UK Net Zero Carbon Buildings Standard

Balancing the UK Stock Against a Net Zero Trajectory to Derive the Pilot Version Limits

May 2025

Table of Contents

01 Executive Summary

UK Net Zero Carbon
Buildings Standard

Executive Summary

Balancing Model & UKNZBCS Limits Our Approach

A fundamental principle of the UKNZCBS is that it is science-led; informed by the UK carbon and energy budgets to remain on a 1.5ºC trajectory, and by the actions required from the built environment to align with these budgets. To develop operational energy and embodied carbon limits which follow this principle, modelling has been carried out of the UK building stock and its evolution from today until 2050, with associated energy use, operational carbon and embodied carbon impacts. This document presents the modelling carried out and how it has informed the operational energy and upfront carbon limits in the UKNZBCS Pilot published Autumn 2024.

The modelling has identified a possible Net-Zero compatible route i.e. a Scenario where the building stock's "spend" of carbon emissions and energy, balances with carbon and energy budgets: this is the "Balanced" Scenario in this document.

The principles of balancing the carbon and energy budgets is described in Section 2, with the Balanced Scenario presented in full in Section 3.

Important Notes

The Balanced Scenario, including its associated inputs or assumptions, is not an expectation or prediction. It represents one possible set of conditions to balance the budgets, whilst seeking to be realistic based on an analysis of external influences including performance, industry trends and policy ambitions.

There are alternative ways to balance the budgets. Additional scenarios have been tested and are presented in Appendix A and signposted throughout the document in pink boxes; additional assumptions are discussed qualitatively in Appendix B; and Appendix C includes comparisons between key assumptions or results in the UKNZCBS model and other industry or policy documents.

The modelling work is presented here as background information on how the Pilot Version of the UKNZBCS was developed. It is expected that the model and scenarios will evolve over time – see Next Steps in Section 5. See p. 73, 'Acknowledgements and Feedback' for further information on how to provide your comments on the scenarios, data sources and modelling approach.

Key

- Additional Scenarios
- Key Notes

Executive Summary

Balancing Model & UKNZBCS Limits: Our Approach

What is required at stock level?

Top Down Budgets

Balancing Scenarios

What can be achieved at asset level?

Operational Energy Performance

Embodied Carbon Performance

Bottom Up Spend

UKNZCBS Limits & Targets

Assumptions and results are described in Section 3. Additional tests and considerations are described in Appendices A, B and C.

How the balancing work has informed the UKNZCBS limits is described in Section 4.

Executive Summary

Results

Overview of Balanced Scenario

Our modelling indicates that balancing the carbon and electricity budgets for the UK built environment is possible, but requires significant intervention on the wider system, and on the performance of the new and existing stock, as the Balanced Scenario includes:

- Decarbonisation of the electricity grid, reaching near-zero carbon content by 2035 (see Section 3.3)
- Materials decarbonisation, to reduce the embodied carbon associated with new build and retrofit works (see Section 3.4)
- Retrofit of the existing stock by 2040, to reduce energy demand and move away from fossil fuels (see Section 3.4)
- Improvements in energy use and embodied carbon practice on new build and retrofit works (see Section 3.4).

In practice, the set of conditions in the Balanced Scenario is very likely to require action from policy and industry. **The Balanced Scenario is therefore ambitious**: without this level of ambition, the modelling work found that it was not possible to balance the carbon and energy budgets; whilst a Balancing Model could be achieved with less ambition in some aspects, it would need to be compensated for in others. In the Balanced Scenario, the interventions build up over time, to represent the need for supply chains and market demand to grow while also capturing the benefits of lower embodied carbon expenditure for new build and retrofit works, as materials decarbonise over time.

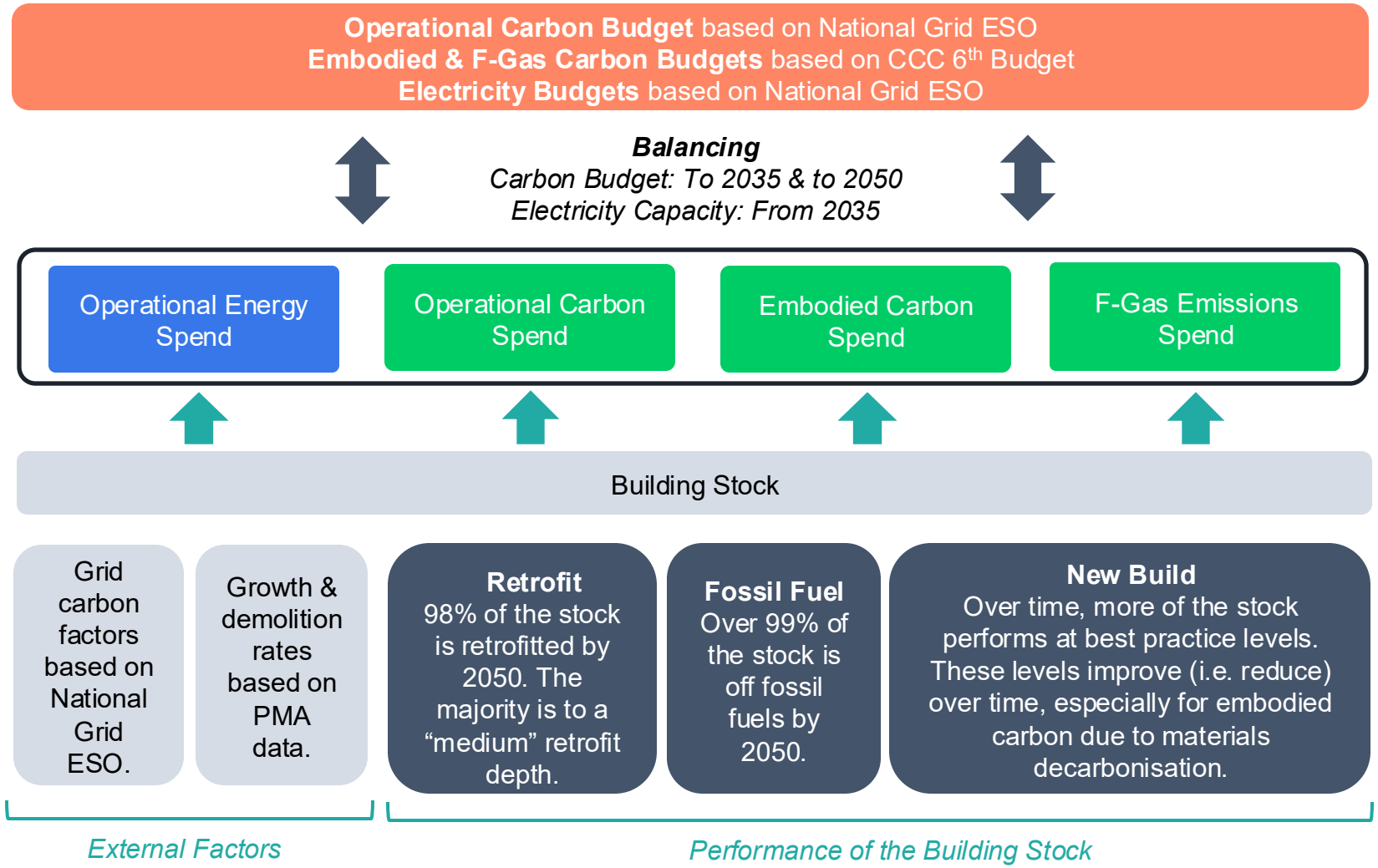
How the Balancing Exercised has Informed UKNZCBS Pilot Limits

The UKNZCBS Pilot Limits have been informed by the balancing exercise, and thus this 'need for action' is reflected in the UKNZCBS Pilot limits as follows (see Sections 3.4 and Section 4):

- **New Build:** The UKNZCBS Pilot limits represent best practice, i.e. feasible but ambitious, in order to limit energy demand on the grid, limit embodied carbon spend in early years, and minimise the need for retrofit in the future.
- **Existing Stock:** The UKNZCBS limits represent what is expected to be **required from the majority of the stock**. They represent retrofit intervention across the large majority of the stock, to reduce energy demand and move away from fossil fuels. They are less ambitious than some retrofits today (e.g. Enerphit, LETI Climate Emergency Retrofit Best Practice).

Executive Summary

The Balanced Scenario: Key Inputs



Notes

Details of these inputs in this Balanced Scenario are presented in Sections 3.2, 3.3 and 3.4.

Results are presented in Section 3.5

Additional scenarios tested are presented in Appendix A.

Executive Summary

Accompanying Documents

This document is accompanied by **a UKNZCBS Input Evidence Report** detailing how the performance levels and UKNZCBS Limits were arrived at, complementing the summary provided in Section 3.4.

An **Assumptions & Data Sources Document** detailing background calculations and data sources behind the inputs, complementing the information provided within this Report and the UKNZCBS Input Evidence Report. This is available on request.

The Standard

Suite of Supporting Technical Documentation

02 Introduction

UK Net Zero Carbon
Buildings Standard

Introduction

Overview

This document provides contextual information on the UKNZCBS Pilot version published on 24th September 2024. It presents the modelling carried out to identify a Net Zero compatible route for the UK Built Environment, and to inform the operational energy and embodied carbon limits in the UKNZBCS Pilot.

Assumptions on the stock level modelling are included here and detailed in a separate Assumptions and Data Sources Document.

Assumptions on the performance of the stock are summarised here and detailed in the UKNZCBS Input Evidence Report which explains the development of the bottom-up performance levels.

Further modelling will be carried out in the future e.g. to reflect changes in context or to test the impact of different scenarios.

02 UKNZCBS Balancing Model

UK Net Zero Carbon Buildings Standard

02.1 UKNZCBS Balancing Model

Principles and Overview

UK Net Zero Carbon Buildings Standard

What Do We Mean by UKNZCBS Balancing?

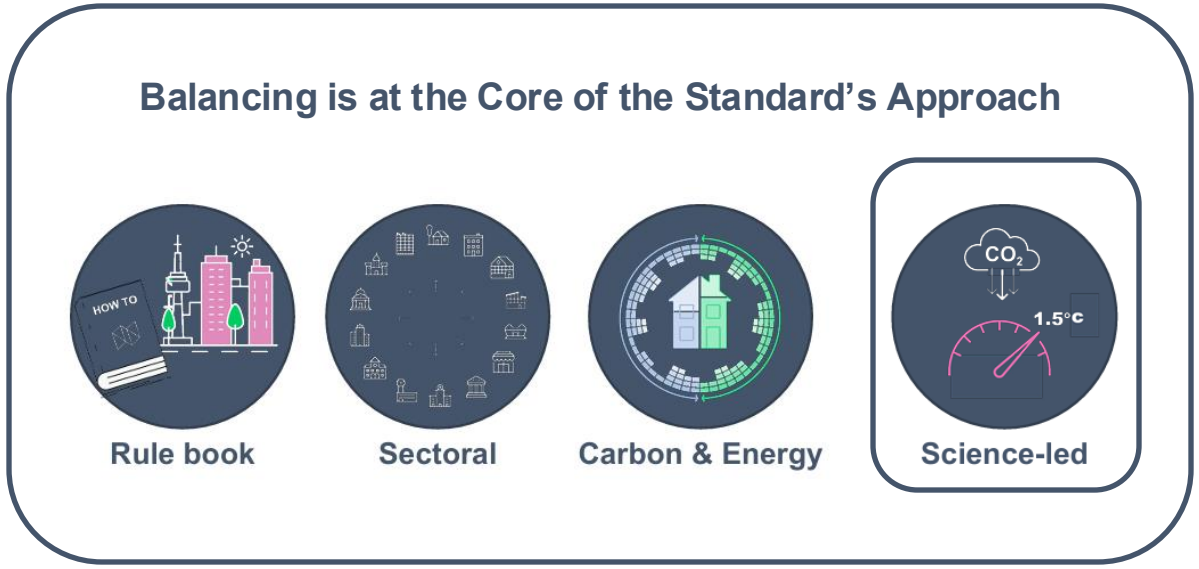
Balancing Model & UKNZBCS Limits Our Approach

A fundamental principle of the UKNZCBS is that it is science-led, informed by the UK carbon and energy budgets to remain on a 1.5ºC trajectory, and by the actions required from the built environment to align with these budgets.

To develop operational energy and embodied carbon limits which follow this principle, an Excel based tool was created which models the UK building stock and its evolution from today until 2050, with associated energy use, operational carbon and embodied carbon impacts.

The tool allows the modelling of, and balancing between:

- **"Bottom Up"** energy and carbon expenditure from the stock; and
- **"Top Down"** energy and carbon budgets for the built environment.



UKNZBCS Balancing Principles

The modelling exercise seeks to achieve a “Balanced” model, meaning that the bottom-up expenditure in carbon and electricity should remain within budgets for the built environment (see right).

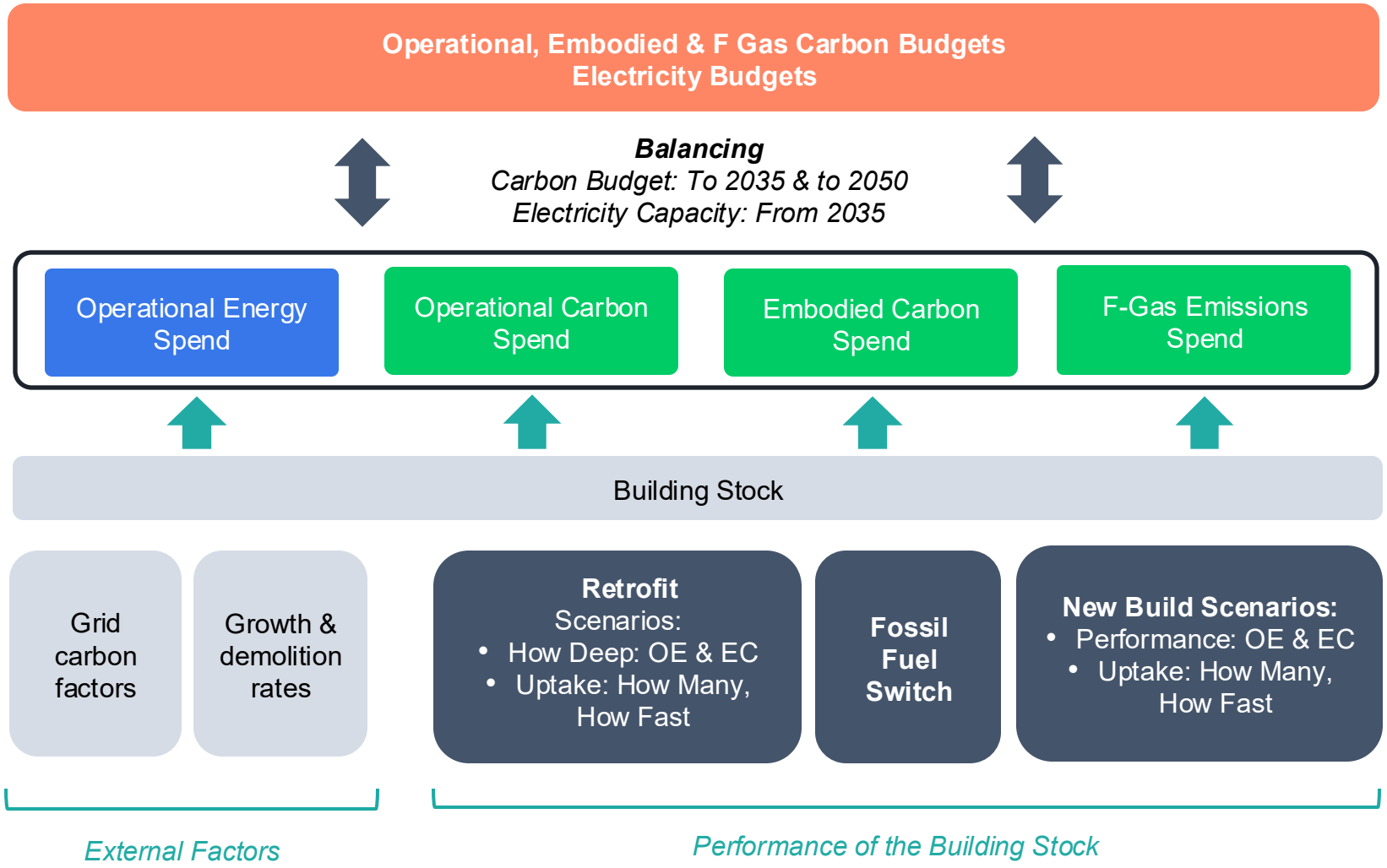
In order to do this, the balancing model allows a number of factors to be set related to the evolution of the building stock (e.g. growth, demolition, retrofit), energy use and embodied carbon performance, and top-down carbon budgets and energy capacity. An overview of the balancing model and its key inputs is presented on the next page.

