



Zero Carbon Task Group Report

The Definition of Zero Carbon



May 2008



Zero Carbon Task Group Report

Foreword

Climate change is the biggest challenge we face today, and the built environment is in the front line of the battle to cut our carbon emissions as far as possible, as fast as possible. The way in which we construct and use our homes and other buildings in the UK accounts for approximately 45% of our total emissions, and while the biggest challenge remains how we can tackle the existing stock, the vast majority of which will still be standing in 2050, it is essential that our new homes and buildings are as energy efficient as possible, and are able to meet all of their energy needs from renewable energy sources.

The challenge of meeting our future commitments to renewable energy generation must not be underestimated. Under the EU Commitment, the UK must deliver 15% of its total energy supply from renewable sources. It is essential that the zero carbon new buildings programme is an active driver towards meeting the renewables target.

The goal for all new homes to be zero carbon by 2016 is perhaps the most ambitious environmental policy this Government has introduced. The Government has also set out an ambition to require all new schools to be zero carbon by 2016, all public sector buildings by 2018, and potentially all new buildings by 2019.

These are the right targets, with the right level of ambition, at a time when we have to make radical changes. Already we have seen extraordinary levels of innovation and determination to succeed from some parts of the industry. The stepwise approach to zero carbon set out in government policy provides a clarity about the future direction of regulations that is essential if the industry is to invest and gear up for the level of change required. Zero carbon is a description of our destination which has forced people to think beyond incremental improvements - doing what we did before, just a bit better, and has brought about a fundamental change of mindset.

The challenge must not be underestimated, and government and other supporters of the zero carbon policy must listen to those who are genuinely striving to deliver it, but encountering real barriers. There will be many obstacles to be overcome, in terms of technology, skills, public engagement and so on, but the first is a definition of zero carbon itself, which allows sufficient flexibility to be achievable in the vast majority of situations, without reducing the level of ambition in terms of carbon emissions reductions overall. The UK-GBC hopes that this report, the product of the Zero Carbon Definition Task Group, will make a positive and timely contribution to that debate.



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Our thanks go to all those who participated in the Zero Carbon Task Group who contributed so much of their time and expertise and helped make this review as comprehensive as it is.

A handwritten signature in black ink, appearing to read 'Paul King', written in a cursive style.

Paul King
Chief Executive
UK-GBC

A handwritten signature in black ink, appearing to read 'Mark Clare', written in a cursive style.

Mark Clare
Chairman
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A list of those that have contributed to this review is shown below.

- Arup
- Barratt Developments
- Berkeley Homes
- BERR
- BRE
- Brooks Devlin
- CLG
- Crest Nicholson
- English Partnerships
- E.ON
- Fulcrum Consulting
- Inbuilt
- Knauf Insulation
- Lane & Partners LLP
- Lend Lease
- Prologis
- REA



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➤ WWF-UK

Executive Summary

Background

The goal for all new homes to be 'zero carbon' by 2016 is perhaps the most ambitious environmental policy this Government has introduced. It sets out improvements to energy requirements in Building Regulations, in 2010, 2013 with a final leap to 'zero carbon' in 2016.

Government recognised that industry needed clarity on the future direction of Building Regulations, and needed to gear up in advance of 2016. As a result, it issued a definition in its Code for Sustainable Homes Technical Guidance in April 2007 which provided an option for off-site renewables to be considered, although no mechanism existed to demonstrate this at the time. The Treasury announced a stamp duty land tax relief scheme for zero carbon homes constructed up to 2012.

In doing, this Treasury defined 'zero carbon' to exclude the use of off-site renewables that weren't connected to the development by a private wire. Following this, the zero carbon definition in the Code for Sustainable Homes Technical Guidance was amended to also exclude the use of off-site renewables, in order to be consistent with the Treasury's definition.

Concerns were raised by housebuilders, both large and small, that this definition was unworkable. A lack of clarity over the definitions, and therefore future trajectory of building regulations, threatened not only the ability to deliver the Government's ambitious housing targets, but also created confusion amongst engineers, architects, developers and their clients.

To help Government respond to these concerns, the UK-GBC established a task group to bring together industry stakeholders to recommend solutions. Government welcomed this and officials from Communities and Local Government (CLG), Business Enterprise Regulatory Reform (BERR) and Her Majesty's Treasury (HMT) sat as observers on the group.

Case Studies and Modelling Scenarios

The task group began by undertaking a review of real case studies where developers have built or were in the process of building exemplar low- and zero carbon developments to assess what solutions were being employed and to identify constraints.

A computer simulation (developed by consultants Element Energy for the recent Renewables Advisory Board report on the potential role of on-site renewable energy solutions) was then used to model further scenarios for zero carbon definitions. It concluded that, according to all the



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available evidence, anywhere from 10% to 80% of new homes may not be able to meet the current definition of 'zero carbon'.

Conclusions and Recommendations

The group felt that Government had three main options:

1. deliver fewer homes that meet the current definition of 'zero carbon'
2. reduce the requirement for carbon savings from new buildings
3. find a suitable mechanism for allowing off-site solutions where on- and near-site installations are not practicable or are prohibitively expensive.

The group concluded that to maintain the ambition of the original policy, which UK-GBC fully supports, a revised definition of zero carbon that allows the use of off-site solutions in certain circumstances is required.

The group was mindful of the need to ensure that energy demand is minimised, use of on- and near-site renewables is optimised, and there is a level playing-field for small and large developers.

The group therefore recommends that:

1. All new buildings must meet strict minimum energy efficiency parameters as part of the definition of 'zero carbon', both in terms of the building design and appliances where supplied by developers.
2. All new buildings should seek to mitigate predicted carbon emissions from all energy uses via on- or near-site solutions. Where this is not possible, a minimum level of carbon mitigation must be required (e.g. 100% regulated energy) on- or near-site.
3. Above this threshold either:
 - Off-site solutions could be allowed, without requiring private wire networks, provided that they are demonstrably additional and have been built specifically to deliver the energy needs of the development.
 - The developer can pay into a 'Community Energy Fund' that will ensure equal or greater net carbon savings are delivered through new installations. (NB: The price of paying into the fund should be set at a margin above the cost of community-scale solutions so as to clearly incentivise the installation of on-site or local measures first.)

The group believes that these proposed changes would provide an appropriate balance of energy reduction measures, whilst continuing to support demand for on- and near-site renewable technologies, and provide the basis for a significant growth in community-scale technology.



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Furthermore, this approach could have the additional benefit of reducing CO₂ emissions from existing buildings by enabling the distribution of heat via district networks.

The proposal fits particularly well with the requirements in the Planning and Climate Change supplement to Planning Policy Statement 1, that require regional planning authorities to plan new development in a manner that reduces carbon emissions in the region.

Points to be considered by the Government's consultation:

1. At what level to set the minimum threshold and how this should be expressed.
2. How to accommodate sites with specific restrictions that are unable to meet the national minimum, including consideration of a higher-price (e.g. above PV) below the minimum threshold.
3. Mechanisms to ensure allowable off-site solutions are genuinely additional.
4. A definition of 'near-site' that encourages community-scale solutions.
5. The principles, purpose and administration of the fund.



