



CLIMATE CHANGE

Developing Guidance to Achieve Net Zero Carbon
Buildings

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LIST OF ABBREVIATIONS AND ACRONYMS

UK	United Kingdom
CO ₂	Carbon Dioxide
PPM	Parts Per Million
CCA	Climate Change Act 2008
RIBA	Royal Institute of British Architects
GCBBM	Green Construction Board Building Mission
CCC	Committee on Climate Change
The Code	Code for Sustainable Home
FHS	Future Homes Standard

ABSTRACT

Climate change is one of the biggest problems the world currently faces, and this will not change unless reductions are made to the amount of greenhouse gasses the planet produces. In an attempt to combat climate change the UK government has introduced a legally binding target to reduce the UK's production of greenhouse gasses by 100% by 2050 against a 1990 baseline.

Almost 20% of the UK's carbon emissions comes from homes, and with a shortage of new homes in the UK and the ambitious aim to build up to 300,000 new homes each year, this will only rise if not combated directly.

It was hypothesised by the researcher that by developing specific guidance which can be utilised by volume housebuilders to create a development framework, new homes being built in the UK will be able to deliver net carbon whole life neutrality. This in turn can aid the UK to meet the legally binding target imposed by the 2050 Target Addendum to the Climate Change Act 2008.

By conducting a thorough literature review, the researcher was been able to establish the benefits and limitations of past and current methodologies and frameworks. The researcher was also able to understand via a case study how a development can achieve net zero carbon emissions in practice. As a result the researcher was able to conclude various key areas for guidance, which can be used to inform a detailed development framework to ensure new homes are more sustainable and therefore achieve the target of the 2050 Target Addendum to the Climate Change Act 2008.

1. INTRODUCTION

1.1 Background

The UK and the rest of the world are facing a global emissions crisis. The last four years have been the hottest on record and global emissions have reached record levels with no sign of peaking (The UN, 2019). For the past 800,000 years the global atmospheric carbon dioxide concentrations (CO₂) in parts per million (ppm) has never climbed higher than 300 ppm, in 2018 it reached 407.4 ppm (Lindsey, 2020). If this problem isn't targeted directly, further un-reversible damage will be done across the globe.

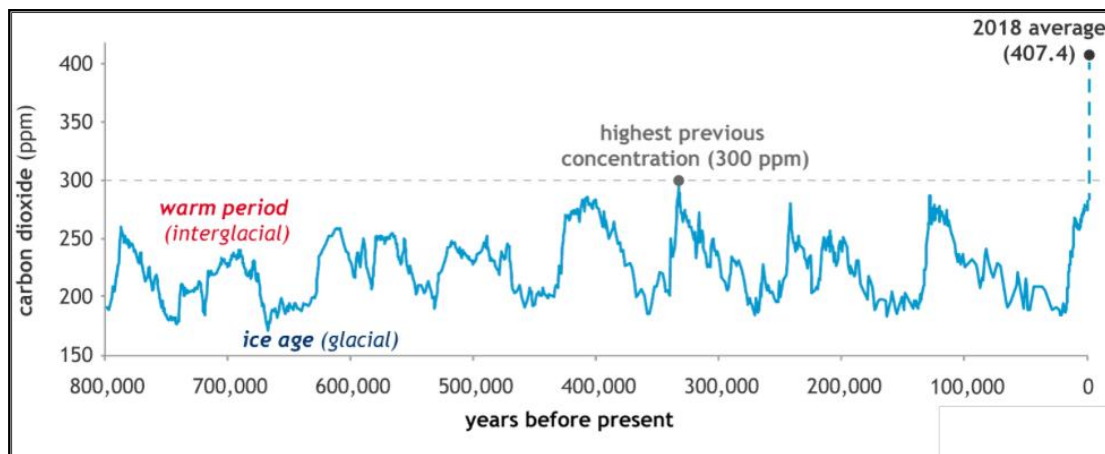


Figure 1: CO₂ Emissions during ice ages and warm periods for the past 800,000 years (Lindsey, 2020).

216 members of the UN made a massive stride forward in implementing a global strategy to reduce greenhouse gas emissions in 2016 when the signed Paris Agreement came into force. The Paris agreement unites all nations with a common goal to make ambitious efforts to combat climate change and adapt to its effects (United Nations Climate Change, 2017), by phasing out greenhouse gas emissions by the second half of the century, while promoting sustainable development and poverty eradication (Doyle, 2019).

In response to the Paris Agreement on the 27th June 2019, the UK became the first major economy in the world to pass laws to end its contribution to global warming by 2050. This was carried out via an amendment to the Climate Change Act 2008. The ambitious target will require the UK to bring all greenhouse gas emissions to net zero by 2050 (Department for Business, Energy & Industrial Strategy, 2019).