UNZCBS Balancing Principles	UK Carbon Budgets*	
	2022-2035	2035-2050
Sum of operational, upfront embodied (including extra-territorial emissions and F-gas carbon)**	Stay within total.	Stay within total.
Embodied carbon, operational carbon and F-gas *components* of total carbon budgets.	Stay as close to each component’s share of the total carbon budget.	Stay as close to each component’s share of the total carbon budget.
Annual electrical grid capability once it is expected to be nearly zero carbon (in annual output i.e. TWh)	Staying within by 2035, if possible.	Stay within by 2050.

**The UK is legally bound to reduce greenhouse gas emissions by 78% by 2035, and net zero emissions by 2050.*
*** In-use embodied carbon emissions have been accounted for separately (see details on p.22).*

UKNZCBS Balancing Model

Inputs Overview



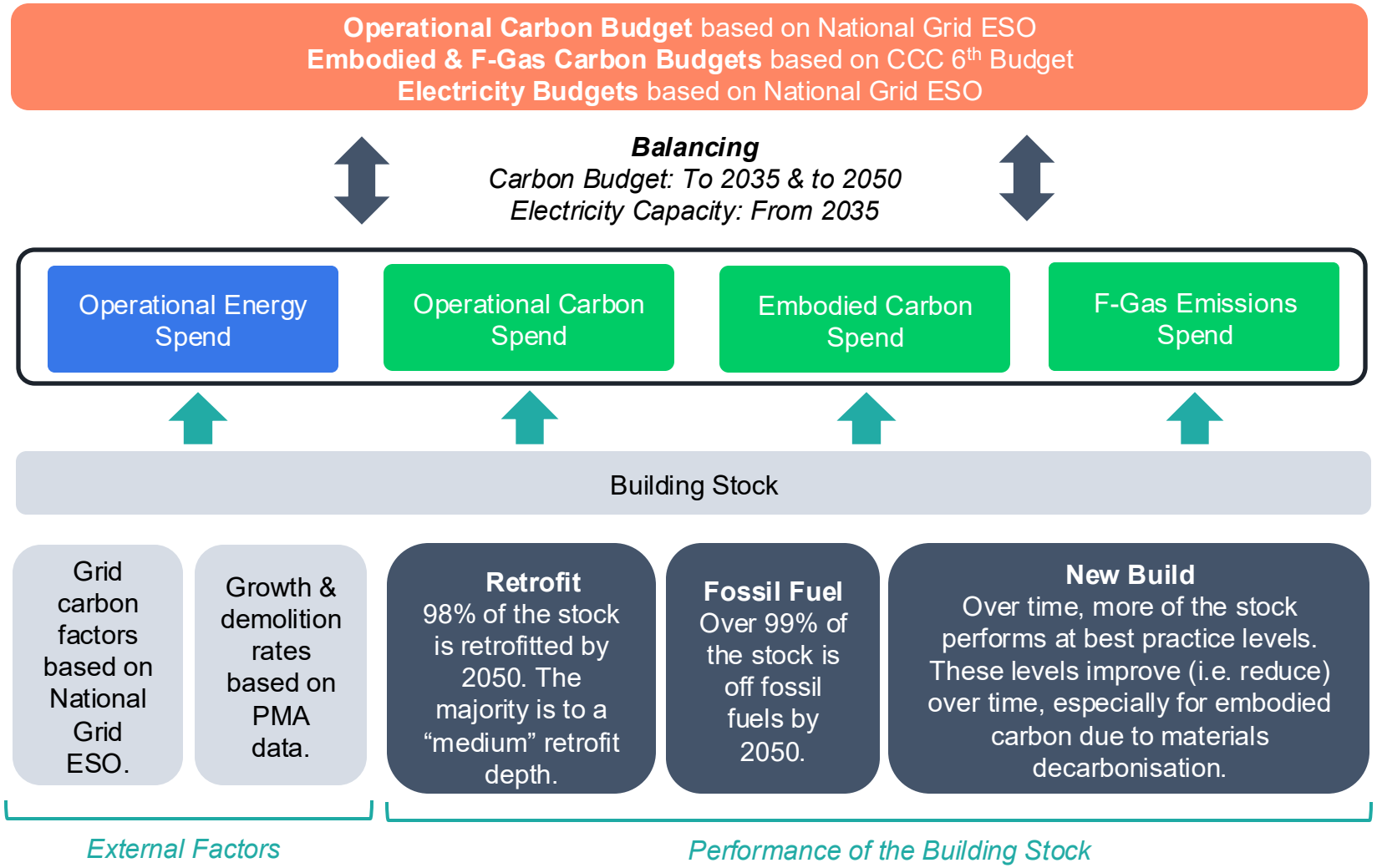
Notes

A range of New Build, Retrofit, and Fossil Fuel Switch scenarios were tested to represent the evolution of the building stock to 2050. This led to the creation of the Balancing Model.

Additional scenarios were also tested, which are presented in Appendix A.

UKNZCBS Balancing Model

The Balanced Scenario: Key Inputs



Notes

Details of these inputs in this Balanced Scenario are presented in Sections 3.2, 3.3 and 3.4.

Results are presented in Section 3.5

Additional scenarios tested are presented in Appendix A.

02.2 – UKNZCBS Balancing Model

The Building Stock

UK Net Zero Carbon Buildings Standard

The Stock Model: Starting Point

The Balancing Model takes 2021 as its starting point. The building stock is represented by **13 sectors** (as per those of the UKNZCBS) and subsectors (as per UKNZCBS sub-sector definitions as far as possible, within data availability constraints).

Floor Area Data for 2021 was sourced from the Building Energy Efficiency Survey (BEES) in most cases, and from the Housing Condition Surveys for England, Northern Ireland, Scotland and Wales. Sectors not covered by the UKNZCBS are represented by an overall allowance in the model, representing approximately 2% of the total UK built environment floor area and energy use.

Energy Benchmarks representing current average energy use of the existing stock, for each sector and sub-sector, were taken from a variety of sources, following a detailed analysis of data sources.

For the residential sector, the CIBSE (Typical Practice) benchmarks were used; these were created by UCL based on data for several 100,000s homes. For non-domestic sectors, BEES was used for most sectors, except when other data sources were considered more reliable or a better match to that sector. Different benchmarks are applied to represent electricity and non-electricity uses separately, and all-electric buildings vs those heated by other fuels.

Sources of floor areas and energy benchmarks are detailed in the separate Assumptions and Data Sources Document.

Quality Assurance Check

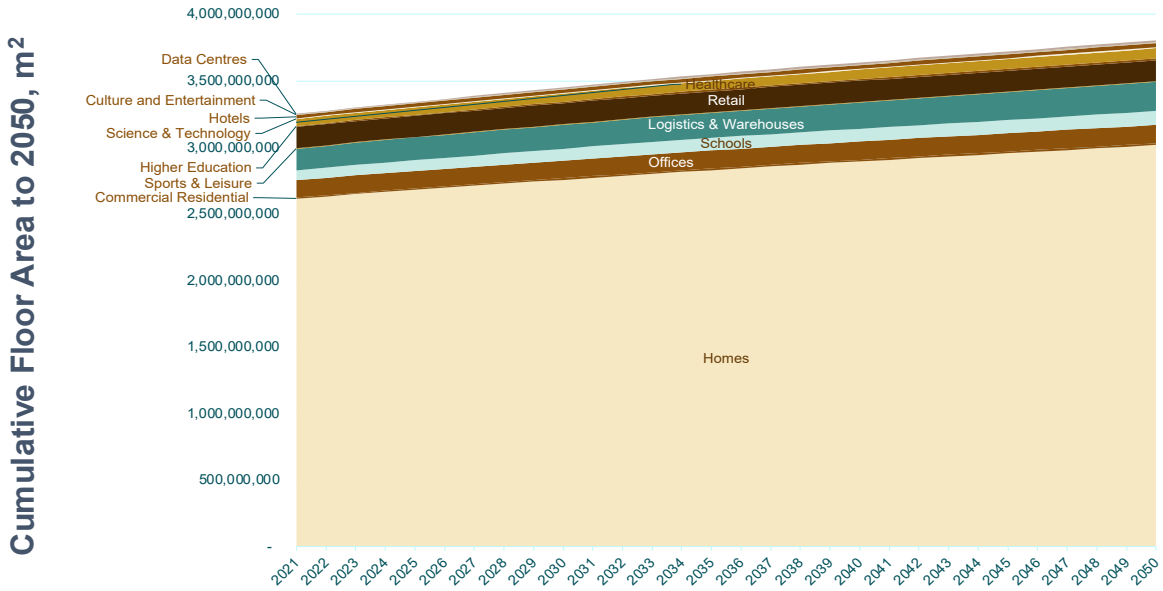
Overall, the summed-up electricity use and non-electricity use in the model, in 2021, are within 2% and 10% respectively of the total electricity use and non-electricity use by UK buildings as sourced from The National Grid Future Energy Scenarios (FES). This gives reasonable confidence in the representation of energy use from the 2021 building stock, for the purpose of the UKNZCBS modelling. Future refinements could be applied within sectors, particularly for non-electrical uses.

The Stock Model: Evolution to 2050

Annual rates of demolition and new build are applied to the 2021 stock, by sector and/or sub-sectors depending on the availability from data, as sourced from Property Market Analysis (PMA) [provided to the UKNZCBS team as part of the model development, see details in the Assumptions and Data Sources Document], from 2021 to 2050. This graph (see right) illustrates growth in floor area according to sector.

Additional Scenarios

- See p. 57-59 for tests on new build housing in line with the new (2024) Government's ambition.
- See p. 62 for a comparison with possible trends and recent announcements on datacentre growth.



Notes

Housing is the dominant sector in floor area.

In the non-domestic sector, the sectors with the largest floor areas are Logistics & Warehouses, Retail, Offices, Schools and Healthcare. Datacentres is by far the sector with the highest expected relative growth in floor area.

Within all other sectors, growth to 2050 is on average 33%, varying between a contraction of 2% (Retail) to a growth of 77% (Higher Education).

02.3 UKNZCBS Balancing Model

Top Down Budgets

UK Net Zero Carbon Buildings Standard

Top Down Budgets

Operational Carbon and Electricity

The **Operational Carbon and Electricity Budgets**, and carbon factors for grid electricity until 2050, are based on National Grid ESO (now NESO – National Energy System Operator) Future Energy Scenarios 2024, "Electric Engagement" Scenario. They are not directly extracted from the CCC budgets, as electricity used by buildings is not separately identified in these CCC budgets. However, the FES are understood to be aligned with decarbonisation pathways for a 2050 Net Zero UK.

"Electrical engagement" is the FES Scenario with the highest electricity demand i.e., for the purpose of the model, the highest electrical budget. FES scenarios with higher overall energy demand are more reliant on other fuels, including Hydrogen. This may evolve in future iterations of the modelling - See Section 5 Next Steps.

As the FES scenarios cover the Great Britain grid, the modelled energy budget in the UKNZCBS tool also includes an allowance for Northern Ireland, which represents an uplift of around 3% compared to the FES figures – see details in the separate Assumptions and Data Sources Document, on how this was estimated.

For **Non-Electricity Fuels**, a carbon factor equivalent to the current factor of gas has been applied. This means higher carbon fuels, such as oil are not accounted for, but nor is a switch to lower carbon fuels such as biomass or biofuels, as is assumed in the FES Scenarios. This simplification was applied to avoid a model which would rely on high levels of switching to biomass and biofuels, with associated uncertainty on sustainable supplies.

Additional Scenario
A test was carried out to estimate the impact of the new (2024) Government's ambition for a near net zero grid by 2030 (see p.60).

Top Down Budgets

Embodied Carbon

The Embodied Carbon Budget in the model is derived from the Climate Change Committee (CCC) UK Budget as follows:

- The part associated with the built environment is extrapolated from the total Manufacture & Construction (M&C) in the CCC budget: it is estimated to represent approximately 15% of the CCC M&C budget (see details in the Assumptions & Data Sources Document).
- An amount is then added to this budget, to account for extra-territorial embodied carbon: 46% is estimated to be territorial (i.e. UK-based) (see details in the Input Evidence Report). Accounting for extra-territorial emissions, rather than UK-based only is more representative of the real-life emissions impact of works. In the model, this allows the top-down budget to be directly compared with the bottom-up embodied carbon impacts of works, which do include extra-territorial impacts.
- This budget is then reduced, to exclude in-use embodied carbon and only include upfront carbon. Upfront carbon is taken as approximately 64% of the total (see details in the Assumptions & Data Sources document). This allows the top-down budget modelling to be aligned with the bottom-up emissions model, which at this stage only represents upfront emissions i.e. those associated with new construction and retrofit works, not in-use embodied carbon for maintenance, repairs etc. This may evolve in future revisions of the model.

F- gases, or fluorinated greenhouse gases, are a group of potent greenhouse gases that are typically used as refrigerants, including in heat pumps. The UK has plans to phase out F-gases.

The **F-Gas Budget** in the model is based on the CCC Budget. It allows for an increase in heat pump penetration over time. Only F-Gas impacts from space cooling and heating are represented in the model, not those from other types of refrigeration.

More details on how these were derived are included in the Input Evidence Report.

02.4 UKNZCBS Balancing Model

Bottom Up Assumptions in the Balanced Scenario

UK Net Zero Carbon Buildings Standard

The Balanced Scenario

A number of tests were carried out and a number of scenarios were developed in the evolution of the Balancing Model. This tested a wide range of scenarios, from assuming only existing policies in place and current industry practice, through to more ambitious assumptions on improvements in the policy framework and industry practices.

This early testing showed that to meet the carbon and electricity budgets requires significant action on the new and existing stock: this section describes the inputs to the model which represent the actions required on the new build and existing stock.