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1 Introduction

1.1 The UK Green Building Council

The UK Green Building Council (UK-GBC) is an independent, membership-based, not-for-profit organisation committed to dramatically improving the sustainability of the built environment by radically transforming the way it is planned, designed, constructed, maintained and operated. The UK-GBC recognises the urgent need to improve the performance of our built environment if we are to mitigate the predicted negative impacts of climate change.

The UK-GBC uses a ground-breaking approach for establishing an evidence-base for future policy drawing together teams from within its membership including top engineering consultancies, developers, architects and cost consultants to deliver a balanced approach to the projects it undertakes. The differing resources and expertise of the UK Green Building Council members means that projects have access to a greater knowledge-base than any one organisation could possess alone.

1.2 Defining the challenge

Climate change is the biggest challenge we face today, and the built environment is in the front line of the battle to cut our carbon emissions as far as possible, as fast as possible. The way in which we construct and use our homes and other buildings in the UK accounts for approximately 45% of our total emissions, and while the biggest challenge remains how we can tackle the existing stock, the vast majority of which will still be standing in 2050, it is essential that we ‘stop the rot’ by ensuring our new homes and buildings are as energy efficient as possible, and are able to meet all of their energy needs from renewable energy sources.

The challenge of meeting our future commitments to renewable energy generation must not be underestimated. Under the EU Commitment, the UK must deliver 15% of its total energy supply from renewable sources by 2020. This will equate to approximately 40-45% of the UK’s electricity supply coming from renewables. It will be essential that the ambitious zero carbon new-build housing programme is an active driver towards meeting the renewables target.

1.3 The UK-GBC Zero Carbon Task Group

The UK-GBC Zero Carbon Task Group was established to review the current definition of ‘Zero Carbon’ as laid out in the Code for Sustainable Homes (CSH) Technical Guidance, and propose amendments where required in order to support effective implementation of Government’s stated targets for zero carbon buildings in the future.

The definition proposed needs to support the delivery of zero carbon homes, the volume aspirations of Government, whilst ensuring affordability for the homeowner.



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While the primary focus of the group was intended to be domestic dwellings, the importance of a universally applicable definition was explored. Previous work done by the UK-GBC investigating the potential for carbon emissions reduction in new non-domestic buildings had started to investigate what was possible. It was agreed that any definition proposed by the group should be tested for applicability in non-domestic buildings.

1.4 Summary of work done in this review

The Zero Carbon Task Group was drawn from the very wide range of UK-GBC members to ensure that the full range of views and perspectives were considered, and that the necessary skills and experience were brought to bear. The group started by reviewing the history of the current definition of zero carbon and the reasons why this review was necessary.

The approach adopted was to establish a clear fact base of relevant information, drawn from a combination of real case studies of zero carbon developments of varying sizes and computer modelling. As a result the group believed it then had a sound basis for exploring possible alternatives to the current definition. .

The group sought to ensure that a wide set of options were explored, through brainstorming and workshops which drew on the breadth of views across the task group. All options were examined and ranked according to a set of agreed criteria before any were dismissed. As a result the group felt the conclusions it came to were robust.

It is hoped that the Government will be able to draw on the considerable work done by the group to inform its expected consultation on the definition of 'zero carbon' in the summer and that the many additional areas of work identified along the way could provide input into the proposed Zero Carbon Delivery Vehicle to ensure it can fulfil its ambition of setting the course for the successful implementation of this policy.

The terms of reference agreed by the group are included as appendix 1.

2 Summary of existing definitions

There have been a number of publications that have attempted to define how renewable technologies can be applied to the task of delivering zero carbon buildings.

2.1 The Code for Sustainable Homes

The Code for Sustainable Homes (CSH) was officially launched in December of 2006, and replaced Ecohomes as the voluntary environmental assessment method for all new residential dwellings in England on April 10th 2007. The CSH attempts to rate the sustainability of residential dwellings by assessing them against nine key criteria including water, materials, surface water run-off, waste, pollution, health and well-being, management, ecology, and energy and CO₂ emissions. The scores from each category are combined to give an overall rating on a 1 to 6 star scale, 1 being the lowest, 6 intending to denote an exemplar sustainable dwelling including net-zero carbon emissions over the course of a year.

2.2 Building a Greener Future: 2016 zero carbon commitment

In December 2006, Communities and Local Government (CLG) published the consultation paper 'Building a Greener Future: Towards Zero Carbon Development' which outlined plans to increase the requirements of the Building Regulations for England and Wales in 3-yearly iterations, culminating in a requirement for all new residential developments to be 'zero carbon' within ten years. Although details of the definition of 'zero carbon' were not made public, it was widely-assumed that this would be similar to the definition contained in the CSH.

2.3 Stamp duty land tax relief scheme

During the 2006 Pre-Budget Report, Government announced its intention to provide a time-limited relief from Stamp Duty Land Tax (SDLT) for 'the vast majority of new zero carbon homes in the UK'. In March 2007 HM Revenue and Customs (HMRC) published Budget Note 26 (BN26) which outlined the details of the qualifying criteria for the scheme. The requirements for the SDLT relief varied significantly from the requirements then outlined in the CSH level 6 definition of 'zero carbon' and prompted many in the construction industry to call for a single definition in order to provide clarity and certainty for business planning.

2.4 Towards a common definition

In July 2007 CLG consulted on the possibility of a single definition, and in October of 2007 they published an updated version of the CSH containing several important changes to bring them into line with the SDLT relief scheme definition. Crucially, whereas previously renewable energy generation equipment had been permissible outside the curtilage of the development (provided it met the requirement for these to be externally accredited and additional) in the updated version this was not allowed unless connected via a 'private wire network'.



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Although there are still minor differences in the wording of the two definitions (SDLT & CSH) that may appear to change the meaning, it is central Government's clearly-stated intention that these two definitions should be the same, and therefore, for the purposes of this report, the definition of 'zero carbon' as published in the April 2008 update for the CSH Technical Guidance is assumed to be the current definition.

2.5 Zero carbon non-domestic buildings

In 2007 the Communities and Local Government Green Commercial Buildings (CLG) Task Force, asked the UK Green Building Council to investigate the possibilities of achieving significant emissions reductions from new non-domestic buildings en route to 'zero carbon'.

CLG asked the task group to use a working definition of 'zero carbon' formulated using the same principles employed for its domestic counterpart. In almost all cases the study found that it was not possible to achieve a Code Level 5 equivalent (all regulated energy supplied by zero carbon energy generated on- or near-site). Even when a building was modelled as if it employed '2020 technology', i.e. highly efficient lighting and appliances, thus reducing the regulated energy loads, these loads could not be met on-site.

In the 2008 Budget Speech, the Chancellor of the Exchequer announced an aspiration from within Government to see 'zero carbon' schools from 2016, 'zero carbon' public buildings from 2018, and all other non-domestic buildings 'zero carbon' from 2019.

