 | -£67 |
| Recent private rental | -£109 | -£109 |
| Established private rental | £184 | £191 |

As seen in Table 17, the results show some variation across treated groups, reflecting findings in Table 14. In the case of the overall private rental properties, the baseline model and the model with control variables show a decrease in annual energy costs of £67. When examining recent private rental properties, both models point towards cost savings equal to £109, suggesting that properties which became rentals from April 2018 onward substantially benefited from the regulations in terms of cost savings. On the other hand, in the case of established private rental properties, the baseline model and the model with control indicates that energy costs decreased by £184 yearly more in Scotland than in the established English and Welsh properties. Therefore, relative to the control group, this value shows that for this specific group, prices are higher in England and Wales than in Scotland in the period after the regulations were introduced from April 2018. Note that it is not the case that energy costs have increased in England and Wales; rather, it is that they have not decreased as fast as they have in Scotland, the control group upon which these calculations are based.

The cost savings in Table 17 are generally smaller than those presented in the first impact evaluation report, reflecting the smaller impact on SAP rates discussed above. One important thing to note, is that the first impact evaluation used 2012 prices, while in this report 2023 prices are used.[17] In the first impact evaluation report cost savings were estimated to be around £120 for all private rental properties, between £195 and £243 for recent rentals and between £33 and £72 for established properties see modest savings. The figures in Table 17 imply a reduction of about a half in the case of all private rentals and recent private rentals, meanwhile, the pace of cost reduction for established rentals has begun to decelerate. Interestingly, properties located in Scotland have surpassed these, indicating that the previously documented cost savings advantage of established rentals in England and Wales over the Scottish control group, as reported in the first impact evaluation, has shifted. The advantage now lies with Scottish properties, reversing the trend observed in the initial report.

### 4.4.4 Impacts of the regulations on the Environmental Impact (EI) rate and CO2 emissions

The calculation of the regulations' impact on CO2 emissions involves estimating the effect of the Environmental Impact (EI) rate, followed by the conversion into CO2 emissions using the BRE (Building Research Establishment) formula, as detailed in Section 2.3.3. The environmental impact rate is an important metric that evaluates a property's effect on the environment, with a higher rating indicating lower levels of CO2 emissions. The determination of this rating considers the overall performance of the building, including its construction, materials, and design, as well as the efficiency of its fixed services like heating, lighting, and other energy-related features.

[17] The savings expressed in 2023 energy prices have been obtained by multiplying the energy cost savings obtained from the SAP computation by the ratio between the value of the price index for domestic fuels in real terms in 2023Q2 and 2012Q2 from the Energy Prices Domestic Prices report published by DESNZ.

## Impact on the Environmental Impact (EI) rate

Table 18 displays the estimated impact of regulations on the EI rate with a positive coefficient indicating an increase in the treated group compared to the control group, implying a positive impact on environmental performance. For the overall set of private rental properties, both the baseline model and the model with control variables show positive impact, with increases in EI rate of 6.9 and 7.1, respectively. In the case of recent private rental properties, the baseline model estimates a positive impact equal to 7.2 points while the model with controls delivers an estimate equal to 7.4. In the case of established private rental properties, the estimated impacts are smaller but still positive, 3.3 and 3.5 points based on the baseline model and the model with control variables, respectively. This consistent set of findings across models suggests that the regulations have led to improvements in the environmental performance of the affected properties.

**Table 18: Estimated impact of the regulations on Environmental Impact (EI) rate relative to the control group[18]**

| Treated | Baseline | Model with control variables |
|---|---|---|
| All private rentals (N = 61,310) | | |
| Coefficient | 6.9** | 7.1** |
| R2 | 0.20 | 0.35 |
| N | 61310 | 61310 |
| Recent private rentals (N = 53,555) | | |
| Coefficient | 7.2** | 7.4** |
| R2 | 0.17 | 0.33 |
| N | 53555 | 53555 |
| Established private (N = 9,916) | | |
| Coefficient | 3.3** | 3.5** |
| R2 | 0.18 | 0.34 |
| N | 9916 | 9916 |

In the case of the EI rate, results from the first impact evaluation report point at a smaller impact compared to those reported here. The impact was estimated to range from 3.0 to 3.4, in the case of the overall private rental properties, compared to an estimate of about 7 EI points in Table 18.

[18] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

The difference between the two reports is more nuanced in the case of recent private rental properties, with the first impact evaluation report showing an increase between 6.7 and 8.0, and the current report presenting a slightly more consistent and narrow range of 7.2 to 7.4. A starker contrast between the two reports is observed in the case of established private rental properties, with the first impact evaluation study reporting coefficients ranging from -1.4 to -0.4 while a clear positive impact, with increases between 3.3 and 3.5 can be seen in Table 18.