The new legislation and targets which have been put in place leads perfectly into the housing situation in the UK. Currently in the UK there is a shortage of new homes, the government in its recent Housing White Paper referred to the need for up to 250,000-300,000 new homes to be constructed per year. In relation to this, according to the Committee on Climate Change, 18% of the UK's carbon emissions comes from buildings, most of them being homes (Energy Saving Trust, 2019).

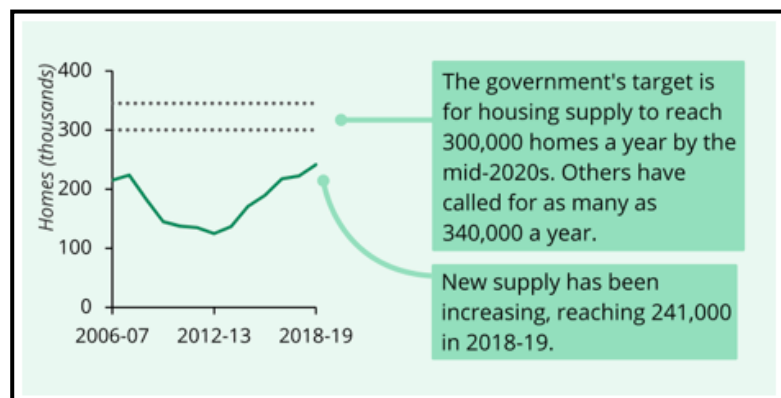


Figure 2: Trends in UK housing supply (Barton and Wilson, 2020).

Professional body the Royal Institute of British Architects (RIBA) see the revised CCA target as a step in the right direction but felt that the UK's target could be achieved as early as 2030, which is 20 years ahead of current Government targets. The RIBA believe that ensuring that new and retrofit buildings deliver net zero whole life carbon neutrality is the way to achieve this target (RIBA, 2019). Their rationale for bringing the deadline forward is due to the findings in the recent Green Construction Board Buildings Mission (GCBBM) 2013 report, which shows that net zero whole life carbon is already possible with today's technologies.

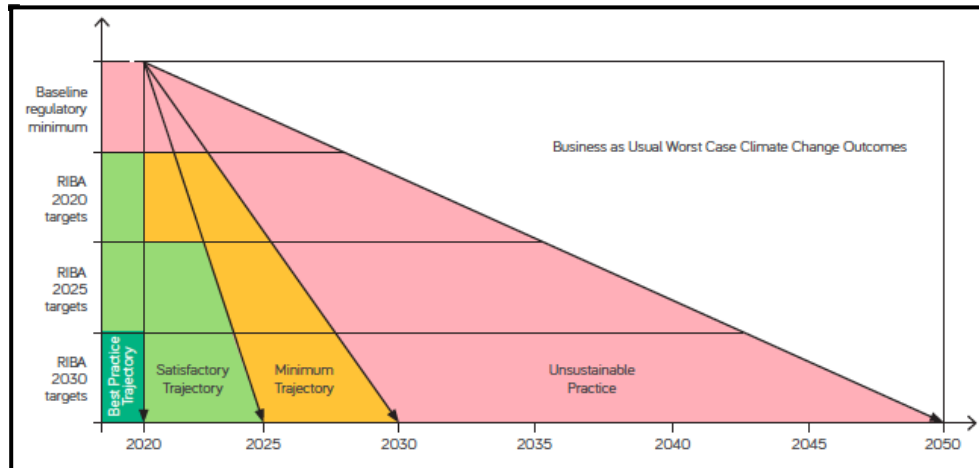


Figure 3: RIBA 2030 Climate Challenge Trajectories (Royal Institute of British Architects, 2019).

A testament to the findings of the GCBBM report and the ambitious target set out by the RIBA, is the 2019 Sterling Prize winner, Goldsmith Street. Goldsmith street is a carbon neutral residential housing development consisting of nearly 100 houses and flats which meets the rigorous Passivhaus standards (Hopkirk, 2019), which proves that the technologies are available to achieve the CCA addendum requirements.

1.2 Problems Statement

Like many other large industries, construction is very slow to change, with most change being legislation led through the Building Regulations and industry-related initiatives such as BREEAM (Patience and Kirkman, n.d.). Nonetheless, to achieve the targets set before the UK by the Government and the RIBA, the construction industry cannot wait for the appropriate legislation to come into place before making the necessary changes.

2. AIM AND OBJECTIVES

2.1 Aim

This research aims to investigate current and past methodologies / frameworks which intend to improve the sustainability of new homes and thereby develop specific guidance which can be utilised to create a development framework to meet the legally binding target of the 2050 Target Addendum to the Climate Change Act 2008.

The legally binding target imposed is:

- 100% reduction in greenhouse gas emissions by 2050, against the 1990 baseline.

