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Measuring the alignment of real economy investments with climate mitigation objectives:

The United Kingdom's building sector

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MEASURING THE ALIGNMENT OF REAL ECONOMY INVESTMENTS WITH CLIMATE MITIGATION OBJECTIVES: THE UNITED KINGDOM'S BUILDING SECTOR

ENVIRONMENT WORKING PAPER N°172

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Abstract

This paper explores data and methods to assess the alignment or misalignment with climate mitigation objectives of investments in the construction and refurbishment of residential and non-residential buildings. It takes the United Kingdom (UK) as a case study, where such investments reached GBP 162 billion (EUR 184 billion) in 2019 or 39% of UK gross fixed capital formation. The analysis trials different reference points that lead to varying results and each currently come with limitations in terms of coverage or granularity.

Sector-level greenhouse gas (GHG) trajectories indicate that, in aggregate, investments in UK buildings have been insufficient, delayed or not aligned enough with caps set by UK Carbon Budgets, but such trajectories currently lack disaggregation for a more granular and insightful matching with investment data. *Energy performance certificates (EPCs)* allow for asset-level analyses: for instance, 79% of 2010-2019 investments in new built residential were in relatively energy efficient buildings but only 1% were consistent with more demanding recommendations towards the UK's objective of reaching net-zero GHG in 2050. The coverage and reliability of EPCs, however, needs to be improved for older buildings, whose deep retrofitting is a major financing challenge. Applying *Climate Bonds Initiative criteria for low-carbon buildings* identifies investments eligible for green bond financing, but such criteria have partial sectoral coverage and are based on currently most efficient buildings within the existing stock, which makes them relatively easy to meet for investments in new built.

Producing more complete and policy relevant assessments of aligned and misaligned investments at national and sectoral levels requires the availability of and access to comparable and granular data on decarbonisation targets and pathways consistent with the Paris Agreement temperature goals, GHG performance of assets, corporate and household investments, as well as underlying sources of financing.

Résumé

Ce rapport explore les données et méthodes pour évaluer l'alignement ou le non-alignement avec les objectifs d'atténuation du changement climatique des investissements dans la construction et la rénovation de bâtiments résidentiels et non résidentiels. Il prend le Royaume-Uni comme étude de cas, où ces investissements ont atteint 162 milliards GBP (184 milliards EUR) en 2019, soit 39% de la formation brute de capital fixe du pays. L'analyse teste différents points de référence qui conduisent à des résultats variables et présentent à l'heure actuelle chacun des limitations en termes de couverture ou de granularité.

Les trajectoires des gaz à effet de serre (GES) au niveau du secteur indiquent que, dans l'ensemble, les investissements dans les bâtiments au Royaume Uni ont été insuffisants, retardés ou insuffisamment alignés avec les plafonds fixés par les budgets carbone du pays, mais ces trajectoires manquent actuellement de désagrégation pour permettre une correspondance plus granulaire et révélatrice avec les données d'investissement. Les certificats de performance énergétique permettent des analyses au niveau des actifs: par exemple, 79% des investissements 2010-2019 dans les nouvelles constructions résidentielles étaient dans des bâtiments relativement économes en énergie, mais seulement 1% étaient cohérents avec des recommandations plus exigeantes pour atteindre l'objectif national de neutralité carbone en 2050. Cependant, la couverture et la fiabilité des certificats doivent être améliorées pour les bâtiments plus anciens, dont la rénovation est un défi majeur de financement. L'application des critères pour les bâtiments à faible émission de carbone de la Climate Bonds Initiative identifie les investissements éligibles au financement des obligations vertes, mais ces critères ont une couverture sectorielle partielle et sont basés sur les bâtiments actuellement les plus efficaces au sein du parc existant, ce qui les rend relativement faciles à satisfaire pour les investissements dans de nouvelles constructions.

La production d'évaluations plus complètes et pertinentes des investissements alignés et non alignés aux niveaux national et sectoriel nécessite la disponibilité et l'accès à des données comparables et granulaires sur les objectifs de décarbonation et trajectoires compatibles avec les objectifs de température de l'Accord de Paris, la performance GES des actifs, les investissements des entreprises et des ménages, ainsi que les sources de financement sous-jacentes.

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This analysis is a contribution to the body of work of the Research Collaborative on Tracking Finance for Climate Action, an OECD-led technical research platform to advance and share knowledge for improving the tracking of climate-relevant finance, including to inform finance-related discussions under the United Nations Framework Convention on Climate Change (UNFCCC). In this context, the paper is the third of a series of studies to measure the alignment of real economy investments with climate mitigation objectives, following similar pilots completed for the manufacturing industries in Norway[1] and the transport sector in Latvia[2]. The analysis and its results were presented and discussed at the February and December 2020 WPCID meetings as well as the October 2020 Research Collaborative workshop.

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[1] Dobrinevski, A. and R. Jachnik (2020), "Exploring options to measure the climate consistency of real economy investments: The manufacturing industries of Norway", OECD Environment Working Papers, No. 159, OECD Publishing, Paris, https://doi.org/10.1787/1012bd81-en.

[2] Dobrinevski, A. and R. Jachnik (2020), "Exploring options to measure the climate consistency of real economy investments: The transport sector in Latvia", OECD Environment Working Papers, No. 163, OECD Publishing, Paris, https://doi.org/10.1787/48d53aac-en.

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Executive summary

The present study tests methods and data availability for measuring the consistency and alignment of real economy investments with national or international climate change mitigation objectives. The aim is to provide climate policymakers with a practical approach to identify not only investments contributing to climate mitigation, but also those misaligned with such objectives and that may lock in future GHG emissions beyond the levels set by the aforementioned objectives. In doing so, this work complements initiatives both that take financial assets as a starting point to measure climate alignment, and that focus on the assessment of climate-related financial risks to the value of such assets.

This study, which follows similar ones for the industry sector in Norway and the transport sector in Latvia, focuses on investments in the construction and renovation of buildings in the United Kingdom (UK). At an aggregate level, the analysis estimates that total investments within the buildings sector in the UK increased from GBP 90 billion (EUR 105 billion) in 2010 to GBP 162 billion (EUR 184 billion) in 2019, reaching 39% of total UK gross fixed capital formation (GFCF) that year.

The buildings sector, which has a long-term influence on GHG emissions because of the long lifetime of buildings, represents a decarbonisation challenge globally. CO_2 emissions from buildings (both direct and indirect from the production of energy consumed by buildings) reached an all-time high in 2019, representing 28% of worldwide energy-related CO_2 emissions. In the UK, buildings accounted for 32% of domestic GHG emissions in 2018, which makes it a critical sector for the country to meet its 68% GHG reduction by 2030 and net-zero by 2050 targets. In addition to their climate change mitigation potential, investments in buildings have economic and social benefits of strong relevance in crisis recovery periods.

Climate change mitigation objectives set by governments, companies, investors and financiers differ in nature, scope and ambition. Rather than relying on a single reference point to assess climate alignment, the present analysis tests the following different approaches based on readily available inputs:

- **Evaluate the overall alignment of buildings investments with sector-level emission reduction pathways.** In 2019, GHG emissions from both residential and non-residential buildings' exceeded the corresponding sector-level trajectories that underpin the national Carbon Budgets set by UK Committee on Climate Change (CCC). This indicates that, as a whole, past investments in UK buildings have been insufficient, delayed or misaligned with the GHG statutory cap from the carbon budgets. Such scenario-based analyses can be performed at a more granular subsector level, different geographies, and varying degrees of climate ambition, subject to the availability of disaggregated data for both emission pathways and investments. For example, a previous study on the industry sector in Norway analysed individual manufacturing industries using subsector-level emission reduction scenarios of the International Energy Agency (IEA).
- **Use energy performance certificates (EPCs) to assess investments in low- or high-emission buildings at asset level.** EPCs categorise buildings according to energy consumption estimated from their physical characteristics. For the UK, using residential property transaction data, the analysis shows that 79% of 2010-2019 new residential construction investments were in the relatively energy efficient EPC band B, but less than 1% (GBP 150 million investment on average per year) were consistent with the CCC recommendation towards 2050 net-zero objectives (most energy-efficient EPC band A combined with low-carbon heating). Regulatory requirements for EPCs ensure their wide prevalence in most European Union countries, providing a useful reference

point for individual buildings, lending portfolios of banks as well as asset portfolios of investors such as Real Estate Investment Trusts. However, the granular data needed to establish links between investments and EPC changes are often only available to building owners. Extending the analysis to renovation investments requires accessing representative sample data from households and companies on renovation costs and resulting EPC changes.

- **Evaluate investments eligible for green financing**. This study assesses investments that comply with the Climate Bonds Initiative (CBI) standards. Criteria for low-carbon buildings consist of location-specific emissions intensity thresholds based on the least-emitting 15% of the current buildings stock. In the UK, CBI provides such thresholds for residential construction in England and Wales and for the construction of offices in ten major cities. Within this limited scope, 94% of new residential and 90% of new office construction investments (including a large share of EPC band B) were consistent with CBI thresholds. The thresholds decrease over time, aiming at net-zero in 2050 and at closing the gap with more ambitious definitions of zero-energy buildings, which for instance underpin criteria of the EU Taxonomy for Sustainable Activities'.
- **Estimate energy efficiency investments based on the evolution of the buildings stock.** Combining data from a national housing survey for England with estimated installation costs for insulation, double glazing and boiler replacements, this study estimates a lower bound of GBP 4.4 billion per year on average in 2010-2019 invested in energy efficiency improvements. This represents 15% of total UK residential renovation investments. While such an approach is relatively practical to implement and indicates the scale of investments in specific technologies that achieve GHG emission reductions, it does not address investments that do not deliver energy efficiency improvements and may be considered misaligned with climate objectives.

The availability of financing is both an important barrier and potential incentive for investments in buildings. In the absence of comprehensive data, this study illustrates the role of finance providers, by:

- **Tracking the level of public support for building investments.** Major UK public schemes supporting capital expenditure on buildings focus on energy efficiency measures in residential renovations. Between 2010 and 2019, such support reached GBP 9.3 billion, accounting for 3% of total UK renovation investment (residential and non-residential).
- **Taking stock of the emergence of green financial instruments while identifying the need for more accessible data on debt finance.** Major UK banks are introducing green financial products for retail lending (green mortgages), corporate lending (green loans and credit facilities), and re-financing (green bonds). Quantifying the volume of financing provided via these innovative mechanisms and, more generally, assessing the climate alignment of overall lending portfolios, will require voluntary or mandatory disclosure by financial institutions.

This analysis was made possible by a range of open data from UK public bodies. Further similar assessments in the UK and other countries would, however, benefit from improved data availability on:

- **Reference points for defining climate alignment**. Assessing investments aligned or misaligned with the Paris Agreement temperature goal requires national-level decarbonisation targets and pathways broken down for individual building categories and parameters such as age. Further, compared to reference points based on incremental improvements to existing buildings, alignment with net-zero GHG emissions by 2050 requires more ambitious investments in deep retrofits.
- **Data on the climate and energy performance:** For buildings, EPCs cover a wide range of data points on the assumed design performance of buildings, allowing for a comparison to climate objectives. This scope is well suited for an analysis of investments in buildings, since actual GHG emissions are also influenced by consumption and behavioural patterns. While the UK's public EPC registers provide a useful view of buildings' climate performance, improving the reliability and coverage of EPCs, notably for older buildings, would significantly enhance measures of alignment.

- **Data on household and company investments**. Corporate accounts (available from business registers such as Companies House in the UK, or commercial providers) as well as national household expenditure surveys (by national statistics offices such as the UK ONS) would need to include separate data points on climate-aligned and -misaligned building investments. Such harmonised reporting requires some degree of consensus on the definition of climate alignment, potentially anchored in legislation akin to the EU's Taxonomy of Sustainable Activities.
- **Data on financing sources.** Financial institutions or regulators would need to report on the climate performance of mortgages and corporate lending. In the UK, the Bank of England's Climate Hub would be well positioned to perform such analysis and disseminate results to relevant stakeholders.

More generally, the present as well as previous similar studies show that data on real economy investments (GFCF) and underlying financing, as well on corresponding GHG emissions, stem from multiple sources with varying quality, granularity, and coverage. Some of the current data limitations are less acute in sectors with fewer and larger infrastructure-related transactions than in the buildings sector. Further, data availability will improve over time as an increasing number of corporations, financial institutions and investors are defining Paris Alignment strategies and targets, while governments have started mandating or incentivising the disclosure of climate-related financial and non-financial data.

1 The UK buildings sector through a climate change mitigation lens

1.1. Rationale

For decades, many governments have designed and implemented public interventions towards mobilising finance for mitigating climate change (EIB/bruegel, 2012[1]), (OECD, 2017[2]). With the Paris Agreement in 2015, they, however, acknowledged that the goal of “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C” would be out of reach if finance is not consistent with such goal (UNFCCC, 2015[3]). Recent science further highlights the need for urgent transformation towards climate-compatible economies in all sectors (IPCC, 2018[4]).

Apart from power generation, there is, however, a current lack of evidence in most economic sectors about the extent to which real economy investments are aligned and consistent with climate policy goals (Jachnik, Mirabile and Dobrinevski, 2019[5]). Such evidence is needed as such investments directly lock in or help reduce a very significant proportion of future greenhouse gas (GHG) emissions. The present study, which focuses on investments in the United Kingdom’s (UK) building sector (new builds and renovation), aims to contribute to filling this gap. It builds and expands on two first pilot studies for the manufacturing sector in Norway (Dobrinevski and Jachnik, 2020[6]) and the transport sector in Latvia (Dobrinevski and Jachnik, 2020[7]). Such focus on real economy investments complements the number and range of ongoing initiatives relating to climate alignment that take the financial sector as a starting point (e.g. (OECD, 2020[8]), (RMI, 2020[9]), (2° Investing Initiative, 2018[10])), as well as those that focus on the assessment of climate-related financial risks to such assets.

The building sector represents a decarbonisation challenge. Carbon dioxide (CO_2) emissions from buildings (including both direct and indirect from upstream energy production) reached 10 gigatons CO_2 in 2019, an all-time high representing 28% of global energy-related CO_2 emissions (IEA, 2020[11]). Indirect emissions doubled since 1990 and are now more than twice higher than direct emissions. Notably, rising demand for space cooling, which is estimated to account for close to 20% of all electricity used in buildings is putting significant pressure on electricity systems in many countries, as well as driving up emissions (IEA, 2018[12]). The level and share of indirect emissions, however, vary greatly at country level depending on equipment ownership, heating and cooling needs and the national energy mix. In the UK, buildings represented 32% of total GHG emissions in 2018, out of which 40% related to direct emissions (mostly related to the use of gas for heating purposes) and 40% to indirect emissions (i.e. from electricity use resulting from lighting, electric heating, as well as the use of household appliances and other electric equipment) (also see Section 2.1).

The IEA analysis highlights “untapped energy efficiency potential, as global building energy code evolution is not keeping pace with rapid floor area expansion in emerging economies, while renovation rates in developed countries remain low.” Hence, CO_2 emissions are being locked in over the lifetime of buildings mostly by new constructions in emerging economies and by low rates of energy efficient retrofitting in developed countries.

The need for energy efficient renovations is particularly high in the UK, where over half of the buildings stock was built before 1965. There is, however, clear evidence that the existing building stock in the UK is energy inefficient and that renovation rate remain modest (see Section 2.3 and (CREDS, 2019[13])). Deep decarbonisation of the sector is one of the critical conditions for the UK to meet its economy wide 68% GHG reduction by 2030 and net zero by 2050 targets, as identified by the Committee on Climate Change (CCC) in its forward-looking scenarios (see Section 3.1 and (CCC, 2019[14])).

In addition to its relevance for climate action, the building sector is of critical economic and social importance, even more so in a situation of crisis and recovery such as the one provoked by the COVID 19 pandemic and its aftermath (see Section 3.4). Construction and refurbishment of buildings represented 39% of total UK gross fixed capital formation (GFCF) on average between 2010-2019, of which around 21% for dwellings and 18% for non-residential buildings (see Section 2.1). In the context of recovering from the aftermath of the COVID 19 crisis, a number of analyses identify support for and investment in energy efficient buildings (retrofits and new built) as measures with high economic (e.g. local job creation) and social benefits (tackling of energy poverty), in addition to their climate mitigation potential (e.g. (Buckle et al., 2020[15]), (McKinsey, 2020[16]) (Hepburn et al., 2020[17]), (IEA, 2020[18]), (Hainaut et al., 2020[19])).

The UK Green Finance Strategy, adopted in July 2019, goes beyond the mobilisation of green capital by stressing the need to integrate climate and environmental factors into financial decision-making across all asset classes in order for the financial sector to help drive the necessary transition (HM Government, 2019[20]). In this context, the buildings sector represents a partly still untapped opportunity for financial innovation to help develop markets for energy efficient retrofitting and low carbon heating, as well as facilitate access to financing to all categories of relevant stakeholders, from individual households to corporate real estate owners (Green Finance Institute, 2020[21]).

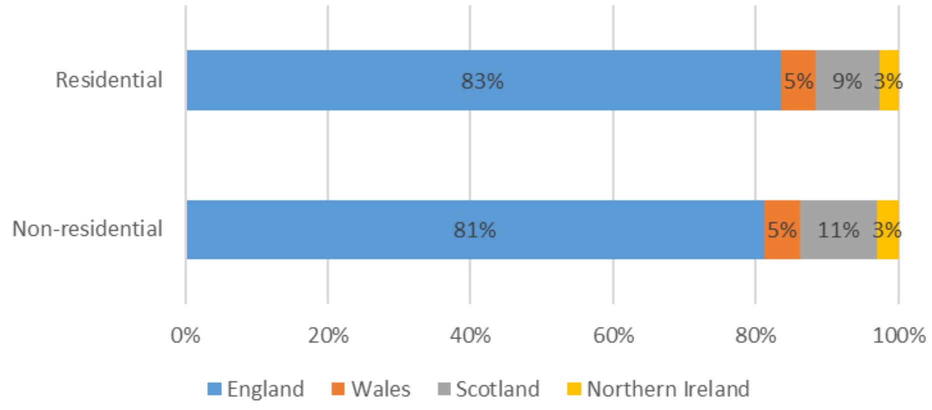
1.2. Scope

The study focuses on investments in the construction of new buildings and in the renovation of existing buildings located in the UK over the period 2010-2019. The aim is to capture total investments and, within this total, to assess the portions that can be considered as aligned or misaligned with different types of climate mitigation-related objectives and targets, or so-called "reference points" (Section 1.3). Where possible, the analysis further characterises the resulting building stock (which also takes into account demolitions although those are not explicitly analysed here).

One key element of potentially climate-aligned investments within the buildings sector are specific energy efficiency measures, which the analysis estimates to the extent possible. Further, the study seeks to identify the sources of finance that underpin the investment captured, although experience shows that data availability beyond public sources of finance is limited.

Due to data availability restrictions, some of the analyses in this study cover England and Wales only. Figure 1.1 shows that this scope covers over 85% of buildings, as the majority of the UK buildings stock is located in England (over 80%, both for residential and for non-residential buildings). Smaller shares are located in Scotland (9-11%), Wales (5%) and Northern Ireland (3%).

Figure 1.1. Distribution of buildings stock across UK constituent countries



Note: Shares in terms of number of buildings.
Source: VOA rating list and council tax statistics, NI Department of Finance summary of valuation lists, Scottish Assessors Association, ONS live tables 104, 106 and 107.

The analysis covers residential buildings (mainly houses and flats[3]) and non-residential buildings (retail, office, public sector buildings buildings). Table 1.1 shows an overview of the characteristics of the corresponding physical buildings stock for the UK. This study uses economy-wide buildings investment estimates from the Office for National Statistics (ONS), and hence covers, in principle, all types of buildings.[4] The investment totals also include fittings, in particular on-site energy generation installations. Infrastructure investments outside of individual buildings, such as water infrastructure and district heating infrastructure, are excluded. The analyses of climate consistency, which rely on buildings' energy performance data, exclude building types where such data is not available (e.g. unheated agricultural buildings).

Structural differences between residential and non-residential buildings, as illustrated in Table 1.1, make it important to consider each separately. Residential buildings account for close to 80% of the UK buildings' floor space (of which 70% are houses and 10% are flats) and non-residential buildings for 21%. The UK split between residential and non-residential floor space is on par with the average in the EU, but the share represented by non-residential is relatively higher in some countries, e.g. over 30% in Germany, Sweden, Luxembourg or the Netherlands (European Commission, 2020[22]).

[3] The breakdown of residential building types in this report follows official statistics such as the English Housing Survey (MHCLG, 2020[42]). Houses include detached houses, semi-detached houses, terraced houses and bungalows. Flats include flats in converted and purpose-built apartment buildings, as well as maisonette flats. A small share of dwellings do not fall in the house or flat categories, e.g. mobile homes, caravans and house boats. Such dwellings are not considered further in the following.

[4] Potential future studies on economy-wide consistency of investments with climate objectives would need to delineate more carefully to avoid double-counting across sectors e.g. industrial buildings investments may be counted both in the buildings and in the industry sector.