Overall, the comparative analysis suggests higher positive impacts of the regulations on EI rates in this study compared to the first impact evaluation report. This indicates an enhanced effectiveness of the regulations over time or a change in the composition or characteristics of the properties within the sample. Particularly noteworthy is the change in case of established private rental properties, with coefficients estimated to be negative in the first impact evaluation report and positive in Table 18.

### Robustness analysis

Table 19 explores the impact of regulations across subcategories of the treated groups. It reinforces the findings from Table 18, demonstrating consistency in the estimates across the two models in the table. On the other hand, the estimated impact of regulations varies considerably across property types. Contrary to the findings in Table 16 for the SAP rate, results in Table 19 for the EI rate consistently shows a larger impact on flats compared to houses across all treated groups. The impact of the regulations on bungalows is similar to the impact on flats for the overall private rental properties. Moreover, the analysis reveals a size-dependent effect of the regulations, with larger properties tending to exhibit higher impacts in terms of EI rates compared to their smaller counterparts.

**Table 19: Estimated impact of the regulations on EI rate from the baseline DiD approach across sub-samples of treated and control groups relative to the control group[19]**

| | Baseline | Model with control variables |
|---|---|---|
| **All private rentals** | | |
| House (N = 30,155) | | |
| Coefficient | 1.6** | 0.9 |
| R2 | 0.24 | 0.25 |
| Bungalow (N = 3,552) | | |
| Coefficient | 8.4** | 7.8** |
| R2 | 0.20 | 0.21 |
| Flat (N = 25,609) | | |

[19] The stars mean that the coefficient is statistically significant at a level of 95%. The coefficients without stars are not statistically significant at this level.

| | Baseline | Model with control variables |
|---|---|---|
| Coefficient | 8.3** | 7.9** |
| R2 | 0.16 | 0.18 |
| Small (N = 21,434) | | |
| Coefficient | 3.1** | 3.2** |
| R2 | 0.16 | 0.17 |
| Medium (N = 19,580) | | |
| Coefficient | 6.1** | 5.8** |
| R2 | 0.22 | 0.24 |
| Large (N = 18,295) | | |
| Coefficient | 8.1** | 8.1** |
| R2 | 0.24 | 0.27 |
| **Recent Rentals** | | |
| House (N = 26,759) | | |
| Coefficient | 1.8** | 1.1** |
| R2 | 0.10 | 0.11 |
| Bungalow (N = 3,071) | | |
| Coefficient | 10.8** | 10.7** |
| R2 | 0.20 | 0.20 |
| Flat (N = 21,721) | | |
| Coefficient | 8.9** | 8.3** |
| R2 | 0.22 | 0.23 |
| Small (N = 18,685) | | |
| Coefficient | 3.1** | 3.2** |
| R2 | 0.10 | 0.11 |
| Medium (N = 17,156) | | |
| Coefficient | 6.9** | 6.5** |
| R2 | 0.19 | 0.21 |

| | Baseline | Model with control variables |
|---|---|---|
| Large (N = 15,707) | | |
| Coefficient | 8.4** | 8.3** |
| R2 | 0.23 | 0.24 |
| **Established Rentals** | | |
| House (N = 3,396) | | |
| Coefficient | 0.3 | -1.1 |
| R2 | 0.19 | 0.19 |
| Bungalow (N = 481) | | |
| Coefficient | 2.1** | 2.1** |
| R2 | 0.15 | 0.17 |
| Flat (N = 3889) | | |
| Coefficient | 7.7** | 7.4** |
| R2 | 0.28 | 0.32 |
| Small (N = 3,590) | | |
| Coefficient | 1.1** | 1.5** |
| R2 | 0.27 | 0.29 |
| Medium (N = 2,264) | | |
| Coefficient | 1.3** | 1.2** |
| R2 | 0.23 | 0.24 |
| Large (N = 1,910) | | |
| Coefficient | 3.8** | 3.2** |
| R2 | 0.20 | 0.22 |

The results in Table 19 differ from the first impact evaluation report, which reported stronger impacts in the case of houses rather than flats. In terms of the impacts of the regulations on properties of different size, the first report documented the highest impact for medium-sized properties with estimates ranging between 5.9 and 6.8, followed by large properties (3.4 and 4.6) and small properties (between -1.1 and 0.7). The current report shows that the impact of the regulation increases with the size of the properties; in addition, the impact is higher compared to those reported in the first impact evaluation for small and large properties. Estimated impact in the two reports is similar in the case of medium properties, between 5.8 and 6.1 in Table 19 compared to a range between 5.9 and 6.8 in the first impact evaluation report.