2.2 Objectives

1. To review existing literature into methods and frameworks which aim to improve the sustainability of new homes and reduce their carbon output.
2. To establish the benefits and limitations of current and past methodologies / frameworks which aim to improve the sustainability of new homes.
3. To critically analyse professional opinion in the topic area collected by questionnaires, thereby developing specific guidance for the construction industry to on future implementation framework to meet targets.

3. LITERATURE REVIEW

3.1 Introduction

In order to form a better understanding of previous research and relating issues surrounding this research topic, it is essential for the researcher to carry out a thorough literature review. Conducting a literature review is essential for the researcher to develop the research idea. It allows the researcher to consolidate what is already known about the topic area and the ability to identify any gaps in knowledge and how the research could contribute to further understanding (Winchester and Salji, 2016).

To meet the ambitious legally binding target of the 2050 Target Addendum to the Climate Change Act 2008, new homes in the UK need to be built to deliver net zero whole life carbon neutrality going forward. Despite this, there is a lack of guidance or development framework currently available so that house builders can deliver the sustainable homes the UK desperately needs. In order to provide house builders with the guidance they need to build sustainable homes, research needs to be carried out current and past methodologies / frameworks to understand as to what extent they were applied, and what results have been found from their implementation. This will determine whether there are suitable aspects which can be utilised to create a new development framework to allow new homes to deliver net zero whole life carbon neutrality, and in turn meet the CCA target to bring all greenhouse gas emissions to net zero by 2050 against the 1990 baseline (NHS, n.d.).

3.2 The Climate Change Act 2008

3.2.1 Policy Change – What Influenced the UK Government to introduce the CCA?

In Order to meet the targets, set out by the UK's Climate Change Act 2008, 2050 Target Addendum and bridge the gap between itself and volume house builders, the researcher must first understand why this target has been introduced.

Greenhouse gasses are necessary to keep the average temperature at the surface of the earth suitable to sustain life (Saunders, 2014). However, increased levels of greenhouse gasses cause warming and affects various aspects of climate, including surface air and ocean temperatures, precipitation and sea levels. Human health, water resources, agriculture, wildlife and coastal areas are all vulnerable to climate change (Greenhouse Gases, n.d.). The major greenhouse gas is carbon dioxide. CO₂ is emitted naturally by burning fossil fuels and stays in the atmosphere (Saunders, 2014) for an extremely long period of time, ranging from a few centuries to many thousands of years (Moore, 2008).

Climate change first started to impinge on UK policy making decisions in the late 1980's. The Rio Earth Summit in 1992, was the catalyst which pushed the UK government to sign the Kyoto protocol in 1997. The protocol committed the UK and other developed countries who signed to binding reductions in greenhouse gas emissions for the period 2008-2012 by 13% - based on 1990 levels (Institute for Government, n.d.).

By the early 1990's the UK was already on track to deliver on its Kyoto commitments, however to show the Government's (Labour party at the time) determination to display leadership on climate issues, it committed itself to a more ambitious domestic target reduction in greenhouse gas (carbon dioxide) emissions of 20% by 2010 (Institute for Government, n.d.).

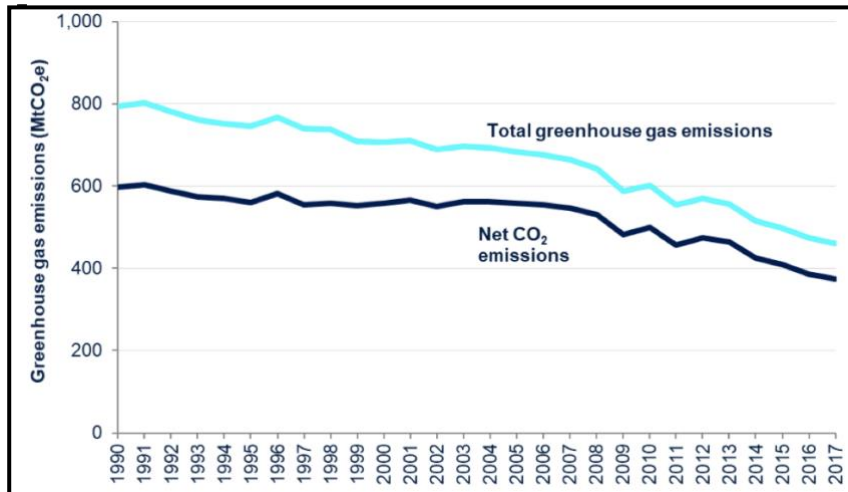


Figure 4: Total UK greenhouse gas emissions, 1990 Baseline – 2017 (MtCO₂e) (Department of Environment, Food and Rural Affairs, 2019)

However, by 2004, it became clear that the government was off target and projected to only achieve a 10.6% reduction by 2010 – of which 5.6% had been achieved between the period 1990-1995. When the 2006 local elections proceeded, climate change had become an increasingly popular topic of discussion and prompted many government parties to change its position on climate change. This led to climate change being at the top of their priorities (Institute for Government, n.d.).