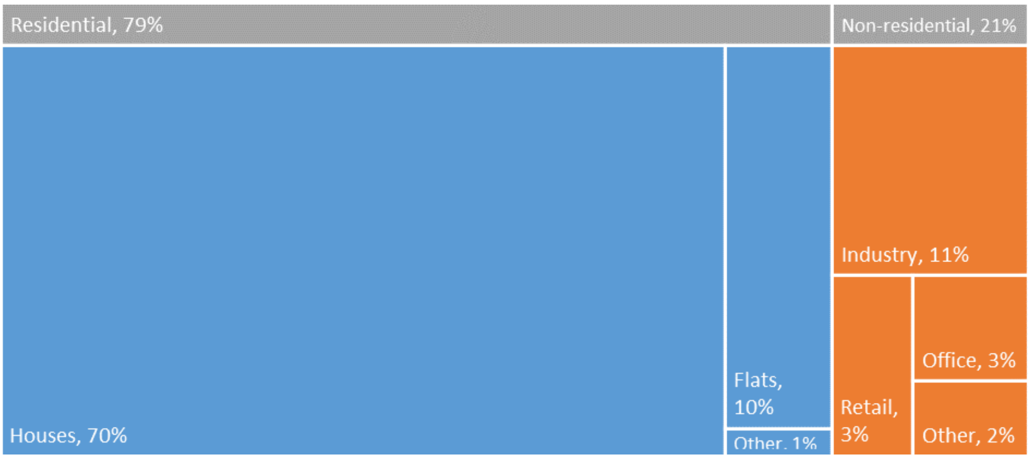
Table 1.1. UK buildings in 2019

Indicator	Unit	Residential	Non-residential	Total
Number of building units	millions	29.3	2.4	31.7
Floor area (England and Wales)	million m^2	2,447	588	3,035
% of stock built before 1965 (England and Wales)	%	55	57	n/a
Investment	% of UK total GFCF	23%	18%	40%
Capital value	trillion GBP	1.8	0.8	2.6
	% of UK net worth	17%	8%	25%
Direct emissions (scope 1)	Mt CO_2eq	69.1	19.7	88.8
	% of UK total	15%	4%	20%
Direct and indirect emissions (scope 1 and 2)	Mt CO_2eq	99	47	146
	% of UK emissions	22%	10%	32%

Note on floor area: Residential floor area is estimated based on numbers typical floor areas of residential units (VOA, 2020[23]). Non-residential floor area is obtained from VOA statistics. Note on buildings age: Percentages of buildings stock constructed before 1965 are estimated based on VOA statistics. For non-residential buildings, the most recent buildings age statistics date back to 2015 (VOA, 2016[24]). Note on emissions: Direct emissions (scope 1) are based on the 2018 UK GHG emission accounts. Indirect emissions (scope 2) are estimated based on electricity and heat consumption in the UK energy consumption statistics and DEFRA emissions intensity factors. See Annex B for details.
Source: VOA floor space statistics, ONS National Accounts Blue Book 2019, UK 2018 GHG emissions national statistics, UK 2018 energy consumption statistics, UK DEFRA GHG reporting conversion factors 2010-2018.

While non-residential buildings only account for 21% of the total floor space in the UK, they were responsible for almost a third of the scope 1 and 2 GHG emissions from buildings, and attract close to half of the total buildings investment. Further, non-residential buildings consist of a range of building types with different investment and emissions characteristics. Hence, some parts of the in-depth analysis in Chapter 2 will focus on relevant buildings subsectors individually.

Figure 1.2. Floor area by building category (England and Wales)



Source: VOA floor space statistics.

1.3. Reference points for assessing the climate consistency of investments

The starting point of the study is to map total investments over the period 2010-2019 based on best-available data and estimation methodologies. Results from this mapping are presented in Section 2.1 (investments), while Annex A provides details about data and information sources. The next analytical step is to assess the alignment of these past investments with climate mitigation-related objectives and targets based on different types of reference points. The granularity of this assessment depends on the availability and granularity of data on investments, actual climate performance, and climate-related objectives or targeted performance thresholds, which varies in different sub-sectors (residential versus non-residential) and for different types of actors (households, corporates, public sector).

This study uses two main categories of reference points to analyse the consistency of investments for the period 2010-2019:

- **Aggregate decarbonisation pathways for the buildings sector in the UK.** Such inputs are useful for evaluating whether the sector's GHG emissions as a whole are on track with respect to climate objectives. However, such aggregate pathways are usually not granular enough to assess the consistency or inconsistency of individual investments. Doing so requires disaggregated pathway data, broken down between new built and renovation in addition to different sub-segments of the sector.
- **Classification systems for the environmental performance of individual buildings and/or specific construction and renovation activities**. Such inputs provide the granularity required to quantify segments of climate-consistent or –inconsistent investments. However, they are typically not directly connected to aggregate national or international emission reduction objectives.

The remainder of this section provides an overview of the specific reference points identified as relevant for the UK buildings sector in the course of this research. Sections 2.2 to 2.4 then test the application of these reference points in practice, and compare the results in order to highlight their commonalities and differences.

For evaluating the climate consistency of the buildings sector as a whole (Section 2.2), this study uses the decarbonisation scenarios produced by the CCC as part of the modelling underlying the fourth and fifth UK Carbon Budgets. Carbon Budgets were introduced by the 2008 Climate Change Act, and provide a restriction on the total amount of GHG that the UK can emit over a 5-year period in order to meet its emission reduction commitments:

- The **Fourth Carbon Budget (CB4)** report was published in 2010 (CCC, 2010[25]). As part of this report, the CCC estimated cost-effective and technologically feasible sectoral emission reduction pathways (including for the buildings sector) for the period 2010-2030. These pathways are consistent with a reduction of UK GHG emissions by 60% by 2030, aiming for an 80% reduction by 2050 (both compared to 1990).
- The **Fifth Carbon Budget (CB5)** report was published in 2015 (CCC, 2015[26]). As part of this report, the CCC estimated cost-effective and technologically feasible sectoral emission reduction pathways (including for the buildings sector) for the period 2015-2035. These pathways are consistent with a reduction of UK GHG emissions by 61% by 2030, with the unchanged aim of an 80% reduction by 2050 (both compared to 1990).
- The **Sixth Carbon Budget (CB6)** was released in December 2020 (CCC, 2020[27]). It identifies future pathways consistent with the UK's updated objective for 2050 to reduce net emissions of GHG by 100% relative to 1990 levels, which would make the UK a 'net zero' emitter. The CB6 pathways, which start in 2020 and provides further granularity than previous CBs for different different sub-segments of the buildings sector, are considered in Section 3 on the Consistency of the buildings stock with forward-looking mitigation objectives.

To classify the environmental performance of individual buildings and/or specific construction and renovation activities (Sections 2.3 and 2.4), this study identified the following combination of regulatory and voluntary reference points:

- **Energy Performance Certificates (EPCs)**. Initially stemming from a 2002 European Union Directive on the Energy Performance of Buildings, EPCs were introduced in the UK in 2007. They consist of a rating scheme to summarise the theoretical energy consumption and efficiency of a building, based on its physical and design characteristics. EPCs take into account the building fabric and integrated services (heating, ventilation, air conditioning) but not appliances. Residential buildings are rated in EPC bands from A to G (with A being the highest rating), non-residential buildings in EPC bands from A+ to G (with A+ being the highest rating). EPCs are mandatory for new construction as well as for existing buildings, which are sold or rented.[5] In addition to evaluating the energy performance of a building, EPCs provide suggestions for improvement measures and estimates of possible energy cost reductions. As discussed in Section 2.3.1, in the context of the UK's net zero target for 2050, the CCC recommends for new residential construction to target EPC band A with low-carbon heating (CCC, 2019[28]).

- **Climate Bonds Initiative (CBI)** criteria for low-carbon buildings (CBI, 2018[29]). The Climate Bonds Standard addresses bond issuers, investors and financial markets. It aims at identifying investments that contribute to mitigating climate change and are consistent with the 2°C warming limit in the Paris Agreement. The CBI criteria for low-carbon buildings were issued in 2015 and distinguish new construction and renovation:
    - New buildings are considered "low-carbon" when being below a location-specific threshold for the emissions intensity (direct and indirect GHG emissions per square meter per year). This threshold is initially set at the best 15% of the relevant region's buildings stock and strengthens over time, decreasing linearly to zero by 2050.
    - Refurbishment of existing buildings qualifies as "low-carbon" if a minimum level of relative energy consumption reduction is achieved. This threshold varies between 30% for a five-year period and 50% for a 30-year period.

Further reference points for environmental performance of buildings were considered initially but are not used in the remainder of this analysis. Such reference points are:

- **Buildings Research Establishment Environmental Assessment Method (BREEAM) certification**. This certification scheme was first launched in the UK in 1990 and evaluates multiple dimensions of buildings' environmental sustainability. In addition to the important role of energy efficiency, other aspects such as waste reduction, water efficiency, health and well-being are also addressed. The precise criteria are defined in detailed technical standards depending on the building category and the project type (new construction/refurbishment) and are revised periodically. At the end of 2019, there were approximately 12.000 BREEAM-certified buildings in the UK (around 0.05% of the total UK buildings stock). Granular BREAM data was not available for use in the context of the present study.
- **The Leadership in Energy and Environmental Design (LEED) certification**. LEED was created in 1998 by the U.S. Green Building Council (USGBC, 2020[30]). Like BREEAM, the LEED standard considers the energy performance of the building and broader environmental criteria. While LEED is widely used in the Americas and in Asia, it is less prevalent than BREEAM in Europe. Specifically in the United Kingdom, at the end of 2019 only approximately 100 buildings have obtained a LEED certification (several of which are also BREEAM-certified). Hence, analysing LEED-certified building investments in depth would not bring significant additional value to this study.
- **The EU Taxonomy for Sustainable Activities** (EU Technical Expert Group on Sustainable Finance, 2019[31]). This initiative aims at establishing legal criteria for investments that make a substantial contribution to different sustainability objectives. The criteria of the EU Taxonomy for a substantial contribution to climate change mitigation in the buildings sector follow similar principles as the criteria of the Climate Bonds Initiative for low-carbon buildings. However, applying the EU Taxonomy in detail is not considered feasible in the UK context with the currently available data and definitions (Box 1.1), but could be an option in the future (Section 4.1.4).

[5] A few limited exceptions exist e.g. for temporary buildings or buildings to be demolished. (HMSO, 2007[153])

- **The transition scenarios from the Energy Technology Perspectives by the International Energy Agency**. Similar to trajectories in the UK Carbon Budgets, the IEA scenarios estimate possible cost-efficient sector-level pathways towards long-term climate objectives. UK specific scenario data could only be sourced for the most recent IEA scenario released in 2020 (IEA, 2020[32]). Hence, the analysis makes use of the IEA scenario in Section 3 on Consistency of the buildings stock with forward-looking mitigation objectives.

Box 1.1. The EU Taxonomy for Sustainable Activities

This initiative aims at establishing legal criteria for investments that make a substantial contribution to different sustainability objectives. The criteria of the EU Taxonomy for a substantial contribution to climate change mitigation in the buildings sector follow similar principles as the criteria of the Climate Bonds Initiative for low-carbon buildings:

- For new construction, the EU Taxonomy criteria require the buildings' primary energy demand to be 20% below the country-specific threshold for near-zero-energy-buildings (NZEBs). Many EU countries defined such national NZEB criteria in the course of implementing the Energy Performance of Buildings Directive (EU Commission, 2020[33]). However, at this stage national NZEB definitions with quantitative primary energy demand thresholds are not yet available universally, and in the present case, not in the United Kingdom.
- For renovations, the EU Taxonomy criteria allow two alternatives: a minimum level of relative improvement or a major renovation. The minimum acceptable level of relative improvement is defined as a reduction of primary energy demand of at least 30%, over a maximum period of three years. The alternative criteria, a major renovation, must involve at least 25% of the surface area of the building envelope or 25% of the building's value[6], and must bring the energy performance of the renovated part(s) to the level of the current applicable building codes. The latter are assumed to be compliant with the cost-optimal minimum energy performance requirements of the EU Energy Performance of Buildings Directive (EU Commission, 2020[33]).
- Certain measures, such as renewable energy installations, automatically count as a substantial contribution to climate change mitigation under the EU Taxonomy criteria.
- Further, the EU Taxonomy defines criteria for acquisition and ownership of existing buildings (built before 2021). In this case, the buildings' operational primary energy demand must be within the most efficient 15% of the overall buildings stock in the relevant region. This primary energy demand threshold will be revisited periodically with the aim to decrease to zero by 2050.
- For investments outside of EU Member States, the usage of other criteria may be needed based e.g. on established certification schemes or standards in the future. Further details of such equivalences are yet to be agreed.

In summary, applying the EU Taxonomy for Sustainable Activities for the purposes of this study does not appear feasible due to the following main reasons: the absence of national NZEB definition in the UK, and the unavailability of data that is sufficiently granular to allow identifying major renovations within the total renovation volume.

Source: (EU Technical Expert Group on Sustainable Finance, 2019[31]).

[6] The choice between the two options is at the discretion of the member states. Specifically in the United Kingdom, a major renovation is defined using the surface criterion, i.e. at least 25% of the surface area of the building envelope must undergo renovation.

2 Consistency of investment flows with climate change mitigation

The first section of this chapter sets the scene by providing an overview of the UK building sector's estimated investments for the period 2010-2019 and of GHG emissions for the period 2010-2018. The second section then compares these emissions with GHG trajectories that had been projected for the period in the context of UK Carbon Budgets. The following two sections then present results of analyses performed to assess, for the residential and non-residential sub-sectors respectively, the consistency of investments with reference points introduced in Section 1.3. Within each of these two subsectors, the analysis is further split between new construction and renovation, as well as provides a deep dive on specific segments, for which data availability allowed more detailed analysis, i.e. social housing for the residential subsector and a selection of Real Estate Investment Trusts for the non-residential sector.

2.1. Investments and GHG emissions in the UK buildings sector

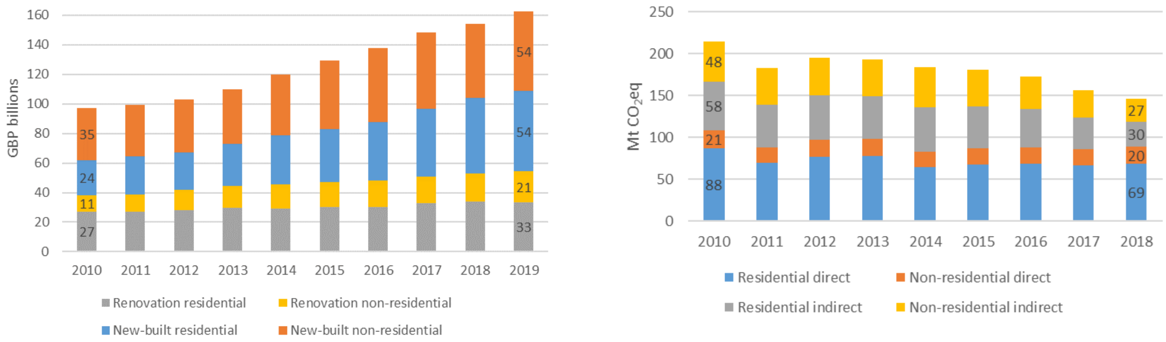
Based on national accounts and construction industry output statistics, this study estimates that the total investments in the construction and renovation of buildings in the UK increased from around GBP 90 billion in 2010 to a little over 162 billion GBP in 2019 (Figure 2.1).[7] National accounts measure investments in buildings as part of GFCF. GFCF covers both new construction and major improvements beyond ordinary repair and maintenance (Eurostat, 2010[34]). The share of buildings investments in the total UK GFCF remained approximately constant, at close to 40%, during this period. Annex A explains the methodology for estimating investments and the precise scope of assets included and excluded.

The growth in total buildings investments was largely due to the expenditure on new construction almost doubling, from 59 billion GBP in 2010 to 108 billion GBP in 2019. During the same period, refurbishment expenditure increased by approximately a third, from 38 billion GBP in 2010 to 54 billion GBP in 2019. Both of these trends are observed similarly for residential buildings[8] and for non-residential buildings. As a result, the share of new construction in total investments increased from 60% in 2010 to 66% in 2019, while the share of renovations decreased from 40% to 34%. During the same period, the shares of residential and non-residential buildings in total buildings investments remained constant at around 55% and 45% respectively.

[7] In this study, all investment volumes are given in current prices and not adjusted for inflation.

[8] "Residential buildings", "dwellings" and "housing" are all used interchangeably in this document.

Figure 2.1. Investments (left) and GHG emissions (right)) in the UK buildings sector



Note on investments: Buildings investments are based on ONS statistics on GFCF by type of asset, further broken down using ONS statistics on construction industry output. Investment estimates exclude transfer costs and are shown in current prices.
Note on emissions: Direct emissions (scope 1) are based on the 2018 UK GHG emission accounts. Indirect emissions (scope 2) are estimated based on electricity and heat consumption in the UK energy consumption statistics. See Annex B for details.
Source: ONS National Accounts Blue Book 2020, ONS Construction Industry Output Statistics, UK 2018 GHG emission accounts, UK 2018 energy consumption statistics, UK GHG reporting conversion factors 2010-2018.

GHG emissions from UK buildings decreased from 215 Mt CO2eq in 2010 to 146 Mt CO_2eq in 2018. These estimates include direct GHG emissions (Scope 1), mostly due to fossil-based on-site heating, as well as indirect emissions from electricity and from the consumption of district heat produced off site (Scope 2). Based on this emissions scope, the buildings sector was responsible for 32% of UK's GHG emissions in 2018. Some of the reference points used in the present study (introduced in Section 1.3 above and applied in Section 2 below) are based on more narrow GHG emissions scopes or, on the contrary, include elements of GHG emissions in the broader buildings value chain (Scope 3). Scope 3 GHG emissions include, in particular, "embodied carbon" from the building construction phase, which can account for up to 10 to 20% of a building's lifecycle emissions (WGBC, 2019[35]). When assessing alignment based on different emissions intensity scenarios or thresholds, the corresponding emissions scope are, therefore adapted as needed.

2.2. Climate consistency of the building sector as a whole

Benchmarking actual GHG emissions against emission trajectories established by the CCC for the period up to 2019 indicates that, despite significantly increased investments over the last decade (Figure 2.1), the buildings sector as a whole appears not to be on track to the GHG emission reduction objectives of the UK carbon budgets,. This observation concurs with the conclusions of the 2020 CCC Progress Report to Parliament (CCC, 2020[36]). In addition to emissions, the CCC tracks progress in the buildings sector in further detail through the number of installed energy efficiency measures per year. According to CCC estimates, the number of lofts, solid walls and cavity walls insulated in 2019 was only 5%, 12% and 21% of the corresponding targets, respectively (CCC, 2020[36]).

Figure 2.2 shows that direct GHG emissions from UK buildings in 2018 exceeded the internal CCC trajectories underlying both the fourth and fifth UK carbon budgets (CB4 and CB5, see Section 1.3). While direct GHG emissions decreased between 2010 and 2014, they did not decrease further between 2015 and 2018. On the other hand, the trajectories behind CB4 and CB5 assumed a yearly decrease of 2-3% in GHG emissions over the same period. These observations apply similarly to both residential and non-residential buildings if considered individually. So as to complement the historical assessment presented in Section 2, Section 3 provides a forward-looking perspective (from 202 onwards) based on the decarbonisation scenarios from the CCC's sixth carbon budget (CCC, 2020[27])and the IEA's most recent Energy Technology Perspectives (IEA, 2020[32]).

Figure 2.2. Consistency of the UK buildings sector with trajectories underpinning carbon budgets

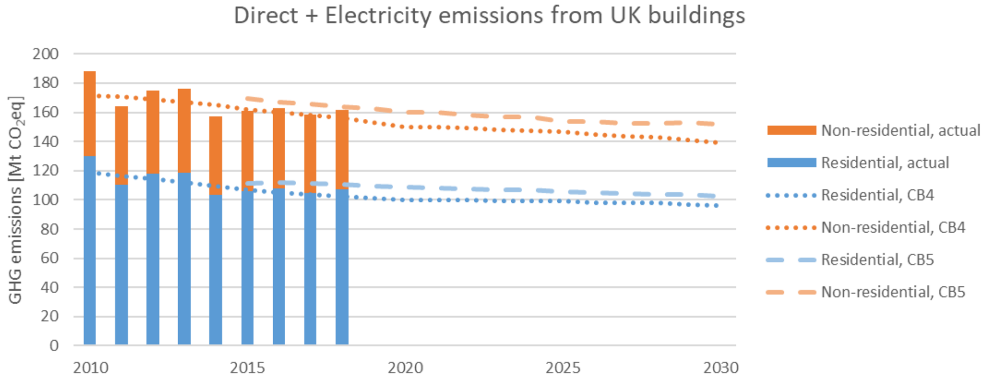
Note: CB4 and CB5 stand for the fourth and fifth carbon budget as proposed by the UK Commission on Climate Change, respectively.
Source: CCC projections underlying CB4 and CB5.

To evaluate the overall consistency of the buildings sector, as of 2019, with the trajectories behind CB4 and CB5, the analysis in this section combines data on direct GHG emissions (scope 1) with estimates of indirect GHG emissions (scope 2), as already displayed in Figure 2.1. Electricity consumption data is translated into indirect GHG emissions using a constant emissions intensity of electricity production. The latter is assumed to be 0.377 kg CO_2eq per kWh, which is the 2015-2019 average of the UK BEIS/DEFRA conversion factors (BEIS, 2020[37])[9]. Calculating with a constant emissions intensity of electricity consumption excludes emission trends due to decarbonisation of the energy sector, and thereby ensures that only indirect emission trends related to buildings' electricity consumption are reflected. This approach is motivated by the fact that investment in buildings may affect buildings' electricity consumption but not the emissions intensity of electricity production. The IPCC uses a similar approach for conducting its assessments of the buildings sector (IPCC, 2014[38]), which focus on the total final building energy use.

