Low carbon cooking appliances

NHBC Foundation

Housing research in partnership with BRE Trust

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FOREWORD

This research report examines the part low carbon cooking appliances can play in reducing CO_2 emissions from new and existing homes. Although cooking appliances currently have very limited inclusion in the building regulations, with no mention in Part L1A, they do figure in the Code for Sustainable Homes Level 6, but without an officially sanctioned method to reflect efficiency savings.

While currently at a relatively low level, modelling suggests that CO_2 emissions from a Code for Sustainable Homes Level 6 compliant home could account for as much as 18% of all emissions meaning that there is increased scope to make cost-effective savings via low carbon cooking technology.

This report considers the use of hobs and ovens using a variety of technologies and fuels including electricity, gas and bio-gas. Interestingly the report also includes details of consumer likes, dislikes and perceptions from the survey and discusses consumer preferences in the desired type of appliance to be installed.

Importantly the modelling indicates that, given future developments in available technology, cooking's contribution to total CO_2 emissions can in theory be cut to just 2% by specifying more carbon efficient cooking appliances.

As we head towards the future for new homes, and begin to address the huge challenge of improving energy efficiency in our homes, it is clear that the correct choice of cooking appliances is likely to make a valuable contribution in reducing emissions.

I hope that you will find the report both useful and informative.

Rt. Hon. Nick Raynsford MP
Chairman, NHBC Foundation

ABOUT THE NHBC FOUNDATION

The NHBC Foundation was established in 2006 by the NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and housebuilders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

Further details on the latest output from the NHBC Foundation can be found at www.nhbcfoundation.org.

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GLOSSARY

Allowable Solutions	The third and final element in the Government's 2016 plan for zero carbon homes (ZCH). The exact definition is yet to be agreed, but the broad aim of allowable solutions is to provide a practical mechanism for housebuilders to further reduce CO_2 arising from new development, beyond the dwelling-specific measures adopted via the Fabric Energy Efficiency Standard and the Carbon Compliance Standard. This could potentially be achieved by refurbishing existing buildings in the surrounding area to reduce their CO_2 emissions, or by paying into a community fund that would then finance other CO_2 reduction measures. For more information on Allowable Solutions, visit the Zero Carbon Hub website: www.zerocarbonhub.org.
Biogas	Gas produced from biodegradable matter, for example food waste. This gas can either be used to directly fuel individual appliances at a household level, or alternatively, it may be burnt in a centralised generation plant to provide low carbon electricity and heat.
Carbon Compliance Standard	The second element in the Government's 2016 plan for zero carbon homes. It builds on the Fabric Energy Efficiency Standard, and is designed to ensure that new dwellings are built with effective CO_2 reduction measures directly installed on-site. Measures such as low carbon heating systems, microgeneration (photovoltaic panels or solar water heating), or a connection to low carbon heat sources such as combined heat and power (CHP), all fall under the Carbon Compliance area.
Carbon Emissions Reduction Target (CERT)	Requires all domestic energy suppliers with a customer base in excess of 50,000 customers to make savings in the amount of CO_2 emitted by householders. Suppliers meet this target by promoting the uptake of low carbon energy solutions to household energy consumers, thereby assisting them to reduce the carbon footprint of their homes.
Code for Sustainable Homes	Environmental assessment method for rating and certifying the performance of new homes. It is a national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home building, and includes categories such as Energy and CO_2 emissions, Water, Materials and several others.
Combined Heat and Power (CHP)	Process by which electricity is generated, and the associated heat is captured for use. This process is typically carried out in centralised power stations, although small domestic micro-CHP units are now available. CHP differs from traditional power stations, which treat the heat created by electricity generation as a waste product; CHP therefore provides a more efficient use of fuel and is typically regarded as a low-carbon technology.
Energy Saving Trust Recommended (ESTR) scheme	Scheme launched in 2000 by the Energy Saving Trust to identify the most energy-efficient products on the market. Where product groups can be differentiated by their energy saving characteristics, the scheme aims to endorse the top 20% of products on the basis of their energy performance.