### Impact on CO2 emissions

Computed impact of the regulations on CO2 emissions are shown in Table 20 using the relationship between EI rates and CO2 emissions discussed in Section 2.3.3. When assessing these results, one should bear in mind the two caveats raised above in relation to energy costs. Firstly, the findings might overestimate the impact of the regulations as they do not take into account 'in-use factors' or deterioration of the technology across time. Secondly, the computations are based on carbon factors related to 2012 rather than current factors.

**Table 20: Computed impact of the regulations on average kilos of CO2 emissions per year per property based on Table 18**

| Treated | Baseline | Model with control variables |
|---|---|---|
| All private rental properties | -1,176 | -1,208 |
| Recent private rental properties | -1,223 | -1,254 |
| Established private rental properties | -587 | -621 |

For the overall set of private rental properties, computations based on the baseline model and the model with control variables show a decrease in CO2 emissions, with values of 1,176 and 1,208 CO2 kg per year, respectively. In the case of recent private rental properties, computations based on the baseline model deliver a reduction of 1,223 kg CO2 per year, slightly smaller than the 254 kg CO2 indicated by the model with control variables. Finally, in the case of established private rental properties, the decrease in emissions is less pronounced, with the baseline model indicating a decrease of 587 kg of CO2 per year, and the model with control variables a decrease of 621.

Compared to the first impact evaluation report, the results in Table 20 point to a higher impact of the regulations on CO2 emissions. In the case of private rental properties, the first report indicated an annual reduction in CO2 emissions of 445 kg according to the baseline model, about half of the value presented in the table above. In the case of recent private rental properties, the reductions reported in the first impact evaluation report were similar to those in this evaluation, i.e. between 987 and 1,156 kg CO2 per year.

One caveat with these emissions savings findings relates to how changes in RdSAP methodology over time may be influencing the results. As explained in section 2.5 of this report, the carbon savings can appear proportionally larger than the bill savings (the findings and methodology of which are outlined in section 4.4.4) when compared against average household carbon emissions and energy bills in England and Wales.[20] This may partly reflect that newer versions of RdSAP assume a lower carbon intensity for grid electricity.[21] This evaluation found that properties subject to the regulations (PRS homes in England and Wales with an F or G rating) had a significantly higher EPC replacement rate in the time period following the introduction of the regulations, whereas the rate of those in the control groups remained unchanged. This suggests that treatment group properties are more likely to have up-to-date EPCs than those in the control group. Consequently, part of the observed carbon savings may reflect the cleaner grid assumption in the RdSAP methodology rather than solely the installed measures, and which could explain why carbon savings appear proportionally larger than bill savings.

[20] DESNZ 'Annual domestic energy bills', GOV.UK
[21] See: DESNZ (2024) 'Energy Company Obligation schemes: SAP and RdSAP amendments - government response', GOV.UK; & BRE 'Standard Assessment Procedure SAP 10'

# 5 Health impacts of the regulations

**Key points:**

- The introduction of the regulations and the resulting change in energy performance among domestic PRS dwellings is estimated as having a benefit to households through increases in wintertime indoor temperature, and a corresponding reduction in the risk of mould growth.
- The potential health impact of retrofits that improved wall insulation, heating systems and air leakage are estimated as being around 1,000 QALYs after the first 5 years, and around 2,150 QALYS after 10 years on the households living therein.
- The savings to health care services is estimated at around £1 Million over 5 years and around £2.1 Million over 10 years.

## 5.1 Introduction

By using health impact assessment (HIA) modelling, it is possible to evaluate the potential range of impacts that energy efficiency measures introduced under the PRS Minimum Energy Efficiency Standard (MEES) regulations could have on households living in those dwellings.

This analysis seeks to quantify the potential health changes associated with the installation of measures through the regulations in terms of impacts on the reduction in the cost of heating a home, either in the form of improvement in welfare (e.g. thermal comfort), or potential change in ill health and the associated costs on health services. Note that HIA is a theoretical assessment which models the potential health impacts of an intervention that see a dwelling move from an EPC F and G level to a higher level of E, and where relevant to D and above in small cases. The HIA estimates the incremental impact on health compared to the previous baseline of no change in EPC. The estimate is not specific to an individual but is rather an estimate of interventions of moving to an EPC level E and higher for the population as a whole. In addition, the modelling conducted here uses a ‘bottom-up’ approach through considering the impacts at a dwelling and household level and then scaled to be representative of the PRS dwellings stock using the EHS. Therefore, the impacts on energy use are somewhat different than the impact analysis as it considers heating preferences and household behaviours.

The analysis of the effects generated by energy efficiency installations on indoor environmental conditions and occupants’ health was performed using the Health Impact of Domestic Energy Efficiency Measures (HIDEEM) model developed for DESNZ (formerly BEIS) and using information from the 2017/18 EHS. The modelling shown here assumes that the efficiency interventions are implemented according to building regulation requirements that mean that the ventilation of a dwelling is not made worse. However, it is not necessarily the case that installations always adhere to the requirements and therefore these estimates may be generally considered as more positive than if installations are poorly installed.