When combining direct GHG emissions with estimated indirect GHG emissions from electricity as above, the overall assessment remains that UK buildings developed inconsistently with the emission pathways behind the UK CB4 and CB5 (Figure 2.3). UK buildings' electricity consumption itself remained below the GHG emission trajectories from the CB4 and CB5 modelling for 2015-2019. However, the majority of the reductions in actual indirect emissions (which can be observed in Figure 2.1) were due to decarbonisation of electricity production, which is attributed to the energy sector and excluded here. Hence, the slight decrease in electricity consumption attributable to the buildings sector was insufficient to compensate for the lack of reductions in direct emissions. In fact, even an increase in electricity demand could lead to overall sector-level consistency if it coincided with electrification, reduction in fossil fuel demand, and decreased direct emissions. A separate trajectory for the consumption of district heat produced offsite is not included in the scenarios underlying CB4 and CB5; however GHG emissions from UK buildings' district heat consumption are insignificant (less than 4% of UK buildings' total scope 1 and 2 GHG emissions).

[9] This may underestimate actual buildings emissions, if buildings' electricity use typically coincides with peak electricity demand times and hence temporarily above-average emissions intensities of electricity production. However, this effect is difficult to quantify.

Figure 2.3. Consistency of the UK buildings sector with GHG carbon budgets emission trajectories



Note: Direct emissions (scope 1) are based on the UK GHG emission accounts. Indirect emissions (scope 2) are estimated based on electricity and heat consumption in the UK energy consumption statistics. In contrast to Figure 2.1, here the emissions intensity of electricity production is assumed to be a constant 0.377 kg CO_2eq per kWh, in order to highlight trends attributable to the buildings sector.
Source: UK 2018 GHG emission accounts, UK 2018 energy consumption statistics, CCC trajectories underlying CB4 and CB5.

The above-described recent developments in the UK buildings sector highlight the need to scrutinise the climate consistency of investments in this sector in more depth. The aggregate sector-level GHG emission trajectories underlying the UK carbon budgets shed light on the climate consistency of residential and non-residential buildings as a whole. However, these trajectories do not provide sufficient detail to analyse investments at a meaningful level of disaggregation, since they for example do not distinguish new construction and renovations separately. Hence, the following sections evaluate the climate consistency of investments within different subsectors using more granular reference points (see Section 1.3 above).

Actual levels of GHG emissions and electricity consumption depend in part on investments in the physical buildings stock, but also on other factors such as weather and behavioural patterns. The discussion in the following sections focuses on the theoretical emissions performance of buildings, estimated based on the physical characteristics of the building fabric and integrated services (heating, ventilation, etc.). This approach makes it possible to address the elements most directly influenced by investments in buildings, and excludes emission trends unrelated to investments.

2.3. Climate consistency of residential buildings investments

2.3.1. New construction

Investments in new residential buildings in the UK rose from approximately 24 billion GBP per year to approximately 53 billion GBP per year between 2010 and 2019.[10] On average, over that period these investments correspond to 55% of the total investments[11] in UK residential buildings, and to 12% of the total UK gross fixed capital formation. This subsection further breaks down and characterises the investments in construction of new dwellings, according to two reference points introduced in Section 1.3:

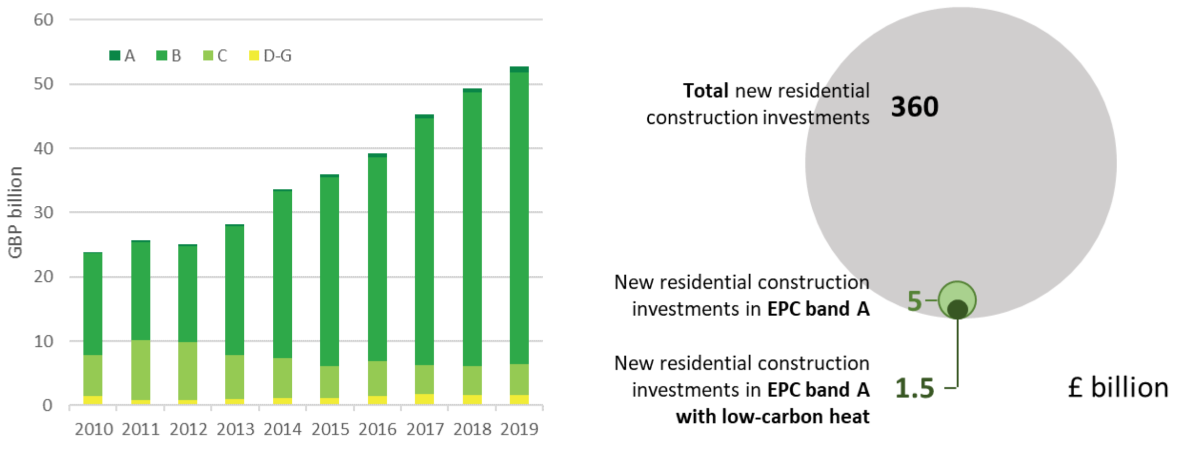
- The energy performance bands as recorded in Energy Performance Certificates (EPCs).
- The Climate Bonds Initiative criteria for low-carbon new residential buildings.

[10] Own estimate based on ONS national accounts and construction industry output statistics.

[11] I.e. construction and major renovation, as captured in the gross fixed capital formation.

The vast majority of new construction is consistent with the Clean Growth Strategy objective to reach at least EPC band C in as many houses as possible by 2035 and as many rented homes as possible by 2030 (HM Government, 2017[39]). Figure 2.4 shows that the rise in new construction investments over the observed period is largely due to an increased construction of relatively energy efficient dwellings in EPC band B (79% of investments). Overall, over the observed period 96% of newly constructed dwellings (corresponding to 97% of new construction investments) have EPC band A, B or C. Nevertheless, around 4% of newly constructed dwellings (corresponding to approximately 1.2 billion GBP investment per year) are currently in EPC bands D to G.[12] These dwellings will require additional energy efficiency investments to reach the Clean Growth Strategy objective of EPC band C.

Figure 2.4. Investments in new construction of residential buildings, by EPC band, 2010-2019



Note: Shares of EPC bands are determined based on public EPC data for England and Wales. Investments per EPC band are approximated from a subset of new dwellings where an EPC could be matched to the price of a purchase transaction in the HM Land Registry Price Paid data. The total investment volume is rescaled based on ONS statistics on GFCF and construction industry output. See Annex A for details.
Source: MHCLG Open Data Communities EPC database, HM Land Registry Price Paid data, ONS GFCF statistics, OECD analysis.

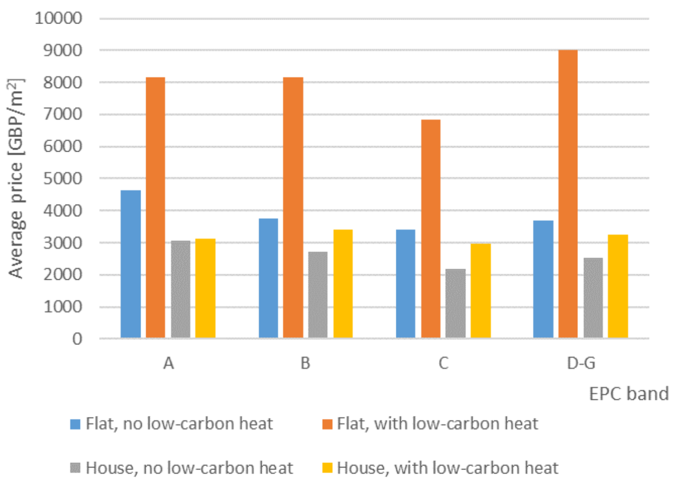
For new construction, given the very long lifetime of buildings, EPC bands B and even more so C, may not be sufficient to reach future ambitious net-zero targets. CCC recommendations imply that new residential construction would have to target EPC band A and to ensure low-carbon heating (CCC, 2020[27]) (CCC, 2019[28]). Figure 2.4 shows that between 2010 and 2019, approximately 1.4% of new residential construction investments (GBP 5 billion) went into EPC band A, of which only approximately 0.4% (GBP 1.5 billion) also included low-carbon heating[13]. While low-carbon heating typically coincides with increased upfront investment, such incremental investment can nevertheless be cost-effective over the lifetime of the building (Currie Brown, AECOM, 2019[40]). In terms of average price of new constructions, Figure 2.5 highlights some price differentiation between EPC bands as well as between dwellings with or without low-carbon heat. However, the price difference appears more strongly driven by the type of dwelling (flats being

[12] In some cases, such relatively inefficient dwellings have been created by converting old buildings into fewer or greater parts, or by converting non-residential buildings for residential use. When retaining a large portion of the existing building fabric, the potential to reach high energy efficiency levels may be limited.

[13] The low-carbon heating options included in this analysis, based on EPC data, were: Heat pumps, wood pellets, micro-cogeneration, liquid biofuels, and community schemes. Unfortunately, EPCs do not provide additional details on how community heating schemes are powered. However, from the perspective of an individual dwelling, connecting it to a community scheme is assumed to make the dwelling suitable for future low-carbon heat generation.

more expensive than houses). Geographical effects likely play an important role here, whereby flats are typically located in more expensive urban environments, which is also low carbon district heating would mostly be available. Some of the EPC band D-G flats (though with low-carbon heat) remain particularly expensive, a surprising finding that could require further analyses.

Figure 2.5. Average new construction prices, by EPC band and low-carbon heating, 2010-2019



Source: MHCLG Open Data Communities EPC database, HM Land Registry Price Paid data, OECD analysis.

Corresponding to the rising share of investments in EPC bands A and B observed since 2010, Figure 2.6 shows that the designed CO_2 emissions intensity[14] of new-built housing decreased between 2010 and 2019, from around 20 kg CO_2 per m^2 and year in 2010, to 15kg CO_2 per m^2 and year in 2019. The latter is 65% lower than the average emissions intensity over the entire buildings stock covered by EPCs.

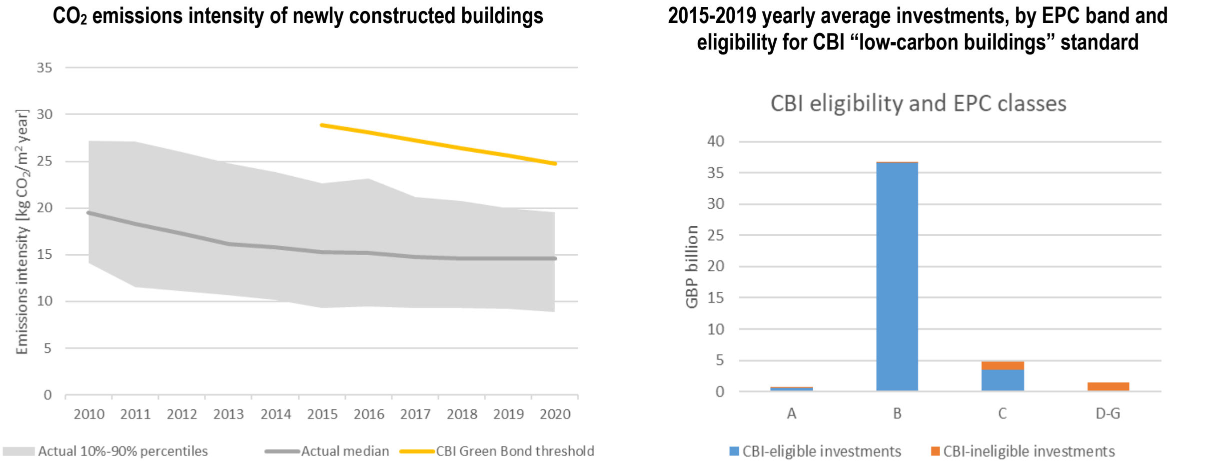
Emissions intensities provide more granularity than the EPC bands for evaluating the climate performance of buildings. For instance, CBI relies on such granularity to define the eligibility of “low-carbon” buildings for refinancing via green bonds. The CBI standard for new-built low-carbon residential buildings requires an emissions intensity corresponding to the top 15% of the buildings stock (see Section 1.3). For England and Wales, this threshold was calibrated to 28 kg CO_2 per m^2 per year in 2015, and decreases linearly year-on-year to zero by 2050. Figure 2.5 shows that the vast majority of new-built dwellings is below the CBI emissions intensity threshold corresponding to the year of construction.[15] Such new-built low-carbon dwellings correspond to 94% of new construction investments in 2015-2019 (GBP 41 billion per year, on average). Such results suggest a threshold based on best performers to date may not be strict enough to reach net-zero, while nonetheless qualifying the investment for green bond financing.[16]

[14] EPCs do not provide data on non-CO_2 emissions.

[15] This comparison is not fully accurate, as the CBI criteria also cover non-CO_2 GHG emissions. The data source used for evaluating buildings’ performance in this study (Open Data Communities EPC database from MHCLG) does not include non-CO_2 GHG emissions, and no other suitable building-level data source could be identified. Nevertheless, non-CO_2 GHG emissions are estimated to represent less than 5% aggregate GHG inventories for the residential sector.

[16] For simplicity this analysis assumes that the midpoint of the bond tenor coincides with the construction year.

Figure 2.6. Emissions intensity of new buildings and Climate Bonds Initiative low-carbon standard



Note: Emissions performance and shares of CBI eligibility are estimated based on public EPC data for England and Wales. The emissions intensity reported in EPCs includes direct and indirect CO_2 emissions but not other greenhouse gases.
Source: MHCLG Open Data Communities EPC database, HM Land Registry Price Paid data, ONS GFCF statistics, OECD analysis.

Figure 2.5 also shows a strong overlap between EPC bands and CBI eligibility. Low-carbon buildings according to the CBI criteria are almost exclusively found in EPC bands A-C. However, buildings not compliant with the CBI low-carbon criteria are found across EPC bands C-G and also, to a smaller extent, A and B. This is explained by the intentionally different focus (see also Section 1.3):

- EPC bands are determined based on the estimated energy consumption of the building.
- The CBI criteria focus on the GHG emissions intensity, which depends not only on the total energy consumption but also on the fuel mix of each dwelling.

2.3.2. Renovation

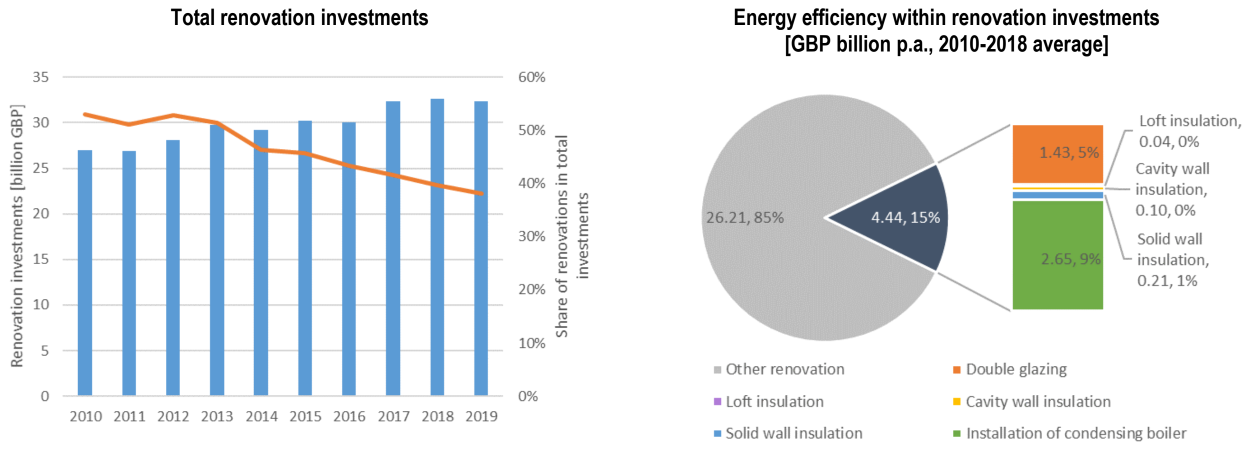
Yearly investments in renovating residential buildings in the UK increased from 27 billion GBP in 2010 to 32 billion GBP in 2019. This modest increase, compared to the strong growth of new construction (see previous section), implies that renovations as a share of total investments in residential buildings decreased from 53% to 38%. In the current absence of available granular data on renovation investments, it was not possible to conduct a comprehensive assessment of the alignment or misalignment of such investments with reference points such as EPCs and CBI criteria as done above for new built.

To provide at least partial insights on the climate consistency of renovation investments, this study, however, estimates investments in energy efficiency. Figure 2.7 shows an estimated 15% of the total renovation investments (corresponding to approximately 4.4 billion GBP per year) attributed to specific energy efficiency measures. These estimates are based on the number of installed measures in the period 2010-2018, and typical installation costs (see Annex A for details):

- Installation of windows with double- or multiple-glazing
- Roof or loft insulation
- Cavity wall insulation
- Solid wall insulation
- Improving on-site heating efficiency by switching to a condensing or condensing-combination boiler (nothing, however, that switching to fully renewable heating sources would be preferable)

Future work could extend such analysis by including estimates of investments in further energy efficiency measures, such as the installation of heat pumps, as well as in on-site renewable energy generation. This would require reliable estimates for the corresponding installation costs and numbers of installed measures. Further work could also include an evaluation of the actual GHG reductions achieved by investments such energy efficiency measures.

Figure 2.7. Investments in renovation of residential buildings, 2010-2019



Note: CWI: Cavity wall insulation, SWI: Solid wall insulation. Investments in specific energy efficiency measures were estimated based on the number of installed measures and cost assumptions (see Annex A).
Source: English Housing Survey, MHCLG Open Data Communities EPC database, Housing Energy Efficiency statistics, CAR/DECC Domestic retrofit cost assumptions study, OECD analysis.

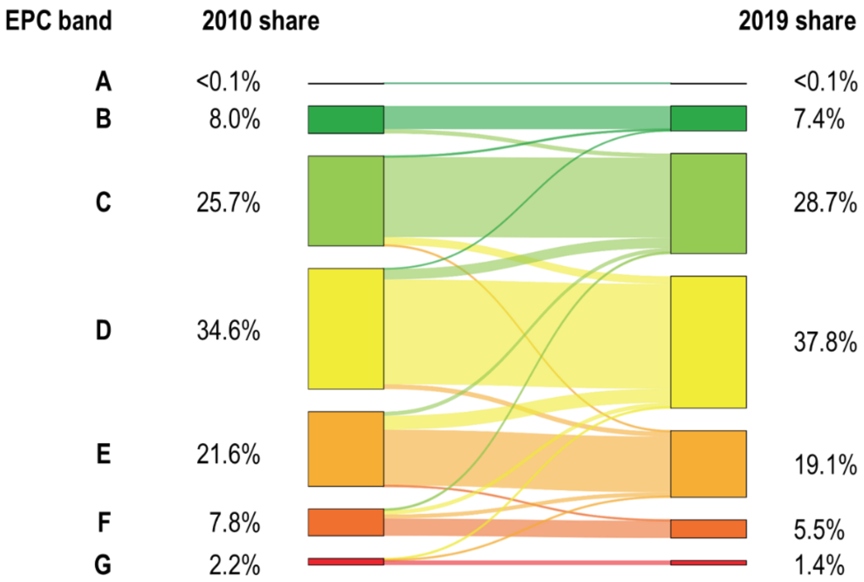
Analysing climate alignment aims at evaluating all investments and not only the elements having a direct climate impact. Considering investments in energy efficiency measures specifically makes it possible to estimate climate-specific investments volumes but underestimates total investment volumes that could be considered as consistent with climate change mitigation objectives. Major renovation investments will typically not be initiated solely for installing energy efficiency measures, but will also involve additional costs for fittings and cosmetic improvements, as well as for required safety improvements (e.g. asbestos removal).

Such costs are part of the overall renovation project and need to be included in the assessment of the climate-alignment of the total investment volume, based on the overall performance achieved through the renovation. For example, the CBI low-carbon buildings criteria follow this logic for defining the eligibility of refinancing via a green bond: if a renovation reduced the emissions intensity by 30%, its entire cost (and not just the cost directly related to energy efficiency) will qualify. This broad scope contrasts with public support schemes, which typically only address the incremental investments directly relevant to energy efficiency (see Section 2.5).

In practice, however, a lack of granular and comprehensive data on actual investments in renovating residential buildings prevents a detailed characterisation of total renovation investments according to reference points for climate change mitigation. Such characterisation (as shown in the previous section for new construction) would need to link total renovation investments to the achieved climate performance. For example, when considering EPC bands as one practical reference point for energy performance, one would need to identify renovation investments that do not change the EPC band as well as renovation investments corresponding to different levels of EPC improvement (or deterioration).

With this in mind, Figure 2.8 shows an analysis of EPC trends in the physical buildings stock over the observed period. Such analyses is produced on a like-to-like basis (i.e. it is only possible for buildings, which already had an EPC as of 2010) and without connecting EPC trends to underlying investments due to above-described data limitations. The vast majority of 2010 building stock that had an EPC band back then (82% of floor area) had remained in the same EPC band by 2019. Improvements by one EPC band occurred for 9% of the floor area. For 4% of the floor area, the EPC improved by two or more bands, which could indicate a deep retrofit. Over the same period, the EPC deteriorated by at least one band for 6% of the floor area.