2.6 Timeline to zero carbon

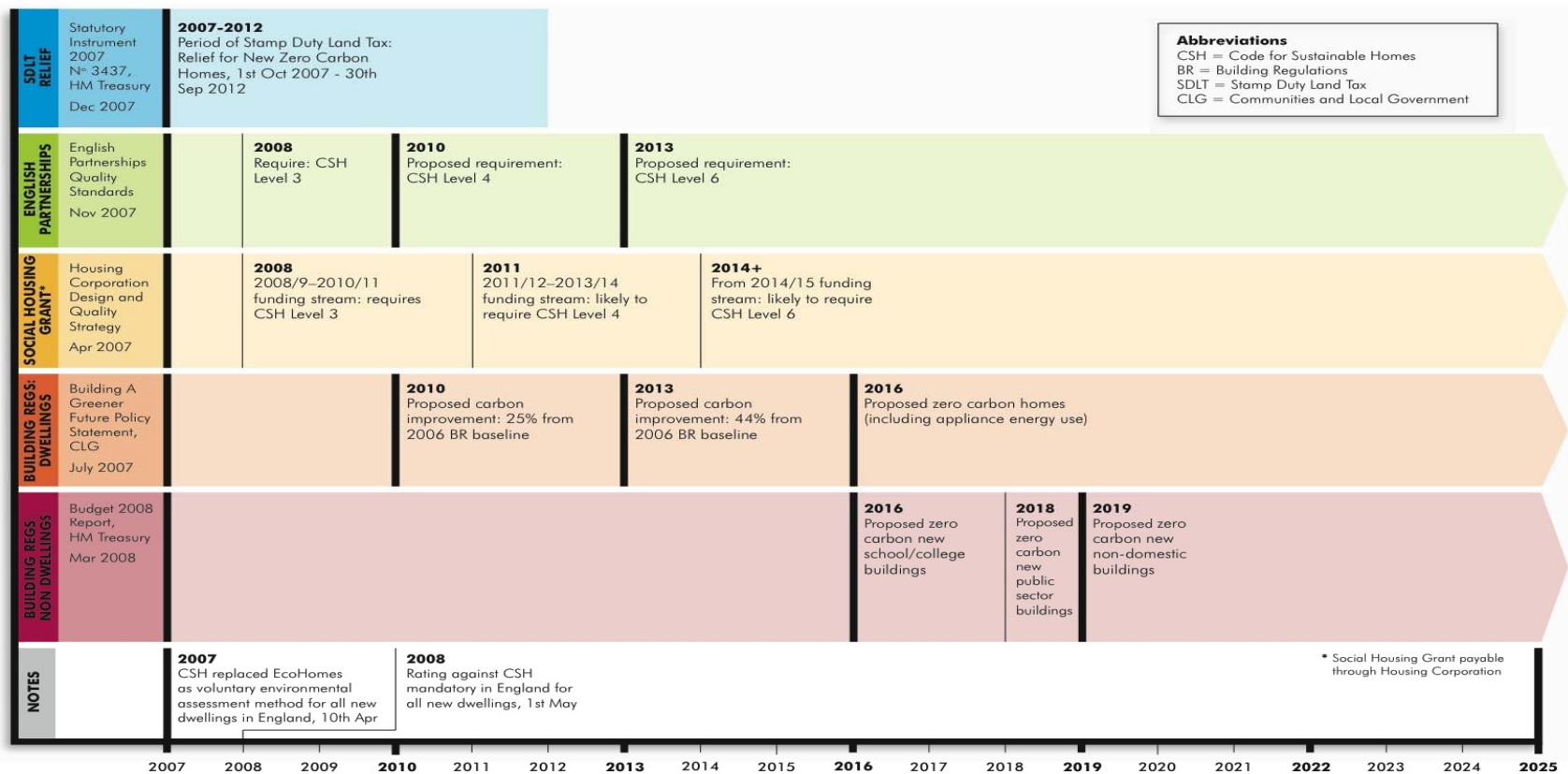
Figure 1 below outlines the current timeline for zero carbon policy.



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Carbon Emissions from Buildings Current timeline to Zero Carbon.

FULCRUMCONSULTING



2.7 Current Definition: Allowable solutions

In the CSH the key requirements relating to ‘zero carbon’ are described under the Ene1 credit ‘Dwelling Emission Rate’ (DER). Box 1 contains a brief summary of the key requirements, followed by discussions of the key points which also serve to highlight the most recent changes. The full description of the Ene1 credit is included in appendix 2.

- Dwelling Emission Rate (predicted emissions from heating, lighting and ventilation energy requirements) = 0
- Calculation of the Target Emissions Rate (TER) follows the approach taken by ADL1A. Where a choice of fuels is available on the site a justification is required to support the choice of a fuel other than gas
 - Utilities maps and a justification statement for choice of fuel must be provided as evidence
- ‘Occupant energy’ (taking account of standard appliance and cooking consumption within the home) must be calculated using calculations sheets provided, and equivalent renewable energy generation capacity must be installed.
- All renewable-energy-generation equipment must be located within the curtilage of the development, or directly connected.
 - In the case of electricity generating equipment this means a private wire connection
- Heat Loss Parameter (HLP) $\leq 0.8W/m^2K$
- Actual installed percentage of low energy lighting allowed to contribute to carbon savings. (Part L 2006 limits effect at 30%)
- No secondary heating required for the calculation of overall carbon emissions. (Part L 2006 assumes secondary system is installed)
- Mechanical cooling is not covered at all under SAP 2005. Bespoke advice on how to include this must be sought from the Code Service Provider if it is specified.

Box 1: Description of Ene1 requirements in the CSH

2.7.1 Explanation of important changes

The updated CSH technical guidance included a requirement for all renewable energy generation equipment to be located 'on/in the dwelling, its curtilage or elsewhere on/off site provided that there is a direct connection to the dwelling.' For electricity generation equipment located

outside the curtilage of the development this means establishing a private wire arrangement. Previous versions of the technical guidance for the CSH had allowed the inclusion of 'accredited off-site renewables' although no mechanism existed to demonstrate this at the time.

2.7.2 Low or Zero Carbon (LZC) Technologies

The CSH adopted the calculation methodology used in SAP to calculate the predicted energy demand and associated carbon emissions. Below is a list of LZC technologies that are currently able to be considered by SAP:

| Fuel | Technology |
|---------------------------------------|--|
| Solar | Solar hot water |
| | Photovoltaic panels |
| Water | Small-scale hydro power |
| Wind | Wind turbines |
| Biomass | Single room heaters/stoves |
| | Boilers |
| | Community heating schemes where the majority of the heating comes from biomass |
| | CHP |
| Waste heat (e.g. from power stations) | Delivered via community heating |
| Ground | Ground-source heat-pumps (GSHPs) including water-source |
| | Geothermal |
| Natural gas (mains gas) | CHP |
| Sewage gas and other biogases | CHP |
| Hydrogen | Fuel cells where hydrogen is generated from a renewable source |

Technologies such as gas-fired CHP and GSHPs are 'low carbon' rather than 'zero carbon' as natural gas emits CO₂ when burned and heat-pumps require electricity to power them. While these technologies can achieve significant greenhouse gas reductions, they would only be acceptable under the current definition of 'zero carbon' if the associated emissions were 'offset' by other renewable technologies located on-site. A more detailed description of each technology and its application at different scales is available in appendix 3; also see appendices 2 and 4 for full details of the Ene1 and Ene7 credits for the CSH respectively.