## 5.2 Health impact assessment method

Change in household warmth and any corresponding health and well-being impacts were estimated using HIDEEM model, which was developed by UCL and the London School of Hygiene and Tropical Medicine for health impact analysis through funding from the UK Research Institute, European Research Council, National Institute for Health Research, and DESNZ (under original contract to BEIS).

HIDEEM is an exposure-determinant and health impact model that uses household-level information to quantify change in indoor environmental exposures and health outcomes through established pathways. The underlying housing stock within the model is the English Housing Survey (EHS). The model comprises (i) a building physics model of English houses that quantifies indoor winter temperatures, exposures to particle pollution, tobacco smoke, radon, mould growth and energy demand in relation to the energy performance of the dwelling; and (ii) a model of the resulting health impacts based on a combination of life table methods and directly modelled changes in disease prevalence.

The treatment group in this analysis is domestic PRS properties that moved from a previous F or G rating to a higher rating, compliant with the regulations, since their introduction. Out of the circa 4 million domestic PRS properties in the EPC database, we estimate around 184,000 properties have moved from an F or G rating to an E or better. The counterfactual is pre-regulation F or G rated properties.

The HIA using HIDEEM requires knowledge of the basic dwelling features and energy performance in order to predict the potential baseline indoor environmental quality (IEQ). To estimate changes in IEQ, PRS EPC data was used, including key features of the dwelling and measures installed (see below). The EPC data was then matched to extract representative dwellings from the EHS for the purpose of modelling the potential health impacts.

Other household determinants of potential health impact include age and sex, and these would be controlled for to estimate the effect of changes in IEQ. Where such information was not available from PRS EPC data, an approximation using a sample of households from the EHS was used to provide a range of impacts.

### 5.2.1 Health impact of domestic energy efficiency measures model

For this evaluation, a standalone version of the HIDEEM model is used to estimate the potential health impact of a selection of energy efficient measures installed in dwellings. The HIDEEM method works by calculating the changes in indoor environmental exposure of wintertime temperature and mould risk related to changes to the energy performance of the dwelling. The model can also estimate changes in air pollution (i.e. PM2.5 (indoor and outdoor sourced), environmental tobacco smoke, and radon). However, due to data limitations on ventilation characteristics and before/after energy performance in PRS dwellings, indoor air quality changes were not estimated except for mould risk, measured as the % change in risk of mould severity index being greater than 1 and relates to risk of asthma.[22]

Exposure to a change in the range of experienced wintertime temperatures can modify the risk of developing a host of cardiovascular and respiratory diseases.[23] Dwelling energy efficiency measures for which health impacts were estimated comprise changes to the fabric performance, including loft, cavity wall and solid wall insulation, double-glazing replacement, along with boiler upgrade and gas central heating system installation.[24]

The HIDEEM model used the environmental changes of indoor temperature following a new installation in the dwelling to determine the effect on household occupant health (measured in QALYs) using households drawn from the 2017/18 EHS that were living in a dwelling with a measured EPC level F and G.  These information from the EHS on these households, who are expected to be representative of the broader PRS household sector, was then used to estimate the health impact and the impact of spending in the health sector. The change in health sector spending uses disease specific change in risks to changes in disease treatment costs, which are drawn from NHS disease treatment spending data.[25]

The quantification of health impacts based on the HIDEEM involved the following steps:

- Identifying dwelling characteristics for properties potentially affected by the regulations that could be used to define the housing stock on which to sample from the EHS; these were: dwelling age and type.
- Characterising relevant energy efficiency interventions and applying them within the HIDEEM modelling framework; adjusting and updating any relevant features of the HIDEEM model accordingly. The interventions included were solid wall insulation, cavity wall insulation, draught proofing, glazing, heat pumps, roof insulation.

[22] William J Fisk, Quanhong Lei-Gomez, Mark J Mendell (2007) 'Meta-analyses of the associations of respiratory health effects with dampness and mold in homes', Indoor Air 2007; 17, Pages 284–96.
[23] Paul Wilkinson, Megan Landon, Ben Armstrong, Simon Stevenson & Martin McKee (2001) 'Cold comfort: The social and environmental determinants of excess winter death in England, 1986-1996', Joseph Rowntree Foundation
[24] Ian Hamilton, James Milner, Zaid Chalabi, Payel Das, Benjamin Jones, Clive Shrubsole, Mike Davies & Paul Wilkinson (2015) 'Health effects of home energy efficiency interventions in England: A modelling study', BMJ Open, 5(4)
[25] James Milner & Ian Hamilton (2014) 'Evidence review and economic analysis of excess winter deaths and illnesses: Economic modelling report', National Institute for Health and Care Excellence.