English Housing Survey	Continuous national survey commissioned by The Department for Communities and Local Government (DCLG) that collects information about people's housing circumstances and the condition and energy efficiency of housing in England.
EU Energy Labelling	Energy labelling scheme for a variety of products including white goods, small electronic goods, light bulbs and others. Each product is rated on a scale of A (best performance) to G. Other information is also presented on a product by product basis; for example, washing machines are also rated for noise.
Fabric Energy Efficiency Standard (FEES)	The first element in the Government's 2016 plan for zero carbon homes. It is designed to ensure that new dwellings are built with highly efficient fabric (walls, roofs, floors, windows and doors, along with airtightness and associated areas), and is measured in $kWh/m^2/year$. FEES has now been adopted within the November 2010 Code for Sustainable Homes update, and replaces the Heat Loss Parameter credit.
Fuel CO_2 factors	Factors allow kWh fuel use (as determined within the Standard Assessment Procedure calculation) to be converted into the resulting kg CO_2 emissions.
Market Transformation Programme (MTP)	Supports the development and implementation of UK Government policy on sustainable products, via a variety of initiatives including helping to develop new standards, research into consumer behaviour and building evidence on the adoption of innovative products.
Passivhaus	German construction standard, widely viewed as one of the most advanced available. It requires a highly efficient building fabric to minimise dwelling heat losses and reduce dwelling space heating requirements.
Regulated emissions	Assessed by SAP. They include emissions resulting from space heating, water heating, associated pumps and fans, and lighting.
Standard Assessment Procedure (SAP)	The Government's method for assessing the running cost and environmental impact (including CO_2 emissions) of dwellings.
Unregulated emissions	Not assessed by SAP. They include emissions resulting from appliance use, and cooking.

1 Executive summary

This report provides guidance to developers who wish to understand the role that low carbon cooking appliances can play in reducing CO_2 emissions within new dwellings. The report is set against the context of the Code for Sustainable Homes, and the Homes and Communities Agency (HCA) funding stream for low or zero carbon (LZC) infrastructure.

The findings of this report are based on:

- a survey of over 260 consumers who bought or built a new build property in the 18 months before the survey
- a half-day expert workshop with delegates from a variety of industry sectors
- an energy and CO_2 modelling exercise
- a detailed literature review and patent search.

1.1 Current developments

An investigation of patents was carried out, which indicates that a number of mainstream manufacturers have recently patented several innovative cooking mechanisms that may reach the marketplace and bring potential CO_2 savings.

1.2 Legislation

Cooking appliances currently have very limited inclusion in the building regulations, and no mention in Part L1A. They do figure in the Code for Sustainable Homes Level 6, but a standardised equation is used to assess emissions, and there is no officially sanctioned method to reflect efficiency savings. There is currently no plan to offer a credit for low carbon cooking appliances in the forthcoming revised edition of the Code. The EU Energy Labelling scheme currently only covers electric ovens, which are also the only cooking appliance covered by the Energy Saving Trust's Energy Saving Recommended (ESTR) scheme. However, in Brazil, energy rating for both electric and gas cookers and hobs has been mandatory since 2003, with the result of driving up efficiencies and removing poorly performing products from the marketplace. Low carbon cooking appliances are moving up the Government's agenda, and the Department for Environment, Food and Rural Affairs (DEFRA) has recently held a consultation seeking additional information on the sector.

1.3 Compliance

This issue was investigated by modelling a representative house type using Standard Assessment Procedure (SAP) software, using an indicative fabric/services specification to achieve a 70% reduction in CO_2 compared to ADL1A 2006 requirements, in line with the proposed on-site Carbon Compliance standard. The existing cooking and appliances equation from the Code was then altered to allow the increased efficiencies of lower carbon cooking appliances to be reflected. Whilst the modelling showed that cooking only accounts for 3% of CO_2 emissions in an existing house, in a Code for Sustainable Homes Level 6 compliant home it accounted for 18%, meaning that there is increased scope to make cost-effective savings via low carbon cooking technology. Various fuel types and technologies are investigated, and the modelling indicates that, given future developments in available technology, cooking's contribution to total CO_2 emissions can in theory be cut to just 2% by specifying alternative appliances. The comparison showed that unless biogas is available, either to provide low carbon electricity or to fire cooking appliances directly, standard mains gas remains the lowest CO_2 cooking technology currently available.

1.4 Biogas as an alternative fuel

Food waste driven biogas production, and integration with new housing developments, were investigated. Because the economics of biogas production are currently marginal, only in very particular circumstances does biogas lend itself to new developments. An example situation would be when a large number of existing houses are also available to provide waste to fire the plant, with local authority commitment and potentially industrial food waste locally to bolster feedstock volumes. Even if connected, the infrastructure costs of piped gas would be excessive, meaning that the most economical option would be to burn the biogas in a combined heat and power (CHP) plant, and supply the renewable electricity to the development. Currently the most cost effective way to link a new development to a biogas plant is via an energy supply company, because of the high transaction costs that are levied when dealing directly with biogas producers. The policy environment is expected to shift in the medium term, both with the introduction of the Renewable Heat Incentive, and streamlined regulatory requirements to reduce transaction costs; these factors would serve to make biogas-coupled new developments more feasible.