The Balancing model is ambitious. Whilst the UKNZCBS model represents outcomes (e.g. fossil fuel switch, improvements in energy use or embodied carbon performance) rather than individual measures to achieve these outcomes, in practice the outcomes assumed would very likely require significant policy, market and industry action: without ambitious assumptions, it was not possible to balance the carbon and energy budgets at stock level.

The results in this section represent a model that is balanced, i.e. under the Balanced Scenario (within the expected margin of error) (see results in section 3.5).

Notes

The Balanced Scenario, and its associated inputs or assumptions, is not an expectation or prediction. It represents one possible set of conditions to balance the budgets, while seeking to be realistic based on an analysis of performance, industry trends, policy ambitions etc. There are alternative ways to balance the budgets.

Notes (Continued)

Additional scenarios have been tested and are presented in Appendix A; some assumptions are discussed qualitatively in Appendix B; Appendix C includes comparisons between key assumptions or results in the UKNZCBS model and other industry or policy documents.

It is expected that the current model and scenarios will evolve over time – see Next Steps in Section 5. The current work is presented here as part of the background to the UKNZBCS Pilot, for transparency on how the pilot limits were arrived at. Comments are welcome on the approach, scenarios tested, and sources of information used.

Performance Of the Building Stock

Bottom Up Performance Levels

The performance levels represent the energy use and upfront carbon performance that is assumed to be achieved by various parts of the stock, across sectors and over time: they are the tool's inputs for building energy use (kWh/m^2/yr) and upfront carbon ($kgCO_{2e}/m^2$). They evolve over time, to represent improvements in technology and practice – see details on the next pages.

The new build performance levels were developed by the UKNZCBS Task Groups and Sector Groups using:

- Data from individual projects and large datasets.
- Industry benchmarks.
- Expertise from the UKNZCBS sectors groups.
- Comparison with other schemes such as Passivhaus and NABERS.

The performance levels for retrofitted buildings were created relative to the existing and new build levels, depending on the level of retrofit (see p.29).

Some information on how these performance levels were developed is available in the June 2023 Technical Update Consultation.

More detailed information on the creation of the performance levels and UKNZCBS limits is included within the **UKNZCBS Inputs Evidence Report**.

New Build Performance Levels

Operational Energy

Two Operational Energy Performance Levels are Used Across the New Build Stock: Best Practice and Building Regulations Compliance.

Part of the New Build Stock is Assumed to Perform at Best Practice Energy Levels

This evolves over time:

- Best Practice improves over time, becoming between 20% and 50% better in 2050 than in 2022, depending on sectors.
- Typically, higher improvements are assumed for sectors currently at a less "mature" stage of low-energy design and operation, while for sectors such as offices, homes and schools, Best Practice from day 1 is assumed to be quite ambitious, and therefore to have relatively less room for improvement over time.
- The uptake of Best Practice, i.e. how much of the stock adopts Best Practice, increases over time (see p. 30).

The Rest of the New Build Stock is Assumed to Perform at Building Regulations Compliance Levels

Homes

Until 2027, their energy use is assumed to be 32% lower for gas and 18% lower for electricity, than existing homes. This is based on evidence from EPC-A and -B rated homes, compared to D-rated homes, from analysis by UCL. From 2028, to represent the implementation of the Future Homes Standard*, new build homes are assumed to be all-electric, and a reduction in energy use is applied to represent a switch to heat pumps (assumed SCOP of 3.5).

Non-Domestic Buildings

Until 2027, their energy use is assumed to be the same as the existing stock, due to limited evidence otherwise. From 2028, to represent the implementation of the Future Buildings Standard*, buildings are assumed to be all-electric and with a 5-20% lower energy use. Typically, sectors with relatively large space heating and/or cooling are applied a 20% improvement, due to the potential for savings through fabric and services, while those more dominated by non-regulated loads are applied smaller improvements, due to the relatively smaller impact of Building Regulations alone.

Please see illustrations overleaf for further information.

** These assumptions could be revised as details of the FHS and FBS become available.*

New Build Performance Levels

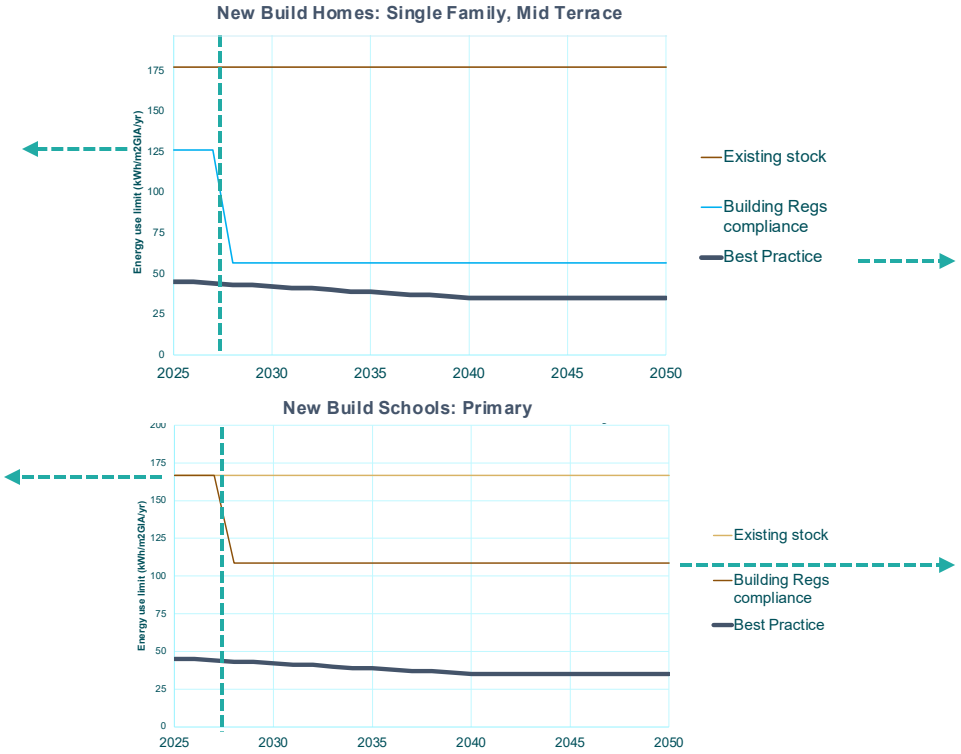
Operational Energy

Best Practice EUIs are Better than Building Regulations Compliance, and Improve Over Time

2025-2027

Homes
Building Regulations compliant homes are assumed to have a lower EUI than the existing stock (see details in previous page).

Non-Domestic Buildings
Non- Domestic buildings are assumed to have the same EUI as the average existing stock, due to lack of evidence otherwise (see details in previous page).



From 2028

Homes
It is assumed that the Future Homes Standard (FHS) will start delivering homes of lower energy use than current Building Regulations compliance (see details in previous page). No further improvements to the FHS are assumed after 2028.

Non-Domestic Buildings
It is assumed that the Future Buildings Standard will start delivering non-domestic buildings of lower energy use than the existing stock (see details in previous page). No further improvements to the FBS are assumed after 2028.

Notes
Existing Stock: *The EUI shown is for non-electrical-heating buildings (i.e. sum of electricity + fuels), but the model also includes all-electric buildings.*
Building Regulations: *The EUI shown is for non-electrical-heating buildings until 2027, but the model also includes all-electric buildings. All new buildings in the model are all-electric from 2028 onwards.*
Best Practice: *The EUI shown is for all-electric buildings. All Best Practice new buildings in the model are assumed to be all-electric.*

New Build Performance Levels

Upfront Carbon

Part of the new build stock is assumed to perform at Best Practice upfront carbon levels.

This evolves over time:

- Best Practice initially represents an improvement of 10 – 20% compared to mean current performance. It improves over time to represent expected trajectories of materials decarbonisation, materials efficiency and, in homes, materials switching (see p.29).
- The proportion of the new build stock that performs at Best Practice increases over time (see p.30).

The other new buildings are assumed to perform at higher Embodied Carbon levels.

This also improves over time due to materials decarbonisation (as per Best Practice), materials efficiency (less than Best Practice) and, in homes, materials switching (less than Best Practice).

Materials decarbonisation is assumed over time.

It is assumed to be the same across the stock, whether Best Practice or other buildings. The trajectory for this is based on industry commitments, largely as per 2021 UKGBC Roadmap – this is detailed in the Input Evidence Report on the creation of the performance levels and UKNZCBS limits.

Under current assumptions, materials decarbonisation represents the largest share of improvements in upfront carbon over time, much more significant than reductions from materials switching and materials efficiency: see illustrations on the next page. As a result of assumed materials decarbonisation, improvements in embodied carbon levels over time are much more significant than those in operational energy.

Additional Scenario

A test was carried out to assess the reliance of the Balancing Model on materials decarbonisation (see p.52).

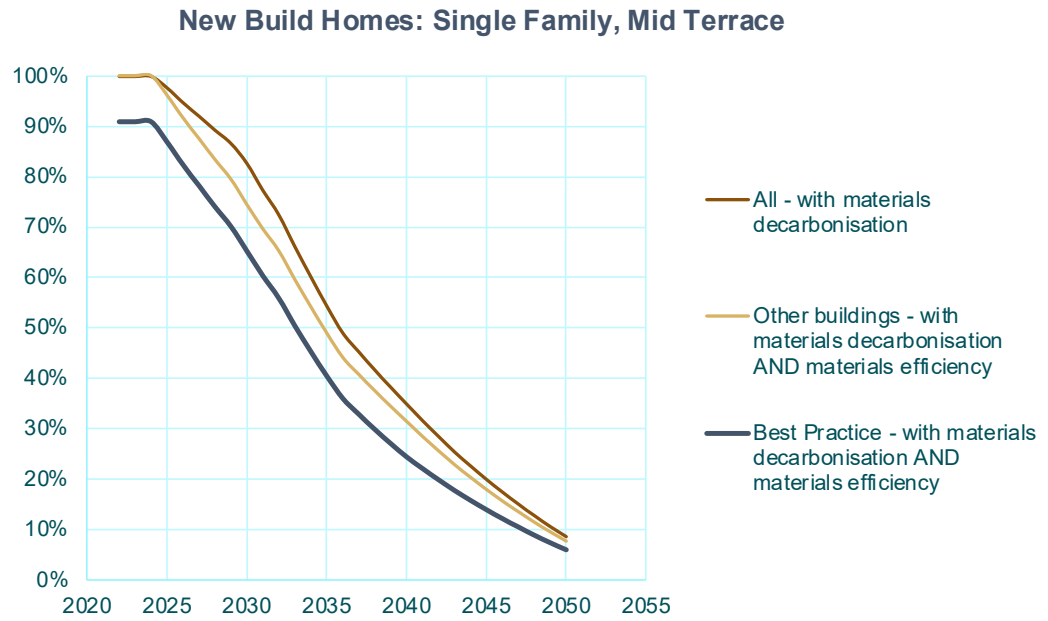
New Build Performance Levels

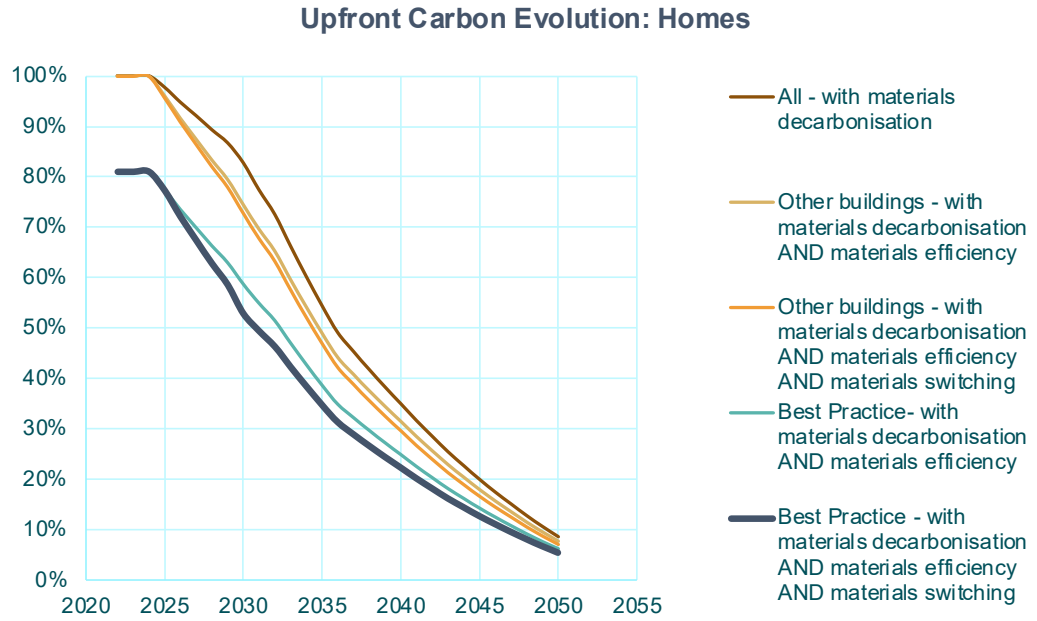
Upfront Carbon

- The same improvements from materials decarbonisation are applied to all buildings (whether Best Practice or not). They represent by far the largest share of overall reductions in embodied carbon.
- Materials efficiency is applied to all buildings, but savings are higher in buildings adopting Best Practice.
- Materials switching is only applied to homes. More switching is assumed in buildings adopting Best Practice.
- For homes, see comparison of the trajectory with Future Homes Hub ambition (see p.69).

Additional Scenario

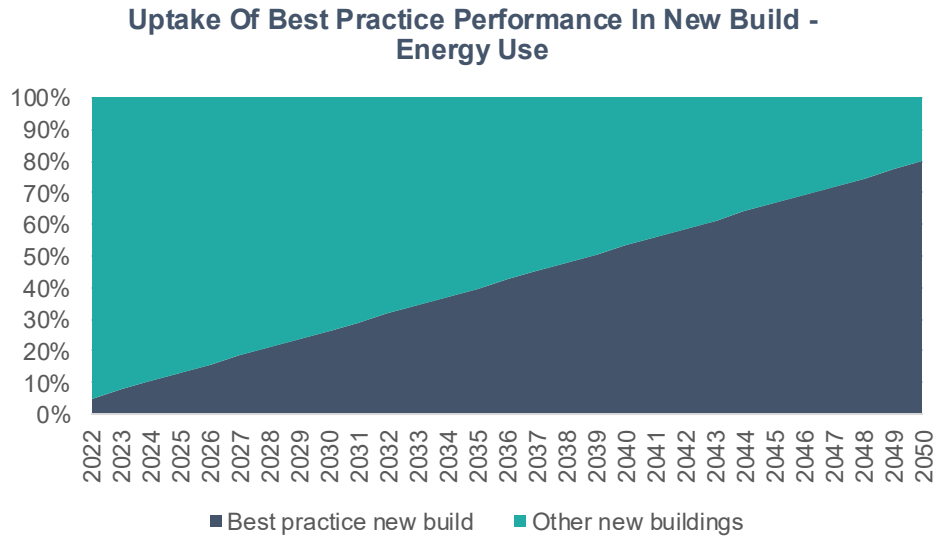
The impact of slower materials decarbonisation was tested (see p.52).