- Running the model using the input data and corresponding EHS sampling to estimate the impacts of energy efficiency interventions on a change from the baseline estimated indoor environmental conditions (e.g. cold and mould risk). The change in exposure then drives an average change in relative risk, which creates a change in estimated health impact using the QALY, among the sample of households potentially affected by the regulations.
- Calculating change in healthcare costs from the QALY by converting this health impact to the impact on health sector spending, with inflation adjustments made to reflect 2020.

The model outputs an evaluation of the ex-ante impact of the energy efficiency measures on estimated changes in indoor environmental conditions and the impact on mortality and morbidity, and associated changes in healthcare expenditure.

Estimating the potential health benefits associated with the regulations required characterising the dwellings energy performance from the available PRS EPC data and drawing a sample of households from the EHS that represent those who live in dwellings similar to PRS households potentially affected by the regulations and using the HIDEEM model to calculate the effect of the introduction of a selection of energy efficiency measures that could change the indoor environmental conditions. This included developing both an intervention and comparison of a pre-intervention state for the target households. The analysis also needed to account for uncertainty in the sample related to occupancy, underlying health conditions, and existing environmental conditions within the dwellings.

The above modelling assumptions mean that the results cannot be used to estimate the health impact for any specific household but are instead indicative of the potential health impacts of the broader population.

## 5.3 Data used in the HIA

The EHS provides detailed data on dwelling attributes and energy performance characteristics, along with information on the households living therein, which is needed for the health impact analysis.

The dwellings characteristics and energy performance data included those shown in Table 23.

**Table 23: EHS dwelling characteristic variables for HIA**

| | |
|---|---|
| Dwelling type | bungalow, detached house, semi-detached house, terraced house, and flats |
| Dwelling age | pre-1900; 1900-1929; 1930-1949; 1950-1966; 1967-1975; 1976-1982; 1983-1990; 1991-1995; 1996-2002 |
| EPC band | A, B, C, D, E, F, G |

The dwellings using in the HIA included all PRS dwellings identified within the EHS where the status of being in EPC band F and G in the 2018 version of the survey. All dwellings within that survey year and which were in the bands required to comply with the standard were used in the analysis. For those selected dwellings, the model altered their energy performance and therefore the EPC level based on the types of measures identified in the EPC data among dwellings that had a previous EPC of F and G and who had an upgrade certificate of EPC E and above. The main measures that impact on indoor environmental conditions considered included: loft insulation, cavity wall insulation, upgraded double glazing, heating system upgrade, and draught proofing. Other efficiency measures, such as lighting, do not affect the environmental conditions considered in the HIDEEM modelling and are therefore not included in the analysis. The measures applied to any given PRS dwelling depended on their eligibility of receiving the retrofit as defined in the survey (i.e. cavity wall insulation for unfilled cavity walls). It is not possible to map a directly one-to-one retrofit change for any given dwelling in the EPC, but the types of measures applied are broadly commensurate.

Combined, these dwelling attributes and energy efficiency measures are the basis of the dwelling IEQ change and the corresponding estimated change in health outcomes.

## 5.4 Limitations

The health impact analysis is subject to the following limitations:

- The full input data points used by the HIDEEM model were not available from the PRS EPC database and therefore several assumptions were made in order to mitigate against these limitations and to estimate household environmental changes.
- To estimate the dwelling indoor temperature baseline condition, the modelling assumes that an intervention was not present prior to the regulations and therefore all interventions are considered as additive from the baseline. The modelling used the dwelling type, age, and knowledge of added interventions to determine the baseline and modified performance levels for driving the indoor temperature calculation. The HIDEEM modelling used data from existing studies to underpin these assumptions, these include measured changes in exposures due to the introduction of retrofits (e.g. insulation and indoor winter temperature) and established exposure response functions from epidemiological studies for temperature and air pollution related impacts.[26]
- Data about the age and sex of the household occupants were drawn from the EHS to estimate the change in health related to the change in IEQ. The potential improvement in health relates to both the underlying vulnerability of the household and the duration of the effect, i.e. how long someone can benefit from the change.

[26] Ian Hamilton, James Milner, Zaid Chalabi, Payel Das, Benjamin Jones, Clive Shrubsole, Mike Davies & Paul Wilkinson (2015) 'Health effects of home energy efficiency interventions in England: A modelling study', BMJ Open, 5(4)

- A lack of data on ventilation remains an important limitation of the HIA. Depending on whether the PRS dwellings were upgraded through government funded schemes or private actions, it is possible that there may be changes in the overall airtightness of the dwelling without additional purpose provided ventilation. Because no data is available from EPCs related to the potential ventilation changes, these effects are excluded from the health analysis, with the exception of mould risk, which is dependent on temperature levels. The implication of this limitation is that the estimates shown here are likely to be overall positive in their impacts, which may not be always the case for dwellings where the change in efficiency makes the dwellings more airtight but without added ventilation to mitigate the accumulation of indoor sources of air pollution.