1.5 Consumer perception

The majority of those who responded to the questionnaire were frequent users of both their hobs and ovens. Well over three-quarters of the questionnaire respondents indicated they used both their hob and their oven at least three times a week.

1.5.1 Hobs

Awareness of hobs: The majority of respondents had heard of electric ceramic, halogen and gas hobs, however, most had only actually cooked on gas and ceramic. Less than half the respondents had heard of sealed plate or electric coil hobs and less than a third had heard of the more recent induction, gas on glass, or dual fuel hobs. The findings indicate that most people are not very aware of the variety of hobs available and even fewer have experience using different types of hobs.

Current, preferred and least preferred hobs: Almost three-quarters of respondents currently use gas hobs. The next highest proportions of respondents (one in 10) were currently using electric sealed plate hobs, followed by ceramic and halogen. Over two-thirds of respondents said a gas hob would be their preferred hob choice. The next most frequent choice was electric halogen hobs. Respondents least preferred choice was electric sealed plate hobs and the next least preferred hob type was electric ceramic.

Hob likes: The features respondents particularly liked about the gas hobs were the level of control over the exact temperature, the ease of cleaning and the visible flame. Other respondents particularly liked the appearance, ease of cleaning and quality of heat distribution across the base of pans offered by the halogen hobs.

Hob dislikes: The features respondents particularly disliked about the sealed plate hobs were the lack of control over the exact cooking temperature, appearance, time taken to reach desired cooking temperature and the increased risk of accidental burning of the user. In reference to the electric ceramic hobs, respondents said they particularly disliked the time taken to reach the desired cooking temperature, speed of cooling after use, and appearance.

Energy use, running cost, environmental efficiency*:* Overall, the majority of respondents felt that gas hobs would use less energy and would be cheaper to run than electric hobs. However, the majority felt electric hobs would be more environmentally friendly than gas.

1.5.2 Ovens

Awareness of ovens*:* The majority of respondents had heard of, and experience using, gas, conventional electric, and electric fan assisted ovens. Few had heard of electric steam ovens and even fewer had actually used one. Respondents seemed to be more aware of different oven types and experienced in using them compared with different hob types.

Current, preferred, least preferred ovens*:* Well over three-quarters of the respondents currently had electric fan assisted ovens and over two-thirds indicated that electric fan assisted ovens were their preferred choice. In contrast, fewer than 5% had gas ovens and fewer than a quarter said that gas would be their preferred choice. The oven type most frequently selected as least preferred was gas, followed by conventional electric and electric steam ovens.

Oven likes*:* The features that respondents particularly liked about the electric fan assisted ovens were the even temperature across the oven, time taken to reach desired cooking temperature, and ease of cleaning.

Oven dislikes*:* The features respondents particularly disliked about the gas ovens were the risk from harmful fumes, difficulty of cleaning, and a perceived increased risk of explosions.

Energy use, running cost, environmental efficiency*:* As was also found for hobs, the majority of respondents felt that gas ovens would use less energy and would be cheaper to run than electric ovens. However, the majority also felt that electric ovens would be more environmentally friendly than gas.

Almost two-thirds of those respondents who preferred gas ovens expected them to be more environmentally friendly than electric ovens. Conversely, over two-thirds of those who preferred electric ovens expected they would be more environmentally friendly.

1.6 Gas supply

The findings indicate, that for 70% of respondents, it was not essential that their kitchen was connected to the gas when they bought their house; however, for many it was desirable.

Of those respondents who showed a preference for gas cooking appliances, having a gas connection was essential for over a third. However, over a quarter of those respondents who showed no preference for gas cooking appliances also stated it was essential that the kitchen was connected to gas and over a third said it would be desirable. It may be that these respondents were considering the ease of resale and the preferences of other future buyers when answering this question.

The findings show that for the majority of respondents (70%), not having gas supplied to the kitchen would not put them off buying a house they liked, and of this group, two-thirds would not expect to pay less for the property. However, for a minority of respondents (30%), not having gas supplied to the kitchen would put them off buying a house they liked and of this group, almost two-thirds would expect to pay less for the property. No significant differences were found for region or house type, suggesting these findings were not driven by particular groups of respondents living in a particular region or particular house type.

A workshop was held to inform the contents of this report, and results from this are included at the end of this report.