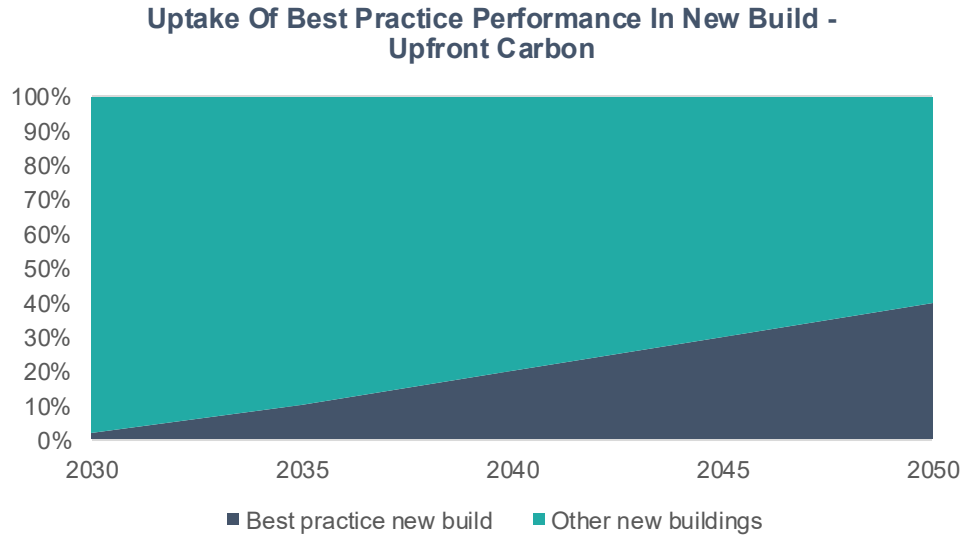




New Build Uptake of Best Practice

In the Balanced Scenario, the proportion of new buildings performing at Best Practice energy use and embodied carbon levels increases over time.





Additional Scenarios
Tests were carried out on the impact of different proportions of the stock performing at Best Practice. See Current Trajectory test on p.50, and a test on p.51 with less ambitious Best Practice but which is achieved by all of the stock.

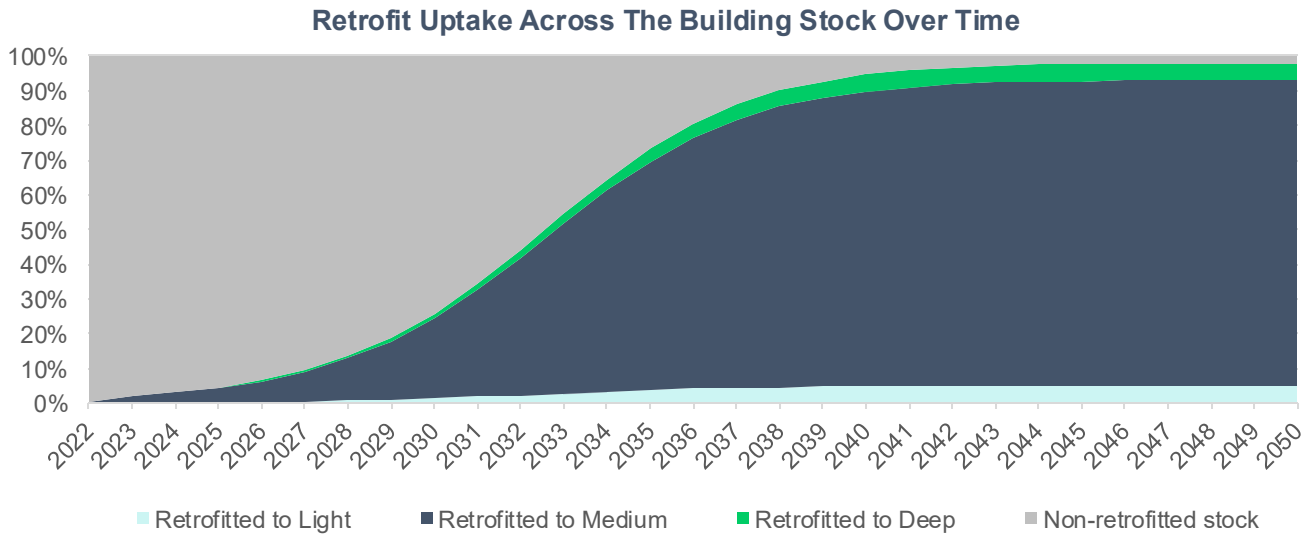
Retrofit of the Existing Stock

The Model Represents Gradual Retrofitting of the Existing Stock

Retrofitting slowly increases in early years, followed by a much more rapid increase, with the retrofit rate peaking around 2033. Ultimately, this results in 98% of the stock retrofitted by 2050. These assumptions are broadly in line with CLC National Retrofit Strategy, 2021 (see comparison on p. 65-66).

A Mix Of Retrofit Levels (Light/Medium/Deep) is Applied Across the Stock

The mix is illustrated below and is informed by the need to both 1) Reduce energy use in order to stay within the grid capability from 2050, and ideally from 2035; and 2) Limit embodied carbon expenditure to stay within carbon budgets. Retrofit levels are explained on p.32.



Notes

Overall, in the period up to 2050, on the housing stock the assumed retrofit uptake and mix of retrofit levels results in an approximate **14-19% energy saving** through demand reduction and energy efficiency, before the introduction of heat pumps (assuming an average SCOP of heat pumps between 3.5 and 4, between now and 2050).

Additional Scenarios

The impact of different mixes of retrofit levels was tested (see p. 53-56).

Retrofit Levels

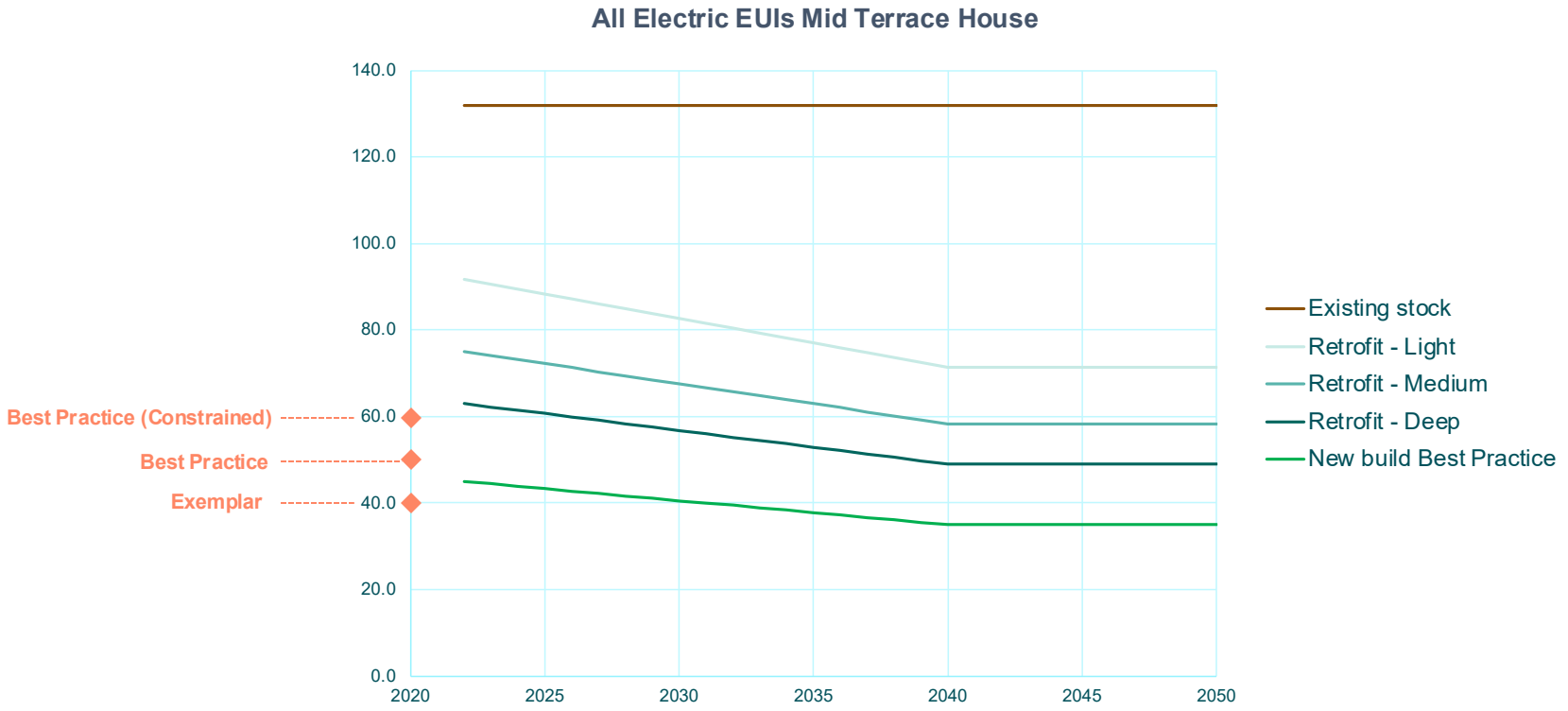
Retrofit Level	**Operational Energy** (2022 Levels, Before Their Improvement Over Time)	**Upfront Carbon Of Retrofit Works**, as % of New Works Upfront Carbon for Relevant Building Elements
Light Applied to **5%** of the retrofitted stock.	**Homes**: Equivalent to changing from boiler to heat pump. This is estimated using a heat pump SCOP of 2.5 (i.e. lower than what is assumed in new build, since this is applied to average existing homes). **Non-Domestic**: Equivalent to operational & management measures and moving to electric heating, with a 20% reduction in total energy use compared to the existing stock.	**Homes**: 50% of MEP **Non-Domestic**: 3.4% of MEP
Medium Applied to **90%** of the retrofitted stock	Equivalent to some fabric improvements and a switch to electric heating, but not as ambitious as today's best practice retrofits. This results in reductions in energy use compared to the existing stock of 50% on average, varying between 30 and 65% across sectors.	**Homes**: 15% of façade + 23% of fit-out + 76% of FF& + 46% of MEP **Non-Domestic**: 6% of façade + 3% of fit-out + 13% of FF&E + 7% of MEP
Deep Applied to **5%** of the retrofitted stock	This represents best or exemplar practice retrofit today (e.g. EnerPHit), requiring substantial fabric and systems improvements, and fuel switch. It is defined as between 45% and 75% of the way from Medium Retrofit to New Build Best Practice, depending on sectors, resulting in reductions in energy use compared to the existing stock of 60% on average, varying between 47 and 72% across sectors.	**Homes**: 20% of façade + 30% of fit-out + 100% of FF&E + 60% of MEP **Non-Domestic**: 45% of façade + 20% of fit-out + 100% of FF&E + 50% of MEP

Notes: From the 2022 starting point, retrofit levels evolve over time, following similar improvement curves as the new build levels (see illustrations for upfront carbon on p.29 and for operational energy of mid-terrace houses on p.33). The buildings which exist in 2021 and do not get demolished nor retrofitted retain the same energy use level and heating type as on day 1 (i.e. around 6% are heated by electricity [As per BEIS: See details in Input Evidence Report].

Retrofit Levels (Energy)

Example: Mid Terrace House

All electric EUI of a mid-terrace house, depending on the year in which the new building or retrofit is completed.



Notes
In the Balancing Model, the majority (90%, as per p.32) of the housing stock gets retrofitted to a “Medium” level. For comparison: this “Medium” level starts around 25% higher than LETI “Best Practice – Constrained” i.e. Best Practice with an additional energy use allowance for constraints such as heritage or space; over time the medium level improves to the same EUI as the LETI target. See p.67 for a comparison with the approach in the ‘Retrofit at Scale’ publication.

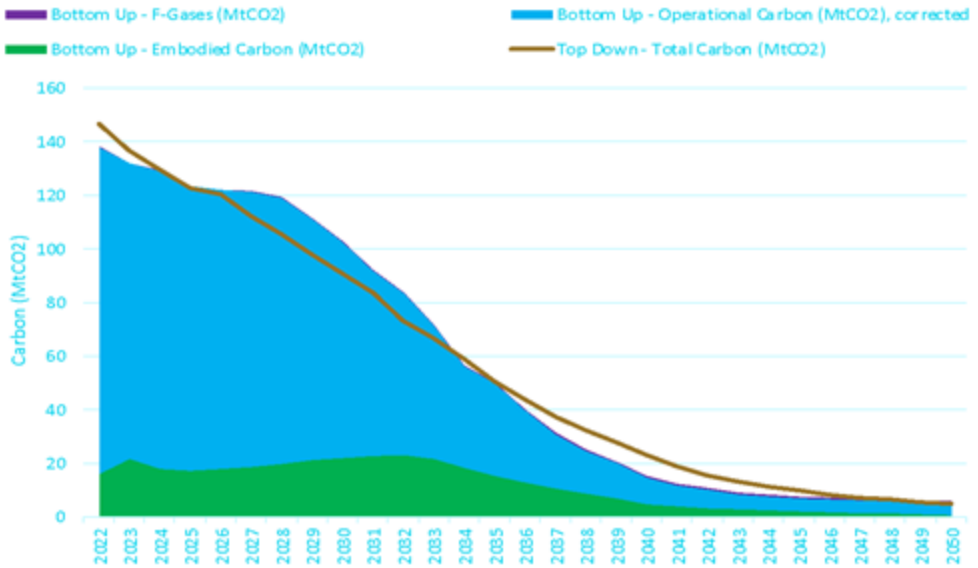
02.5 UKNZCBS Balancing Model

Results in the Balanced Scenario

UK Net Zero Carbon Buildings Standard

Balanced Scenario

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON ($MTCO_2$)*			
Budget (Top Down)	1,352	1,133	219
Used (Bottom Up)	1,316	1,172	145
Difference	-36	39	-74
Difference, % of Budget	-2.6%	3.4%	-34%
UPFRONT CARBON ($MTCO_2$)			
Budget (Top Down)	278	241	37
Used (Bottom Up)	338	275	63
Difference	60	35	26
Difference, % of Budget	22%	15%	69%
F GASES ($MTCO_2$)			
Budget (Top Down)	24	16	8
Used (Bottom Up)	14	4	11
Difference	-10	-13	3
Difference, % of Budget	-41%	-78%	33%
TOTAL CARBON ($MTCO_2$)			
Budget (Top Down)	1,654	1,390	264
Used (Bottom Up)	1,669	1,451	218
Difference	15	601	-46
Difference, % of Budget	**0.9%**	**4.4%**	**-17.5%**