## 5.5 Health impact assessment results

The analysis below shows the results of the HIDEEM modelling. The analysis is shown with two timespans, one showing the impact of the interventions over a 5-year period to illustrate short term impacts, and the second over a 10-year period to illustrate longer term impacts that span a relevant human health period.

Table 24 shows the change in indoor environmental conditions for PRS households that had a change in EPC levels based on potential eligible interventions. The change in indoor temperature related to relevant measures, i.e. fabric and heating system measures, shows modest changes in indoor temperature, ranging 0.1-0.3 ºC during wintertime conditions.

**Table 24: PRS household energy performance changes**

| | Current | Modified | Change | % Change |
|---|---|---|---|---|
| Intervention stock* condition | Mean | Mean | Mean | Mean % |
| Fabric heat loss (W/K) | 337.1 | 215.5 | -121.6 | -36% |
| Heat system efficiency (%) | 87.8 | 87.8 | 0 | 0% |
| Fabric & heat system heat loss (Evalue [W/K]) | 496 | 344.8 | -151.2 | -30% |
| Ventilation heat loss (W/K) | 66.7 | 66.7 | 0 | 0% |
| Ventilation (permeability [m3/m2/hr]) | 13.9 | 13.9 | 0 | 0% |

*Presents only the stock that has received a measure

The positive environmental exposure changes have a corresponding modest positive benefit for health. The change in health over a period of 5 years amounts to around 1,046 QALYs and around 2,151 QALYs after 10 years (Table 25). When these QALYs are converted to health care contacts, the change in QALYs results in a change in the number of people seeking medical services, and health-related expenditure for that disease.

**Table 25: Results of the health impact analysis for PRS households over 5 and 10 years**

| Selected stock* health impacts | Change over 5 years Mortality (Lys) | Change over 5 years Morbidity (QALYs) | Change over 5 years Total (QALYs) | Change over 10 years Mortality (Lys) | Change over 10 years Morbidity (QALYs) | Change over 10 years Total (QALYs) |
|---|---|---|---|---|---|---|
| Cardiovascular | 20 | 114 | 134 | 42 | 239 | 281 |
| Stroke | 5 | 14 | 20 | 11 | 30 | 42 |
| Heart attack | 6 | 16 | 22 | 12 | 32 | 44 |
| Cardiopulmonary | 0 | 0 | 0 | 0 | 0 | 0 |
| Lung cancer | 0 | 0 | 0 | 0 | 0 | 0 |
| Common mental disorders | | 322 | 322 | 0 | 621 | 621 |
| COPD | | 548 | 548 | 0 | 1162 | 1162 |
| Asthma (children) | | 0 | 0 | 0 | 0 | 0 |
| Total | 31 | 1,015 | 1,046 | 65 | 2,084 | 2,151 |

*Presents only the stock that has received a measure

When considering the impact these environmental exposure changes have on health sector expenditure for treatment of temperature related disease, the impacts amount to total estimated savings of around £1 million after 5 years and £2.1 million after 10 years (Table 26).

**Table 26: Further results of the health impact analysis for PRS households over 5 and 10 years**

| | | Total estimated costs<br><br>Over 5 years | Total estimated costs<br><br>Over 10 years |
|---|---|---|---|
| Energy costs (incremental) | Space heating energy (£) | -£258,127,785 | -£565,041,721 |
| NHS healthcare costs (incremental) | Hospital admissions (£) | -£555,984 | -£1,160,339 |
| | GP consultations (£) | -£437,392 | -£912,837 |
| | Total | -£993,376 | -£2,073,176 |

Based on the above analysis and keeping in mind the limitations of the input data, differences in actual costs of interventions and healthcare treatments, the results show a theoretical improvement in wintertime indoor temperatures and a related reduction of mould risk from warmer air for households installing measures under the regulations.

The results show that the change in temperature is modest at the household level but would correspond to a positive change in health and could reduce health sector spending in temperature-related disease treatments.

These estimates reflect the data limitations wherever possible to provide an average effect, whose estimate can be improved on with further health specific data (e.g. age and sex of households). Overall, however, the regulations are likely to have provided health benefits to participating households where the interventions are highly likely to result in an improvement in temperatures and reduction in mould risk.