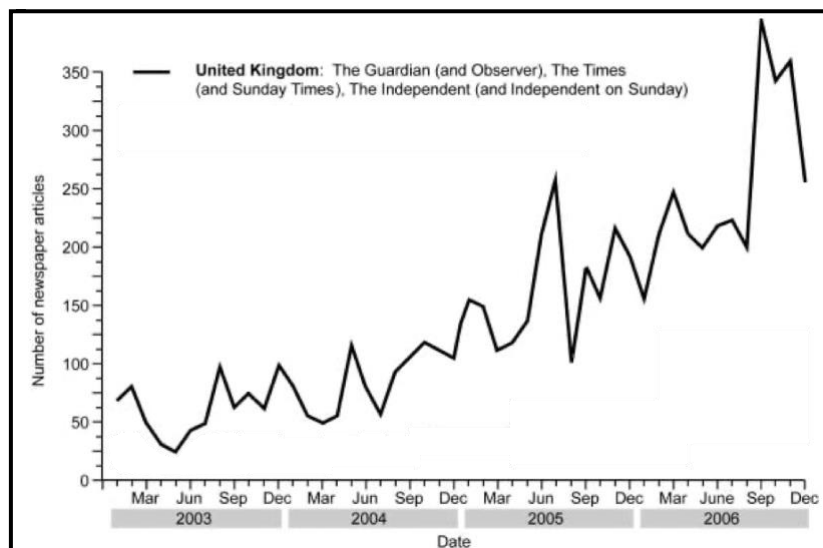


Figure 5: UK Newspaper coverage of Climate Change - Reproduced from (T Boykoff, 2007).

With climate change at the top of the government's political agenda and the later release of two highly influential documents, one by 'Friends of Earth', and the second was Nick Stern's review of the report 'The Economics of Climate Change'. They stressed that taking early action was the lowest cost policy option to combat climate change which led to the accelerated creation and implementation of the Climate Change Act 2008 (Institute for Government, n.d.).

3.2.2 What is the Climate Change Act 2008?

The Climate Change Act became law on 26th November 2008, the act was introduced to address both the causes and consequences of climate change. The act created a new approach for the UK to manage and respond to climate change by setting ambitious targets, assuming powers to help achieve them, strengthening the institutional framework, enhancing the UK's ability to adapt to the impact of climate change and lastly establish clear and regular accountability to the UK and Parliament (NHS, n.d.).

There are two key aims which underpin the Act:

1. Improve carbon management and help the transition towards a low carbon economy in the UK.
2. Demonstrate strong UK leadership internationally, to signal that the UK is committed to taking its fair share of responsibility for reducing global emissions.

In order to achieve the above key aims the CCA also introduced a series of key provisions. A selection which can be seen below.

1. Legally binding targets – the initial targets were at an 80% reduction in greenhouse gas emissions by 2050 and a reduction of at least 26% in CO₂ emissions by 2020, against a 1990 baseline. However, in 2019, following advice from the Committee on Climate Change (CCC), the Act

was amended to change the 2050 target to a reduction of at least 100%, against a 1990 baseline (NHS, n.d.).

2. A Carbon budgeting system which caps emissions over five-year periods, with three budgets set at a time, which the government must report to parliament its policies and proposals to meet these budgets. A table showing the targets of the current carbon budgets can be seen below (NHS, n.d.).

3. The creation of the committee on climate, which is an independent expert body whose aim is to advise the Government on the level of carbon budgets and propose cost effective saving solution where applicable. The Committee is also responsible for submitting annual reports to Parliament on the UK's progress towards targets and budgets, which the Government must respond to, ensuring transparency and accountability on an annual basis (NHS, n.d.).

Budgetary Period	Years Covered	Carbon Budget (MtCO ₂ e)	Average annual reduction (cf.1990)
1	2008-12	3,018	-23%
2	2013-18	2,782	-29%
3	2018-22	2,554	-35%
4	2023-27	1,950	-50%
5	2028-32	1,765	-57%
6	2033-37	Set by 30/06/2021	...
...	2050	0	-100%

Table 1: Carbon Budgets range 2008 -2032. Reproduced from (What is the Climate Change Act?, 2016)

3.3 RIBA 2030 Climate Challenge

Following the introduction of the 2050 Target Addendum to the Climate Change Act 2008, the RIBA announced that they had developed a document called the '2030 Climate Challenge'. The purpose being to help architects meet net zero (or better) whole life carbon for new and retrofitted buildings by 2030 (2030 Climate Challenge FAQs, 2020).

Based on the latest recommendations from the Green Construction Board, the RIBA believe that net zero whole life carbon is already possible. They acknowledge that their targets outlined in their guidance document are progressive, but stress they are a vital first step to ensure that the construction industry delivers significant carbon reductions by 2030, so the industry has a realistic prospect of achieving net zero carbon for the whole UK building stock by 2050 (RIBA, 2019).