Notes

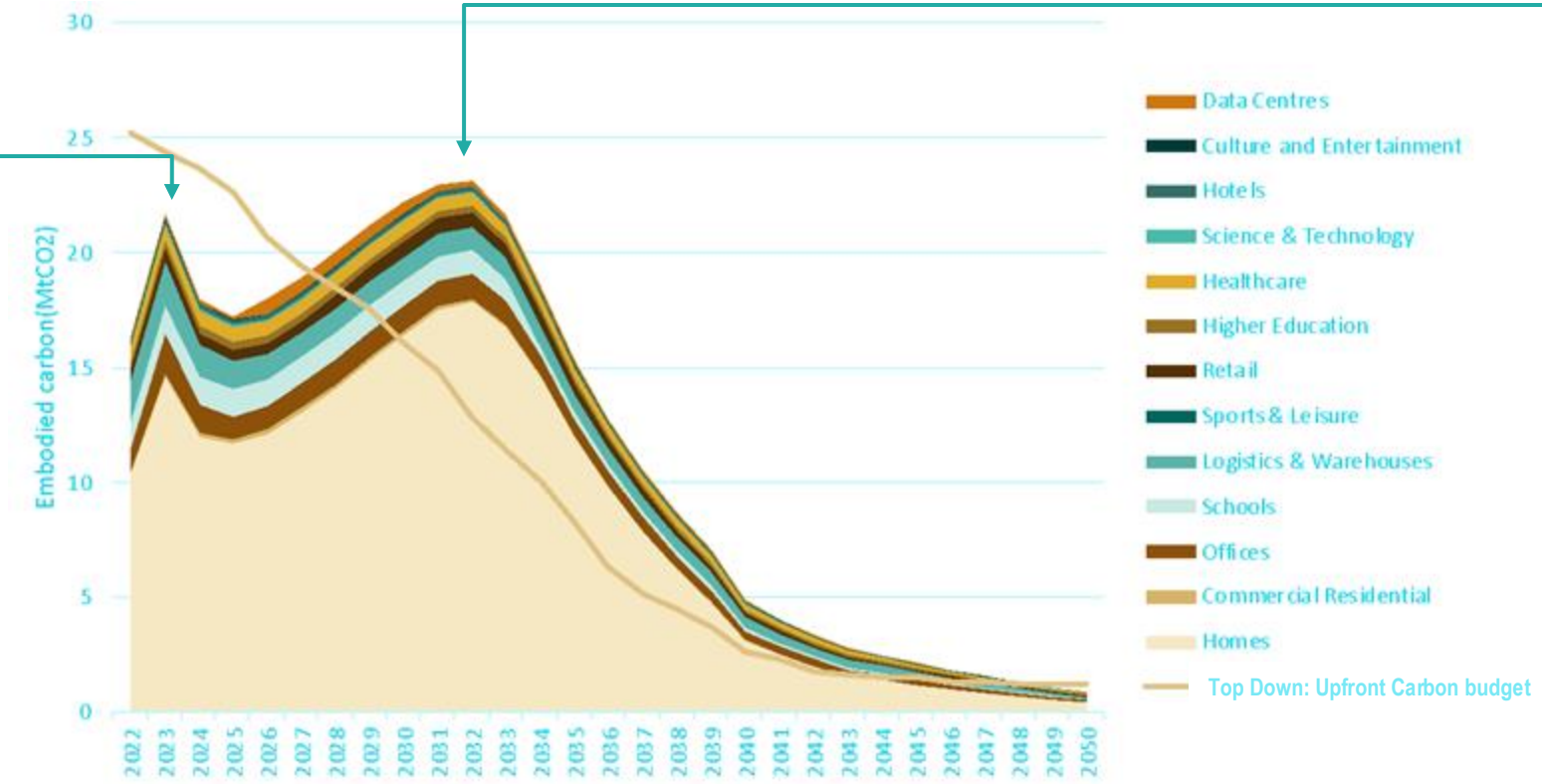
In the Balanced Scenario, the total (operational + upfront + F-gas) carbon budget is balanced over 2025-2050, within error margins. Exceedance is higher in early years, to 2035, but emissions are under-budget in the 2036-2050 period.

** In the calculation, operational carbon is "corrected": from 2035, any electricity use over the decarbonised electricity capability is applied a non-decarbonised (2021) carbon factor. This follows a similar approach to that recommended at project level in the RICS Professional Standard 2023, for energy use over net-zero-compatible levels. This only affects the calculation up to 2040, after which the electricity spend is within capability– see p.35.*

Balanced Scenario (Upfront Carbon)

Bottom Up Spend Vs Budget

Upfront embodied carbon (by sector) mapped against the expected budget.



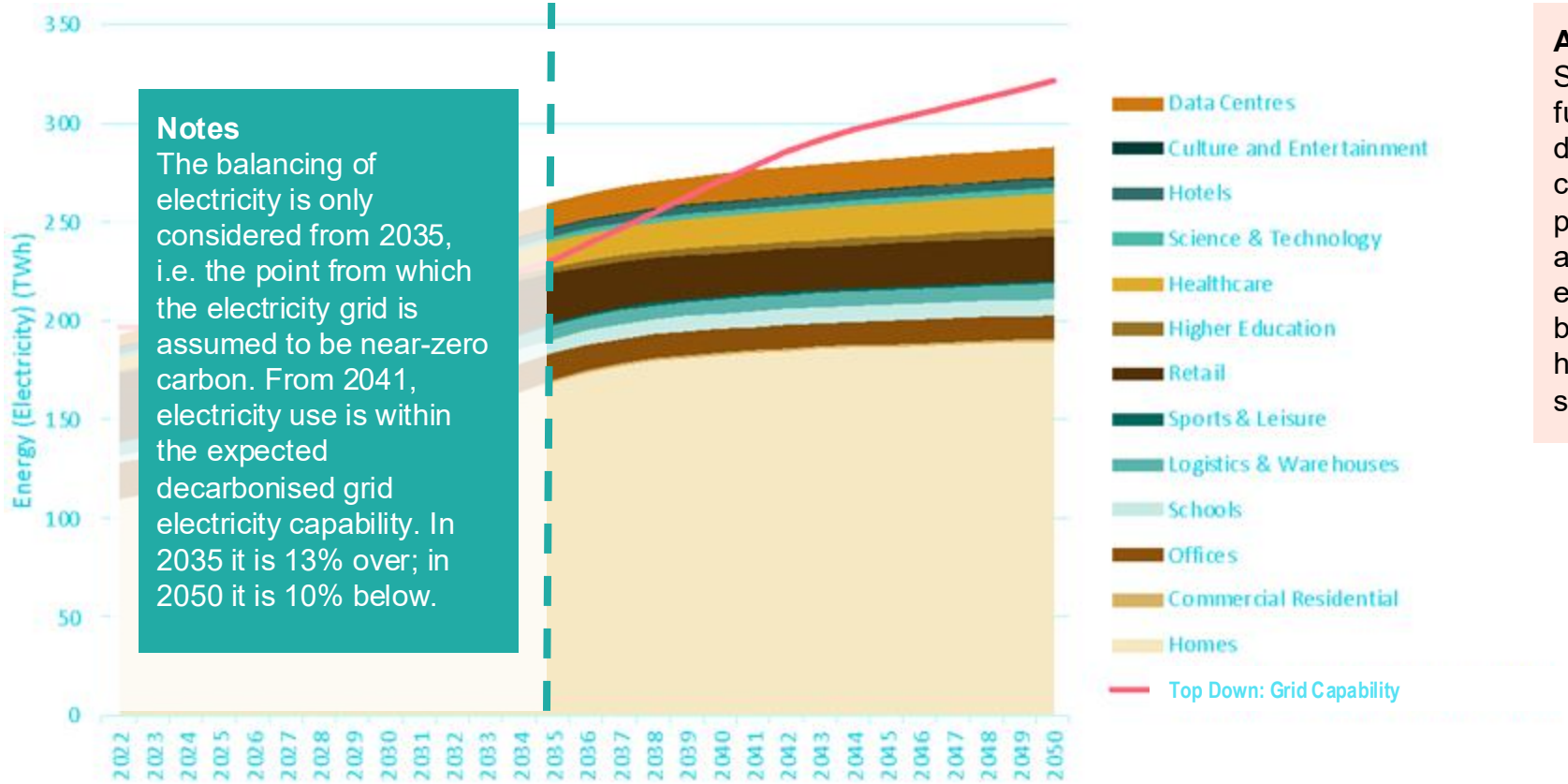
Notes
The early peak in embodied carbon is due to predicted increases in housebuilding (based on PMA rates, not factoring the new (2024) government's housing targets – for tests on this, see p. 57-59).

Notes
The second, larger, peak in embodied carbon is related to the uptake of retrofit, which is at its higher rate in 2033; it then shrinks as the embodied carbon of retrofit works reduces (mostly due to materials decarbonisation – see p.29), and as the rate of retrofit decreases.

Balanced Scenario (Electricity)

Bottom-Up Electricity Use Vs Grid Capability

Electricity use (by sector) mapped against the expected decarbonised grid capability.



Notes
The balancing of electricity is only considered from 2035, i.e. the point from which the electricity grid is assumed to be near-zero carbon. From 2041, electricity use is within the expected decarbonised grid electricity capability. In 2035 it is 13% over; in 2050 it is 10% below.

Additional Scenarios
Seeking to reduce energy use further and faster, to stay within decarbonised grid electricity capability from 2035, would imply probably unrealistic retrofit uptake and/or depth and more expenditure in embodied carbon, before materials decarbonisation has led to significant reductions - see tests on p.55-56.

Impact of New Build

Whilst the existing stock dominates total carbon spend and electricity use, the new build stock, and assumptions about its performance are still significant, particularly related to upfront carbon and, to a smaller extent, electricity use.

In the model, the stock projected to be newly built between 2022 and 2050 represents:

- **17% of the total 2050 floor area**
- **4% of the 2022 – 2050 operational carbon spend**
- **63% of the 2022 – 2050 upfront carbon spend**
- **22% of the 2050 electricity spend**

03 - UKNZCBS Limits

& How They Were Informed by the Balancing Exercise

UK Net Zero Carbon Buildings Standard

How the Balancing Modelling Informed the UKNZCBS Pilot Limits

Operational Energy & Embodied Carbon

The stock modelling and scenario testing indicate that balancing the carbon and electricity budgets to 2035 and to 2050 is possible (under current assumptions about the building stock and its future evolution) but requires significant action on the building stock.

In its approach to limit setting, the UKNZCBS is therefore positioned as follows:

- **New Build**: The UKNZCBS limits represent best practice*, i.e. **feasible but ambitious**, in order to minimise the need for retrofit in the future. See p.26 - 30 for details on what the Best Practice levels represent, compared to the rest of the new build stock.
- **Existing Stock**: The UKNZCBS limits represent what is expected to be required from the majority of the stock i.e. a “medium” depth retrofit. In the UKNZCBS each asset can achieve this in one go, or over time (“stepped retrofit”). See p.32 for details on what the Medium retrofit levels represent, and p.33 for where they sit compared to the overall retrofit uptake.

In the UKNZCBS, new build limits and end point (2040) retrofit limits are more onerous for later projects than for the earlier ones, in a similar way that the model assumes improvements in the performance levels over time.

Detailed information on how the limits were arrived at is presented in the **UKNZCBS Input Evidence Report** .

** Note that in the previous section, which details the assumed uptake of Best Practice across the stock (e.g. p.30), this is not necessarily uptake of the UKNZCBS itself: buildings may perform at Best Practice levels, but not be formally verified; some may perform at that level for energy use, and not embodied carbon, or vice versa.*

Aims and Approach Within UKNZCBS Limit Setting

	Operational Energy	Upfront Carbon
New Build	**Aim:** Limits to be achievable but ambitious to incentivise low energy buildings. **Approach:** Limits are best practice at the time of build. Best practice improves over time so later New Build will have more onerous limits.	**Aim:** Limits to be achievable but ambitious to incentivise low upfront carbon. **Approach:** Limits are best practice at the time of build. Best practice improves over time so later New Build will have more onerous limits.
Existing Buildings/ Retrofit	**Aim:** To incentivise **low energy buildings**. Limits to be **achievable by most buildings once retrofitted, to support mass roll out.** **Approach:** Support mass roll out, but later retrofits will have more onerous limits. Ultimately by 2040, buildings have to meet the equivalent of a 'Medium Retrofit'. As an option, the 2040 limit can be met in steps, with less onerous early steps if buildings have a 'Retrofit Plan'.	**Aim:** To **encourage** retrofit and **prohibit the highest upfront carbon** retrofits. **Approach: Typical Practice** (i.e. Best Practice but assuming a lot of works) at the time of the works. Typical Practice improves over time, so later retrofits will have more onerous limits.

04 - Next Steps

UK Net Zero Carbon Buildings Standard

Next Steps: Evolution of the Model

This document presents current modelling results, based on current assumptions, available data, and modelling functionality. The model is intended to evolve over time, as new information becomes available and through industry feedback and collaboration with other organisations on the assumptions.

1 – Evolution of Data Inputs and Associated Assumptions

Key areas include (not exhaustively):

- Assumptions on Top Down Budgets e.g. through collaboration with the Climate Change Committee and NESO:
    - The assumed embodied carbon budget, which currently relies on a number of assumptions such as the part of the Manufacturing & Construction carbon budget related to buildings, the amount of extra-territorial emissions, and the ratio of upfront vs in-use embodied carbon; (see p.22)
    - The assumed operational energy and carbon budget for buildings: this is currently not directly available from the CCC as electricity usage is presented as "the power sector", without differentiation of end uses (see p.18). Assumptions on low-carbon grid capability and associated grid carbon factors should also be revised as new scenarios become available from NESO, to reflect the government's ambition for a near net-zero grid by 2030 (see p.21 and p.60).
- Assumptions on the evolution of the building stock's floor areas, through PMA projections or others (see p.22)
- Assumptions on the building stock's current energy use e.g. through collaboration with UCL and DESNZ, including the National Building Database (see p.18)
- Assumptions on the performance of new buildings e.g. through publication of the Future Homes/Buildings Standard, evolution of other policies/ regulations, and collaboration with the Future Homes Hub (see p.26-27).

Next Steps: Evolution of the Model

2 – Evolution of Scenarios

Modified or additional scenarios will be explored, which could be driven by feedback from industry and policy-makers (e.g. advice from the CCC and NESO on which grid Scenario to use for the purpose of the UKNZCBS model – see p.21), changes in context (e.g. datacentre growth – see p.62) as well as responding to the evolution and refinement of data sources, as noted on the previous page.

3 – Evolution of the Model Itself

The tool developed to carry out the modelling presented here is expected to evolve in order to improve its functionality and allow additional factors to be tested, updated outputs to be created, and further analysis of the results.

06 Appendix A Additional Tests

This section presents additional tests which were carried out, varying some of the assumptions compared to the Balancing Model.

Additional Tests: Overview

A series of tests were carried out on some of the assumptions in the Balancing Model. The following pages detail the assumptions and results from these tests. Other important contextual factors may in the future evolve differently than in the UKNZCBS model. The model is intended to be adapted over time, such that these changes can be explored in the future.

- Current trajectory
- Less ambitious best practice, full uptake
- Slower materials decarbonisation than the industrial commitments represented in the Balancing Model
- Different retrofit mixes:
    - 85% at light retrofit level, with less medium retrofit as a result;
    - 50% at light retrofit level, with less medium retrofit as a result;
    - 50% at deep retrofit level, with less medium retrofit as a result;
    - 50% at deep retrofit level, with less medium retrofit but more light retrofit as a result.
- Increased new build housing, to represent the new Government's "1.5 million homes" manifesto commitment:
    - On its own
    - With deep retrofit conversion of long-term empty homes, to meet some of the 1.5 million new homes
    - With increased uptake of best practice
- Near zero carbon grid by 2030 rather than 2035, to represent the new Government's ambition.