Figure 2.8. Evolution of EPC bands of residential buildings (like-to-like, England and Wales, 2010-2019)



Note: This analysis is based on 4.2 million dwellings in England and Wales, which had at least one EPC filed in 2010 or earlier. Shares of EPC bands are weighted by floor area. Buildings constructed after 2010 and buildings where the first publicly available EPC dates after 2010 are not included. Due to these reasons, the overall shares in 2010 and 2019 differ from the averages across the residential buildings stock as estimated e.g. in the English Housing Survey. In contrast to the EHS, the analysis here aims to highlight the movement between different EPC bands. For visual clarity, only flows between EPC bands corresponding to at least 0.15% of the total floor area are shown.
Source: MHCLG Open Data Communities EPC database, OECD analysis.

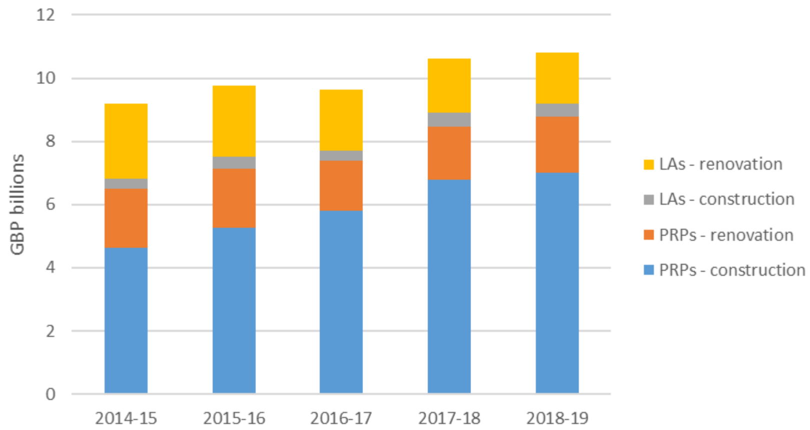
2.3.3. Deep dive: Social housing

The social rented sector represents 17% of dwellings in the UK, in contrast to 19% for the privately rented sector and 63% for owner-occupied dwellings (Table 102 in (ONS, 2020[41])). Within the 17% represented by social housing, local authorities own and rent out 7% and housing associations (i.e. private registered providers of social housing (PRPs)) the remaining 10%.

This section analyses social housing investments and resulting trends in environmental performance, in the period 2015-2019, in England. This reduced scope is chosen according to the availability of granular data from specialised data sources (local authorities' annual reports, statistical data return of private providers of social housing, and the HM Land Registry Corporate Ownership data). Furthermore, according to the conventions in the local authority and PRP reports, this section will use financial years ending in March instead of calendar years elsewhere in the study.

Figure 2.9 shows that investments in social housing in England averaged approximately GBP 10 billion per year between 2015 and 2019. This volume corresponds to approximately 14% of the yearly GFCF in the residential sector over that period, and is commensurate with the share of social housing in the total dwellings stock. While local authorities invested mostly in renovation (84% of LA investments), PRPs invested mostly in new construction (77% of PRP investments).

Figure 2.9. Housing investments by local authorities and PRPs (England)



Note: Construction investments of PRPs are estimated based on total additions, sales to other PRPs, and renovation expenditures. This approach could overestimate construction investments, in case a significant share of PRP stock additions are purchases of existing dwellings from actors other than PRPs or LAs, or in case not all sales to PRPs are reported as such in the LA and PRP reports.
Source: Local Authority housing statistics, Statistical data return of PRPs.

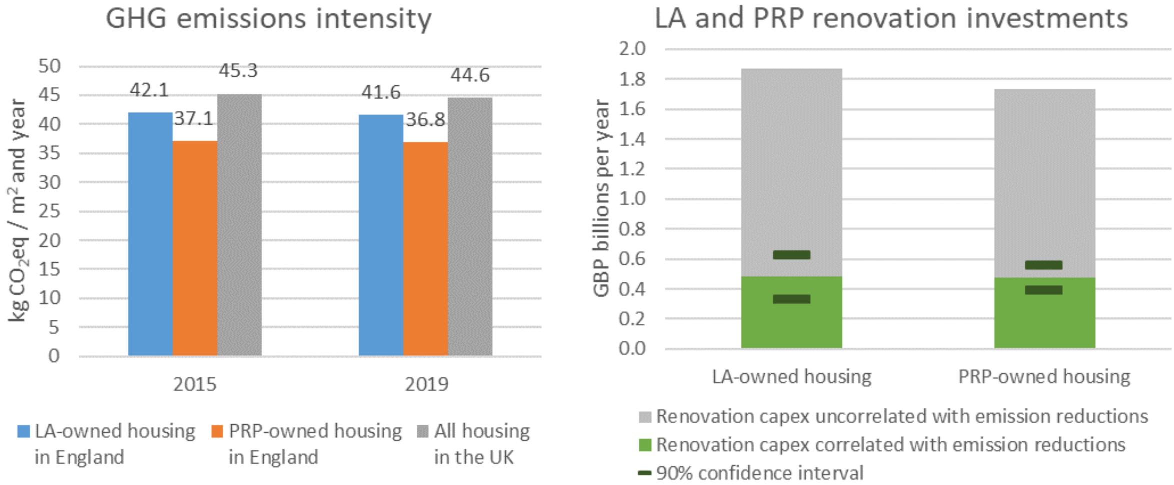
On average, dwellings in the social rented sector have better environmental performance than the overall UK buildings stock. In 2018, the share of EPC bands A-C in social housing was 56%, compared to 33% in the private rented sector and 29% among owner-occupied dwellings (MHCLG, 2020[42]). However, the absence of detailed year-by-year building ownership data over the 2010-2019 period prevents a quantitative breakdown of social housing investments by EPC band, such as performed for overall investments in new residential construction in Section 2.3.1.

On the other hand, local authorities and PRPs of social housing publish yearly data on their social housing investments, including a breakdown between construction and renovation expenditures. The availability of investment data granular to the level of individual local authorities and PRPs allows for an analysis of the correlation between renovation investments and environmental performance improvements. This provides an estimate of the share of total social housing renovation investments that coincided with climate performance improvements. Such analysis, taking the total investments as a starting point, is complementary to the narrow focus on energy efficiency investments in Section 2.3.2.

On average, over the period 2015-2019, a reduction in yearly CO_2 emissions of 1 kg correlates with 42 GBP additional renovation expenditure for social housing owned by local authorities, and 12 GBP additional renovation expenditure in the case of PRPs.[17] Based on the overall level of achieved GHG emission reductions, around 26% and 27% of renovation investments are estimated to be correlated with GHG emission reductions, for LAs and for PRPs, respectively (Figure 2.10). Annex B provides further details on this statistical analysis.

[17] This difference in the apparent cost of emission reductions does not necessarily reflect a difference in cost-efficiency between LAs and PRPs. At least in part, this difference may be due to the different initial conditions of the physical stock, as well as different lot sizes and economies of scale.

Figure 2.10. Social housing emission reductions and renovation investments in England, 2015-2019



Note: GHG emissions intensities and their correlation with investments were estimated based on a sample of approximately a quarter of the LA- and PRP-owned dwellings, where a HMLR ownership record could be matched with EPC information. Annex B provides further details on this statistical analysis.
Source: MHCLG Open Data Communities EPC database, Local Authority housing statistics, Statistical data return of PRPs, HM Land Registry corporate ownership data, OECD analysis.

As highlighted in Figure 2.10, social housing is on average less GHG intensive than the remainder of UK dwellings. At the same time, average renovation investments per dwelling by LAs and PRPs are 28% and 62% lower than across all UK buildings. Possible reasons for the relatively good performance of social housing despite below-average investments are:

- Less spending on amenities and a focus of renovations on energy efficiency. The latter is encouraged by government schemes targeting specifically low-income households (e.g. ECO, see Section 2.5).
- Economies of scale due to large volumes of similar housing units owned by the same entity. This simplifies investment decision-making and allows for efficient procurement.

It would be interesting to explore how the social housing sector could serve as a role model to the privately rented sector (see also the BEIS consultation on improving the energy performance of privately rented homes (BEIS, 2020[43])). However, the majority of landlords in the PRS are other households (England: 83% of tenancies (MHCLG, 2019[44])), and only a small share are companies (England: 13% of tenancies). Individual landlords are typically small-scale buy-to-let investors, while the focus of companies investing in residential buildings are large build-to-rent schemes and purpose-built student accommodation (IPF, 2019[45]). Hence, translating these findings from the social housing to the broader residential sector will require a dedicated analysis taking into account these differences in investment decision making.

Box 2.1. Mortgage financing

Mortgages play a crucial role in financing UK residential building investments. At the end of 2019, the outstanding residential mortgages in the UK amounted to GBP 1.5 trillion and gross mortgage advances in 2019 amounted to GBP 276 billion (FCA/Bank of England, 2020[46]).

For owner-occupied mortgages, six financial institutions represent around 70% of the values of both mortgages outstanding andgross lending as of 2019. This includes five commercial banks (Lloyds, NatWest, Santander, Barclays, HSBC) and a building society (Nationwide) (UK Finance, 2020[47]). For buy-to-let mortgages, which are about six times lower that owner-occupied lending in terms of outstanding and gross lending volumes, the concentration is lower (even though Lloyds and Nationwide each represent over 10%) (UK Finance, 2020[48]). The average loan-to-value ratio of a mortgage was 59% for buy-to-let mortgages and 88% for owner-occupier mortgages (Bank of England, 2020[49]).

Establishing the connection from mortgages to investments in physical buildings is challenging. Aggregate mortgage statistics published by regulators, central banks, and banking associations typically do not contain information on whether a mortgage served to build a new property or to purchase an existing one, and whether the proceeds were in practice also (partially) used for renovations.

A possible approach to evaluating the alignment of mortgage financing with climate objectives is to use detailed transaction-level mortgage data, and combine it with asset-level data on the climate performance of buildings notably from the public EPC register. Annual disclosure by mortgage lenders of average portfolio wide EPC ratings and of the gross value of lending for energy performance improvement, as suggested in the context of government consultations (HM Government, 2020[50]), would require such granular data collection and matching. However, due to the commercial sensitivity and confidentiality of transaction-level mortgage data, such analysis can only be performed by:

- Financial institutions on their own mortgage books. For instance, Nationwide’s Interim Results from September 2020 include an indication that 32% of its residential mortgage book relates to buildings with EPC rating currently below the UK’s objective of upgrading existing homes to at least EPC Band C. However, there remain challenges to overcome: 47% of mortgages relate to buildings without an EPC or for which EPC matching is difficult (Nationwide, 2020[51]).
- Financial regulators across all mortgage lenders. The Bank of England piloted such an approach for analysing the connection between buildings’ energy performance and mortgage defaults (Bank of England, 2020[52]). Similar data sets could also be used for measuring the alignment of mortgages with climate objectives.

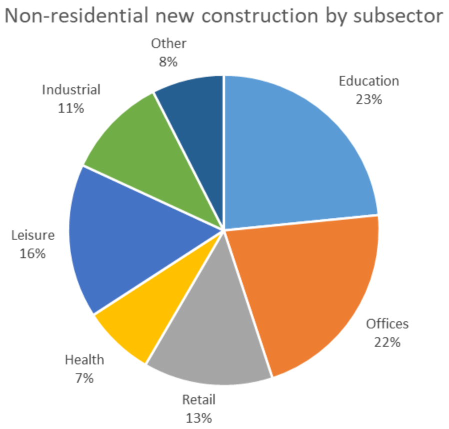
Further, granular data on mortgages would facilitate exploring economic risks and opportunities linked to climate performance, such as connections between energy performance and property values ((DECC, 2013[53]), (CA-EPBD, 2019[54])), or ways how mortgages can incentivise energy efficiency renovations rather than being a barrier ((EeMAP, 2019[55]), (DEEP, 2020[56])). This could in turn encourage financial institutions to increase financing of energy efficiency projects and to, more generally, improve the average energy efficiency of the properties they finance.

2.4. Climate consistency of non-residential buildings investments

2.4.1. New construction

The total investment in construction of new non-residential buildings increased from GBP 33 billion in 2010, to GBP 49 billion in 2019 (Figure 2.1). The subsectors with the largest construction activity were education and offices (23% and 22% of total 2010-2019 investments), corresponding to 9 billion GBP per year, respectively, see also Figure 2.11). Similarly to the residential sector, the assessment of climate consistency in the non-residential sector relies on EPCs and the CBI criteria for low-carbon buildings. The analysis of residential construction in Section 2.3.1 used transaction-level property prices to estimate of investment volumes corresponding to floor space additions in different climate performance categories. However, a suitably granular data source for non-residential construction investments could not be identified. Hence, the analysis of non-residential construction is based on construction volumes (floor space additions) rather than corresponding investment values.

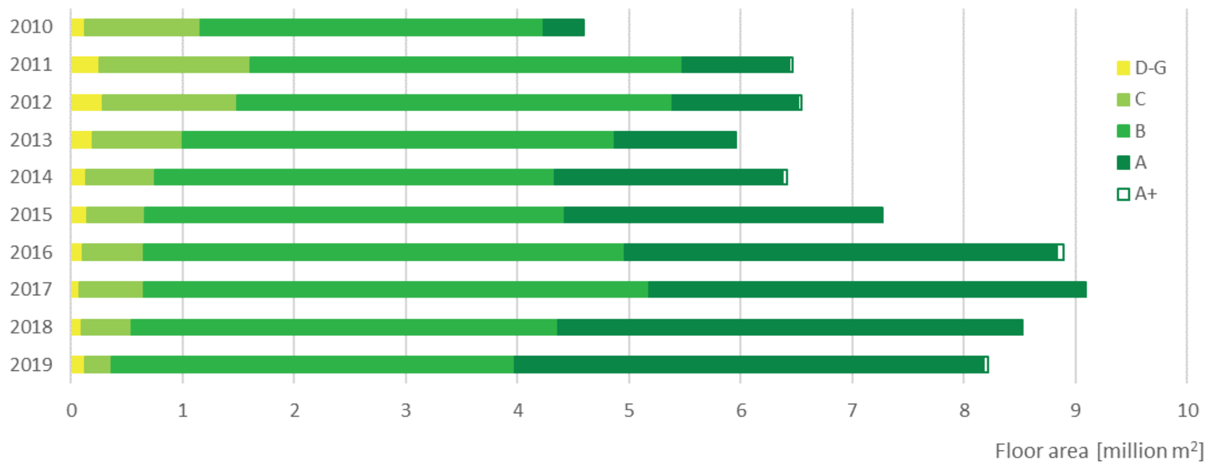
Figure 2.11. Non-residential new construction investments by subsector (2010-2019 average)



Source: ONS construction industry output statistics.

The majority of the non-residential construction occurred in EPC band B, whose share fell from 67% of the new floor space in 2010 to 44% in 2019. On the other hand, the share of EPC band A increased from 8% of the new floor space in 2010 to 51% in 2019. Over the 2010-2019 period, only 2% of new construction rated below EPC band C, and the EPC band C itself diminished from 23% in 2010 to 3% in 2019 (Figure 2.12).

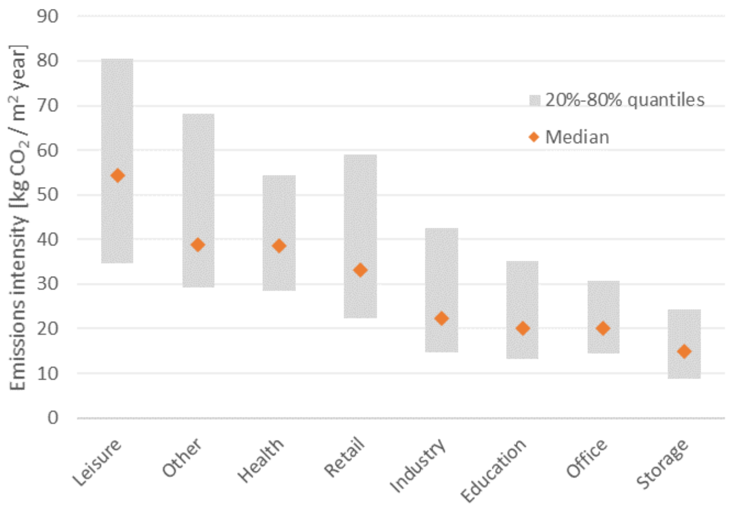
Figure 2.12. Non-residential construction volumes per EPC band and subsector, 2010-2019



Note: The statistics of floor area by EPC band are based on the MHCLG Open Data Communities EPC database and cover England and Wales only. The breakdown by subsector is showing the shares of total 2010-2019 investments based on ONS construction industry output statistics.
Source: MHCLG Open Data Communities EPC database, OECD analysis.

The GHG emissions intensity of non-residential buildings varies strongly depending on the considered subsector. Figure 2.13 shows that the typical emissions intensity of newly constructed leisure buildings (including e.g. restaurants, hotels, entertainment and sports facilities) with 54 kg CO_2 per m^2 and year is more than twice as high than e.g. for offices with 20 kg CO_2 per m^2 and year.

Figure 2.13. CO_2 intensities of new non-residential construction, (England and Wales, 2010-2019)



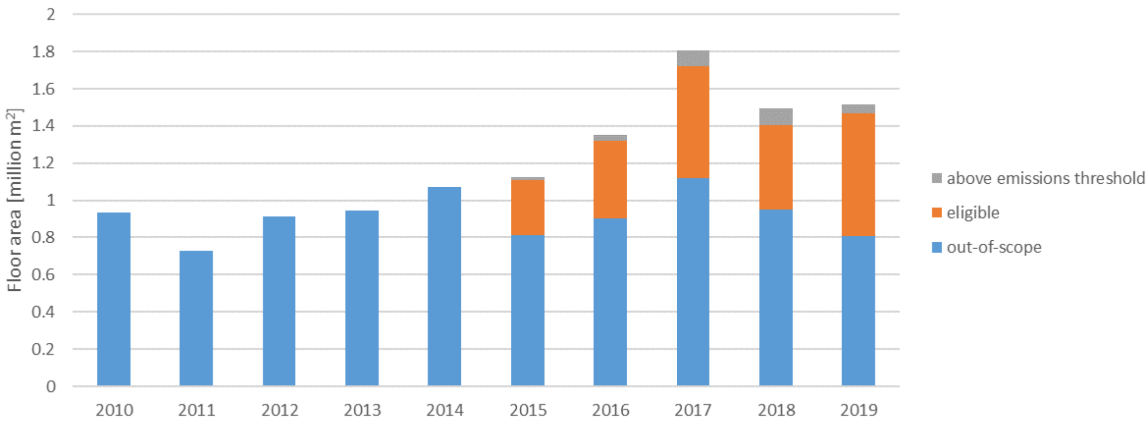
Note: Emissions performance is estimated based on public EPC data for England and Wales. The total emissions intensity reported in EPCs includes direct (scope 1) and indirect (scope 2) CO_2 emissions but not other greenhouse gases.
Source: MHCLG Open Data Communities EPC database.

Like for residential buildings, the CBI criteria define construction of non-residential buildings as being low-carbon, when it meets a threshold on Scope 1 and 2 GHG emissions aiming at the top 15% of the current buildings stock. However, for non-residential buildings these thresholds depend on the building type and on its location. In the UK, CBI established specific thresholds for office buildings in London in 2015 and in nine other cities in 2019 (see Table B.3). These thresholds become more ambitious over time, decreasing linearly to zero by 2050. Offices in other UK cities than listed in Table B.3, as well as UK non-residential buildings other than offices, are not covered by standardised CBI criteria at the time of writing.

Within the limited scope of applicability of the current CBI criteria, 90% of the newly constructed floor space satisfied the GHG emission thresholds. The corresponding investment volumes, that are eligible for green bond refinancing, are approximately[18] 3.2 billion GBP per year in 2015-2018 and 4.8 billion GBP in 2019. However, approximately 53% of the office floor space constructed in 2019 was outside the geographical scope of the CBI criteria, despite its broadening in that year (Figure 2.14). Further, as detailed above, offices only make up less than a quarter of total non-residential buildings construction in terms of investments, and less than a fifth in terms of floor area. Overall, the CBI criteria even in their most recent 2019 form only address less than 10% of newly constructed non-residential floor space.

[18] These are pro-rata estimates, based on the volume of CBI-eligible floor space, the total floor space, and the total investment volumes. These estimates assume that average square metre prices for CBI-eligible buildings are similar to sector average square metre prices for the same building type.

Figure 2.14. Assessment based on CBI low-carbon buildings criteria for construction of new office buildings



Note: Emissions performance and shares of CBI eligibility are estimated based on public EPC data for England and Wales. The emissions intensity reported in EPCs includes direct and indirect CO_2 emissions but not other greenhouse gases.
Source: MHCLG Open Data Communities EPC database.