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3 The need for this review

3.1.1 Practical difficulties

While there have been some concerns as to whether ‘zero carbon’ could be delivered, or that greater carbon savings could be achieved through more cost-effective measures, much of the industry approached the problem with a determination to innovate, recognising the potential benefits for those able to provide effective solutions. However, after the CSH was changed in the April 2008 technical guidance, it became clear that there was widespread concern, supported by predictive modelling and anecdotal evidence from design-stage projects, that there may be serious practical difficulties in meeting the new definition for all developments.

3.1.2 The RAB report

In August 2007 the Renewables Advisory Board (RAB) published a report entitled ‘The Role of Onsite Energy Generation in Delivering Zero Carbon Homes’. The report used a computer model developed by consultants Element Energy to simulate the choices that developers would have to make when attempting to build ‘zero carbon homes’. Using the RAB assumptions the model predicted that at least 11.6% of dwellings constructed would be unable to meet the current requirements. Given that Government has set stretching targets for the number of dwellings that need to be delivered, a zero carbon definition that constrains this is clearly not desirable.

3.1.3 The Callcutt review

Published in November 2007, the Callcutt review recommended that: *‘The Government should set out, as soon as possible and no later than the end of 2008, exactly how zero carbon performance is to be defined, and how far the use of renewable energy is to be taken into account into the assessment of performance. The assessment rules should differentiate between local and remote renewable generation, and should allow for the different circumstances of different sites.’*

3.1.4 Non-domestic buildings

During the work done for the report *Carbon Emissions in New Non-Domestic Buildings* it became clear that non-domestic buildings were likely to represent a much greater challenge than the domestic stock for a number of reasons. Therefore it was clear to the members of the UK-GBC that urgent work was required in order to provide constructive input towards a definition of ‘zero carbon’.

The group felt that alignment of domestic and non domestic definitions was important to ensure the benefits of mixed used schemes could be delivered in reality. Recognising the different load profiles and energy uses in domestic and non domestic buildings, mixed-use renewable installations often provide a lower cost and more efficient solution. As it currently stands, a



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mixed use development might end up with two energy solutions given the lack of regulation surrounding non domestic buildings.



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4 Project Approach

In order to tackle this issue, the UK-GBC formed a task group of relevant members including developers of varying sizes, engineers, independent consultants, energy suppliers, representatives from the renewables industry, relevant Government agencies and NGO's. Using such a varied group ensured that no one point of view was automatically favoured, and the concepts and recommendations could be tested against different sectors to see how robust they were.

The group then used the following process:

- Establish the current industry approach to 'zero carbon';

Case studies were collected using projects that were aiming to achieve 'zero carbon' or similarly high levels of performance in order to understand the current approaches being used to deliver.

- Review RAB/Element Energy model;

While the RAB report made useful contributions to the debate, the group felt that because of some of the assumptions used, the model could represent a 'best case' scenario. As such, the model was reviewed and re-run with different assumptions tested to assess the impacts.

- Compare Element Energy output with current industry approach;

The task group then reviewed the anecdotal evidence gleaned from the case studies alongside the results of the computer modelling. This served as a 'sense check' to highlight any potential anomalies in either data-set, or any potential problems with the assumptions made.

- Results and conclusions;

The results of the case studies and the computer modelling gave the group a good sense of the current situation and how this is likely to develop in the future if the current definition remains unchanged. By altering some of the assumptions used in the original RAB report, the group also gained an idea of which key factors influenced the outcomes most. The group discussed potential alterations and improvements to the definition and allowable solutions that might better support the successful delivery of Government-stated targets.



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4.1 Parked issues

All projects of this type face inevitable time and resource restrictions, and analysing the definition of 'zero carbon' presents opportunities to investigate a plethora of related issues. The group created a list of issues which were recognised to be important for successful delivery of the policy targets, but outside the scope of this report. The list was maintained and added to throughout the work, and it is suggested that it should be passed on to the proposed Zero Carbon Delivery Vehicle as recommendations for further work. The full list of parked issues is included in appendix 5.



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5 Establishing the current industry approach

Case studies were used to gain a view of the current industry approach to delivering zero carbon developments. All of the case studies used were real building projects that had progressed at least as far as the submission of a planning application so that a cost plan might be available. A good number of the projects studied were built or in construction, and the vast majority of cases were located in the United Kingdom, and therefore subject to the UK financial, legislative, and technological environment.

In order to ensure that a representative view of the industry was established, the group looked for case studies that covered different scales of development as outlined below:

- Single dwelling
- Cluster dwellings
- Average house developments (25-100 units, brownfield & lower density)
- High density urban in-fill sites (25 units- 150 units)
- Smaller non-domestic building <1000m²
- Medium non-domestic building <10,000m²
- Large & mixed-use developments

Given the lack of consistency of information available, a proforma was developed to ensure that comparable data was used for each case study. A copy of the proforma used is included as Figure 2 below:

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| Data entry for each Zero Carbon Case Study | | | | | | Insert ✓ or ✗ into each clear box | | | | |
|---|-----------------------------------|-----------------------------------|----------------------------|------------------------------------|--|-----------------------------------|----------------------|--------------------------------------|------------------------------|-----------------------|
| Development name | | | | | | | | | | |
| Development size | Residential: | 1 unit | 2-20 units | 21-70 units | Larger | Non-domestic: | <1000m ² | <5000m ² | <10,000m ² | Larger |
| Development stage | Pre-planning | Design stage | In construction | In use | | | | | | |
| Location | City centre | Town centre | Suburban infill | Suburban | Non-urban | | | | | |
| Renewable source | Solar thermal | Solar PV | Micro wind | Larger wind | Biomass heat | Biomass CHP | Ground source | Other: state | On-site | Near-site |
| Zero carbon definition used | Regulated energy only (eg Part L) | Occupant systems (eg from ECON19) | CSH (regulated & occupant) | ECON 19 Typical (or other – state) | ECON 19 Best practice (or other – state) | Materials embodied energy | Occupants' transport | Operational consumables (exc energy) | Demolition / disposal energy | Other: describe below |
| Renewables cost (ref bulding capital) | <5% | <25% | <100% | | | | | | | |
| Expected running costs (ref no renewable) | increase | decrease | Due to added manpower | Due to fuel cost | Due to added maintenance | Other : describe below | | | | |
| Reason for renewables choice | Capital cost | Whole life cost | Proven equipment | Fuel availability | Non-profit operation | Commercial ESCO operated | Other: describe | | | |
| Other renewables considered | Solar thermal | Solar PV | Micro wind | Larger wind | Biomass heat | Biomass CHP | Ground source | Other: state | On-site | Near-site |
| Descriptions: barriers, workarounds used, etc | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Figure 2: case study data collection proforma

5.1 Key Insights from the case studies

While a good spread of developments was achieved, it was clear that non-domestic examples were much harder to find, and even the mixed-use developments tended to be heavily weighted towards the domestic sector. This is almost certainly due to the current lack of legislative requirements and highlights another reason for a universal definition and timetable that is applicable to both sectors.

It should also be noted that the client motivation for many of the case studies will not have been wholly the same as would be expected for mainstream construction. However, the group recognised that the case studies still provided a useful insight into how design teams were responding to the current regulatory framework.