Assumptions in the Additional Tests

Compared to the Balanced Scenario (1/2)

	Balanced Scenario	Current Trajectory (see *p.50)*	Less Ambitious Best Practice, Full Uptake (see *p.51)*	Slower Material Decarbonisation (see p. 52)	Different Retrofit Mix (4 tests) (see p.53 – 56)
Embodied Carbon & F-Gas Budget	CCC, with assumptions on construction part of Manufacturing & Construction; extra-territorial emissions; upfront vs in-use share of emissions *(see p.22).*				
Electricity & Operational Carbon Budget & Carbon Factors	FES Electric Engagement Scenario, 2024 *(see p.21).*				
New Build And Demolition Rates	Annual new build and demolition rates to 2050 from PMA. Over 2025-2029, this means approx. 81,652,000 m^2 new build housing, equivalent to approx. 878,200 new build homes (based on average new build dwelling sizes from the English Housing Survey) *(see p.19).*				
New Build Best Practice OE Level i.e. UKNZCBS	Performance Levels i.e. as per Bottom-Up analysis. Best Practice improves over time, reaching "Future Exemplar" performance level by 2040 *(see p.26-27).*	Reaches FE in 2050.	Less ambitious: average between Best Practice and Building Regulations compliance in Balanced Scenario.		
New Build Best Practice OE Uptake	Uptake starts at 5%, increasing to 80% by 2050 *(see p.30).*	Reduced uptake: starts at 5%, increasing to 15% by 2050.	Faster and higher uptake: uptake starts at 5% and increases to 100% by 2030.		
Materials Decarbonisation	Trajectory in line with industrial commitments (e.g. from concrete & steel), leading to 91% reduction by 2050 *(see p.29).*	Slower decarbonisation, leading to 61% reduction by 2050.		Slower, leading to 61% reduction by 2050.	
New Build Best Practice EC Level i.e. UKNZCBS	Performance Levels i.e. as per Bottom-Up analysis. Best Practice improves over time due to materials decarbonisation, materials efficiency and (for housing) materials switching. This leads to 95% (non-domestic) and 96% (Housing) reductions by 2050 *(see p.29).*		Less ambitious: average between Best Practice, and "rest of the stock" from the Balanced Scenario.		
New Build Best Practice EC Uptake	Uptake starts at 2%, increasing to 20% by 2050 *(see p.30).*	Reduced uptake: starts at 2%, increasing to 15% by 2050.	Faster and higher uptake: uptake starts at 2% and increases to 100% by 2030.		
New Build "Rest of the Stock" OE Level	Initially, new build housing is assumed to perform better than the average existing stock; new build non-domestic is assumed to perform as the average existing stock. Both improve from 2028 *(see p.27).*		More ambitious: average between Best Practice and Building Regulations compliance in Balanced Scenario.		
New Build "Rest of the Stock" EC Level	EC improves over time due to materials decarbonisation (same as Best Practice) and materials efficiency (less than Best Practice). No material switching is assumed. This leads to 92% reduction by 2050 *(see p.29).*		More ambitious: average between Best Practice, and "rest of the stock" from Balanced Scenario.		
Retrofit Uptake	Cumulative uptake of retrofit across the stock increases following an S-curve; it reaches 98% by 2040 and flattens afterwards. The peak rate is in 2033 (*see p.31).*	Slower increase in uptake: it reaches 98% by 2050, and the peak rate is 2038.			
Mix Of Retrofitted Stock	5% Light, 90% Medium, 5% Deep Retrofit (*see p.32).*	85% Light, 10% Medium, 5% Deep Retrofit			• 50% L / 45% M / 5% D • 85% L / 10% M / 5% D • 5% L / 45% M /50% D • 25% L / 25% M /50% D
Year from which all New Build is Electrified	2028				

Assumptions in the Additional Tests

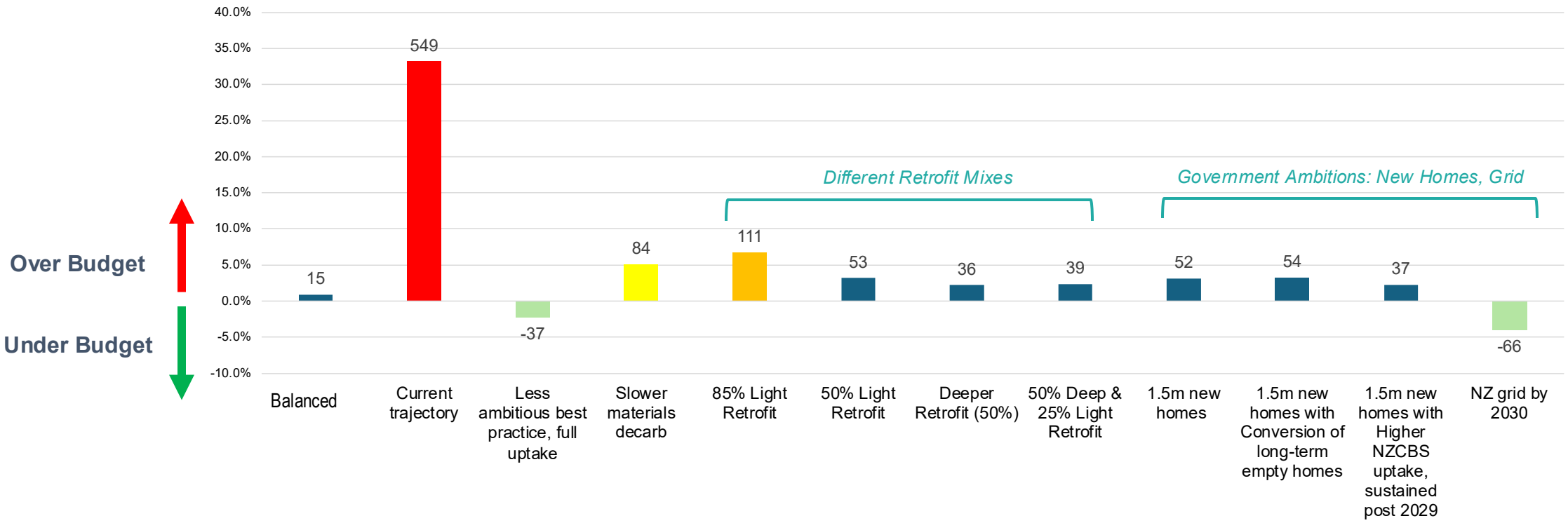
Compared to the Balanced Scenario (2/2)

	Balanced Scenario	1.5 Million New Homes (see p.57).	1.5 Million New Homes with Deep Retrofit Conversion (see p.58).	1.5 Million New Homes, Increased Best Practice Uptake (see p.59).	Net Zero Grid by 2030 (see p.60).
Embodied Carbon & F-Gas Budget	CCC, with assumptions on construction part of Manufacturing & Construction; extra-territorial emissions; upfront vs in-use share of emissions *(see p.22).*				
Electricity & Operational Carbon Budget & Carbon Factors	FES Electric Engagement Scenario, 2024 *(see p.21).*				Estimated trajectory to reach the same grid capability and carbon factor in 2030, as in 2035 in Balanced Scenario.
New Build And Demolition Rates	Annual new build and demolition rates to 2050 from PMA. Over 2025-2029, this means approx. 81,652,000 m^2 new build housing, equivalent to approx. 878,200 new build homes (based on average new build dwelling sizes from the English Housing Survey) *(see p.19).*	Increased new housing: 1.5m homes over 2025-2029.	Increased new housing: 1.5m new homes over 2025-2029 including approx. 265,000 by Deep Retrofit of empty homes.	Increased new housing: 1.5m homes over 2025-2029.	
New Build Best Practice OE Level i.e. UKNZCBS	Performance Levels i.e. as per Bottom-Up analysis. Best Practice improves over time, reaching "Future Exemplar" performance level by 2040 *(see pp.26-27).*				
New Build Best Practice OE Uptake	Uptake starts at 5%, increasing to 80% by 2050 *(see p.30).*			Uptake reaches 30% by 2029 (2032 in the Balanced Scenario).	
Materials Decarbonisation	Trajectory in line with industrial commitments (e.g. from concrete & steel), leading to 91% reduction by 2050 *(see p.29).*				
New Build Best Practice EC Level i.e. UKNZCBS	Performance levels i.e. as per Bottom-Up analysis. Best Practice improves over time due to materials decarbonisation, materials efficiency and (for housing) materials switching. This leads to 95% (non-domestic) and 96% (Housing) reductions by 2050 *(see p.29).*				
New Build Best Practice EC Uptake	Uptake starts at 2%, increasing to 20% by 2050 *(see p.30).*			Uptake reaches 30% by 2030 (2045 in the Balanced Scenario).	
New Build "Rest of the Stock" OE Level	Initially, new build housing is assumed to perform better than the average existing stock; new build non-domestic is assumed to perform as the average existing stock. Both improve from 2028 *(see p.27).*				
New Build "Rest of the Stock" EC Level	EC improves over time due to materials decarbonisation (same as Best Practice) and materials efficiency (less than Best Practice). No material switching is assumed. This leads to 92% reduction by 2050 *(see p.29).*				
Retrofit Uptake	Cumulative uptake of retrofit across the stock increases following an S-curve; it reaches 98% by 2040 and flattens afterwards. The peak rate is in 2033 (*see p.31).*				
Mix Of Retrofitted Stock	5% Light, 90% Medium, 5% Deep Retrofit (*see p.32).*				
Year from which all New Build is Electrified	2028				

Balanced Scenario & Additional Tests

Comparison with 2022 - 50 Carbon Budget

Comparison with Carbon Budget 2022 - 2050, in % (vertical axis) and million tons (number above each bar)



Notes: Results from each test are detailed in the following pages. Because emissions from F-gases are a very small part of the total, and do not vary significantly across these tests, they are not shown on the tables of results in this section.

Test: Current Trajectory

The "Current Trajectory" test assumes, broadly speaking, similar policies and trajectories as currently, with some progress on key factors such as retrofit uptake and materials decarbonisation, but less significant than in the Balanced Scenario in terms of change in outcomes and speed. In particular:

Most of the retrofit would be at a "Light" level i.e. only a switch to heat pumps in homes and some energy efficiency savings & fuel switch in non-domestic buildings. Decarbonisation of materials would be slower.

Detailed changes compared to the Balanced Scenario assumptions are as described on p.47.

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,834	1,387	447
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	357	214	143
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	2,203	1,603	600

Notes
The carbon budget would be significantly exceeded in the Current Trajectory Scenario, overall and in both 2022-2035 and 2035-2050 periods.

Test: Less Ambitious Best Practice, Full Uptake

In the Balanced Scenario, new build performance is differentiated between 1) Best Practice (which the UKNZCBS adopts for new build), and 2) Rest of the stock. In this test, instead, from 2030 all new build stock adopts the same level, pitched at the average of Best Practice and "Rest of the stock" from the Balanced Scenario i.e. Best Practice is less ambitious, but is adopted by the whole stock from that date.

This could represent, for example, a less ambitious UKNZCBS which was adopted in regulations; or, independently from the UKNZCBS, a significant upgrade to regulations and policies for both operational and embodied carbon.

Full assumptions are as described on p.47.

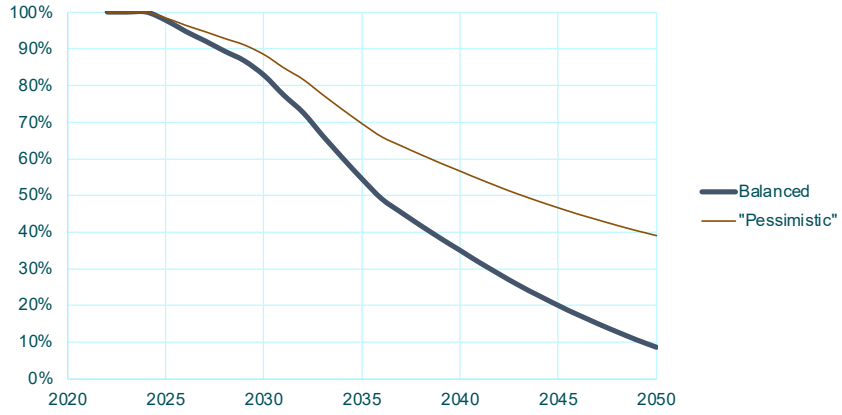
	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,289	1,166	122
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	314	256	58
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,617	1,426	191

Notes
In this test, carbon emissions are balanced, and slightly lower (i.e. better) than in the Balanced Scenario: less ambitious Best Practice for part of the stock is more than compensated by efforts across the stock. To achieve this full uptake would require regulations on both operational and embodied carbon.

Test: Slower Materials Decarbonisation

In the Balanced Scenario, as illustrated on p.29, materials decarbonisation makes up the large majority of modelled reductions in upfront embodied carbon over time. Instead, this test assumes less ambitious materials decarbonisation, resulting in 60% rather than 90% reduction by 2050 compared to 2024 levels, as illustrated in the graph below.

Materials Decarbonisation Scenarios
(as % of 2022 Upfront Carbon)



	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,316	1,172	145
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	408	297	110
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,738	1,473	266

Notes
With less ambitious materials decarbonisation, the model would exceed total carbon budgets, with a significant increase compared to the Balancing Model.
This highlights the dependence of carbon budget balancing on materials decarbonisation.

Test: Retrofit Mix 85% Light

In this test, the retrofit mix is changed to 85% Light, and the rest Medium (10%) and Deep (5%). This would represent electrifying the stock and achieving some levels of energy use reduction (e.g. through the switch to heat pumps, or in non-domestic buildings through operation & maintenance improvements), but limited or no other improvements.

All other assumptions are the same. See details on p.47.

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,316	1,185	290
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	276	223	53
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,765	1,411	354

Notes
A retrofit mix dominated by Light retrofit (instead of Medium in the Balanced Scenario) is overall detrimental to the carbon balance. It reduces embodied carbon expenditure significantly (by 1/3rd, bringing it to within the top-down upfront carbon budget), but it also significantly increases operational carbon, due to increased energy use and exceedance of low-carbon grid capability.

Test: Retrofit Mix 50% Light

In this test, the retrofit mix is changed to 50% Light, and the rest Medium (45%) and Deep (5%): seeking to capture some of the benefits of reducing embodied carbon expenditure, as in the “85% Light” Scenario, but reducing the detrimental impact on energy use and operational carbon.

All other assumptions are the same. See details on p.47.

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,390	1,179	210
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	303	246	57
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,707	1,428	279

Notes
While not as detrimental as the “85% Light” test, reducing the amount of Medium retrofit to 50% and replacing it with Light retrofit is still overall detrimental to carbon emissions, compared to the Balanced Scenario.

Test: Retrofit Mix 50% Deep

In this test, the retrofit mix is “deeper” overall, with 50% Deep, a reduction in the proportion of Medium retrofit (45%), and the same proportion of Light retrofit (5%) as in the Balanced Scenario.

Contrary to the previous two tests, this seeks to significantly reduce energy use to better stay within low-carbon grid capability and therefore reduce operational carbon.

All other assumptions are the same as in the Balanced Scenario. See details on p.47.

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,299	1,169	131
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	377	309	68
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,691	1,481	209

Notes
The overall effect compared to the Balanced Scenario is limited, but detrimental, particularly in the 2022 - 2035 budget period. The reduction in operational carbon expenditure due to a higher amount of Deep retrofit is smaller than the increase in embodied carbon expenditure.

Test: Retrofit Mix 50% Deep, 25% Light

In this test, the retrofit mix is changed to 50% Deep, and the rest split equally between Light and Medium i.e. a higher proportion of Light retrofit than in the Balanced Scenario.

All other assumptions are the same as in the Balanced Scenario. See details on p.47.