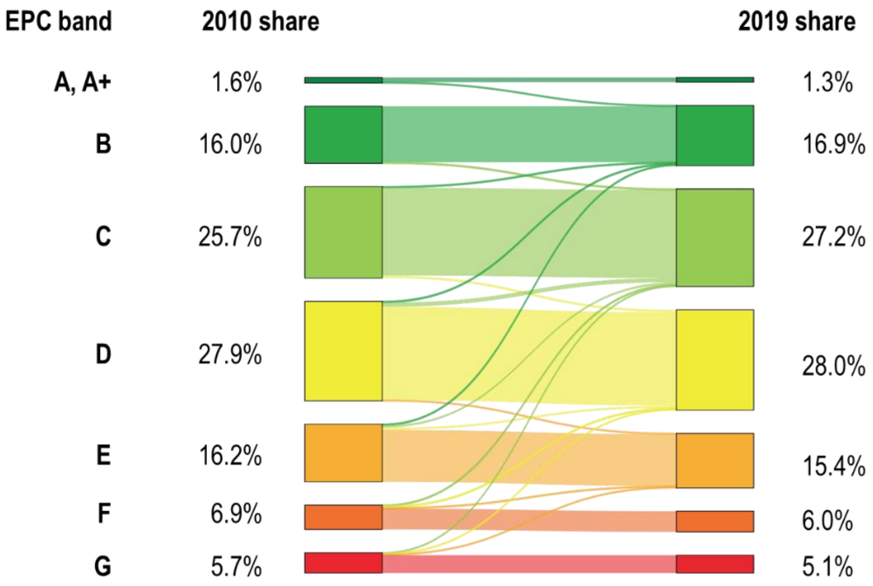
2.4.2. Renovation

The data sources explored in this study do not allow for a comprehensive analysis of the consistency of non-residential renovation investments with climate objectives:

- Companies' financial reports typically do not provide a breakdown between construction, renovation, and acquisition investments.
- Local authorities' capital outturn reports do not provide a breakdown between construction and renovation investments in public buildings.
- The ONS construction industry output statistics do not include details on renovation volumes per subsector or types of renovations, and are not sufficiently granular to estimate the impacts on environmental performance.

Figure 2.15 shows an analysis of EPC trends in the non-residential physical buildings stock over the observed period. As for the corresponding Figure 2.8 for the residential sector, such analysis is produced on a like-to-like basis (i.e. it is only possible for buildings, which already had an EPC as of 2010) and without connecting EPC trends to underlying investments due to data limitations. The vast majority of non-residential buildings that had an EPC band back in 2010 remained in the same EPC band by 2019, with only relatively modest increases in the percentages represented by EPC bands B and C and corresponding slight decreases of the shares of EPC bands E and F.

Figure 2.15. Evolution of EPC bands of non-residential buildings (like-to-like, England and Wales, 2010-2019)



Note: This analysis is based on 62 thousand non-residential buildings in England and Wales, which had at least one EPC filed in 2010 or earlier. Shares of EPC bands are weighted by floor area. Buildings constructed after 2010 and buildings where the first publicly available EPC dates after 2010 are not included. For visual clarity, only flows between EPC bands corresponding to at least 0.15% of the total floor area are shown.
Source: MHCLG Open Data Communities EPC database, OECD analysis.

Section 4.1.2 provides more details on these limitations, as well as possible ways forward to fill these data gaps. For certain subsectors such as education or healthcare (see Box 2.2), specialised data sets can already provide the required level of detail.

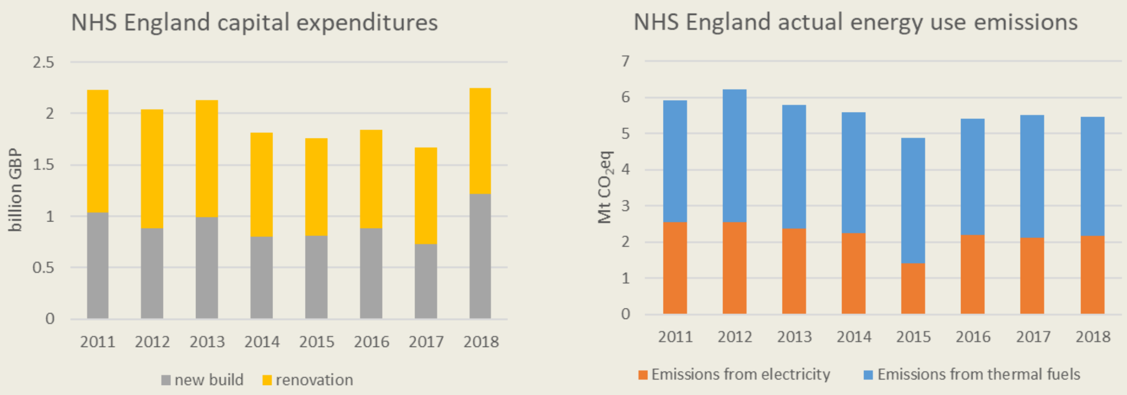
Box 2.2. National Health Service (NHS) buildings investments and emissions

Central government departments have reduced emissions from their buildings and operations by an estimated 46% since 2010, but this only covers central government's estate, excluding significant areas of impact such as schools, military activities as well as healthcare, which did not have formal GG reduction objectives as of 2020 (National Audit Office, 2020[57]).

Healthcare buildings represented 7% of new construction investments in the UK non-residential sector between 2010 and 2019 (see Figure 2.11). Healthcare buildings consist of primary care buildings (e.g. general practitioner premises) and secondary/specialised care buildings (e.g. hospitals). While ownership of primary care buildings is decentralised, the NHS owns and manages the vast majority of secondary/specialised care buildings.

The NHS publishes an annual Estates Returns Information Collection (NHS Digital, 2020[58]) with detailed data on the buildings owned by each of the NHS Trusts in England. Based on this data, Figure 2.16 shows the buildings investments and emissions of NHS England in the period 2011-2018. Comparing to total UK healthcare construction investments, NHS England contributes approximately 52%. Both the investments and the emissions remained largely stable over the considered period.

Figure 2.16. NHS England buildings investments and emissions, 2011-2018



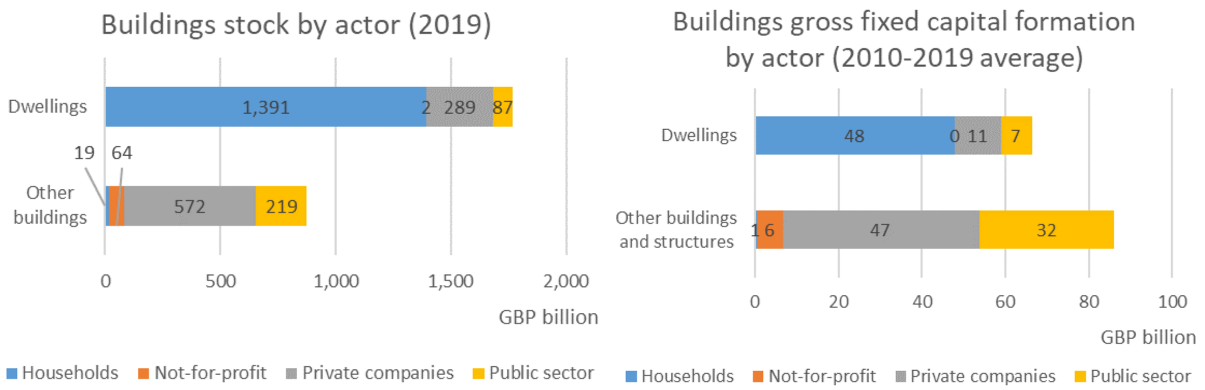
Note: Emissions were estimated from energy consumption using the BEIS/DEFRA average emission factors for the corresponding fuels.
Source: (NHS Digital, 2020[58]).

2.4.3. Deep dive: Corporate real estate ownership and real estate investment trusts

Private companies own 68% of the non-residential buildings stock (GBP 552 billion in 2018), and contribute 58% to investments in non-residential buildings and other structures (GBP 44 billion per year on average between 2010 and 2018), as indicated in Figure 2.17. However, the category "other buildings and structures" in national statistics covers not only commercial buildings and public buildings, but also industrial buildings, infrastructure (roads, railways, etc.), and land improvements.[19]

[19] Investments in "other structures" mostly relate to public investment in infrastructure. As a result, the share of private company investments in non-residential buildings is likely higher than 58%. Potentially, non-residential buildings can be separated from other

Figure 2.17. Ownership and investment in UK buildings, by economic actor



Note: The buildings capital stock values do not include the land value on which buildings are constructed. GFCF includes investments in construction and major improvements. The GFCF category "Other buildings and structures" includes non-residential buildings, other structures, and land improvements. "Public sector" includes central and local government, as well as public non-financial corporations.
Source: ONS National Accounts Blue Book 2019.

Large UK real estate companies are frequently organised as listed real-estate investment trusts (REITs). Around 50 REITs are currently listed at the London Stock Exchange, with a total book value of assets of GBP 109 billion, the majority of which is real estate.[20] Between 2010 and 2019, the average yearly capital expenditures of UK REITs amounted to GBP 6 billion. However, this amount includes not only construction or renovation of buildings (i.e. fixed capital formation as analysed in Section 2.1), but also acquisitions of existing properties. While REITs typically report acquisition expenditures separately in their annual reports, in commercial databases that provide data across institutions, such break down is either not available (Refinitiv, Moody's ORBIS) or not straightforward to extract (S&P Global Market Intelligence) (see Section 4.1.2 for further details).

Hence, only a sample of large REITs is analysed in the following, based on the granular investment data from their individual annual reports. In contrast to the overview of the evolution of EPC bands for the non-residential building stock presented in Figure 2.15 above, such analysis is based on actual emissions due to the difficulty of matching the relevant EPC data. This is a second-best solution for analysing investments: compared to EPCs, which record the designed performance, actual GHG emissions are influenced by consumption and behavioural patterns, as well as the GHG emission profile of energy supply.

Figure 2.18 shows property development investments and related GHG emission reductions for a sample of eight UK REITs that publish detailed GHG emissions data.[21] Analysing emission reductions due to investment in physical improvements (as opposed to the acquisition and disposal of existing properties) requires granular GHG data. This analysis relies on like-for-like GHG emission changes, i.e. year-on-year emission changes of properties which were continuously part of the company's portfolio both in a given year and in the preceding one. While a number of REITs and private property companies publish portfolio totals for GHG emissions and emission intensities, only few disclose like-for-like GHG emission changes or more granular data. For the sample shown in Figure 2.18, like-for-like GHG emission changes were

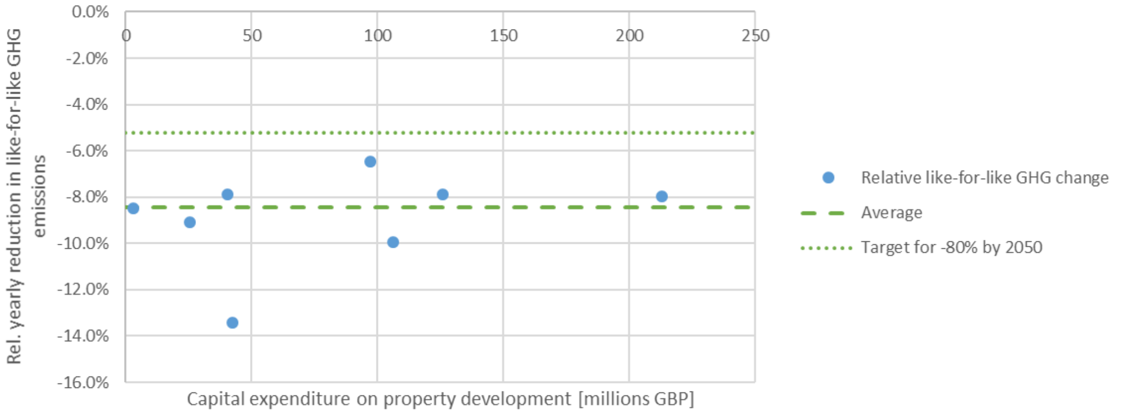
structures in the ONS Annual Acquisitions and Disposals of Capital Assets survey (ONS, 2020[128]). However, this data set could not be accessed in the course of this study (see also Section 4.1.2).

[20] While a precise estimate is difficult, the REIT legal structure requires at least 75% of total assets to be real estate or cash (KPMG, 2015[154]).

[21] Landsec, Derwent London, Shaftesbury, Great Portland Estates, LondonMetric Property, Hammerson, Picton Property Income, Workplace Group.

extracted from the Sustainability Best Practices Recommendations database of the European Public Real Estate association (EPRA, 2020[59]). Capital expenditures on property development (i.e. construction of new properties and renovation of existing ones) were extracted manually from annual reports of the eight REITs.

Figure 2.18. Capital expenditures and emission reductions of a selection of UK REITs (2010-2019 averages)



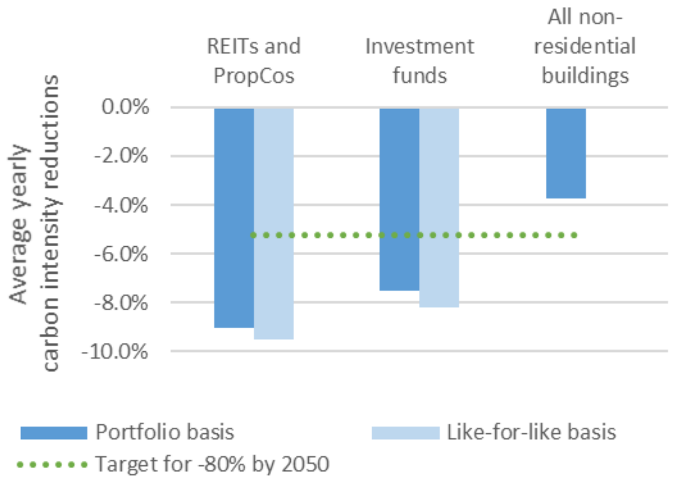
Note: The displayed averages of yearly changes are based on a "like-for-like" scope, i.e. exclude changes from acquisitions and disposals of properties. The sample includes 8 UK REITs where like-for-like GHG scope 1 and 2 emission changes were reported for at least 4 years in the period 2010-2019. The vertical axis indicates the average of the yearly like-for-like GHG scope 1+2 emission reductions. The horizontal axis indicates the average of the yearly capital expenditures on property development, i.e. excluding acquisitions. Within the property development CAPEX, there is no breakdown between new construction and refurbishment (the latter would be more adequate to plot on the x-axis).
Source: Capital expenditures: Annual reports, GHG emissions: EPRA sBPR database.

On average, between 2010 and 2019 the eight REITs included in this analysis invested a total of GBP 650 million per year in property development (corresponding to 11% of all UK REITs' capital expenditures), and reduced their like-for-like GHG emissions by 8.5% per year. As shown in Figure 2.18, all of the REITs analysed here achieved the typical yearly emission reductions of 5.2% per year required to reach an 80% reduction by 2050 (which is the science-based target of Landsec, the largest UK REIT (SBTI, 2017[60])). Hence, the capital expenditures on property development of the REITs included in this analysis can be considered consistent with this objective. This does not necessarily indicate the consistency of all REITs or corporates more broadly with such an objective, since the availability of granular data used in this research is likely to be biased towards corporates with good environmental performance, which typically communicate more than laggards.

Beyond the eight REITs analysed above, GHG emissions data for UK real estate investors are more widely available from the Real Estate Environmental Benchmark (REEB) dataset hosted by the Better Buildings Partnership (BBP) (Better Buildings Partnership, 2020[61]). Based on the annual utility consumption data of the commercial property portfolios of BBP members, it provides benchmarks based on the performance of buildings 'in-use'. The underlying granular data was used, on an anonymous basis, to analyse trends in GHG intensity reductions between 2010 and 2019 for two distinct groups of real estate investors: REITs and property companies (PropCos) on the one hand, investment funds on the other hand).

As shown in Figure 2.19, real estate portfolios of both REITs-PropCos and investment funds achieved GHG emission reductions significantly above those for non-residential buildings as a whole. In the absence of granular enough financial data, it is, however, not possible to separate out the respective roles of investments that might have been made in energy efficiency improvements on the one hand, and of changes in consumption and behavioural patterns on the other hand.

Figure 2.19. Trends in GHG intensity reductions of real estate investment portfolios (2010-2019)



Note: REITs stands for Real Estate Investment Trusts, which are companies dedicated to owning, operating, and financing income-generating real estate assets. PropCos stands for property companies, which are secondary entities created a business to hold and manage their real estate assets.
Source: Based on anonymised data from the Real Estate Environmental Benchmark (REEB) dataset hosted by the Better Buildings Partnership (BBP) (Better Buildings Partnership, 2020[61]).

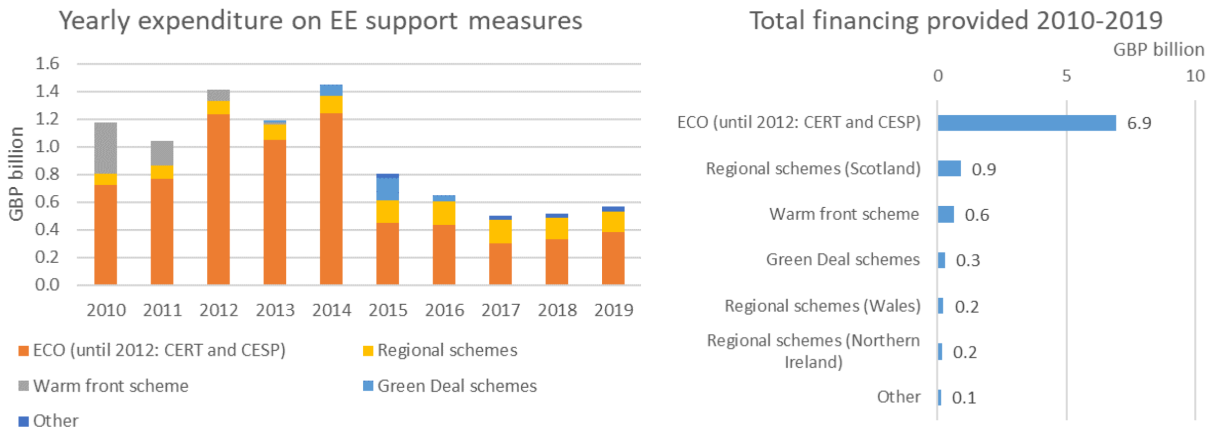
Beyond real estate investors, the analysis of climate alignment is rapidly gaining attention within the financial sector. Both asset owners (e.g. pension funds) and asset managers started measuring the environmental footprint of their real estate portfolios (GRESB, 2020[62]) in order to monitor climate-related risks (CRREM, 2019[63]) and fulfil decarbonisation pledges (UNEP-FI, 2020[64]). However, relating the alignment of financial portfolios to investments in the real economy poses challenges:

- Most real estate investors and investment vehicles manage a geographically diversified portfolio. They do not always report financial and environmental data with the country-level breakdowns necessary to assess the alignment of specific investments and assets.
- Climate metrics used by different stakeholders differ in scope and methodology, for instance with respect to the inclusion or exclusion of Scope 3 GHG emissions from construction and tenants' energy consumption.
- Trends in actual portfolio GHG emissions arise due a combination of investments in construction or refurbishment, asset purchases or disposals, as well as behavioural changes. As already mentioned, quantifying the contribution of each of these factors is challenging.

2.5. Public grants and subsidies

Between 2010 and 2019, public support schemes contributed 9.3 billion GBP to finance residential energy efficiency investments in the UK. This investment volume corresponds to approximately 3% of total residential renovation investments over that period. Figure 2.20 breaks down the total public support towards residential energy efficiency investments by year and by support scheme. Annex A provides details on the data sources used to estimate the volumes of public support. New schemes established in 2020 are discussed in Chapter 3 in relation to forward-looking mitigation objectives.

Figure 2.20. Public support schemes for residential energy efficiency renovation (UK, 2010-2019)



Note: Only public support schemes targeting installation costs (capital expenditures) are included. Schemes targeting running/operating costs are out of scope. The breakdown of expenditures by calendar year, as well as 2019 values, are in part based on estimates. Annex A and Table Table A.2 provide additional details on the included schemes and on the estimation methodology.
Source: BEIS, Scottish Government, Welsh Government, Northern Ireland Department for Communities, OECD analysis.

Over 80% of the total observed support towards residential energy efficiency investments is delivered through energy companies. Between 2010 and 2019, successive regulations mandated companies providing energy and energy services to assist households in Great Britain with the installation of energy efficiency measures ((ofgem, 2020[65]), (DECC, 2014[66])):

- **Carbon Emission Reduction Target** (CERT). This scheme was established in 2008, and delivered approximately GBP 2.1 billion in energy efficiency measures between 2010 and its closure in 2012 (DECC, 2014[66]). Six large energy suppliers[22] were obliged to ensure a quota of CO_2 savings by assisting households in the installation of energy efficiency measures encompassing insulation, heating, and electricity micro-generation. Additional targets were set for specific measures and vulnerable household groups.
- **Community Energy Saving Programme** (CESP). This scheme was active between 2009 and 2012 and delivered GBP 665 million in energy efficiency measures (DECC, 2014[66]). While the overall design was similar to CERT, CESP targeted low-income households only and encouraged a 'whole-house approach', similar to the concept of "deep retrofit".
- **Energy Company Obligation** (ECO) (ofgem, 2020[67]). The ECO regulation replaced CERT and CESP in 2013. Having undergone multiple revisions (ECO1: January 2013 – March 2015, ECO2: April 2015 – March 2017, ECO3: April 2017 – March 2022), this scheme was extended until 2026 with an interim consultation expected in 2021. Between 2013 and 2019, ECO delivered approximately 4.2 billion GBP in energy efficiency measures. Similarly to the previous CERT and CESP schemes, ECO assigns large energy suppliers targets of CO_2 savings across different dimensions (carbon emission reduction obligation, carbon saving community obligation, home heating cost reduction obligation, provisional solid wall minimum requirement). Accredited providers bid for implementation contracts via a brokerage system, aimed at minimising the delivery cost. Energy companies then re-coup the costs via energy bills. Since the ECO3 phase, the focus of this scheme is exclusively on low-income and vulnerable households.