Various trends were recognised from the case studies:

1. Cost of 'zero carbon' reduces considerably as developments increase in size.
 - Larger developments tend to find it easier to comply.
 - Mid-sized developments can often achieve zero carbon on-site; however cost effective technology options reduce at the smaller end of this scale. Some technologies are not currently available in the UK.
 - Smaller developments can achieve zero carbon heat, but have limited ability to generate significant amounts of renewable electricity.
 - Non-domestic developments often have a significantly greater electricity demand, thus increasing the cost of achieving 'zero carbon'
2. After site and technology constraints, it is typically capital cost that dictates which particular renewable technologies are used.
3. The market cost pressures tend to drive towards a more restricted selection of technologies. Large-scale wind, where sites permitted it, and bio-energy CHP for the larger developments, appeared to be favoured when available. Certain technologies generally regarded as 'zero carbon' or 'low carbon' rarely feature.
4. The cost of delivering on smaller housing developments was cited as a reason that developers were only considering larger schemes for the commercialisation of 'zero carbon'.
5. The introduction of the CSH carbon targets into the future Building Regulations was quoted as the main reason for investigating 'zero carbon'
6. There are no mainstream market drivers for non-domestic zero carbon developments. In almost all of the non-domestic case studies the occupier's core business related directly to sustainability and building procurement.
7. The lack of regulatory incentive to reduce electrical demand (particularly occupant energy) as a means of reducing the renewable electricity generation capacity requirement was cited as a drawback.
8. It was generally cited as easier in capital cost terms to deliver renewable heat than to deliver renewable electricity.
9. The lack of ability to connect into wider district heating systems so that waste renewable CHP heat could be supplied to other buildings was quoted as a frequent concern.

Figure 3 shows the results of the case-studies, demonstrating the additional costs as a percentage of construction cost, and highlighting the key technologies used in each project.



Zero Carbon case studies:
Renewables used, its cost and development size

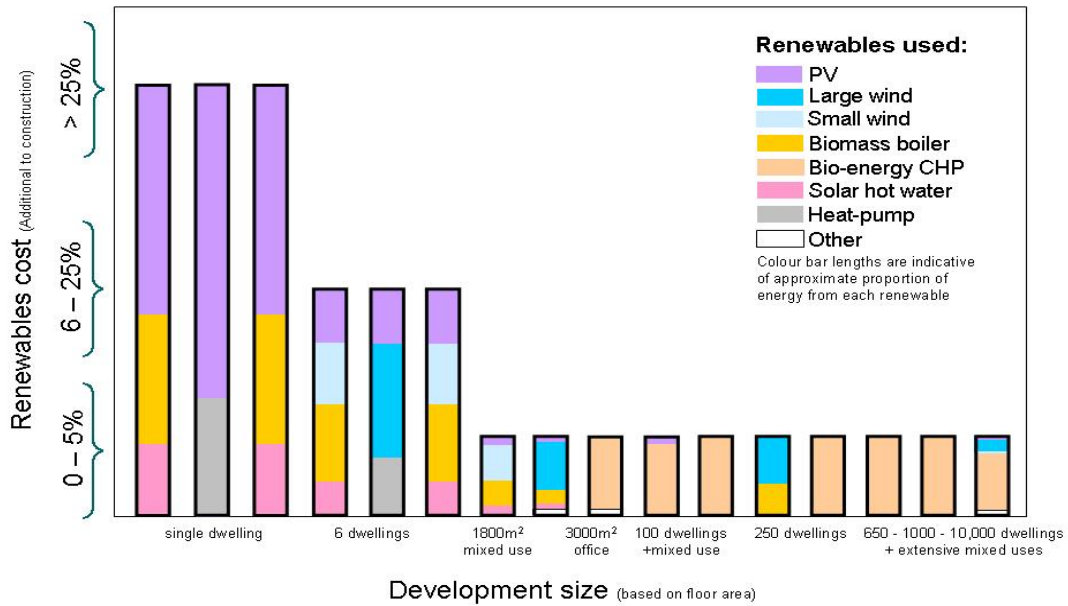


Figure 3: case study results

5.2 Standardising the case studies

Using the information gathered during the case studies, typical approach scenarios were drawn up, outlining the most likely options for each development type and indicating the common problems encountered. A full list of these approach scenarios can be found in appendix 6.



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6 Modelling Approach

6.1 Element Energy Model

In August 2007 the Renewables Advisory Board (RAB) published a report entitled 'The Role of Onsite Energy Generation in Delivering Zero Carbon Homes'. The report used a computer model developed by consultants Element Energy, which attempted to simulate the likely choices developers could face when building zero carbon homes as currently defined. The uptake model assesses a comprehensive list of on-site energy generation technologies for an indicative range of developments. The different options were assessed against a number of criteria to try to assess which solutions developers would opt for in order to satisfy the current legislation. A dwelling stock-model was then used to estimate the total number of installations, cost, and total generation capacity required, as well as other factors such as the likely number of installers required.

Appendix 7 contains a process diagram demonstrating the basic principles of the model.

It is important to note that although the model estimates predicted cost, and developers will opt for the cheaper-of-any-two options, it does not consider overall capital cost to be a barrier to development, i.e. it assumes that developers will pay any cost to build a dwelling.

6.2 Key findings from the RAB Report

- At least 11.6% of homes fail to meet the target;
- Predicted additional costs per dwelling for renewable energy vary from £13,018 for micro-urban development, to £789 for a large-rural development;
- Average predicted cost increase is ~£6,000 per dwelling;
- CSH 6 is significantly harder for smaller, urban in-fill developments;
- High use of PV because, despite being expensive, it is 'the only renewable electricity technology available to all development sizes';
- Predicted size of PV market by 2016 = £833m per annum; medium and large-scale biomass = £716m per annum;

6.3 Changes to the RAB Model

The RAB report made an important contribution to the discussions, and it was the first substantial attempt to model impacts of zero carbon policy in this manner; however, there were elements of the model that the UK-GBC task group felt needed testing in different ways to properly understand the effects. Two scenarios were tested, ‘high on-site’ and ‘high off-site’, in order to understand the potential outcomes of the two extremes. Table 1 demonstrates the changes made in different modelling runs:

| Variable | RAB Base case | High on-site Base case | High off-site Base case |
|--------------------------------------|---|---|---|
| Heat energy efficiency standards | Low | High (HLP 0.8) | High (HLP 0.8) |
| Technological development | High learning rate | High and low learning rate tested | Low learning rate |
| Biomass CHP availability | Available | Not available | Not available |
| CHP Heat dumping | Not allowed | N/A | N/A |
| Direct electric heating allowed | Yes | Yes | Both options tested |
| Off-site renewable energy generation | No | Both: scenario test without off-site, and with high cost off-site | Yes |
| Grid CO2 emission factors | SAP differential allowed Intensity high | SAP differential allowed and not allowed tested Intensity high | SAP differential not allowed Intensity high |
| Consumer behaviour | Capital expenditure only | Capital expenditure only | Capital expenditure only |

Table 1: Assumptions used in modelling runs

6.3.1 The ‘SAP differential’

One of the most important variables in the model, in terms of how much impact it had on the results, was the effect of the export/import differential included in SAP. A short description of



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what we have termed ‘the SAP differential’ follows and a more detailed explanation is available in appendix 8.