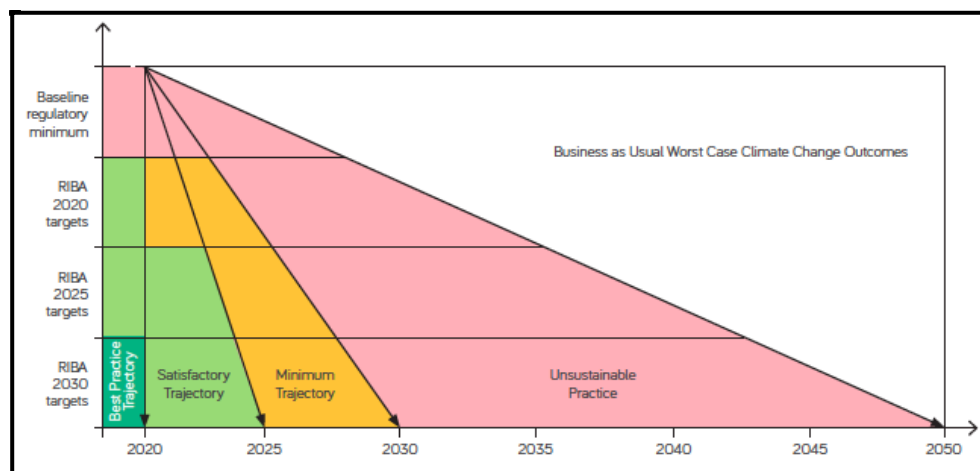


Figure 6: RIBA 2030 Climate Challenge Trajectories (Royal Institute of British Architects, 2019).

RIBA target reductions:

1. Reduce operation energy demand by at least 75%, before UK offsetting.
2. Reduce embodied carbon by at least 50-70%, before UK offsetting.
3. Reduce potable water use by 40%.
4. Achieve all core health and wellbeing targets (RIBA, 2019).

The targets developed are for operational energy use, embodied carbon and water use reduction (RIBA, 2019). These targets will be useful for volume housebuilders to work to when designing and constructing new homes, however as previously mentioned these are just targets. The guidance does not tell developers and other members of the construction industry how to achieve these targets, it simply recommends that project teams aim for a percentage reduction of current baselines and minimum standards, based on the trajectory figure above and targets set out below.

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m ² /y 	146 kWh/m ² /y (Ofgem benchmark)	< 105 kWh/m ² /y	< 70 kWh/m ² /y	< 0 to 35 kWh/m ² /y	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon kgCO ₂ e/m ² 	1000 kgCO ₂ e/m ² (M4i benchmark)	< 600 kgCO ₂ e/m ²	< 450 kgCO ₂ e/m ²	< 300 kgCO ₂ e/m ²	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day 	125 l/p/day (Building Regulations England and Wales)	< 110 l/p/day	< 95 l/p/day	< 75 l/p/day	CIBSE Guide G

Figure 7: RIBA 2030 Climate Challenge target metrics for domestic buildings (Royal Institute of British Architects, 2019).

3.4 Zero Carbon Homes

To achieve the 2050 Target Addendum to the Climate Change Act 2008, understanding what net zero Carbon will mean for the construction of new homes in the UK is crucial. The UK Green Building Council (UKGBC) published the document 'Net Zero Carbon Buildings: A Framework Definition' on April 30th, 2019 to provide the construction industry with clarity on how to achieve Net Zero Carbon in construction and operation (in-use energy consumption) (Morris, 2019).

For a building's construction the term net zero definition provided is "when the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the

use of offsets or the net export of on-site renewable energy” (Net Zero Carbon Buildings: A Framework Definition, 2019).

For a building’s operational energy, it is “when the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative”. A net zero carbon building is “highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset” (Net Zero Carbon Buildings: A Framework Definition, 2019).

As previously mentioned, the ‘Net Zero Carbon Buildings: A Framework Definition’ is intended to provide the construction industry with clarity on how to achieve Net Zero Carbon on construction (Morris, 2019). However, the framework itself only outlines the key principles which should be followed.

The key principles outlined in the framework are:

1. Establish Net Zero Carbon Scope. (Whether its net zero carbon construction or operational energy)
2. Reduce Construction Impacts.
 - a. Undertake a whole life carbon assessment
 - b. Embodied carbon impacts from the product and construction stages should be offset.
3. Reduce Operational Energy Use.
 - a. Reduction in energy demand and consumption should be prioritised.
4. Increase Renewable Energy Supply.
 - a. On-site renewable energy source should be prioritised.
 - b. Off-site renewables should demonstrate additionally.
5. Offset Any Remaining Carbon
 - a. Any remaining carbon should be offset using a recognised offsetting framework.

(Net Zero Carbon Buildings: A Framework Definition, 2019).