In 2013, the UK government initiated the "Green Deal" initiative to help homeowners pay for energy efficiency improvements. Between 2013 and 2016, as part of the Green Deal a number of further schemes

[22] A mandatory CERT obligation was assigned to suppliers having at least 250,000 residential customers.

provided direct financial support towards the installation costs of residential energy efficiency measures (see also Annex Table A.2):

- **Green Deal Finance Plans** (DECC, 2015[68]). This financing mechanism provided subsidised loans of approximately 49 GBP million between 2013 and 2015. The Green Deal Finance Company financed certain energy efficiency measures recommended by a Green Deal Assessment and installed by a Green Deal Provider. The owner/occupier of the building then repaid the initial investment via their energy bills. The loan repayment was attached to the property and transferred in case of resale, similarly to the US property-assessed clean energy programmes (PACE, see (DoE, 2020[69])).
- **Green Deal Cashback Scheme** (DECC, 2014[70]). This scheme was active in 2013 and 2014 and provided grants of GBP 16 million. It provided a public subsidy to households in England and Wales for implementing certain energy efficiency measures. The subsidy amount was limited by ceiling amounts depending on the installed measures, amounting overall to several hundred to a few thousand GBP per dwelling.
- **Green Deal Home Improvement Fund** (DECC, 2015[68]). This scheme followed the Cashback scheme and was active in three releases in 2014 and 2015. It provided a total of GBP 162 million of public subsidies to households in England and Wales for implementing certain energy efficiency measures. The subsidy was limited to certain ceiling amounts depending on the installed measures, up to several thousand GBP per household.
- **Green Deal Communities** (DECC, 2017[71]). This scheme provided grants of around GBP 85 million to Local Authorities between 2014 and 2016. It subsidised both the Green Deal Assessments and the delivery of Green Deal measures.

Scotland, Wales, and Northern Ireland have set up tailored schemes for subsidising energy efficiency improvements (also listed in Annex Table A.2):

- **Scotland**: Home Energy Efficiency Programmes (GBP 0.7 billion provided between April 2013 and 2019), Home Energy Programmes (GBP 0.2 billion provided between 2010 and March 2013). In addition, Scotland provides concessional private sector landlord loans for energy efficiency improvements (Energy Saving Trust, 2020[72]).
- **Wales**: Nest scheme (GBP 160 million provided between April 2011 and 2019), Arbed scheme (GBP 77 million provided between 2010 and 2019).
- **Northern Ireland**: Affordable Warmth scheme (GBP 76 million provided between April 2014 and 2019), Warm Home scheme (GBP 60 million provided between 2010 and March 2015), Boiler replacement scheme (GBP 25 million provided between April 2012 and 2019).

In addition to the housing-focused public support schemes listed above, this study identified a few smaller, specialised schemes supporting the upfront capital expenditures for energy efficiency in non-residential buildings:

- The Scottish Government provides loans to SMEs via its Energy Efficiency Business Support programme (Zero Waste Scotland, 2020[73]).
- The BEIS Electricity Demand Reduction pilot provided approximately GBP 5 million towards projects that reduce electricity demand at peak times between 2014 and 2019 (BEIS, 2019[74]).

The UK government indirectly incentivises non-residential energy efficiency by encouraging energy performance contracting (DECC, 2015[75]). In general, energy performance contracts are possible financing mechanisms for all types of energy efficiency investments. In these types of contracts, the energy service company ("ESCO") guarantees a given level of energy savings, invests in corresponding energy efficiency measures, and recoups the costs via energy bills. While this setup is similar to the Energy Company Obligation described above, energy performance contracting is purely voluntary. In the UK, energy performance contracting is mostly used for public sector buildings in the education and healthcare sectors via corresponding public procurement frameworks (QualitEE, 2018[76]). Due to the decentralised structure of the energy performance contracting market, the capital investments triggered through this mechanism cannot be reliably quantified in this study. However, they are likely to be below GBP 100 million per year (QualitEE, 2018, p. 40[76]).

In addition to the schemes listed above, a number of UK policies in 2010-2019 resulted in investments improving the energy performance, without providing direct support towards the installation costs. Such broader policy measures include:

- **Support for operating expenditure / running costs**. One notable example is the Renewable Heat Incentive, available since November 2011 for non-residential properties and since April 2014 for residential properties. The owner of a property installing a climate-friendly heating system (biomass boiler, heat pump, solar thermal) is eligible to receive quarterly tariff payments from the UK government depending on the amount of heat produced and the utilised technology. Another example is the feed-in tariff for the generation of renewable electricity from on-site small-scale installations, introduced by the Department for Energy and Climate Change (DECC) in 2010. Consumers who generate their own electricity from a renewable or low-carbon source can qualify for a payment for each unit of electricity generated.
- **Tightening building standards and norms**. For example, the 2013 UK Building Regulations aim to deliver 6-9% lower CO_2 emissions compared to the 2010 UK Building Regulations (CA-EPB, 2018[77]). Further, businesses are subject to mandatory energy saving opportunities audits (BEIS, 2019[78]).
- **Taxes and charges**. This includes, for example, the CRC energy efficiency scheme (active until 2018) and the Climate Change Levy (ongoing) addressing companies' energy use. The Climate Change Levy excluded (and thus incentivised) renewable electricity generation until 2015 (ofgem, 2015[79]). Furthermore, Enhanced Capital Allowances (HMSO, 2001[80]) allow companies to immediately deduct 100% of capital expenditures on environmentally beneficial machinery and equipment from corporate tax.

The actual volume of investment triggered by such measures is challenging to estimate and not included in available documentation evaluating these policies. Hence, these policies are not considered quantitatively in this study.

3 Consistency of the buildings stock with forward-looking mitigation objectives

3.1. Forward-looking decarbonisation objectives

The UK defined legally binding national climate change mitigation commitments in its 2008 Climate Change Act (HM Stationery Office, 2008[81]). This act stipulates, in particular:

- A long-term goal of 80% emission reductions by 2050, compared to the base year 1990. In June 2019, this long-term goal was updated to net zero emissions by 2050 (HM Stationery Office, 2019[82]).
- The creation of the Committee on Climate Change (CCC) as an independent organisation tasked with proposing carbon budgets and monitoring progress.
- A series of binding five-year carbon budgets (introduced in Section 1.3), covering economy-wide net GHG emissions, including LULUCF.

In December 2020, the UK government put forward a new interim target for 2030 of at least 68% reduction in GHG, compared to 1990 levels (BEIS, 2020[83]), thereby raising the ambition of its previous 53% reduction target set under its first NDC. This new target is aimed at setting the UK on the path to net zero by 2050, and is supported by a "The ten point plan for a green industrial revolution", which includes dedicated points on "greener buildings" (point 7) and on "green finance and innovation" (point 10) (BEIS, 2020[84]).

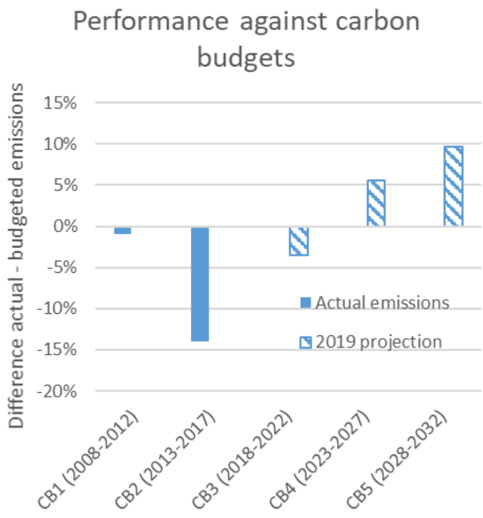
As introduced in Section 2.2, the UK government sets carbon budgets 12 years in advance, following advice from the CCC. Figure 3.1 summarises past and current carbon budgets for the UK economy as a whole. Between 2008 and 2017, the UK delivered emission reductions in excess of those required by the first (2008-2012) and second (2013-2017) carbon budgets. Likewise, under recent governmental energy and emission projections ((BEIS, 2019[85]), (House of Commons, 2019[86])), it appears on track to stay within the third carbon budget (2018-2022). However, as illustrated by Figure 3.1, additional emission reductions will be required to stay within the limits of the fourth carbon budget (set in 2011 for the period 2023-27) and fifth carbon budget (set in 2016 for the period 2028 and 2032). As analysed and discussed in Section 3.2, the sixth carbon budget now provides an updated pathway towards the Net Zero objective (CCC, 2020[27]).

The CCC also tracks progress towards emission reduction targets through sector-specific indicators. For the buildings sector, the metrics used in the CCC progress reports are the number of installed energy efficiency and low-carbon heating measures. As illustrated in Section 2.2, the current uptake of such measures during the period observed in this report (2010-2019) was insufficient to reach the emission reduction potential targeted by the CCC in the buildings sector.

Figure 3.1. Economy-wide UK carbon budgets

Summary of UK CB1-CB6

Period	Date set	Emissions budget [Mt CO_2eq]	Relative reduction compared to 1990
CB1 (2008-2012)	May 2009	3,018	25%
CB2 (2013-2017)	May 2009	2,782	31%
CB3 (2018-2022)	May 2009	2,544	37%
CB4 (2023-2027)	June 2011	1,950	50%
CB5 (2028-2032)	November 2015	1,725	57%
CB6 (2033-2037)	December 2020	tbc	tbc



Source: (BEIS, 2019[85]), (House of Commons, 2019[86]).

In addition to the top-down perspective of the Climate Change Act, the UK government's Clean Growth Strategy and Industrial Strategy include specific objectives for the buildings sector:

- The Construction 2025 strategy (BIS, 2013[87]) sets, among others, a target of 50% GHG emission reductions in the built environment by 2025. This strategy is being implemented in five-year periods, see for example the Government Construction Strategy 2016-2020 (Cabinet Office/Infrastructure and Projects Authority, 2016[88]).
- The Clean Growth Strategy includes the aspiration to upgrade as many homes as possible to EPC Band C by 2035 (HM Government, 2017, p. 13[39]), and to upgrade all fuel poor homes to EPC Band C already by 2030. Privately rented homes should also be upgraded to EPC Band C by 2030 where practical, cost-effective and affordable. As discussed in Sections 2.3.1 and 2.3.2 respectively, the vast majority of investments in new construction over the period 2011-2019 were consistent with the 2035 objective while only slow progress was achieved in terms of investing in improving the performance of the existing building stock.
- The Industrial Strategy Grand Challenge mission on Clean Growth (BEIS, 2019[89]) includes a buildings component: halving the energy use of new buildings by 2030, and halving the cost of renovating existing buildings to a similar standard.

In addition to country-level targets, some UK organisations have set climate change mitigation targets of their own of relevance to the building sector. This includes, for example:

- The UK Green Buildings Council's "Advancing Net Zero" campaign, aiming at 100% net-zero buildings by 2050 (UKGBC, 2020[90]). Several large UK real estate companies, such as Grosvenor and JLL, participate in this campaign. A similar net-zero by 2050 commitment has been signed by members of the Better Buildings Partnership (BBP, 2019[91]).
- Several UK real estate companies pledged to achieve net-zero portfolios earlier than 2050, e.g. British Land by 2030 (British Land, 2020[92]).
- Some local authorities have set target dates for becoming carbon-neutral, e.g. Nottingham by 2028 (Nottingham, 2020[93]).

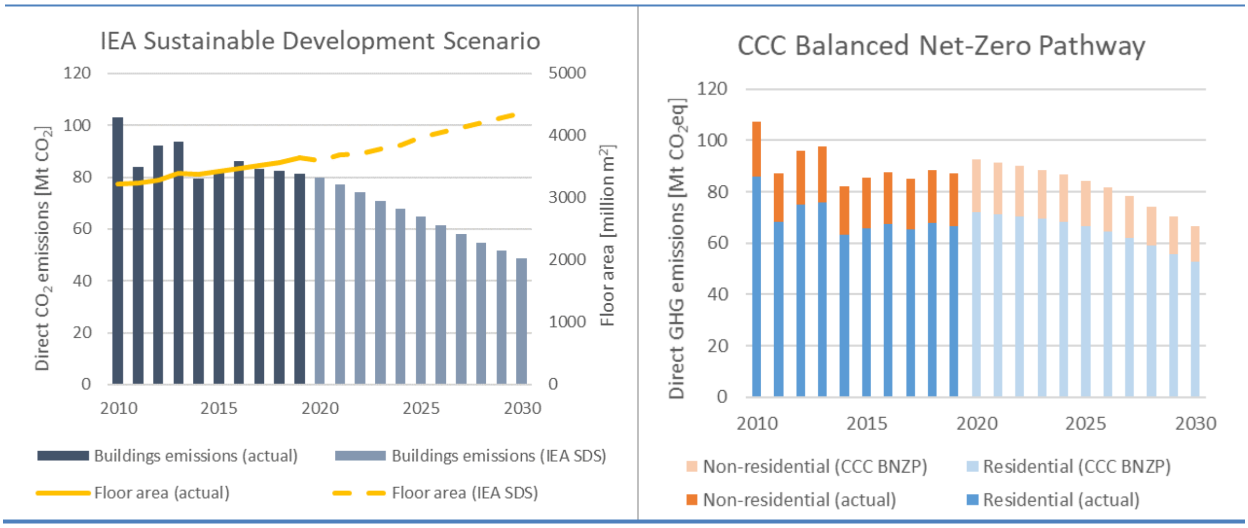
3.2. Aligning investments with future decarbonisation needs

The IEA and the UK CCC provide forward-looking scenarios and trajectories respectively, broken down by sectors. The IEA's Energy Technology Perspectives (ETP) Sustainable Development Scenario (SDS), released in September 2020, provides a global perspective calibrated to meet the Paris Agreement temperature goal (IEA, 2020[32]). It includes different geographical breakdowns, including one for the UK, which the IEA supplied for the purpose of the present analysis. The CCC's most recent trajectory, released in December 2020, is designed to place the UK on a path to net zero (CCC, 2020[27]). Figure 3.2 indicates a need to further reduce the GHG intensity of the UK buildings sector in order to be consistent with either the IEA SDS or the CCC trajectory:

- The IEA SDS assumes an increasing growth rate for the UK buildings floor space (1.7% p.a. in 2020-2024 compared to 1.4% p.a. in 2015-2019). This is coherent with the ONS projections for population growth over the next decades (ONS, 2019[94]).
- Both the CCC scenario (for all GHG) and the IEA scenario (for CO_2 only) imply significant annual average reductions in direct CO_2 emissions from buildings. The IEA scenario, which appears more demanding in the short term, requires such reductions to be multiplied by four, from 0.75 Mt CO_2 per year in 2015-2019 to 3 Mt CO_2 pear year in 2020-2024. Combined with the assumed floor space growth, this means that the relative yearly emission intensity reductions need to more than double, from 2.3% to 5.7%.

The IEA SDS further relies on a significant increase in the rate of electrification in the buildings sector, measured as the share of electricity in the final energy demand. While the electricity share grew by less than 0.1 percentage point per year in 2015-2019, in the SDS it grows by 0.9 percentage points per year in 2020-2024.

Figure 3.2. Climate performance trends of the current building stock in light of future objectives



Note: Available IEA data for the UK considers residential and non-residential buildings together, and models CO_2 emissions only. On the other hand, the CCC CB6 dataset disaggregates residential from non-residential buildings, and considers all greenhouse gases. However, it does not model the underlying floor area and hence does not provide information on emission intensities.
Sources: (IEA, 2020[95]) and UK specific scenario data provided by the IEA to the OECD; (CCC, 2020[27]).

The assumptions that underpin the IEA SDS and CCC trajectory towards net zero highlight the need for further investments in both highly efficient new construction as well as in significantly improving the energy efficiency and emissions intensity of the building stock. At the EU-27 level, McKinsey estimated that the building sector represents 30% of total investments needed to reach net zero by 2050. The analysis further highlights that while most of the technologies needed to decarbonise buildings are already available (such as insulation solutions and heat pumps), the scale of implementation is a challenge, most notably to renovate the existing building stock. For instance, the share of dwellings using renewable heating sources would need to rise from 35% to 100%, while more than halving the usage of gas (McKinsey, 2020[16]).

For the UK as well, one key element and challenge for aligning the building sector with climate objectives is scaling up investments in energy efficiency retrofits of existing buildings. To this end, the Ten Point Plan released in November 2020 aims at a rapid implement of a "Future Homes Standard" and consultations on an equivalent standard for non-residential buildings, as part of the "Future Buildings Standard" (HM Government, 2021[96]). In quantified terms, the plan targets the installation of 600,000 heat pumps per year by 2028, and the improvement of around 1.5 million homes to EPC C standard by 2030 (BEIS, 2020[97]). While estimates of corresponding investment needs are scarce, the Green Finance Strategy estimates that upgrading most homes to EPC band C by 2035 could require GBP 36-65 billion in investment (HM Government, 2019, pp. 21, 40[20]). The CCC's Balanced Net Zero Pathway that underpins the sixth carbon budget entails an estimated GBP 55 billion of investments to 2050 for a drastic increase in the uptake of energy and heating efficiency measures in existing homes (CCC, 2020[27]). To put these figures in context, the 2010-2019 estimated yearly total investments in residential renovation were GBP 30 billion.

As discussed in Section 3.4 below, the UK government COVID-19 recovery package includes a Green Homes Grant scheme. Section 2.5 above highlighted existing public finance and support measures towards mobilising energy efficiency investments, including subsidies and energy company obligations. However, these existing energy efficiency programmes are subject to a number of limitations (see also Section 2.5):

- Most existing government support schemes are tailored to specific target groups. In particular, the ECO3 scheme, currently the largest programme with 0.4 billion GBP in 2019, is limited to vulnerable and low-income households. While such targeting ensures the efficient use of public resources, it may limit the economy-wide uptake of energy efficiency investments. The new Green Home Grant Scheme will contribute to addressing this aspect (see 3.4).
- The non-domestic Renewable Heat Incentive is the only major support scheme for energy-related investments in the private non-residential sector.[23] Support for financing the upfront costs of major non-residential refurbishments, such as insulation measures, is currently limited to a few small-scale schemes (see Section 2.5). However, BEIS is exploring options for expanding this area through an energy efficiency scheme for SMEs (BEIS, 2020[98]).
- Most schemes currently focus on easily identifiable, individual energy efficiency measures. However, ambitious future climate targets will likely require deep retrofits with a holistic perspective on the entire building, and suitable combinations of EE measures (IPCC, 2014[38]).

Meeting long-term climate targets will also require revisiting the role of new construction. Sections 2.3.1 and 2.4.1 point out that most investments in newly constructed buildings result in good environmental performance compared to the overall buildings stock. However, the EPC band B that is the most frequent one among new construction is unlikely to suffice for meeting the net-zero target by 2050. Existing criteria for new construction of near-zero energy buildings in other European countries are typically stricter than the criteria for EPC band A (CA-EPB, 2015[99]), which currently amounts to less than 2% of UK new dwellings investments. In addition to being in EPC band A, the CCC further recommends all new construction to be equipped with low-carbon heating. Section 2.3.1 highlights that less than 1% of new construction investments are compatible with these criteria. Given the long lifetime of buildings of up

[23] Since this scheme supports operating costs and not upfront installation costs, it is not discussed quantitatively in section 2.5.

50-100 years (EC, 2008[100]), or even more for historic buildings, ensuring compatibility with future (and not just current) requirements is key to avoid locking in GHG emissions. With this in mind, following the completion of a consultation on a "Future Homes Standard", the UK Government is notably planning to ensure that new homes produce at least 75% lower CO_2 emissions compared to those built to current standards (HM Government, 2021[101]). Specific steps are envisioned to also strengthen standards for non-residential new construction, as part of the "Future Buildings Standard" (HM Government, 2021[96]). However, even at low emission intensities, new buildings can be a driver for floor space expansion, leading to additional GHG emissions that may not be consistent with Paris-aligned carbon budgets and decarbonisation pathways (GAB/IEA/UNEP, 2019[102]). In some cases, renovation of existing buildings may also be a more cost-effective way of achieving energy efficiency improvements (La Fleur, Rohdin and Moshfegh, 2019[103]).

3.3. Current developments in the UK financial sector

3.3.1. Policy developments

The UK Green Finance Strategy (HM Government, 2019[20]) highlights the importance of investments and financing for delivering the UK Clean Growth Strategy, the UK Industrial Strategy, as well as domestic and international climate commitments. The objectives of the Green Finance Strategy are "aligning private sector financial flows with clean, environmentally sustainable and resilient growth" and "strengthening the competitiveness of the UK financial sector". To this end, the Green Finance Strategy includes three key elements:

- **Greening finance**. This objective aims at mainstreaming climate and environmental factors in the decision-making of financial institutions. One key element for such integration is the disclosure of climate-related financial risks and opportunities, as mandated by the TCFD. Going beyond a purely risk-oriented perspective, this objective also includes establishing sustainable finance standards.
- **Financing Green**: This objective means accelerating finance to support the delivery of UK's carbon targets and clean growth objectives. The Green Finance Strategy explicitly mentions mobilising green finance for home energy efficiency under this objective.
- **Capturing commercial opportunities**. This objective aims at positioning the UK as a global leader in the green finance sphere. A key pre-requisite for this goal is enhancing the climate-related skills, data and analytics available to the financial sector.

The Green Finance Institute, established in 2019, serves as a platform for collaboration between the public and the private sectors in the implementation of the Green Finance Strategy. In December 2019, the Green Finance Institute founded the Coalition for the Energy Efficiency of Buildings (CEEB), which brings together over 150 organisations from the finance, property, energy and non-profit sectors. The CEEB aims at catalysing the wide-scale retrofitting of UK residential buildings. To this end, it explores demonstration projects for testing and scaling up potential financing innovations. The May 2020 CEEB report on financing energy efficient buildings presents a number of "demonstrator" financial solutions as well as suggestions for further government policy measures (Green Finance Institute, 2020[21]).