For a number of reasons, the carbon factors used in SAP for grid electricity vary from those presented in DEFRA’s environmental reporting guidelines, as used for the UK Emissions Trading Scheme (UK ETS); this could lead to some confusion. Firstly, SAP has to consider the likely emissions expected from the generation mix over the period for which the emissions factor is to be used; for SAP 2005 this is 2005-2010. Furthermore, SAP attempts to compensate for the emissions avoided as a result of reduced demand for grid electricity.

In SAP, when electricity is imported from the grid is assumed to have a carbon content of 0.422kgCO₂/mWh, and when renewable electricity is exported to the grid, it is assumed to offset 0.568kgCO₂/kWh. In practice this means that an all-electric development need only supply ~74% of its electricity demand with renewable energy in order to offset the total predicted CO₂ emissions. As such, the group felt that the SAP differential risked allowing building to class as ‘zero carbon’ without mitigating all of their carbon emissions and therefore sought to examine the effects of removing the differential.

6.3.2 Minimum energy efficiency standards

Although seeking to avoid a prescriptive hierarchy, the group recognised a need to use all resources efficiently, and any zero carbon policy should encourage the developer to address energy efficiency first, and then seek to mitigate as much carbon as possible on- or near-site before looking at off-site solutions.

Therefore, for the purposes of the work undertaken for this report it was assumed that the definition of ‘zero carbon’ would include a specific requirement for minimum energy efficiency parameters. For domestic dwellings, the Heat Loss Parameter (HLP), as defined in the Standard Assessment Procedure (SAP), was used as a proxy for overall energy efficiency and all dwellings were assumed to have a HLP ≤ 0.8W/m²K (as required by the SDLT definition of ‘zero carbon’).

As discussed in *Carbon Reductions in New Non-Domestic Buildings*, HLP is not an appropriate measure for energy efficiency in non-domestic buildings. This report echoes the UK-GBC’s previous recommendations that appropriate minimum energy efficiency parameters be drawn-up for non-domestic buildings.

6.3.3 Availability of bio-energy CHP

Both UK-GBC scenarios include a somewhat cautious view of the development and commercialisation of bio-energy CHP in recognition of the fact that the technology is not yet fully mature, particularly at the medium and small scales. The original RAB report base case scenario assumed bio-energy CHP to be fully commercialised.

7 Modelling Scenarios

The RAB version of the model had already attempted to simulate the current situation for developers trying to meet the policy. The first UK-GBC scenario run was very similar in that it required all zero carbon energy to be generated on-site, but the SAP differential was removed so that electricity was imported and exported with the same carbon intensity. This was termed the ‘high on-site’ scenario by the group.

7.1 Key results for ‘high on-site’ scenario

- Using the RAB assumption the model predicts that 11.6% of developments would fail to meet the target.
- If the availability of bio-energy CHP is limited, due to not being sufficiently developed for example, but all other factors remain the same, then the failure rate increases to 31%.
- Removing the SAP differential increases the number of fails significantly, to 78.4%, with 69.2% of the developments failing by more than 10%. It is important to recognise that the SAP differential does not actually improve the performance of the buildings in any way, but over-estimates the carbon-savings achieved with certain technologies when it is in-place.
- Failure rate for ‘high on-site’ scenario is predicted to be between 10% - 80% of dwellings depending on the assumptions used.

7.2 Discussions arising

The group felt that because of some of the assumptions used, the model could represent a ‘best case’ scenario. Changing the assumptions increased significantly the number of dwellings failing to meet the target, and the margin by which they missed it.

Given that the predicted failure rate could be much higher than originally anticipated, the group felt that there were three main courses of action available to Government:

- Reduce the number of dwellings delivered.
- Reduce the requirement for ‘zero carbon’.
- Find a suitable mechanism to allow off-site, grid connected renewables to contribute to ‘zero carbon’.

Given existing Government policy, the group felt that the first two options were unacceptable and therefore it was decided that the impacts of allowing off-site solutions should be investigated.



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One of the most controversial and complicated aspects of allowing grid-connected off-site renewables, is the ability to ensure that the renewables delivered are truly additional. That is, to be able to show that the generation equipment installed to serve the development in question is additional to that required under other schemes, such as the Renewables Obligation, which seek to incentivise new installations. Additionality is assumed to be a prerequisite for off-site renewable installations throughout this report.

With this in mind, the next scenario modelled assumed that zero carbon electricity could be purchased off-site at a relatively low cost in order to test 'the other extreme'. The group termed this the 'high off-site' scenario.

7.3 Key results of 'high off-site' scenario

- If the SAP differential is removed, the availability of Bio-energy CHP is considered to be limited, additional capital cost is not limited, but all 'zero carbon energy' can be purchased through off-site measures, then all developments can achieve 'zero carbon' status.
- As would be expected, this scenario produces almost no on-site installations of energy generation equipment.
- The off-site renewable energy demand in this scenario would be expected to be somewhere in the order of 2TWh every year just for new housing.
- The model predicts that up to 0.7TWh a year could be required for direct heating alone.

7.4 Discussions arising

This scenario produced some positive outcomes in that, all developments could achieve 'zero carbon', it would provide market certainty and it lowers costs for the developer and therefore the home buyers. However, there were a number of down-sides that needed consideration:

- Buildings offer the potential to incorporate renewable energy production facilities, and in an era of constrained emissions and demanding sustainable energy targets, it is essential that this potential is harnessed.
- As competition for large-scale renewables increases from other sectors, costs may go up in future.
- There would be little incentive for the UK micro-renewables industry to continue to innovate and come up with solutions for the market in general without demand from the new-build sector.
- Developers would have to get planning permission on the development site, as well as for the location of the generation equipment.



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- Ultimately the group felt that, in order to meet the overall targets for renewable generation in the UK, all viable technologies will be required to contribute. To rely solely on remote off-site renewables would likely leave the country short of its target and would miss the opportunity to utilise otherwise viable solutions.

7.5 Compare with case studies with modelling output

The group checked the results of the case studies against the predictive modelling to see how they measured up against what was being delivered in reality. In general the group felt that both sets of results were broadly aligned and that, when used together, provided a robust evidence base.

7.6 Conclusions from scenarios modelled

Strict adherence to the current definition requiring all renewable energy to be delivered on-site could result in a significant proportion of homes unable to meet the target, regardless of capital expenditure. Therefore; either the number of buildings delivered is substantially reduced, or the overall requirement for 'zero carbon' would need to be relaxed in order to allow all developments to proceed.

It was therefore felt that alternative solutions should be considered that allowed off-site solutions, albeit in a controlled way.

8 Potential alternative solutions

A desirable definition of ‘zero carbon’ would incentivise developers to address the problem using the following hierarchy: energy efficiency, on- or near-site zero carbon technologies, and then off-site technologies. Of course, the proposed solution should also encourage the maximum reduction in greenhouse gas emissions which are demonstrably additional, allow developments to be delivered at the required rate, and provide developers with the flexibility required to innovate using a broad range of technologies.

In order to guide the group’s discussions, a set of criteria was established against which suggestions could be tested in an attempt to judge their suitability. These are outlined in appendix 9:

Having gone through the modelling process and understood the sensitivities, the group decided that the three key elements of a definition of ‘zero carbon’ that need to be set are:

- A minimum energy efficiency requirement.
- A minimum requirement for on-site and near-site solutions.
- A mechanism for allowing off-site solutions.