# 6 Conclusions

**Key points:**

- Of the 4,021,488 domestic PRS dwellings in the national EPC database, 4.7% were estimated to be non-compliant with the regulations as of August 2023.
- The analysis indicates that the introduction of the regulations has incentivised landlords of PRS properties in England and Wales with an F or G rated EPC to make energy efficiency improvements.
- The regulations are estimated to have increased energy efficiency (about 1 point in the SAP metric in the Energy Performance certificates), reduced energy costs (by an average of £67 per year per affected property) and CO2 emissions (by an average of 1,176kg CO2 per year per affected property).
- The impact of the regulations was found to be higher in the first couple of years after their implementation. Since then, properties not affected by the regulations have caught up to some extent with the progress made by the rental properties affected by the regulations.
- Energy efficiency improvements made in response to the regulations are estimated to have modest health benefits to households through increases in wintertime indoor temperature, and a corresponding reduction in the risk of mould growth, resulting in an increase of 2,150 QALYS and a cost savings of £2.1 million over 10 years.

## 6.1 Summary of the key findings

The Energy Efficiency (Private Rented Property) Regulations 2016 have mandated a minimum 2018 level of energy efficiency for privately rented property in England and Wales. These properties are required to achieve an Energy Performance Certificate (EPC) with a minimum of band E, barring specific exemptions. The EPCs are certificates indicating the energy efficiency of domestic and non-domestic properties through an A-G band system with A being the most efficient properties and G the least efficient ones. The regulations essentially outlawed privately rented properties with an EPC band equal to F or G, unless they obtained an exemption granted on the basis of a limited set of specific circumstances. Non-compliance with the regulations results in a fine of up to £5,000 for the landlord. Local authorities in England and Wales are responsible for enforcing compliance with the regulations.

This impact evaluation focused on the analysis of the compliance with the regulations, their impact on the propensity of landlords to make upgrades improving energy efficiency and their impact on the energy efficiency of the affected properties, energy costs and CO2 emissions. The analysis of compliance assessed the overall compliance with the regulations and the extent to which compliance rates differed across residential units with different characteristics. In this analysis, the energy efficiency was measured by the 'Standard Assessment Procedure' (SAP) rate included in the EPCs.[27] The SAP score underlines the EPC bands; in particular one needs a minimum SAP rate of 39 to achieve the EPC band E mandated by the regulations. The impact on the SAP core was converted into cost savings by using the methodology described in the Building Research Establishment (BRE) report from 2014. The impact on CO2 emissions was obtained by first estimating the change in the Environmental Impact (EI) attributable to the regulations and then converting the estimated impact by using the methodology in the same BRE report.

## 6.2 Conclusions on the overall impacts of the regulations to date

### 6.2.1 Compliance with the regulations

As of August 2023, 95.7% of the 4,021,488 properties with a current EPC were meeting the required standards. Insulation improvements have been identified as the predominant method for enhancing EPC ratings, indicating a strategic focus on this aspect of energy efficiency. Older properties, particularly those constructed before 1950, have demonstrated potential for attaining higher efficiency levels despite their initially lower EPC ratings.

### 6.2.2 Impact of the regulations on the propensity of landlords to undertake energy efficiency improvements

This evaluation also assessed the impact of the regulations on the propensity of owners of properties not meeting the minimum requirements mandated by the regulations to make energy efficiency improvements. This was delivered by exploring the share of PRS dwellings in England and Wales with an F or G rated EPC, i.e. those affected by the regulations, which applied for another EPC within the 10 years' validity of their pre-existing EPC. Taking 2013 and 2014 as a starting point, the share of the properties applying for another EPC by any point in time was computed so that the profile of this metric was investigated across time and across four comparison groups. The findings from this analysis indicated that:

- The behaviour of the computed share described above for the affected properties in England and Wales changed radically when regulations were introduced.
- In the 24 months between April 2018 and April 2020, the computed share described above increased by 20.5 percentage points for the properties in England and Wales affected by the regulations but only 6.5 percentage points for similar PRS properties in Scotland.

[27] The SAP score is an index between 1 and 100 allowing the comparison of energy efficiency across different properties. The higher the SAP rate, the higher the energy efficiency of a home.

- The introduction of the regulations therefore seems to have been a factor that increased the propensity of landlords of PRS properties in England and Wales with an F or G rated property to make energy efficiency improvements and register a new EPC.

### 6.2.3 Impact of the regulations on energy efficiency, energy costs and CO2 emissions

This evaluation estimated the impact on three group of properties affected by the regulations:

- ‘Established private rental properties’ (units with an F or G EPC band prior to the regulations which were classified as privately rented both before and after the regulations).
- ‘Recent private rental properties’ (units with an F or G EPC band prior to the regulations which are classified as privately rented only after the introduction of the regulations).
- ‘Private rental properties’ (simply the sum of the other two groups).

Scottish properties with a F or G rated EPC issued before the introduction the regulations in England and Wales were used as control group. The analysis was restricted to properties in the treatment and control group that had an EPC registered before the introduction of the regulations and a second EPC issued afterwards, up to August 2023. The findings described in this report are based on the implementation of three models: a Difference-in-Difference (DiD) model with fixed effects, a DiD model without fixed effects but incorporating total floor area, built form and fuel type, and an entropy balanced DiD model that reweights the control group for greater comparability with the treatment group.