The key principles outlined are useful for outlining the steps needed to achieve a Net Zero Carbon Building, however the framework fails to provide developers with the appropriate methods which can be followed to achieve Net Zero Carbon.

3.5 Code for Sustainable Homes

As part of the UK government's first initiative to tackle climate change, it promoted the construction of sustainable homes. They achieved this through the introduction of the Code for Sustainable Homes (the Code) (Patience and Kirkman, n.d.) in 2006 which later became operational in 2007 (Code for Sustainable Homes, 2019). The Code was an environmental impact rating for housing in England and Wales, which sought to set new standards for energy efficiency (above those which were set out in the building regulations) and sustainability (BREEAM and Code for Sustainable Homes, 2017). Homes were rated against nine categories and were awarded a star rating between levels 1 and 6, with 6 being the most sustainable (Heffernan, Pan, Liang and de Wilde, 2015).

The nine categories which the Code measured sustainability were:

- Energy and carbon dioxide emissions.
- Water.
- Materials.
- Surface water run-off.
- Waste.
- Pollution.
- Health and Wellbeing.
- Management.
- Ecology.

Each category represented a known source of environmental impact for which mitigation measures can be implemented. Performance targets were set for each area, and credits were awarded depending on the performance of the dwelling in each area. These credits were then totalled, resulting in the dwellings overall star rating (Code for Sustainable Homes, 2019).

During the 8-year life span of the Code there were many positive and negative outcomes. One of the main objectives of the code was to drive sustainable improvements within the construction industry, and many would agree in that respect that the code delivered. Max Fordham, British designer, engineer and pioneer of sustainable design describes the Code as “a hook for reluctant designers and developers to think about sustainability, something they would never have done before” (Fordham, n.d.).

On the other hand many designers failed to see the positive benefits of the Code, instead it was seen as just an analysis of credit against cost, even more so in the eyes of the contractors, where the cheapest option would always be the winner (Heffernan, Pan, Liang and de Wilde, 2015).

In Max Fordham's blog he does support the view of the designers as he describes that throughout the construction industry many saw the Code as a preconceived tick box exercise to gain credits to achieve the best possible star rating. This combined with the lack of flexibility in the code often led to designers implementing credit gaining measures into their designs which were not applicable to the development. Whereas if the credit scoring feature had been more flexible it would have allowed designers to be more creative whilst still delivering quality sustainable housing (Fordham, n.d.).

The Code was eventually 'wound down' in 2015, with many of the requirements being consolidated into the building regulations (equivalent to the Code star rating 4), which was welcomed by the industry (Code for Sustainable Homes, 2019). Although concerns were expressed regarding the potential negative effect on the quality of homes as a result of the removal of the code (Heffernan, Pan, Liang and de Wilde, 2015). This correlates with the findings of

Max Fordham. His findings show that it is widely accepted that the code wasn't perfect and was in need of an overhaul. However, without a system like the Code being in place, there is a danger now that all the good work up until its consolidation will be lost (Fordham, n.d.).

3.6 2020 Future Homes Standard (Part L Update)

In October 2019, the Ministry of Housing, Communities & Local Government published a consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings, known as 'The Future Homes Standard' (FHS).

The purpose of the FHS is to ensure that the new homes being built in the next five to ten years (which will still exist in 2050) will meet the energy efficiency standards needed to meet the 2050 Target Addendum to the Climate Change Act 2008. However, the FHS standard will not be introduced until 2025, instead a meaningful but achievable uplift to energy efficiency standards will be introduced as a steppingstone to the FHS (Ministry of Housing, Communities and Local Government, 2019).

The consultation sets out two options for comment, to up lift the energy efficiency standards and requirements:

- Option 1 – 20% reduction in carbon emissions compared to the current standard for an average home. The consultation explains this could be delivered by very high fabric standards (typically with triple glazing and minimal heat loss from wall, ceilings and roofs).
- Option 2 – 31% reduction in carbon emissions compared to the current standard. The consultation explains this could be delivered by the installation of carbon saving technologies such as photovoltaic panels and better fabric standards, though not as high as in option 1.

(Ministry of Housing, Communities and Local Government, 2019).

Many have been quick to point out that waiting till 2025 is too late to introduce the FHS. Sue Riddlestone OBE argues that all new buildings will need to operate at net zero carbon to limit global heating to 1.5 degrees by 2030. Working back from this means that by 2025 every single new home will need designed as such. Riddlestone argues that the FHS could firmly put us on track to achieve this if it is made available before 2025 (Riddlestone, 2020). However, the consultation states that the reason for the delayed introduction, and instead opting for a meaningful uplift in the meantime, is to prepare supply chains and increase the number of trained installers for systems such as heat pumps (Ministry of Housing, Communities and Local Government, 2019).