These elements are discussed in more detail over the course of the following sections:

8.1 Energy efficiency requirements

Energy efficiency should always be the first step to reducing carbon emissions as improving the building fabric reduces the amount of energy required, regardless of how one then supplies the energy. Furthermore, building fabric measures can be difficult and expensive to retro-fit, and savings made tend to last the lifetime of the building. It was also felt that the National Calculation Methodology (NCM) should recognise the effect of installing high efficiency appliances in order to encourage developers to install them.

All dwellings should have to achieve an HLP $\leq 0.8 \text{ W/m}^2\text{K}$, and when a non-domestic definition is announced, similar energy efficiency requirements should be required as a first step.

8.2 Defining the minimum level of mitigation required on- or near-site

The group used workshops and brainstorming sessions to generate a list of suggested mechanisms for defining the minimum level of mitigation required on- or near-site. These scenarios were then assessed against the criteria outlined in appendix 9. Each option was then considered in more detail in appendix 10. The options assessed are outlined below:



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- Planners decide
- Renewable resource estimation tool
- Tradable 'carbon quotas' for developers
- Define requirement based on development size or type
- Define 'energy types' required on-site
- Define requirement for on-site 'carbon performance'

The group felt that there would be opportunities for large and small sites to take advantage of community solutions for developments that could be clustered in particular geographies. Instead of investing in multiple smaller installations, investment could be channelled into much larger, more efficient, and lower cost solutions which could also serve the wider community including the existing stock. For this reason the group believes that for 'proven' situations non private wire, near-site solutions should be considered alongside on-site. In the report we have therefore referred to the two solutions together. Clearly this needs further exploration as part of the Government consultation.

8.2.1 Minimum on- near-site requirement - Conclusions

After reviewing the suggestions outlined above, the group felt that defining the minimum requirement in terms of carbon performance was the most appropriate approach as it offered the most flexibility for designers and developers, and focused on the primary policy objective of delivering carbon reductions from the built environment. There was then some considerable further debate over precisely how the requirement should be defined and expressed.

8.3 Defining on- or near-site carbon performance

The two main approaches to implementing this idea are discussed in more detail below:

8.3.1 Setting the minimum by Code level:

If mitigating all predicted emissions on- or near-site is deemed to be too tough a target, the next logical step would be to set a 'back-stop' as the Ene1 requirements for CSH level 5; meaning all predicted emissions from regulated energy uses must be mitigated on- or near-site.

There is currently no equivalent Code for non-domestic buildings, and the modelling done for the *Carbon Reductions in New Non-Domestic Buildings* report suggested that most non-domestic buildings would struggle to mitigate all regulated emissions on-site.

8.3.2 Setting the minimum using a percentage of total predicted emissions:

Rather than using the criteria for a particular Code level as a back-stop, the requirement would be expressed in terms of a percentage of the total predicted emissions. Requiring a percentage reduction provides greater flexibility to deliver a range of solutions as well as enabling greater fine-tuning of the policy.

Furthermore this approach resolves the issue of having to translate a requirement set in terms of the Code for Sustainable Homes into non-domestic buildings, as the target for non-domestic could still be expressed as a percentage.

8.3.3 Defining on- or near-site carbon performance - conclusions

Clearly both approaches are very similar, and the subtle differences between them result in a mixture of potential benefits and drawbacks:

Although aligning the requirements for 'zero carbon' with the Code for Sustainable Homes has an attractive simplicity, the CSH only has a limited number of levels, which reduces the precision with which the definition can be set.

Furthermore, the CSH deals with much more than just energy and carbon and there is potential for confusion as achieving 'zero carbon' does not mean that a project must also achieve a 5 star rating on the Code for Sustainable Homes, nor is it a guarantee that a project will achieve a 5 star rating.

Finally, given there is currently no non-domestic equivalent, and the modelling done so far indicates that all regulated energy, or 'Code 5 energy equivalent' is not likely to be possible for a large proportion of non-domestic buildings.

The group also recognised that there may be specific circumstances, such as developments in conservation areas, that prohibit renewable installations even if they are practically possible and financially viable. Further consideration needs to be given to these special circumstances. This is discussed in more detail in section 8.4.3

The group believes that the Government consultation needs to properly consider where the minimum threshold is set and how it should be expressed. This must be informed by further modelling.

8.4 Allowable off-site solutions

The group considered three main mechanisms for allowing off-site contributions:

- Direct purchase of additional off-site renewable generation capacity.



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- A 'market-based approach' similar to (or indeed including) the Renewables Obligation.
- Paying into a 'fund' at a price relative to specific technologies.

Each option is discussed in more detail below:

8.4.1 Direct purchase of off-site renewable solutions

It would be the responsibility of the housebuilder to either directly or via a third party, identify and purchase a site, obtain planning permission, and install the renewable generation capacity. This would be in parallel to obtaining planning permission for the particular development and go-ahead would be dependent on the renewables capacity being secured.

In order for the zero carbon policy objectives to be met, the renewable capacity would need to be additional to other programmes such as the Renewables Obligation. Whilst the installation of a large wind turbine, for example, on a hill-top some miles from the development, might be considered to be truly additional, it is hard to see how funding an additional wind turbine at an off-shore wind farm being built by a large energy company could be.

8.4.2 Market-based carbon purchase

The housebuilder would purchase carbon from a carbon trading scheme. This could either be done through an existing scheme, or a new scheme could be developed specifically. The group did not feel that this was an appropriate mechanism to use as it could not guarantee delivery of additional, physical zero carbon installations.

8.4.3 Community energy fund

Payments could be made into a managed fund at a price set at a margin above the cost of installing appropriate, community level, zero carbon technologies.

If the price of paying into the fund was set at a margin above the typical cost of community-scale renewable solutions, then the price of delivering carbon savings could be somewhat equalised across different development sizes. Larger developments could still opt to install the equipment on- or near-site as the most cost effective option, but smaller or more constrained sites, would not be exposed to disproportionate costs as they could pay into the fund at a similar price per kgCO₂ as larger sites. The fund could then be used to install strategic community-scale installations, potentially engaging the existing stock, in order to achieve equivalent carbon savings that are genuinely additional.

The group were concerned about the possibility of having to set the minimum level of carbon performance too low in order to accommodate sites where there are specific restrictions (e.g. conservation areas). It was felt that the flexibility afforded by the fund mechanism could avoid this as these restricted sites would have the option of paying into the fund at a price relative to



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the more expensive on-site solutions (e.g. PV) up to the agreed minimum level. It was felt that this would provide the maximum incentive to provide other solutions. After this, they could pay additional monies into the fund at the 'standard rate' or utilise other off-site solutions. It was felt that the mere presence of this fund would incentivise the micro-renewables industry to come up with lower cost solutions.

Using the fund could also enable greater distribution of heat via district networks which could achieve significant carbon savings from the existing stock. This clearly represents an exciting opportunity to tackle a key priority.

8.4.4 Allowable off-site solutions - conclusions

In considering the mechanism for allowing off-site solutions the group felt that they should be allowed without requiring private wire networks, provided that they were demonstrably additional and had been built specifically to deliver the energy needs of the development.