As a consequence of the introduction of the regulations, the most inefficient properties in the privately rental market, i.e. those with an F or G rated EPC have been much more likely to increase their energy efficiency to a minimum of an E-rated EPC.  This result, which is robust across treated groups, indicates that the odds of achieving an EPC band E or above in the properties affected by the regulations is at least 3.5 times the level observed in the control group.

The positive impact of the regulations on energy efficiency was confirmed by analysis focused on the SAP rate. The impact of the regulations on the energy efficiency of private rental properties has been estimated to be about 1 SAP point. Estimated impact, however, varies between an increase of about 1.8 SAP points in recent private rental properties and a decrease of 2.9 points in established private rental properties. These results, which are consistent across estimated models and property types affected by the regulations, imply a reduction in energy costs of about £67 per year.

Results for the SAP score and energy costs show that properties not affected by the regulations have somewhat caught up with the progress in the rental sector estimated in the interim evaluation. This can be due to two factors. Firstly, the energy efficiency in the control group might have started to increase as a consequence of a forthcoming policy change. Scottish properties with a F or G rated EPC issued before the introduction of the regulations in England and Wales, which are used as control group, were due to be affected by the Scottish

PRS regulations from 2020 onwards. Although the introduction of these regulations has been delayed several times as a consequence of the pandemic and is currently on hold, there is a possibility that landlords have already started increasing the energy efficiency of their properties in preparation of the forthcoming regulations. The timeline of the Scottish policy and the way in which it has been modified and delayed in the last 3 years has been discussed in Section 2.3.1. Secondly, the type of properties applying for an EPC at different points in time might not be completely comparable. In the case of the first impact evaluation, compliant properties used in the original as of April 2020 sample (both established and recent rentals) will have complied with the regulations before the deadline for all types of tenancy to meet the minimum E standard. This is not the case for all the compliant properties which have been added to the sample in this study:

- Recent private rentals, i.e. properties not rented out before April 2018, which have been added to the sample in this study are likely to have complied with the regulations and increased energy efficiency to meet the minimum threshold when entering the rental market. The estimated impact of the regulations presented in this report confirms an increase in the level of energy efficiency and cost savings, confirming the results from the first impact evaluation report.
- Established private rentals, i.e. properties rented out before April 2018, which have been added to the sample in this study are likely to have complied with the regulations only after the deadline. These are properties which were in breach of their obligations to take action to increase energy efficiency by April 2020 are likely to be properties for which it is difficult to increase energy efficiency or properties owned which landlords who are not motivated to comply with regulations. It is also possible that these properties have not been rented out as they did not meet the requirements mandated by the regulations. The estimated impact of the regulations presented in this report for established private rentals indicates that the change in the energy efficiency in these properties is smaller than the change observed in the control group. The factors above offer a plausible explanation of the difference in the estimated impact of the regulations in discussed in this report compared to the results presented in the first impact evaluation.

In terms of Environmental Impact (EI) rate, the regulations delivered positive impact across the three treated group, although the impact is higher in recent rentals compared to established rentals. The estimated impact on the EI rate implies an average reduction of 1,176 kg CO2 from each property.

### 6.2.4 Health Impact Analysis Conclusions

In conclusion, the Health Impact Analysis modelling for PRS households, spanning both short-term (5 years) and long-term (10 years) periods, illustrates the potential impact on health through the introduction of energy efficiency interventions on indoor environmental conditions, particularly in relation to wintertime indoor temperatures. The modest increase in indoor temperatures, as a result of fabric and heating system measures, has been shown to correspond with a modest yet positive impact on health, as evidenced by the increase in

Quality Adjusted Life Years (QALYs) - approximately 1,046 QALYs over 5 years and 2,151 QALYs over 10 years. This improvement in health is not only beneficial to the individuals within these households but also has a broader societal benefit in terms of reduced health sector spending on temperature-related diseases, estimated at around £1 million over 5 years and £2.1 million over 10 years.

The analysis highlights the importance of considering the long-term health benefits and cost savings that can be achieved through targeted interventions in household energy efficiency. While the changes in indoor temperature and subsequent health benefits may appear modest at the individual household level, when aggregated across the population, these benefits represent a significant improvement in public health and a reduction in healthcare expenditures.

The analysis highlights the potential for the regulations to contribute positively to the health and well-being of participating households. By improving indoor environmental conditions, the regulations not only enhance the comfort and living conditions of households but also contribute to a reduction in the risk of mould growth, a known factor in various respiratory and other health issues.

This publication is available from:
www.gov.uk/government/publications/domestic-private-rental-sector-minimum-energy-efficiency-standards-evaluation-final-report