Another concern that has been raised is that new homes will be less energy efficient if important linked standards are scrapped such as the Fabric Energy Efficiency Standard (Fees). Findings by Julie Godefroy outlines that the loss of such standards could lead to relaxed performance of individual fabric element, but also remove the incentive to consider building form (Godefroy, 2020). Riddlestone further supports Godefroy's findings as she states that should the Fees be scrapped, there would be a risk that new homes being built in 2020 could be less insulated than a home under the 2013 building regulations. If building fabric is not improved, the reductions we need to achieve, won't be able to be met. Which raises a further concern that new homes being built from this year onwards will have to be retrofitted before 2050, resulting in cost almost 5 times more expensive than getting things right now (Riddlestone, 2020).

3.7 Case Study – Goldsmith Street, Norwich (Sterling Prize Winner)

Goldsmith Street, Norwich is the UK's largest Passivhaus development which was commissioned by Norwich Council as a 100% social housing scheme. The aim of the scheme was to deliver successful urban regeneration and exemplary sustainable homes. Goldsmith street delivers 105 homes, 56 of which are one bed flats, with the rest being a mixture of two and three bedroom flats and two to four-bedroom homes (Goldsmith Street, 2018).

3.7.1 Design Principles

As previously mentioned, Goldsmith Street, was designed to meet the rigorous Passivhaus standard. The main aim of Passivhaus is to dramatically reduce the requirement for space heating and cooling, whilst still creating excellent indoor comfort levels. This is typically achieved by adopting a 'Fabric First' approach to the design by specifying high levels of insulation to the thermal envelope of the building with exceptional levels of airtightness, and through the use of whole house mechanical ventilation and heat recovery (BRE Group, n.d).

Goldsmith street achieved Passivhaus, firstly by looking at the fabric of their buildings. They choose to use a timber frame construction, to keep costs down, but opted to increase their wall thicknesses to 600mm to allow for more insulation to be put into the cavity (Goldsmith Street, 2018). They utilised triple glazed windows with aluminium frames to target low u-values for their windows (Mikhail, Riches and Hawley, 2015).

All of the terraces face south in order to maximise solar gain and exposure to natural daylight. The buildings have been designed to feature asymmetrical pitched roofs with a longer, lower and shallower profile to the north. This arrangement was chosen so that each terrace doesn't overshadow the one behind it (Goldsmith Street, 2018).

When it comes to the internal layouts of the buildings, the large habitable rooms, such as bedrooms and living rooms have been designed to have larger south facing windows. Whereas smaller rooms such as offices and bathrooms are positioned to be north facing which small windows to prevent heat loss (Goldsmith Street, 2018).

4. RESEARCH METHODOLOGY

4.1 Introduction

Researchers must be able to understand and clearly explain their choices regarding the research methodology utilised with their studies, while also appreciating the methods that may not be suitable for their chosen study. Only one form will be used for the majority of the research carried out. However other methods may be applied only where required.

Due to the 2050 Target Addendum to the Climate Change Act 2008, the researcher aims to develop specific guidance, which can be utilised to create a development framework to meet the previously mention target.

The legally binding target imposed is:

- 100% reduction in greenhouse gas emissions by 2050, against the 1990 baseline.

4.2 Hypothesis

It is the researchers understanding that by developing specific guidance which can be utilised by volume housebuilders to create a development framework, new homes being built in the UK will be able to deliver net carbon whole life neutrality. This in turn can aid the UK to meet the legally binding target imposed by the 2050 Target Addendum to the Climate Change Act 2008.

4.3 Data Collection Method

The research carried out will use a combination of primary data and secondary data. Primary data will be in the form of information collected by the researcher from professionals within the construction industry. This data is required for the researcher to better inform the aim of this research paper. The

secondary data used in this research is of that collected by an external source. The data will be collected from sources such as books, journals, previous studies, websites and publications, which will be presented in the literature review.

4.3.1 Literature

Conducting a careful and thorough literature review is an essential part of any research document. A literature review enables the researcher to survey what research has been done in the past surrounding the chosen topic, allowing the researcher to attain a better understanding of research relevant to the given study. It also allows the researcher to appraise and form a critical review of the literature which enables the researcher to present this information so that it also educates the reader (Kim, 2018).

The purpose of the literature analysis was to identify any current development frameworks in place for guiding volume house builder's towards meeting the 2050 Target Addendum the Climate Change Act 2008. In addition, the literature review was crucial to understand what current and past methodologies and frameworks available and what benefits and limitations there are following their implementation.

The results from the literature review have enabled the researcher to determine what further means of research was required to continue with this study.

4.3.2 Qualitative Research

Qualitative research is a type of research that collects and works with non-numerical data (Crossman, 2020). There are many different methods of data collection in qualitative research, such as observations, textural or visual analysis (from books or videos) and individual or group interviews. The most common method used is interviews, as they can be used to explore the views,

experiences beliefs and motivations of individual participants (Gill, Stewart, Treasure et al, 2008).