Alternatively the developer could be allowed to pay into a 'Community Energy Fund' that would then ensure equal or greater net carbon savings are delivered through new installations of carbon saving technologies. The price of paying into the fund should clearly incentivise the installation of on- or near-site measures first.

8.5 *Alternative solutions - conclusions*

The group concluded that a suitable solution should include:

1. Minimum energy efficiency measures to be included as a first step.
2. A requirement for minimum on- or near-site carbon reduction based on either Code levels or as a percentage reduction.
3. A mechanism for allowing truly additional off-site solutions via direct purchase or payment to a fund.

The group believes that these proposed changes would provide an appropriate balance of energy reduction measures, whilst continuing to support demand for on- or near-site renewable technologies, and provide the basis for a significant growth in community-scale technology.



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9 Community energy fund principles

While a full proposal for the establishment of such a mechanism was outside the scope of this project, the group did consider the key principles that must apply to the fund in order to ensure that it works as intended:

9.1.1 Equivalent, additional carbon savings

The fund should be used to support installations that achieve additional carbon savings at least equivalent to those that could not be mitigated on- or near-site by the developments making contributions. One example put forward by the group, was that the fund could be used to install district heat networks to serve the existing stock using heat from new developments. There is currently a lack of a policies incentivising efficient heat production and delivery, and such a mechanism would help deliver low-carbon heat to the existing stock while making new 'zero carbon' developments easier to deliver.

9.1.2 Local project bias

The fund should, where possible, have a preference for installations close to projects that have paid into the fund. As well as being 'fairer' in terms of spending the money in the same area that it was originally intended for, this also fits with the principle of maximising efficient use of resources at every level. As local authorities implement Regional Spatial Strategies new developments could help deliver the infrastructure to drive improvements from which the whole community can benefit. This aligns with the Planning and Climate Change supplement to Planning Policy Statement 1 (PPS1) which states that *'new development should be planned to make good use of opportunities for decentralised and renewable or low carbon energy;'*

9.1.3 Predictability

While the cost of paying into the fund needs to remain at the intended level relative to other mitigation solutions, it must remain stable enough to provide certainty for strategic land purchases and business planning. Appropriate timescales for reviewing and updating the price of the fund should be consulted on.

9.2 Operation of the fund

The group discussed where responsibility for the fund should lie and how the money should be allocated for projects. While further discussions and input are needed, one suggested approach was that the fund should be managed by trustees who administer it according to the principles outlined above. Organisations and companies, possibly forming consortiums, could then bid for projects out of the fund that deliver carbon savings as part of a wider strategic plan.

Also, whether the fund is established as an extension of an existing programme, to avoid further crowding of the regulatory landscape, or whether a new system is required needs proper



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investigation. The cost of establishing a new scheme needs to be weighed against the suitability of existing schemes and their ability to clearly deliver additional carbon savings.

9.2.1 Delivering community energy solutions

The Planning and Climate Change supplement to PPS1 clearly outlines the key principles for regional planning bodies establishing spatial strategies and development plans. Many of these principles align almost directly with the intended function of the fund. Whether publicly or privately administered, the spending of the fund should be aligned with regional spatial strategies and local development plans in order to ensure that maximum benefit is achieved from spending the money in a considered and strategic manner.

A more detailed outline of how the various stakeholders may contribute is contained in appendix 11.

10 Proposed definition of 'zero carbon'

In assessing what form the hybrid solution should take, the group were mindful of the need to ensure that demand is minimised, use of on- and near-site renewables are optimised, and there is a level playing-field for small and large developers.

The group therefore recommends that:

1. All new buildings must meet strict minimum energy efficiency parameters as part of the definition of 'zero carbon', both in terms of the building design and appliances where supplied by developers.
2. All new buildings should seek to mitigate predicted carbon emissions from all energy uses via on- or near-site solutions. Where this is not possible, a minimum level of carbon mitigation must be required (e.g. 100% regulated energy) on- or near-site.
3. Above this threshold either:
 - Off-site solutions could be allowed, without requiring private wire networks, provided that they are demonstrably additional and have been built specifically to deliver the energy needs of the development.
 - The developer can pay into a 'Community Energy Fund' that will ensure equal or greater net carbon savings are delivered through new installations. (NB: The price of paying into the fund should be set at a margin above the cost of community-scale solutions so as to clearly incentivise the installation of on-site or local measures first.)

The group believes that these proposed changes would provide an appropriate balance of energy reduction measures, whilst continuing to support demand for on- and near-site renewable technologies, and provide the basis for a significant growth in community-scale technology. Furthermore, this approach could have the additional benefit of reducing CO₂ emissions from existing buildings by enabling the distribution of heat via district networks.

10.1 Non-domestic buildings

Although most of the work for this project concentrated on domestic buildings, using the insights gained from this work and the *Carbon Reductions in Non-Domestic Buildings Report* some strong conclusions can be drawn:

- The same principles should be used to form a similar definition for the non-domestic sector in order to better accommodate good mixed-use developments and achieve greater national emissions reductions



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- The non-domestic definition must be sympathetic to the greater variety and disparity of the non-domestic stock, and should endeavor to avoid unduly disadvantaging particular uses as far as is practicable.
- Work must begin urgently if Government aspirations for zero carbon schools and public buildings are to be met



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11 Next steps

As a result of the work done in this review, the group believes its recommendations should be used as a basis for the Government's expected consultation in the summer. In addition, there is a large number of items that need further work or resolution over the course of delivering zero carbon buildings over the coming months and years. Many of these could be taken forward by the proposed Zero Carbon Delivery Vehicle, currently under development.

11.1 Recommended inputs to the Government's expected consultation

As well as taking the revised definition contained in this report into consultation, the group recommended several key points that should be addressed as part of the process:

1. At what level to set the minimum threshold and how this should be expressed.
2. How to accommodate sites with specific restrictions that are unable to meet the national minimum, including consideration of a higher-price (e.g. above PV) below the minimum threshold.
3. Mechanisms to ensure allowable off-site solutions are genuinely additional.
4. A definition of 'near-site' that encourages community-scale solutions.
5. The principles, purpose and administration of the fund.

11.2 Other areas where further work is recommended

The group also recognised that there was more work to be done building up a robust body of evidence around some of the wider implications of 'zero carbon' buildings. The following list is not intended to be exhaustive and will almost certainly need adding to after the expected consultation in the summer:

- Review of technology mix with different assumptions including: reduced grid intensity, limited biomass availability, etc.
- Implications of Biomass demand.
- The implications of widespread use of wood-fuelled systems taking into account the impacts of new technological developments.
- The discrepancy between real and predicted carbon emissions.



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- The ability of the National Calculation Methodology to predict occupant energy emissions more accurately than at present.
- The expected temporal term of 'zero carbon' status.
- Regulatory and legal issues (a brief discussion is included in appendix 13).
- The timing and mechanism for changes to any fund prices that might be set.

A number of these important issues are discussed further in appendix 12.

And finally consideration must be given to the 'parked issues' that arose in the course of discussion, which were outside of the scope of the review but that must be taken forward to ensure effective delivery of the zero carbon policy. These are listed in appendix 5.



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