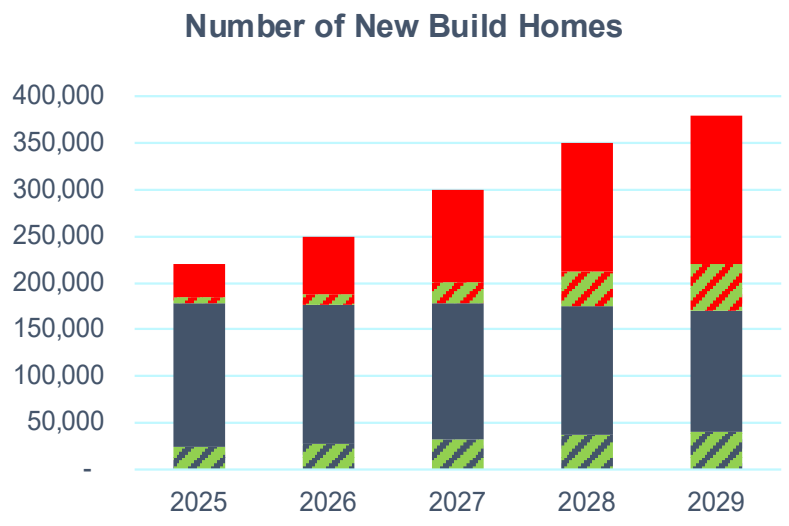
	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,317	1,172	145
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	362	296	66
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,693	1,471	221

Notes
The overall effect compared to the Balanced Scenario is limited, but detrimental: operational carbon is very similar, as the reduction due to more Deep retrofit is compensated by the increase in Light retrofit. Embodied carbon expenditure increases, leading to an overall increase in total carbon expenditure, particularly in the 2022-2035 budget period.

Test: 1.5m New Build Homes

This test intends to represent, in a simplified manner, the new (2024) government's ambition to build 1.5 million new homes within five years. The addition in new homes is weighted towards the second half of that 5-year period – see illustration below.

All other assumptions are the same as in the Balanced Scenario. See p.48.



	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,325	1,174	151
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	367	304	63
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,706	1,482	224

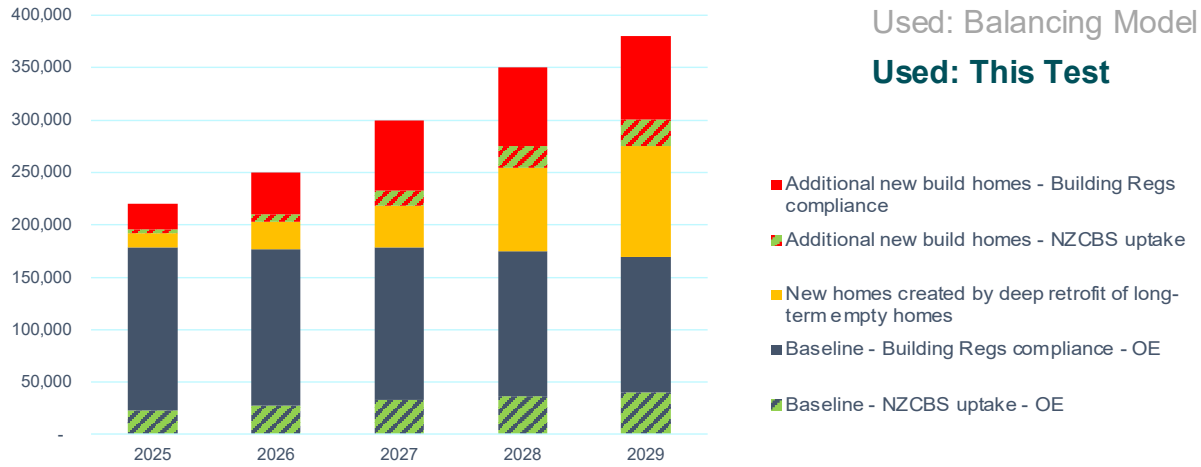
Notes
The additional new build homes would increase both embodied carbon and operational carbon expenditure, with a significant increase compared to the budget.

Test: 1.5m New Build Homes, with Conversion of long-term empty homes

This test builds on the previous one, but it assumes that some of the new 1.5m homes would not be new build, instead delivered through Deep Retrofit of empty homes: this assumes 265,000 homes, based on November 2024 MHCLG data on long-term empty homes in England i.e. excluding short-term empty homes, those in the devolved nations, and conversion of non-domestic buildings. This would represent 45% of the additional homes needed, from the Balanced Scenario to the "1.5m new homes" Scenario. Full assumptions are as described on p.48.

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,337	1,177	159
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	357	294	63
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,708	1,475	233

Number of New Homes (New Build & Deep Retrofit Conversion)



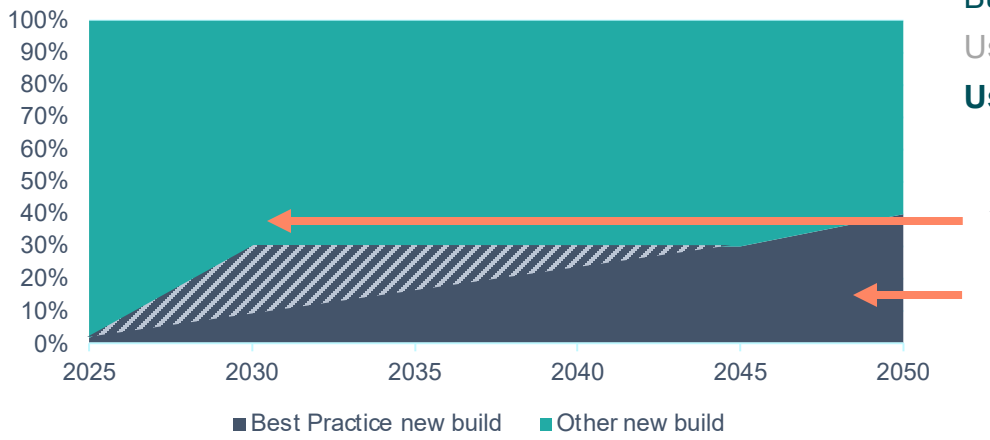
Notes
Delivering some of the new homes through Deep retrofit rather than new construction would significantly reduce embodied carbon spend. However, it would also lead to homes with higher energy use, increasing the exceedance in low-carbon grid capability and leading to an overall neutral impact, compared to the 1.5m homes being all new-build.

Test: 1.5m New Build Homes, with Increased Best Practice Uptake

This test builds on the "1.5m new homes" test, but it assumes a higher uptake of Best Practice operational energy and embodied carbon performance (i.e. UKNZCBS or equivalent) among new build homes, compared to the Balanced Scenario: see illustration below. It is also assumed that this higher uptake, once achieved, would be sustained over time i.e. in new homes built in subsequent years.

Full assumptions are as described on p.48.

Uptake of Best Practice Performance in New Build – Upfront Carbon



	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,325	1,174	150
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	352	291	61
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,691	1,469	222

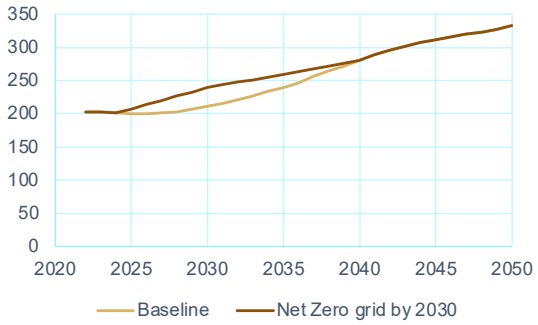
Notes
Increasing uptake of best practice performance among new build homes, for both operational and embodied carbon, would help reduce the impact of the additional new build homes, especially if this could then be sustained over time for future new build homes.

Test: Zero Carbon Grid by 2030

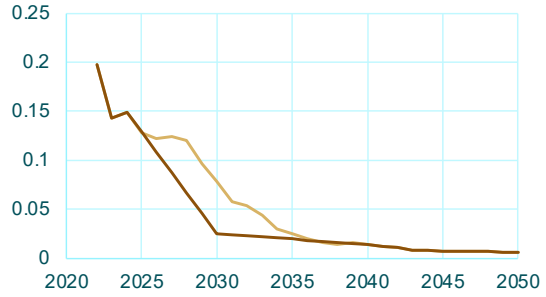
This test intends to represent, in a simplified way, the new (2024) government's ambition for a near-zero carbon grid by 2030, rather than 2035. It was modelled by modifying the assumptions for electrical grid capability and carbon factor (see p.21), to achieve in 2030 the values which are achieved in the baseline Scenario in 2035: see illustrations below. **These are approximations only; the assumptions should be revised once updated data is available from the National Energy System Operator (NESO).**

	2022-2050	2022-2035	2036-2050
OPERATIONAL CARBON (MTCO2)			
Budget	1,352	1,133	219
Used: Balancing Model	1,316	1,172	145
Used: This Test	1,235	1,101	134
UPFRONT CARBON (MTCO2)			
Budget (Top Down)	278	241	37
Used: Balancing Model	338	275	63
Used: This Test	338	275	63
TOTAL CARBON (MTCO2) (incl. F-Gas, though not shown on this table)			
Budget (Top Down)	1,654	1,390	264
Used: Balancing Model	1,669	1,451	218
Used: This Test	1,588	1,380	208

Low Carbon Grid Capability, TWh



Grid Carbon Factor, $kgCO_2/kWh$



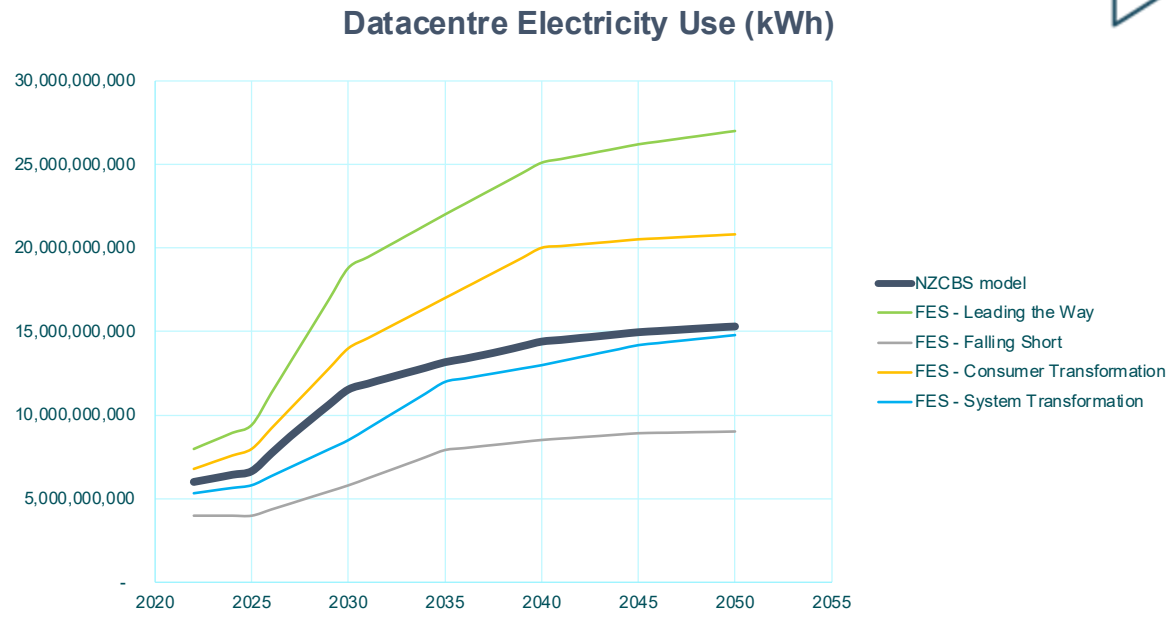
Notes
Under the current (very approximate) assumptions, the increased and earlier low carbon grid capability would have a significant positive impact on overall carbon and electricity balance.

07 Appendix B Consideration of Other Trends

Other factors than those tested in the previous section could differ in the future from what has been assumed in the model. This section presents non-quantitative considerations on two of these factors: datacentre growth, and UK-based industry & manufacturing. Other important contextual factors may in the future evolve differently than in the UKNZCBS model. The model is intended to evolve over time, so these changes can be explored in the future.

Datacentre Growth

The UKNZCBS Balancing Model includes a higher increase in datacentre energy use than in the Future Energy Scenarios (2022) ”System Transformation” and “Falling Short” scenarios, but lower than the “Leading the Way” and “Consumer Transformation” scenarios. This represents significant growth in datacentre energy use, increasing almost threefold from 2021 to 2050. It is the sector in the UKNZCBS model which by far sees the highest floor area growth (see p.19) and the only one which sees an overall increase in energy use. Its share of energy (electricity + other fuels) use by the total building stock increases from 0.9% in 2021, to 5% in 2050.



Notes

Growth in AI, and the location of datacentres in the UK to cater for it, could potentially lead to even higher impacts on energy use than currently modelled in the Balanced Scenario. In October 2024, Government signalled it is seeking significant growth in datacentre and AI capacity in the UK. Announcements by the National Grid suggest a six-fold increase in demand (power or annual energy use, tbc) from commercial data centres over 10 years. Information available at this stage does not allow a comparison of these announcements with the assumptions in the UKNZCBS model. This could be an area to consider for future revisions of the model, including discussions with PMA on whether they expect recent announcements to modify their projections.

Industry & Manufacturing

The new UK Government has announced its intention for industrial growth, including manufacturing. Information available at this stage does not allow a comparison with the assumptions in the UKNZCBS model.

This should be examined as more information becomes available including:

- Updated energy and carbon budgets for the UK and, within this, for the built environment: it is currently not known whether and how an increase in UK manufacturing and industrial capacity would be reflected in the budgets and associated CCC recommendations.
- Potential impacts on UK imports of materials for construction, vs used of UK-sourced materials.