A number of public initiatives further attempt to scale up energy efficiency investments by raising awareness and developing relevant knowledge. For example, the De-Risking Energy Efficiency Platform collects and publishes data on the payback profiles of buildings energy efficiency projects (EEFIG, 2020[104]).

Other countries are also exploring policies for encouraging green financing for real estate. For catalysing private investment towards green buildings in emerging markets, the IFC recommends defining green buildings as an asset class, monitoring allocation of finance to green buildings, reducing capital adequacy requirements for green buildings finance, and developing guidance on green bond issuance. (IFC, 2019, p. 72[105]). China's 13th five-year plan foresees an RMB 1.65 trillion investment in buildings' energy efficiency, to be mobilised predominantly from private sources (Cushman&Wakefield, 2018, p. 29[106]). One potential mechanism to this end is green securitisation, for which the China Securities Commission has issued several regulatory standards.

3.3.2. Market developments

Overall, a number of actors in the UK financial sector have launched specialised financing instruments for facilitating investments in energy efficient, low-carbon buildings. The following paragraphs provide details on these developments. However, up until the time of writing, the volume of financing mobilised by these initiatives has been limited (none exceeds GBP 1 billion). This volume is comparable to the total financing mobilised through government schemes (GBP 9.3 billion between 2010 and 2019, see section 2.5), and both are very small compared to the total investments in buildings construction and renovation (GBP 1.2 trillion between 2010 and 2019, see section 2.1). Hence, green financing instruments would need to be scaled up in order to contribute significantly to future financing needs.

Several private financial institutions recently brought to market first specialised green financial products in the UK. These include green mortgages aimed at retail borrowers, sustainable loans provided to real estate companies, as well as green bonds issued by banks for refinancing their lending portfolio. The following paragraphs illustrate specific examples in each of these categories.

As of end 2020, the green mortgages offering to retail customers in the UK involved nine financial institutions (Green Finance Institute, 2020[107]), among which the following:

- Barclays launched a Green Home Mortgage in 2018 (Barclays, 2018[108]). This mortgage provides financing at a discounted interest rate for new-built housing with EPC bands A and B. The discount is made possible since an internal credit risk analysis revealed lower default risks in this specific category of borrowers. As of November 2020, Barclays had originated approximately GBP 400 million of Green Home Mortgages, aiming to further expand this product range in 2020 and beyond.
- The Nationwide Building Society launched a Green Additional Borrowing mortgage product in March 2020 (Nationwide, 2020[109]). Existing Nationwide mortgage borrowers can borrow up to GBP 25,000 additionally, at a significantly discounted interest rate, with the condition that at least 50% of the additional drawdown is invested in energy efficiency home improvements.
- A few smaller, specialised lenders provide financing for energy-efficient buildings: this includes, for example, the Ecology Building Society and Allium Money. While such lenders are small in terms of total volume, they drive awareness and financial innovation in the green finance space.

The Green Home Finance Innovation Fund (BEIS, 2019[110]) awarded a GBP 1.8 million grant to another three organisations in order to develop and pilot green retail financial products for residential energy efficiency improvements. The aim is to overcome the barrier to innovation posed by high initial development costs in the still relatively nascent green finance market.

A number of UK real estate investment companies benefit from green loans and credit facilities:

- In 2019, Derwent PLC (a large London-focused Real Estate Investment Trust (REIT)) received GBP 300 million in "green" credit from HSBC, Barclays and NatWest (Derwent, 2019[111]). Derwent will invest the proceeds from this green loan in development and refurbishment of commercial and residential buildings in accordance with the Loan Market Association Green Loan Principles (LMA, 2020[112]) and the Derwent Green Finance Framework (Derwent, 2020[113]). While the LMA principles only provide indicative categories of eligibility for green projects, the Derwent Green

Finance Framework defines specific thresholds on EPC bands and building certifications for projects financed by the green loan proceeds.

- In early 2020, Great Portland Estates (another large UK REIT) signed a GBP 450 million ESG-linked revolving credit facility (GPE, 2020[114]). This new financial instrument provides financing for general corporate purposes (not restricted to specific activities) at an interest rate that varies depending on the environmental performance of the company. It provides a larger degree of flexibility than green loans with a use of proceeds limitation. At this stage the variation in interest rates is small (up to 0.025% of a total interest rate of 1%), limiting the associated economic incentives.

Several banks also offer business loans to corporates and SMEs, which can benefit from reduced interest rates for eligible “green” projects ((Barclays, 2020[115]), (HSBC, 2020[116])). However, detailed information on the disbursed green lending amounts, and on the share of UK buildings within the range of all eligible projects, is not available.

Finally, a number of UK banks issued green bonds for refinancing their lending portfolio.

- HSBC issued six green bonds and two SDG bonds between 2015 and 2018, with a total volume of GBP 2.6 billion (HSBC, 2019[117]). From the proceeds of these green bonds, approximately GBP 0.7 billion were allocated to construction and renovation of buildings in the UK. This financing was mainly provided in form of loans to corporates owning commercial and residential buildings. The compliance of the corresponding buildings investments with the green bond criteria was verified mainly based on BREEAM and LEED certifications. This is consistent with the CBI green bond criteria (Section 1.3), which allow using BREEAM and LEED certifications as proxies in situations where a quantitative emissions threshold has not (yet) been established (CBI, 2018[29]).
- Barclays issued a EUR 0.5 billion (GBP 0.45 billion) green bond in 2017. The proceeds of this bond issuance were used to finance and refinance residential mortgages in the 15% of the least carbon intensive properties in England and Wales, based on EPC data.

Financial institutions in other countries are introducing similar green financial instruments for real estate. With green bonds being well established in general, some institutions are exploring green securitisation products. Examples are the Green Storm residential mortgage-backed securities issued by Obvion (Netherlands) and Fanny Mae’s Multifamily Green Bond portfolio (USA), as well as commercial mortgage-backed securities issued by CSAIL (USA) (CBI, 2018[118]). A survey of 10 European banks shows that the majority are already tagging green lending transactions internally, especially for commercial real estate (UNEP-FI, 2017[119]). The participating banks also identified access to green bond markets as a key motivation for such green tagging efforts.

3.4. COVID-19 considerations

In the current economic situation, COVID-19 recovery measures play an important role in determining how countries address health, environmental, and economic challenges simultaneously. Ensuring that the public expenditures of support and stimulus packages are aligned with broader socio-economic goals is crucial to avoid locking in investments incompatible with long-term climate objectives. This is particularly important for buildings, given their long lifetime of 50-100 years and even more for historic buildings (see Section 3.2), in addition to achieving their well-documented economic potential (e.g. local job creation) and social benefits (tackling of energy poverty) ((McKinsey, 2020[16]) (Hepburn et al., 2020[17]), (IEA, 2020[18]), (Hainaut et al., 2020[19]))..

In response to the COVID-19 crisis, the UK government decided on a number of policies with total fiscal costs of approximately GBP 200 billion, of which GBP 180 billion to be provided in the form of direct government spending in the UK fiscal year 2020-21 (OBR, 2020[120]).[24] The majority of these expenditures relate to economy-wide job retention and business support schemes, as well as additional spending on health services. Nevertheless, substantial investments in buildings are planned through dedicated programmes presented in the following.

As part of the COVID-19 recovery measures, in August 2020 the UK government announced a GBP 2 billion Green Home Grant Scheme (BEIS, 2020[97]). This programme aims to fund up to two-thirds of the cost of energy efficiency improvements for over 600,000 dwellings in England. Home owners (landlords or owner-occupiers) will be provided with up to GBP 10,000 per dwelling towards the installation of insulation, heat pumps, draft proofing, and other energy efficiency improvements. In contrast to other government schemes discussed in Section 2.5, in particular to the large ECO3 scheme, the Green Home Grant Scheme is not limited to vulnerable households. However, low-income households are eligible for higher payments in some cases. Further, the UK government announced a GBP 1 billion investment towards making public buildings more energy efficient and warmer, as well as a GBP 50 million “Social Housing Decarbonisation Fund” scheme for piloting large-scale retrofits of social housing.

Such measures represent a step towards placing climate change mitigation at the heart of the recovery strategy, which recent OECD/IEA analysis identifies as a “decoupling” pathway (Buckle et al., 2020[15]). This contrasts with a “rebound” pathway, which would solely focus on a rapid re-establishment of economic growth and macroeconomic stability without prioritising GHG emission reductions. On the other hand, a third and wider “well-being” pathway would, in addition to economic recovery and GHG emission reductions, require the systematic integration of improvements in other areas such as income, jobs, and health. In the residential sector, this would entail broadening the mitigation potential beyond the individual dwelling, to consider the neighbourhood, city and wider hinterland levels, in order to promote holistic planning, retrofits, as well as green spaces to regulate microclimates and provide safe spaces for inhabitants.

In any case, the rapid economic changes due to the COVID-19 pandemic highlight challenges in terms of timely access to updated data and information in order to inform policy and decision-making. In the specific context of the present analysis aimed at measuring the alignment of investments and financing with climate mitigation objectives, such challenges include:

- Most data sources on investments and financing are updated with an annual frequency, which implies an at least one year delay in conducting any comprehensive analyses, and is therefore not frequent or early enough to incorporate the effects of COVID-19 at the time of writing.
- Trajectories and projections of future GHG emissions depend on economic forecasts, which are already uncertain in relatively stable socio-economic periods. In times of crises, these forecasts are both continuously evolving and much more uncertain. This very high degree of uncertainty makes it challenging to apply emission trajectories for estimating whether current developments within the buildings sector, including different types of underlying investments, are aligned with UK’s climate objectives and, at an international level, with the mitigation and temperature goals under the Paris Agreement.

[24] These figures are fiscal costs as estimated by the OBR. For instruments such as loan guarantees, the fiscal costs only account for the expected losses (write-offs). Other organisations sometimes account for guarantees at face value, leading to higher estimates of the total recovery package volume.

4 Implications for data, methods, and further tracking efforts

4.1. UK and building sector data availability and potential for replication

Several data sources identified in this study can inform a regular tracking of the consistency of buildings investments in the UK with climate objectives. Nevertheless, operationalising a comprehensive analysis would require dedicated efforts to access and collect further data, as well as collaboration with additional stakeholders in order to fill a range of currently significant data gaps.

4.1.1. Data on the physical stock of buildings

While all of the data sources used in this study cover England, data on other UK constituent countries is more limited. Detailed, yearly housing surveys are only available for England and Scotland. The most recent Welsh Housing Condition Surveys were performed in 2017 and 2008, and the most recent Northern Ireland Housing Condition Surveys in 2016 and 2011 (BRE Trust, 2020[121]). Hence, comprehensive data on the physical housing stock in Wales and Northern Ireland is limited.[25]

Administrative data on the residential and non-residential buildings stock is available for England and Wales from the Valuation Office Authority. However, this study did not identify any similar data source for Scotland and Northern Ireland. As the VOA data is the only source of statistics on the physical stock of non-residential buildings, its coverage limitations mean that a reliable analysis of trends in Scottish and Northern Irish non-residential buildings is currently not possible.

To obtain comprehensive and granular data on the UK physical buildings stock in the future, data gaps for Wales, Scotland, and Northern Ireland, especially for non-residential buildings, need to be addressed. For example, regular housing condition surveys could provide an unbiased and large enough sample that could be extrapolated to the entire buildings stock. Such data collection requires further coordination between relevant central and devolved government departments, as well as raising their awareness of the need for of climate-related data.

4.1.2. Data on UK buildings investments

At an aggregate level, the UK ONS reports total investment volumes in construction and renovation of UK buildings, as part of the GFCF in the UK national accounts. Combining the national accounts with ONS statistics on construction industry output shows the breakdown of the total buildings investments by subsector and economic actor. However, these aggregate data sets neither contain information on the climate change-related performance of the underlying investments, nor make it possible to establish links

[25] EPC statistics collected by MHCLG provide some data on the physical buildings stock for Wales. However, in contrast to housing surveys, such EPC registers do not currently provide an unbiased sample over the entire buildings stock. Notably, the lack of EPCs for older buildings that have not been sold or rented prevents e.g. a reliable calculation of renovation rates.

with such information. Hence, this study had to investigate the availability of more granular investment-related datasets.

For residential new construction investments, the study makes use of transaction-level data on residential property purchases from the HMLR publicly available Price Paid dataset for England and Wales (HM Land Registry, 2020[122]). The granularity of this data set makes it possible to estimate the breakdowns of new construction investments by EPC band and emissions intensity (as analysed in Section 2.3.1). The transaction prices for new-built properties provide a reasonable approximation for the tracked new construction investments, even if they do not match the desired scope precisely[26]. However, this approach does not shed light on renovation investments, which do not have a clear connection to the transaction prices of existing properties.

For residential renovation investments, this research did not identify any data source with a granularity sufficient to establish a link to climate performance. As one climate-relevant subset of investments, Section 2.3.2 estimates investments in specific energy efficiency measures based on changes in physical stock characteristics. However, this approach only covers a small share of total renovation investments, and does not address the climate consistency of total renovation investments. Notably, this analysis does not capture investments that do not include any energy efficiency improvements and would likely be misaligned with climate objectives. Similarly, while the residential energy efficiency investments triggered by government initiatives can be measured, such tracking falls short of mapping the entire volume of renovation investments.

As households own over 80% of residential buildings (in monetary terms) and represent over 70% of GFCF (2010-18 estimates), as estimated in Figure 2.17, comprehensive estimates on renovation investments would require granular information from household surveys, such as the following:

- The Household Living Costs and Food Survey (LCFS) (ONS, 2017[123]) includes, in principle, data on the actual expenditures of households on major renovations. While it currently does not include any data on the energy performance of the households' dwellings, the LCFS data could be connected with public data sources on energy performance. Doing so, however, requires the full survey results including addresses, which are confidential and could not be accessed in the course of this study.
- Housing Surveys in the UK constituent countries (see Section 4.1.1 above) include data on physical characteristics of the buildings stock, types of installed energy efficiency measures, as well as current energy performance. However, these surveys would need to be expanded in order to also collect information on actual expenditures incurred for installing energy efficiency measures, and on total renovation investments.

Potentially, an alternative or complementary solution to fill the data on renovation investments in the residential sector could rely on Trustmark, a Government endorsed quality scheme covering work that households choose to have carried out in or around their home. The Trustmark Data Warehouse initiative has, as of mid-2020, started recording relevant renovation investments for residential properties and has the potential to become a comprehensive source of data over time (Trustmark, 2020[124]). Such data collection also has potential synergies with the development of building renovation passports that the UK Green Finance Institute is exploring.

For investments in non-residential buildings, this study did not identify any data source sufficiently granular to separate out individual new construction or renovation investments. Companies report real estate investments in their annual financial statements. However, assessments of three possible sources for companies' financial data highlighted challenges in using such data for evaluating climate consistency of buildings investments:

[26] For example, property transaction prices may include a share of investments in land, which is outside the scope of this study.

- Moody's ORBIS database provides financial data on public and private companies globally (Moody's, 2020[125]). While it covers the majority of property-owning UK companies, it only provides data on the total stock of their tangible fixed assets. This means that separating out investments specifically in construction or renovation of buildings is not possible. Moody's underlying UK-specific database, FAME, provides additional granularity on the stock of land and buildings. However, a spot check, conducted together with the provider, indicated that such granularity is unavailable for the majority of private companies.
- The Refinitiv EIKON service[27] (Refinitiv, 2020[126]), like Moody's ORBIS database, provides financial data on public and private companies globally. However, granular details on the stock of buildings as part of the total assets on the company's balance sheet are mostly available for publicly listed companies only.
- The UK Companies House provides public access to financial statements of all UK companies (Companies House, 2020[127]). For the majority of companies, financial statements are available in a structured iXBRL format designed for regulators and financial analysts. However, even with such structured data, it is difficult if not impossible to identify construction or renovation investments, as the financial statements rarely provide the breakdown of investments between acquisitions of existing buildings, new construction, and capitalised major improvements expenditures. Further, for most large companies, representing the majority of the buildings stock in terms of value, financial statements are only available from Companies House as unstructured scanned PDF files. Here, an automatic extraction and analysis of buildings investments was tested in collaboration with Companies House but was not considered feasible. Instead, a few annual reports of large real estate companies were analysed manually for a deep dive (Section 2.4.3).

Future studies could explore options to obtain disaggregated data on investments relating to the construction and renovation of non-residential buildings via building owners (mostly companies and public authorities) and via construction companies. Some data on companies' investments in buildings may already be available via the ONS Annual Acquisitions and Disposals of Capital Assets survey (ONS, 2020[128]). Since the survey could not be accessed in the course of this study, it remains to be confirmed whether it is sufficiently detailed to be linked to climate performance data. As a complementary route, collecting data from construction companies would likely require collaboration with specialised data providers such as Barbour ABI (Barbour ABI, 2020[129]) and Glenigan (Glenigan, 2020[130]). While such databases already deliver semi aggregates to ONS for inclusion in the compilation of sector-wide statistics, the coverage and granularity of the underlying project-level data could not be evaluated in this study.

4.1.3. Data on the climate performance of buildings

Comprehensive building-level data on the environmental performance of buildings are publicly available for England and Wales via the MHCLG Open Data Communities database of EPCs described in Section 4.1.3. This database is updated semi-annually, and covers the majority of residential and non-residential buildings. While EPC registers also exist in Scotland and Northern Ireland, these constituent countries do not currently provide EPC data publicly.

At the time when the present analysis was conducted, about a third of residential buildings in England and Wales did not have an EPC published in the MHCLG Open Data Communities database. This complicates analyses of the climate performance across the entire buildings stock. Informal exchanges with UK financial institutions indicate that they also consider this data gap as an important barrier by when attempting to use the EPC database towards analysing the climate performance of their mortgage books.

[27] Formerly known as Thomson Reuters.

EPCs cover a wide range of data points on buildings' environmental performance: apart from an overall energy efficiency rating and an overall estimate of GHG emissions, EPCs include information on installed insulation measures, the type of heating system and of on-site power generation. These different data points allow for a detailed comparison to climate objectives. EPCs assess the assumed energy use and GHG emissions of buildings, not actual energy consumption or actual emissions. This scope is well-suited for an analysis of the climate consistency of investments in buildings, since actual GHG emissions are influenced by non-financial factors such as consumption and behavioural patterns.

Nevertheless, future studies could take into account the well documented "performance gap" between designed performance (as recorded in EPCs) and actual as-built performance ((Zero Carbon Hub, 2014[131]), (BBP, 2020, p. 10[132])). In the UK, targeted improvements to the EPC methodology (Government's call for evidence (BEIS/MHCLG, 2018[133]) and resulting EPC action plan (BEIS/MHCLG, 2020[134])) should contribute to reducing this gap. Such efforts can further build, on other assessments of how to achieve improved and more harmonised EPC data e.g. (BPIE, 2020[135]), (Li et al., 2019[136]), (Pasichnyi et al., 2019[137]).

As a complement to EPC-based assessments that reflect the design features of a building (fabric, services and installed improvement measures), analyses based on statistics on actual energy usage could be incorporated. In the UK, these could make use of the BEIS National Energy Efficiency Data framework (NEED) (BEIS, 2020[138]), as well as building on the emergence of smart metering data. The NEED database sources electricity and gas consumption data from utilities companies, and consolidates it, on property level, for residential buildings. Combined with data on the physical buildings stock, NEED allows for an estimation of actual emission savings from the installation of various energy efficiency measures (insulation, solar PV, condensing boilers). Such data could be used in the future to estimate the actual emission savings from the energy efficiency investments analysed in Section 2.3.2.

Complementary to individual buildings' data, this study considers aggregate climate performance indicators published by some institutional owners of UK buildings. Some actors, such as the REITs analysed in Section 2.4.3, report granular GHG emission data on their real estate portfolios on a voluntary basis. Such corporate non-financial reporting will likely be harmonised and significantly extended through upcoming disclosure initiatives ((FRC, 2020[139]), (CDP et al., 2020[140]), (IFRS Foundation, 2020[141])), thereby facilitating climate-related assessments across institutions.

4.1.4. Reference points for measuring the climate alignment of investments

In contrast to relatively good data availability on the environmental performance of buildings are available, identifying suitable reference points, both precise and disaggregated enough to characterise the consistency of investments in individual buildings with climate objectives was challenging. The following reference points were identified and tested in the course of this study (see also Section 1.3):

- **The emission reduction scenarios underlying the CCCs fourth and fifth carbon budgets**. These scenarios make it possible to assess whether, during the period considered, residential and non-residential buildings, as entire sub-sectors, developed in line with the UK's medium- and long-term climate objectives. However, these scenarios are not sufficiently granular to indicate whether specific building investments are consistent with such sub-sector wide objectives. Such a comparison would require emission reduction pathways for individual building categories, broken down by relevant parameters such as built form and age. For example, the required emission reduction trajectory for newly constructed buildings will likely differ from the trajectory for renovation of the existing stock, and likewise differ between houses and flats. The sixth carbon budget released in December 2020 provides some of these elements (CCC, 2020[27]).
- **Energy Performance Certificates.** As described in Section 4.1.3, EPCs are available for most of the residential and non-residential buildings in the UK. The EPC band and detailed EPC data on emissions, energy use, building fabric, and type of heating can be compared to benchmarks or

objectives for different building subsectors. For example, Section 2.3.1 evaluates the share of new residential construction investments consistent with the CCC recommendation of ensuring EPC band A and low-carbon heating. Across the entire buildings stock, the UK Clean Growth Strategy aims at upgrading as many houses as possible to EPC band C by 2035. However, evaluating the share of past and current investments consistent with such a forward-looking target would require a translation to interim objectives for individual building categories.