Qualitative Research will be collected when required in primary and secondary forms. Primary data that expressed the views of professionals within the construction industry was collected. This data is required by the researcher to aid discovering what is the appropriate guidance which can be utilised to create a development framework. Secondary data was collected which outlined how methodologies / frameworks which intend to improve the sustainability of new homes had been implemented and their success.

Qualitative research advantages:

- Provides depth and detail – Analysing thoughts, behaviours and feelings to explore 'Why'.
- Encourages discussion.
- Increased flexibility – Questioning can adapt in real-time to the quality of information being gathered.

Qualitative research disadvantages:

- Smaller sample size
- Difficult to generalise
- Lack of anonymity – For some topic areas, respondents may feel more comfortable/willing to respond vi anonymous surveys as opposed to one-on-one interviews or discussion groups.

4.3.3 Quantitative Research

In contrast to qualitative research, quantitative research deals with data that are numerical or that can be converted into numbers (Williamson and Johanson, 2018). The goal of gathering quantitative data is to describe, understand and predict the nature of a phenomenon, particularly through the

development of models and theories (Lucas-Alfieri, 2015). As the aim of this study is to develop specific guidance which can be utilised to create a development framework to meet the legally binding target of the 2050 Target Addendum to the Climate Change Act 2008, the method of collecting data will be quantitative.

Quantitative research advantages:

- Larger Samples - The research can conduct a broader study, involving more subjects and enabling more generalisation of results.
- Objectivity and accuracy – There are fewer variables involved as the data relates to close-ended information.
- Faster and easier

Quantitative research disadvantages:

- Less detail - it will not offer much insight into thoughts and behaviours.
- Artificiality - The research can be carried out in unnatural environments so that control can be applied, which could lead to results differing to real world findings.
- Limiting - Typically answers are pre-set, which might mask how people really behave or think, making them select an answer that might not reflect their true feelings.

4.3.4 Data Collection Limitations

During the course of this research paper, due to the current COVID-19 global pandemic it was no longer reasonable for the researcher to conduct primary research via the means of a questionnaire to professionals within the construction industry. Instead the researcher has chosen to develop the literature review further with the inclusion of a case study, which can be analysed in correlation with the contents of the literature review to inform the aim of this paper.

5. RESULTS AND CONCLUSION

5.1 Results

By conducting a thorough literature review, the researcher has been able to establish the benefits and limitations of past and current methodologies and frameworks. The researcher also understands via a case study how a development can achieve net zero carbon emissions in practice. In light of the findings in the literature review, the researcher proposes the following specific guidance to volume housebuilders to improve the sustainability of new homes:

Design Guidance

- Reduce Operational Energy Demand –Follow a ‘Fabric First’ methodology.
 - Increase wall thicknesses to allow for high levels of insulation.
 - Utilise triple glazed windows
 - Optimise solar gain through appropriately located windows.
 - Maximum level of airtightness – through good detailing.
 - Aim for heating requirement of no more than 15kWh/m²/yr.
 - Position pipe work in such a way to minimise puncturing through the building fabric.
- Introduce on site renewable energy sources such as solar photovoltaics
- Implement air/ground source heat pumps into the building design.
- Optimise solar gain through appropriately located windows.
- Design floor plans so that large habitable rooms like the living room have south facing windows. Position smaller rooms like bathrooms so that they have small north facing windows to prevent heat loss.

Framework Guidance

- Have core principles which must be followed but allow flexibility in the framework, to allow designers to be more creative whilst still delivering quality sustainable housing.
- Introduce incentives so that best methods are used instead of the cheapest.

5.2 Conclusion

Climate change is one of the biggest problems the world currently faces, and this will not change unless reductions are made to the amount of greenhouse gasses the planet produces. Almost 20% of the UK's carbon emissions comes from homes, and with a shortage of new homes in the UK this will only rise if not combated directly. As per chapter two the purpose of this research was to investigate current and past methodologies / frameworks which intend to improve the sustainability of new homes and thereby develop specific guidance which can be utilised to create a development framework to meet the legally binding target of the 2050 Target Addendum to the Climate Change Act 2008.

By carrying out a thorough literature review and case study the researcher has been able to conclude various key areas for guidance, which can be used to inform a detailed development framework to ensure new homes are more sustainable and therefore achieve the target of the 2050 Target Addendum to the Climate Change Act 2008. However, there are limitations to the guidance suggested. The researcher was only able to partly fulfil objective 3 as outlined in chapter 2. Due to the COVID-19 global pandemic it was no longer viable for the researcher to conduct primary research via the means of a questionnaire to professionals within the construction industry. It is the researcher's recommendation that if further research should be carried out, it should focus on gathering the views from industry professionals. To gain an understanding of how they think new homes can become more sustainable to achieve the CCA

target and better inform the guidance for the developers and development framework.

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