08 Appendix C
Comparison with Industry and Policy Context

UK Net Zero Carbon Buildings Standard

Comparison: CLC Retrofit Strategy

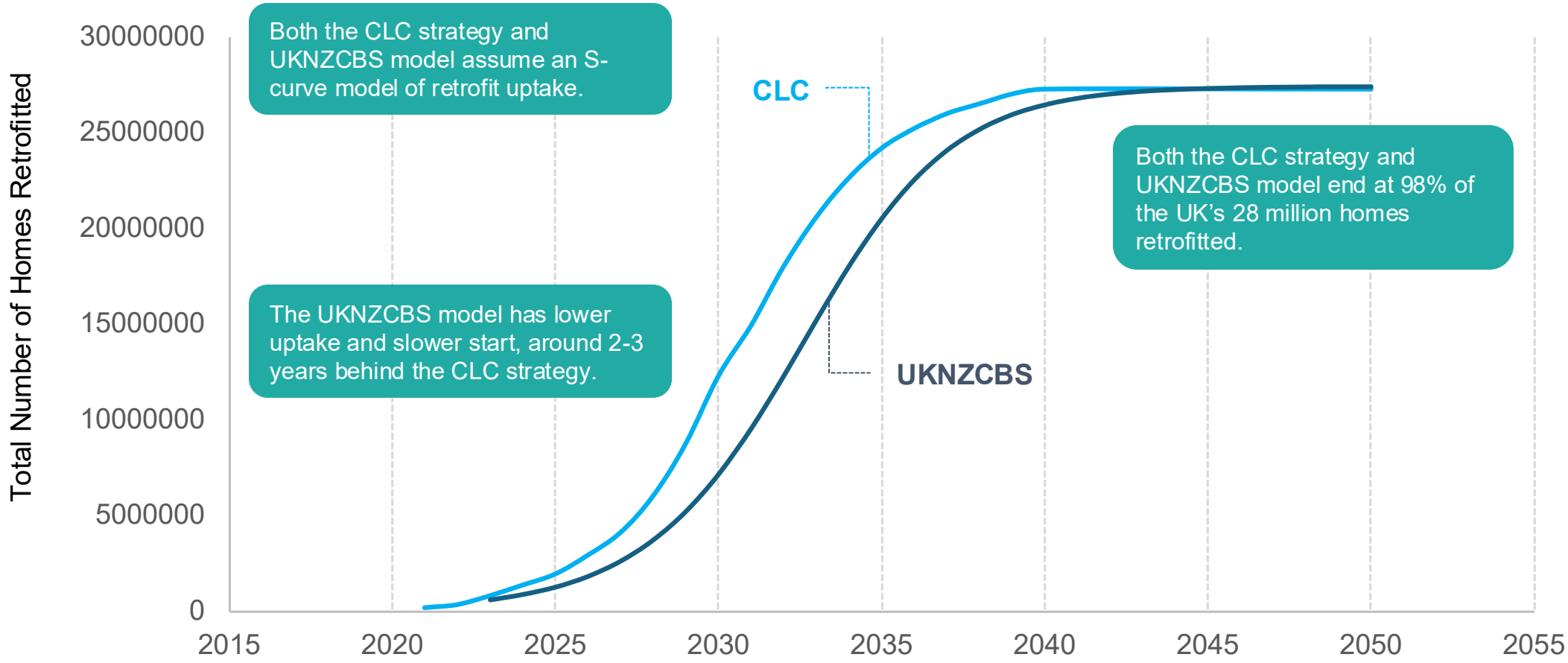
Both the CLC National Retrofit Strategy (V2, May 2021) and the UKNZCBS model follow an S-curve of retrofit uptake across the stock, and both end at 98% of the 28 million homes being retrofitted.

The main differences between both are about timing:

- The CLC Retrofit Strategy assumed that around 1,055,000 homes would be retrofitted over 2021-4. The UKNZCBS shows lower uptake in these early years, with around 868,000 in that period.
- The CLC Retrofit Strategy assumed that by 2030 12,300,000 homes, or 44%, would be retrofitted. The UKNZCBS reaches this uptake by 2032, reflecting a slower start in early years.
- The CLC Retrofit Strategy assumed that 98% would be retrofitted by 2040. The UKNZCBS reaches this uptake by 2050, though it is very close (97%) from 2043 and plateaus from that point.

This is illustrated on the following page.

Comparison: CLC Retrofit Strategy



Comparison: Retrofit at Scale

Retrofit at Scale examines “how retrofit could, and should, become a mass rollout across 28 million UK homes”. It proposes a “Basic” level of retrofit as key to enable this mass roll out.

Retrofit Levels

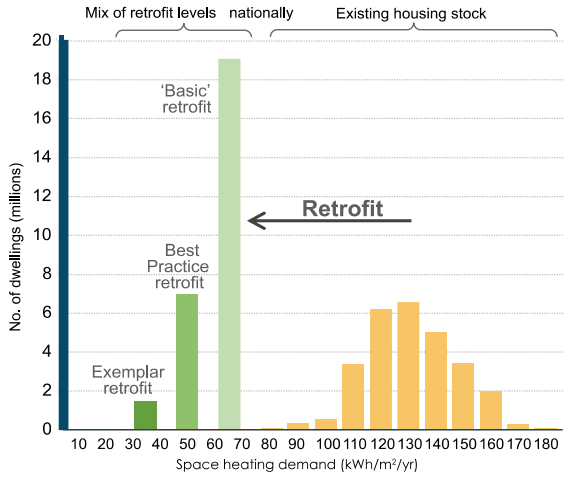
- The EUI equivalent of Retrofit at Scale “Basic” level is not published, therefore a direct comparison with UKNZCBS Retrofit levels is not possible. However:
- It represents some intervention on the fabric, as well as the installation of a heat pump
- It is less ambitious than LETI “Best Practice”.

Notes
It is therefore expected that the UKNZCBS “Medium” Retrofit is not dissimilar, in intended outcomes, to Retrofit at Scale “Basic” level.

Stock Modelling

- In both models, approximately 98% of the stock gets retrofitted.
- In the UKNZCBS stock modelling, Medium retrofit is applied to 90% of the retrofitted stock. In the Retrofit at Scale stock modelling, the “Basic” retrofit is applied to approximately 68% of the stock.
- In the UKNZCBS stock modelling, Light retrofit is applied to 5% of the retrofitted stock, and Deep to 5% of the retrofitted stock. In the Retrofit at Scale stock modelling, Best Practice Retrofit (from LETI) is applied to 25% of homes and Exemplar Retrofit (also from LETI) to around 5% of homes. LETI Best Practice and Exemplar are more ambitious than UKNZCBS Medium Retrofit (see p.33).

Notes
Overall, while no exact comparison is possible, the level of intervention in Retrofit at Scale is therefore likely “deeper” than in the UKNZCBS model.



Retrofit at Scale – Mix of Retrofit Levels

Comparison: Future Homes Hub OE levels

An indicative comparison is shown here between the energy use levels expected of new build homes post 2028 i.e. after implementation of the Future Homes Standard: 1) from the Future Homes Hub, as provided to the UKNZBCS team as part of their involvement in the UKNZCBS development; 2) in the UKNZCBS model, for new build homes meeting compliance only (not the Best Practice ones – see pp. 26-27).

Per m²	Future Homes Hub "contender specs" for the FHS, kWh/m²TFA/yr *(TBC – possibly in GIA)*				Post-2028 Homes Assumption in UKNZCBS Model, kWh/m²GIA/yr
	CS1 (FHS 2023 consultation option 2)	CS2 (FHS 2023 consultation option 1)	CS3	CS4	
End Terrace	N/A	57.3	53.7	50.3	61.9
Room in Roof Semi-Detached *	N/A	56.1	50.7	47.3	61.9
Mid-terrace *	N/A	51.6	47.4	45.2	56.7
Detached *	N/A	N/A	47.3	N/A	61.0
Large Detached*	N/A	42.5	40.5	36	61.0
Bungalow*	N/A	57.5	54.8	49.4	68.6

Per Dwelling	Future Homes Hub "contender specs" for the FHS Annual Energy Use, kWh/yr					Post-2028 Homes in UKNZCBS Model	
	Dwelling Size, m²TFA	CS1 (FHS 2023 Consultation Option 2)	CS2 (FHS 2023 Consultation Option 1)	CS3	CS4	Dwelling Size, m²GIA	Annual Energy Use, kWh/yr
End Terrace	81	N/A	4,650	4,350	4,080	88	5,450
Room in Roof Semi-Detached *	113	N/A	6,340	5,730	5,350	97	6,010
Mid-terrace *	81	N/A	4,180	3,840	3,670	88	4,990
Detached *	127	N/A	N/A	6,010	N/A	149	9,090
Large Detached*	246	N/A	10,460	9,970	8,860	149	9,090
Bungalow*	98	N/A	5,640	5,380	4,850	77	5,290

** FHH number should be higher, as the one shown is "net" of PV*
*** Size of homes: extrapolated from England data, EHS*

Notes
The comparison is not exact:
- Some of the figures available from the FHH take account of the benefits of on-site PVs.
- The FHH figures come from SAP, which is for compliance purposes, not intended as performance modelling of energy use.
- Assumed dwelling sizes are different, and FHH typologies do not include flats.

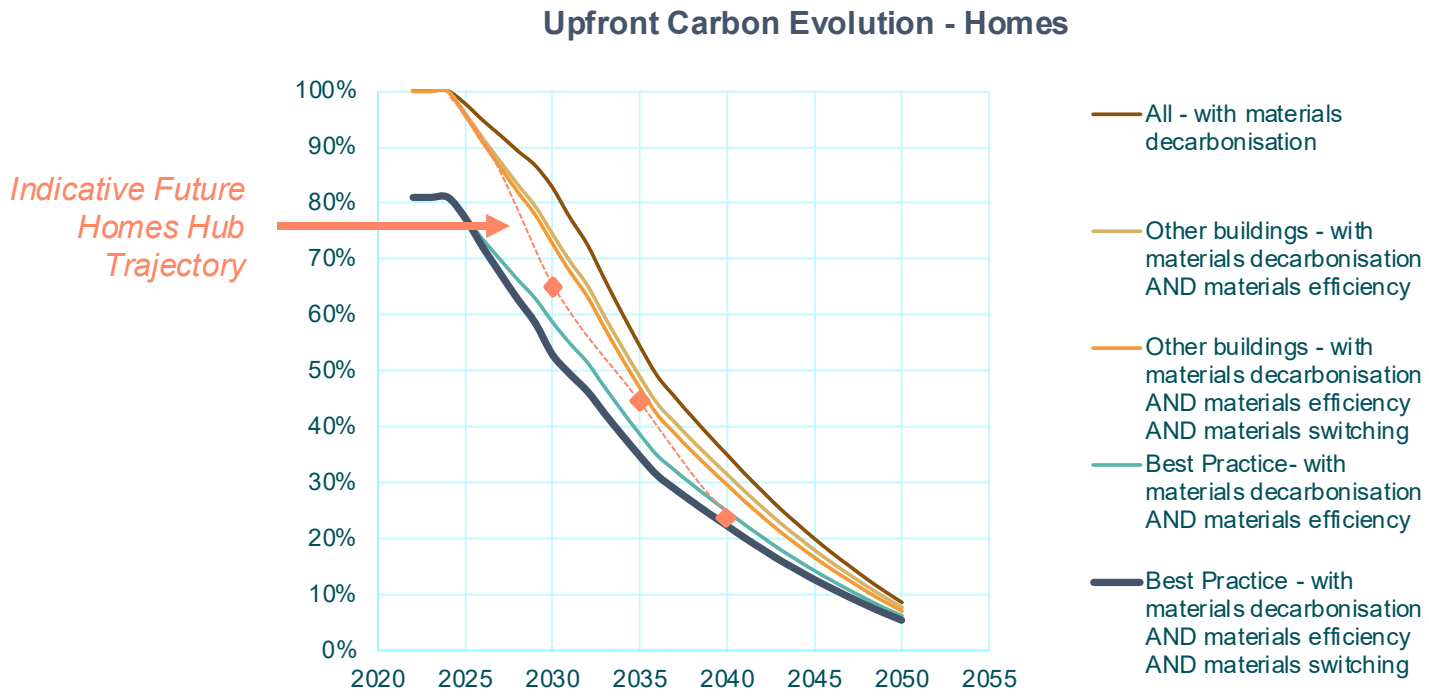
Overall however, the assumptions on energy use for new homes built to compliance (rather than Best Practice) in UKNZCBS model are not dissimilar (+/-20%) to the Future Homes Hub "contender specs" for the FHS.

Comparison: Future Homes Hub UC trajectory

As illustrated on p.29, materials decarbonisation makes up the large majority of modelled reductions in upfront embodied carbon over time. A comparison is shown here, for new build homes, with the Future Homes Hub Roadmap (One Plan, December 2024), whose ambitions are reductions in UC delivered to site of 25% by 2030, 55% by 2035, and 75% by 2040. These percentages are understood to be viewed relative the FHH upfront carbon baseline that is around 10-15% lower than the UKNZCBS upfront carbon performance levels and are shown as such on this graph.

Notes
The trajectories from the FHH and NZBCS model are relatively consistent:

- In early years, to 2035, the FHH trajectory is very similar to the “Other Buildings” one in the UKNZCBS model i.e. the majority of the industry, not adopting Best Practice.
- From 2040, the FHH trajectory joins the Best Practice/UKNZCBS one.



Comparison: Government Targets for Heat Pump Uptake

Government Targets

Previous Government targets for heat pump installations are outlined here and summarised below. It is not known whether these will be revised by the new (2024) Government.

- 600,000 heat pump installations annually by 2028, across the domestic and non-domestic sectors. 200,000 of these are assumed by government be from new build homes.
- 1.7m heat pump installations annually by mid 2030s.

UKNZCBS Balancing Model

Non Domestic: Inputs to the model are in floor area, not number of buildings or demises, therefore estimating the number of installed heat pumps from the floor areas is not straightforward.

As a result, only Domestic heat pump installations are examined here.

- **New Build:** In 2028 approximately 175,300 dwellings (based on English Housing Survey data of which 31% are heat pumps i.e. 54,300 installations). In 2035, the model assumes approximately 159,900 dwellings, of which 48% are heat pumps i.e. 76,500 installations.
- **Retrofitted Dwellings:** In 2028, the model assumes that just under 4% of the stock is getting retrofitted, equivalent to approximately 1,112,600 homes. In 2035, it assumes around 8.9% of the stock getting retrofitted, equivalent to approximately 2,504,200 homes. In both cases, the large majority is assumed to have heat pumps.

The UKNZCBS model therefore assumes a significantly higher number of heat pump installations in 2028 and in the mid-2030s, than under (previous) government plans.

9 – Glossary, Acknowledgements & Feedback

UK Net Zero Carbon Buildings Standard

Glossary

BEES	Building Energy Efficiency Survey
BEIS	Department for Business, Energy and Industrial Strategy
CCC	Climate Change Committee
CIBSE	Chartered Institution of Building Services Engineers
CLC	Construction Leadership Council
DESNZ	Department for Energy Security and Net Zero
EC	Embodied Carbon
EPC	Energy Performance Certificate
ESO	Energy Systems Operator
EUI	Energy Use Intensity
FBS	Future Buildings Standard
FES	Future Energy Scenarios (from National Grid ESO)
FF	Furniture & Fixtures
FHH	Future Homes Hub
FHS	Future Homes Standard
LETI	Low Energy Transformation Initiative
M&C	Manufacture & Construction
MEP	Mechanical, Electrical & Public Health (Equipment)
NESO	National Energy Systems Operator
NZ	Net Zero
OE	Operational Energy
PMA	Property Market Analysis
SAP	Standard Assessment Procedure
SCOP	Seasonal Coefficient of Performance
UCL	University College London
UKGBC	United Kingdom Green Building Council
UKNZCBS	United Kingdom Net Zero Carbon Buildings Standard

Acknowledgements & Feedback

Acknowledgements

The UKNZCBS wishes to thank the RIBA for funding the development of an excel based data model which was developed by Verco, supported by Turley. This model brought a vast amount of information together, including industry information and datasets from the UKNZCBS Task Groups and brought together the top down and bottom-up work. The UKNZCBS are incredibly grateful to Julie Godefroy (CIBSE) and Clara Bagenal George (LETI) as members of the Technical Steering Group (TSG) who - on behalf of the UKNZCBS – worked to further test and refine the model and create the performance scenarios that are fundamental to the Standard's limit setting process.

Any Feedback?

Thank you for reading and engaging with this document and the Standard more widely. If you have read the background and Scenario testing included within this documents and its Appendices and wish to provide the UKNZCBS team with comments and feedback on the approach, scenarios and data sources used, we would welcome your engagement.

Please email us at info@nzcbuildings.co.uk with the subject line ‘Feedback on UKNZCBS Limit Setting’.