- **The CBI low-carbon buildings criteria**. In principle, these criteria are sufficiently detailed to assess individual construction or renovation investments, for both residential and non-residential buildings. In practice, coverage of CBI thresholds for UK non-residential buildings is limited to office buildings in ten major cities (see Section 2.4.1 and Table B.3). For residential buildings, coverage is limited to England and Wales due to the current unavailability of public EPC data for Scotland and Northern Ireland. Within these scope constraints, Sections 2.3 and 2.4 nevertheless succeed in deriving estimates for the share of investments that qualify as "low-carbon" under the CBI criteria. Improving the coverage would require gathering energy performance data throughout the UK (see above), and consensus among CBI stakeholders on emissions intensity thresholds for non-residential buildings other than offices.

Among the reference points tested in this study, the criteria for low-carbon buildings set by the Climate Bonds Initiative currently appear most suited for evaluating the volume of climate-consistent investments. Future UK tracking work would benefit from additional reference points for determining the consistency of specific investments with national and international climate objectives:

- One possibility would be to define national transition pathways with specific emission reduction targets for individual building categories, broken down by relevant parameters such as built form and age. Such targets would be particularly useful for identifying buildings where current and past investments were inconsistent or insufficient to reach the desired climate objectives. The definition of such transition pathways could become part of BEIS work on the delivery of net zero and domestic climate commitments. It could also inform the setting of building codes and standards, in order to avoid investments locking in unsustainable GHG emissions.
- Another possibility would be to leverage the wide prevalence of EPCs and to define detailed objectives based on EPC bands and/or other data points included in EPCs. In order to be applicable in practice, such objectives would need to provide not only a long-term target, but also intermediary, year-on-year objectives. Like emission reduction targets, such EPC-based objectives would need to be sufficiently granular to differentiate different categories of residential and non-residential buildings, and different building ages. The specific ambition levels need to be defined based on UK carbon budgets and international climate objectives.
- The EU Taxonomy for Sustainable Activities (see Box 1.1) includes an alternative set of screening criteria for buildings-related activities that provide a substantial contribution to climate change mitigation. The UK intends to implement its own taxonomy, which will take the scientific metrics in the EU taxonomy as its basis. A UK Green Technical Advisory Group will review these metrics to assess whether they are appropriate for the UK market (HM Government, 2020[142]). With this in mind, an important element of the EU Taxonomy criteria currently missing in UK legislation is a quantitative threshold for the primary energy demand of near-zero energy buildings.

4.1.5. Data on sources of finance

Data on financing mechanisms for construction and renovation investments is currently mostly limited to public sources of finance (direct and indirect subsidies, loans):

- Debt finance providers such as commercial banks do not have comprehensive data on how the borrower uses the funds they disburse. For example, lenders typically do not track the use of proceeds of general-purpose loans to commercial real estate companies. Similarly, mortgage providers are not necessarily aware of whether the disbursed funds are used only for purchasing a property, or also towards renovations. Hence, establishing a link between the financing provided and the climate-consistency or –inconsistency of resulting investments is challenging.

- With the currently available data from household surveys and company financial statements, it is not possible to quantify the contribution of household savings or companies' retained earnings towards construction or renovation investments. In turn, this prevents the identification of any connection between the share of own funds and climate consistency.

Future studies could unlock the availability of detailed data on debt financing, in particular mortgages, via individual financial institutions or financial regulators. Within this project, initial discussions with the Bank of England indicated a possibility of evaluating the climate alignment of mortgage financing by combining product sales data from the Financial Conduct Authority (FCA) with EPCs. An alternative is the collection of loan data directly from financial institutions representing a large proportion of the market in the UK (most notably but not limited to Lloyds, Nationwide, Barclays, NatWest, HSBC and Santander). While such primary data collection would allow for greater detail, it would likely pose confidentiality issues and require additional efforts to generate a consolidated and harmonised dataset. Possibilities to integrate such a dataset within the Trustmark Data Warehouse remain to be explored at the time of writing.

Another challenge in analysing the sources of financing underlying buildings investments are cross-border flows. While the direct responsibility for construction and renovation works typically lies with a UK household or legal entity, the upstream providers of financing will, in some cases, reside outside the UK. Comprehensively analysing the sources of financing would thus require additional data on foreign direct investing flows in this sector. Another related aspect, relevant to be explored in further work, is financing provided by UK investors towards real estate located outside the UK.

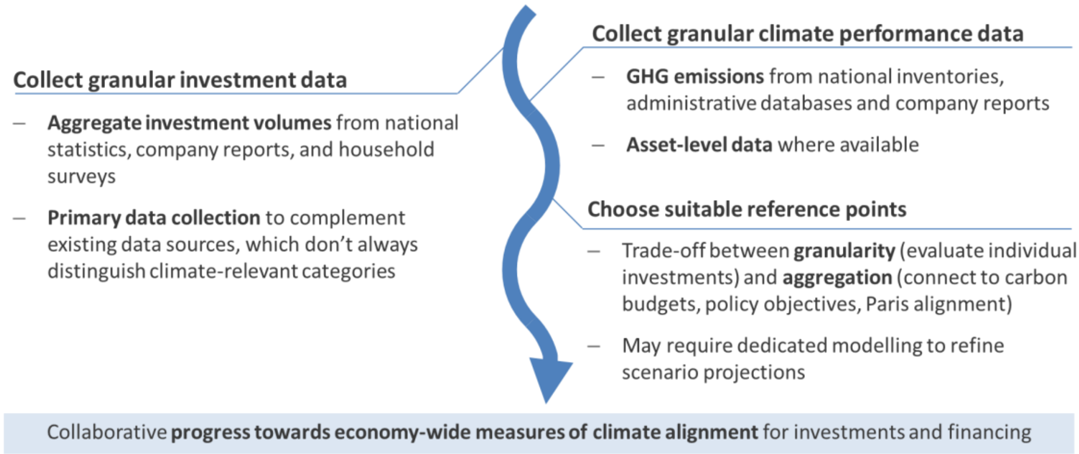
4.2. Scaling up the analysis across sectors and countries

This study follows similar work on the climate consistency of investments and financing in the manufacturing industries in Norway (Dobrinevski and Jachnik, 2020[6]) and in the transport sector in Latvia (Dobrinevski and Jachnik, 2020[7]). As illustrated in Figure 4.1, exploring the feasibility of such measurements for different sectors and different countries provides insights on the steps, data and information needed towards conducting comprehensive analysis of climate alignment of economy-wide investments. In addition to collecting granular investment and climate performance data, these steps include the identification and choice of suitable methodological approaches and reference points for evaluating the consistency with climate objectives.

Additional country-level studies similar to the ones conducted to date but for different country-sector combinations would make it possible to derive more robust and systematic insights and conclusions. Researching different economic sectors could also help to cover additional elements, which were less relevant in the three case studies so far, such as investments in intangible assets.

Measuring climate consistency across countries (e.g. in the context of OECD work to produce indicators) and at a global level (e.g. to inform finance-related elements of the UNFCCC Global Stocktake in 2023) requires extending the geographic scope beyond a single country. For the buildings sector specifically, the present analysis relied heavily on climate performance data from the public register of EPCs for England and Wales. EPCs are part of the EU's legislative framework to reduce energy demand from buildings, with the aim to contribute to the improvement of the overall buildings' performance in a transparent and comparable way across Europe. In addition to the UK, a limited number of European countries publish such EPC registers openly (EC, n.d.[143]), and could thus be natural candidates for analysing the buildings sector on a broader geographic scope. At the EU level, criteria set by the EU Taxonomy for Sustainable Activities also provide an opportunity for sectoral analyses across countries.

Figure 4.1. Steps towards comprehensive analysis of climate alignment of economy-wide investments



Source: Authors.

Some of the data limitations for the buildings sector could be less acute if conducting a similar analysis in sectors with fewer and, on average, larger infrastructure-related transactions. However, the present as well as previous similar pilot studies ((Dobrinevski and Jachnik, 2020[7]), (Dobrinevski and Jachnik, 2020[6])) highlight that accessing granular and comprehensive data on domestic investments and corresponding GHG emissions is a time consuming endeavour that may only yield partial results in terms of characterising investments within a given sector as climate consistent or inconsistent. Future work could investigate options for producing indicators that would be relatively easier and timelier to produce. Such efforts would also need to identify ways of linking real economy investments with underlying sources of financing, as a means to make it possible to establish bridges with climate alignment and climate-related risk assessments conducted by the financial sector.

In any case, the availability of data relevant to measuring climate alignment is likely to improve rapidly due to the combination of two factors. First, an increasing number of stakeholders across public bodies and private actors across the real economy and the financial sector are defining strategies and targets to align their activities with the Paris Agreement temperature goal. Second, disclosure of climate-related financial data is being mandated or incentivised in a growing number of countries and jurisdictions. Such data would, to the greatest extent possible, need to be publicly available in order for third parties to conduct comprehensive and policy relevant analyses.

Further, assessments of the alignment of finance with climate mitigation goals need to be complemented by analyses of alignment with:

- Resilience to climate change, for instance based on the increasing availability of geospatial data. This aspect is particularly important for buildings, which are location specific, immobile and have a long life span over which physical climate risks may strike. Such analysis would further provide input for the evaluation of climate-related risks, which investors, financial institutions, and financial regulators are increasingly undertaking.
- Other environmental and wellbeing priorities, notably biodiversity and ecosystem protection, water access and quality, air pollution and health prevention. Holistic analyses of the alignment of investments and financing can help avoid unintended misalignments across policy objectives, i.e. ensure that alignment towards one of them (e.g. climate mitigation) is either also contributing to other priorities at the same time (co-benefits) or at least not harming them.

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Annex A. Data sources and methodology for measuring investments and financing

Buildings investments aggregates

This study bases estimates of total buildings investments (Section 2.1) based on the gross fixed capital formation per asset as reported in the UK National Accounts Blue Book 2019 (ONS, 2019[144]), Table 8.1. The investment in residential buildings is based on the asset type "Dwellings" (AN.111), the investment in non-residential buildings is based on the asset type "Other buildings and structures" (AN.112). In both cases, investments in land and transfer costs are excluded by definition of the corresponding ONS asset types. The breakdown between construction and refurbishment, as well as the breakdown between different non-residential building types (Figure 2.13) is estimated based on ONS construction industry output statistics (ONS, 2020[145]).

The ratio of construction to renovation investments for dwellings is assumed to be equal to the ratio of new housing work to repair and maintenance work for housing, as reported in Table 4 of the construction industry output statistics. This approximation neglects the share of non-capitalisable routine repairs that do not contribute to GFCF, as well as the share of renovations that households perform without contracting construction companies. Nevertheless, the obtained proportion is within 5% of the more precise estimates provided by the ONS for the private dwellings sub-sector.

Investments in non-residential buildings are estimated from the GFCF in other buildings and structures as follows:

- First, infrastructure investments[28] are excluded by rescaling the GFCF in other buildings and structures with a factor that corresponds to the construction industry output excluding housing and infrastructure work, in relation to the construction industry output excluding housing but including infrastructure work (Table 4 of the construction industry output statistics). The resulting share of GFCF is assumed to be the total investment in construction and renovation of non-residential buildings.
- The ratio of construction to renovation investments for non-residential buildings is estimated to be the same as the ratio of new work to repair and maintenance construction industry output, excluding housing and infrastructure (Table 4 of the construction industry output statistics). As for residential renovations, this approximation neglects the share of routine repairs that do not contribute to GFCF.
- The breakdown of non-residential construction investments by building type is estimated with the proportions of the corresponding non-residential building types (as above, excluding infrastructure) in Table 1 of the sub-national and sub-sector construction industry output statistics.

[28] These are investments in construction and renovation of roads, railways and other structures that form part of the GFCF in "Other buildings and structures" (asset type AN.112) however are outside the scope of this study.

Detailed residential buildings investments

Data on social housing investments by local authorities is obtained from the Local Authorities Housing Statistics data returns (MHCLG, 2020[146]). Expenditure on renovations is obtained from the field f25ab, expenditure on new construction is obtained from the field f25db. This analysis did not consider expenditure on demolitions (f25bb) and conversions (f25cb) which are very small (less than 2% of the total).

Data on investments by private registered providers of social housing (PRPs) is obtained from the statistical data return filed with the Regulator of Social Housing (RSH, 2020[147]). This reporting is only mandatory for PRPs owning at least 1,000 housing units. Hence, the estimates obtained on the basis of this data are likely an underestimate of the total investments by PRPs.

Energy efficiency investments

This study approximates investments in energy efficiency of residential buildings (used in Section 2.3.2) based on estimates for the number of installed energy efficiency measures, and typical installation costs. The number of installed energy efficiency measures was estimated based on the English Housing Survey (MHCLG, 2020[42]), and the typical installation costs were taken from a joint study by BEIS and Cambridge Architectural Research (CAR/BEIS, 2017[148]). Table A.1 shows details of the underlying estimates.

Table A.1. Estimated numbers of installed energy efficiency measures, and associated investment volumes, England, 2010-2018

Type of measure	Yearly installed measures, millions, 2010-2018 average	Estimated yearly installation costs, GBP billions, 2010-2018 average	Implied average cost per measure, GBP
Double glazing	0.29	1.43	4995.87
Loft insulation	0.11	0.04	425.74
Cavity wall insulation	0.17	0.10	563.02
Solid wall insulation	0.02	0.21	8932.59
Installation of condensing boiler	1.01	2.65	2620.28

Note: Numbers of installed measures are estimated based on the English Housing Survey (EHS). Installation costs are estimated by combining the EHS results with the BEIS/CAR cost estimates (CAR/BEIS, 2017[148]), per built form and size of dwelling. Estimates for solid wall insulation are averages over 2014-2018, since the underlying EHS data is not available prior to 2014. Cost estimates for loft insulation assume installation between joists, in case of installation between rafters the investment volume could be up to four times higher. The number of loft insulation installations (and hence the estimated investment volume) considers first-time loft insulations only, not top-ups.
Source: (CAR/BEIS, 2017[148]), (MHCLG, 2020[42])

Sources of financing

Table A.2. Public support schemes

Scheme	Category	Geography	Start year	End year	2010-2019 volume [GBP million]
Green Deal Finance Plans	Green Deal	GB	2013	2019	49
Green Deal Cashback Scheme	Green Deal	EN, WA	2013	2014	16
Green Deal Home Improvement Fund	Green Deal	EN, WA	2014	2016	154
Green Deal Communities	Green Deal	EN	2014	2016	85
ECO	ECO (until 2012: CERT and CESP)	GB	2013	ongoing	4193
Scotland: HEEPS schemes	Regional schemes (Scotland)	SC	2013	ongoing	728
Scotland: UHIS, HIS, EAP, Boiler Scrappage Scheme	Regional schemes (Scotland)	SC	2009	2013	189
Wales: Nest scheme	Regional schemes (Wales)	WA	2011	ongoing	158
Wales: Arbed scheme	Regional schemes (Wales)	WA	2010	ongoing	77
England: Warm Front Scheme	Regional schemes (England)	EN	2000	2013	637
CERT	ECO (until 2012: CERT and CESP)	GB	2008	2012	2065
CESP	ECO (until 2012: CERT and CESP)	GB	2009	2012	665
Northern Ireland: Warm Home Scheme	Regional schemes (Northern Ireland)	NI	2009	2015	60
Northern Ireland: Affordable Warmth Scheme	Regional schemes (Northern Ireland)	NI	2014	ongoing	76
Northern Ireland: Boiler replacement scheme	Regional schemes (Northern Ireland)	NI	2012	ongoing	25
England: Central Heating Fund	Regional schemes (England)	EN	2015	2015	25
National Grid Warm Homes Fund	Other	GB	2017	ongoing	100

Annex B. Data sources and methodology for measuring climate consistency

This study estimates aggregate GHG emissions for residential and non-residential buildings (as reported in Section 2.1) based on two inputs:

- The yearly **UK GHG inventory** (BEIS, 2020[149]), which reports in particular direct emissions from buildings. Direct emissions from residential buildings are taken from the GHG inventory category "Residential combustion". Direct emissions from non-residential buildings are estimated by summing the GHG inventory categories "Commercial and miscellaneous combustion and electricity" and "Public".
- The **UK Energy Consumption Statistics** (ECUK, (BEIS, 2019[150])), which report the consumption of electricity and heat by residential buildings (ECUK sector "Domestic") and non-residential buildings (ECUK sector "Public Administration" and "Commercial & Miscellaneous"). The indirect emissions of each buildings category are estimated by multiplying the electricity and heat consumption with the corresponding emission factors as reported by BEIS/DEFRA (BEIS, 2020[37]).

Table B.1 shows a summary of the resulting estimates for different categories of buildings-related GHG emissions.

Table B.1. Estimated GHG emissions from UK buildings (2010-2018, $MtCO_2eq$)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Residential, direct	85	68	75	76	63	65	67	65	68
Non-residential, direct	21	18	20	21	18	19	20	19	20
Residential, electricity and heat	58	51	53	51	54	50	45	38	30
Non-residential, electricity and heat	48	44	46	45	47	44	39	33	27
Residential, scope 1+2	143	119	127	126	116	116	112	102	98
Non-residential, scope 1+2	69	62	66	66	65	64	59	52	47
All buildings, direct	106	86	95	97	81	85	87	84	87
All buildings, scope 1+2	213	181	193	192	182	180	171	155	144
All UK GHG emissions	601	553	570	556	516	498	472	461	451

Source: UK 2018 GHG emission accounts, UK 2018 energy consumption statistics, UK GHG reporting conversion factors 2010-2018.

The detailed analysis of consistency with climate objectives in Sections 2.3 and 2.4 relies on building-level Energy Performance Certificates. These EPCs are sourced from an open-access database published by MHCLG (MHCLG, 2020[151]). This database contains close to 20 million residential EPCs and close to 1 million non-residential EPCs, covering the majority of buildings in England and Wales. The analyses in Sections 2.3 and 2.4 exclude a number of EPCs for data quality reasons:

- EPCs with an invalid EPC band (i.e. not in the range A to G or A+ to G for non-residential buildings).
- EPCs where the floor area is zero, negative, or not specified.
- EPCs with an implausibly high emissions intensity above 10 t CO_2eq / m^2 and year.

For the analysis of new residential construction (Section 2.3.1), only EPCs with the transaction type "new dwelling" are taken into account. For the analysis of new non-residential construction (Section 2.4.1), only EPCs with the transaction type "Mandatory issue (Property on construction)." are taken into account. The building types specified in non-residential EPCs are mapped to the categories used in this study as specified in Table B.2.

Table B.2. Mapping of EPC building categories to non-residential sectors

EPC building type	Non-residential category
A1/A2 Retail and Financial/Professional services	Retail
B1 Offices and Workshop businesses	Office
D1 Non-residential Institutions - Education	Education
B8 Storage or Distribution	Storage
C2 Residential Institutions - Hospitals and Care Homes	Health
C2 Residential Institutions - Universities and colleges	Education
A3/A4/A5 Restaurant and Cafes/Drinking Establishments and Hot Food takeaways	Leisure
B2 to B7 General Industrial and Special Industrial Groups	Industry
D2 General Assembly and Leisure plus Night Clubs and Theatres	Leisure
C1 Hotels	Leisure
D1 Non-residential Institutions - Community/Day Centre	Leisure
D1 Non-residential Institutions - Primary Health Care Building	Health
Office	Office
Retail	Retail
Residential spaces	Education
C2 Residential Institutions - Residential schools	Education
Primary school	Education
Secondary school	Education
Nursing residential homes and hostels	Health
Others - Emergency services	Other
D1 Non-residential Institutions - Libraries Museums and Galleries	Leisure
Warehouse and storage	Storage
Others - Passenger terminals	Other
Hotel	Leisure
Community/day centre	Leisure
Workshops/maintenance depot	Office
Further education universities	Education
Sports centre/leisure centre	Leisure
Industrial process building	Industry
Primary health care buildings	Health
C2A Secure Residential Institutions	Other
Restaurant/public house	Leisure
Others - Miscellaneous 24hr activities	Other
Retail warehouses	Storage
Hospital	Health
Social clubs	Leisure
Emergency services	Other
Others - Stand alone utility block	Other
Libraries/museums/galleries	Leisure
Sports ground arena	Leisure
Others - Car Parks 24 hrs	Other
Prisons	Other
Airport terminals	Other

Miscellaneous 24hr activities	Other
Theatres/cinemas/music halls and auditoria	Leisure
D1 Non-residential Institutions - Crown and County Courts	Other
Crown and county courts	Other
Bus station/train station/seaport terminal	Other
Dwelling	Other
Telephone exchanges	Other
Others -Telephone exchanges	Other
All other building types	Other

Table B.3. CBI GHG emission thresholds for low-carbon office buildings in the UK

City	Year added	Initial GHG emission threshold [kg CO_2eq / m^2 and year]
London	2015	36.01
Belfast	2019	27.44
Birmingham	2019	27.33
Bristol	2019	24.83
Edinburgh	2019	28.22
Glasgow	2019	28.21
Leeds	2019	26.45
Liverpool	2019	27.33
Manchester	2019	26.97
Southampton	2019	25.47

Source: (CBI, 2020[152]).