Please note that modelling and consumer research for this report was undertaken prior to the Government's March 2011 Budget announcement regarding the altered zero carbon homes definition, which indicates that unregulated emissions from cooking and appliances will no longer be included within the compliance metrics for zero carbon.

The current expectation is that unregulated emissions will not form part of the requirements for 2016 building regulations compliance. However, it is expected that they will continue to be included within Code for Sustainable Homes Level 6.

2 Introduction

The rapidly progressing sustainability agenda is requiring many large scale developers to consider technical and consumer perception issues on long-term current projects. A number of these schemes are seeking to take advantage of the Homes and Communities Agency (HCA) funding stream for LZC infrastructure[1].

Developers are beginning to accept the conceptual shift towards increased usage of district energy schemes providing low carbon heat and power. However, there is a concern that the shift away from provision of individual gas-fuelled cooking appliances, particularly hobs, risks alienating consumers. Previous work by the Market Transformation Programme (MTP) indicates that the percentage of all households with an electric hob is expected to fall from 46% in 2000 to 42.5% in 2020, due to a preference for gas[2]. While they acknowledge that technical developments may influence this trend, there is clearly a strong consumer issue to be considered.

In parallel to consumer perspectives, the issue of carbon emissions resulting from cooking appliances merits investigation. MTP projections are based on the assumption that in 2007, only 3% of all electric hob sales were of the more energy efficient induction type[2]. These are assumed to be around 20% more energy efficient than other electric hob types.

This report therefore presents research with regard to consumer awareness of the different products available, consumer preferences for different heat sources and hob types, consumer perceptions of the products available and the relative impact of these perceptions on choice of house or perceived value of a property. In addition, the report investigates the potential carbon implications if alternative approaches – such as the use of stand-alone biogas hobs – were to be adopted on a large scale in the new build sector. Central to this issue will be technology readiness and potential product development and regulatory barriers faced by such innovative cooking appliances.

3 Technical research

The project research was broken down into two broad areas:

- technical developments
- legislation.

To source information, an industry consultation was carried out, as well as desk and field research.

3.1 Technical developments

3.1.1 Manufacturers

A broad selection of domestic appliance manufacturers were contacted. Unfortunately, no useful information was gained as part of this exercise, with manufacturers understandably citing reasons of commercial confidentiality.

3.1.2 Trade bodies

The Association of Manufacturers of Domestic Appliances (AMDEA)

AMDEA agreed to attend the workshop day, and provided a useful overview of the issues surrounding greater energy efficiency in cooking appliances, as well as a historical perspective on increases in efficiency. However, due to reasons of commercial confidentiality as discussed above, they were unable to reveal any forthcoming new developments in domestic cooking appliances.

3.1.3 Literature search

A catalogue search of the British Library's holdings was carried out, which produced a variety of matches from the late 1970s to present. It was assumed that any developments before 2000 would be largely irrelevant, or subsumed into more recent research, and so results before this were disregarded. The following categories were identified:

- university research (PhD and Masters dissertations)
- Government research
- conference proceedings.

A large number of the results were of limited relevance to this project. The most useful resources were the proceedings from the various *International Conferences on Energy Efficiency in Domestic Appliances and Lighting* (2003, 2006, 2009). These conferences cut across a number of topics, but contained useful information specifically dealing with domestic cooking appliances, and this has been utilised within a number of sections of this report.

3.1.4 Patent search

A search of the Patents database (2007 to present) was conducted, with the following technologies being noted:

- electromagnetic bodied induction oven
- microwave assisted oven
- vapour assisted oven
- microwave/vapour assisted oven
- pressure assisted oven
- lightwave oven
- variable size oven
- dual fuel oven
- new gas burner designs.

The majority of innovations appear linked to speed of cooking, but potentially would also have positive effects on efficiency.

Patents are registered to individuals, as well as a variety of well-known international manufacturers, including Bosch, Siemens, and Matsushita.

Given the variety of technologies and the nature of patent holders, it seems likely that some of the technologies listed above will reach the marketplace in the future. The volume of patents also indicates that research into innovative cooking methods is active and ongoing.

3.2 Legislation

3.2.1 DEFRA

DEFRA issued the July 2008 *Policy Brief: Improving the Energy Performance of Domestic Cooking Products*[3], which projects the annual savings achievable by accelerated manufacture of more efficient cooking appliances. The key numbers from this report (drawn from work carried out by the MTP, see below) underpin results in Section 4 – *Energy modelling and CO_2 impacts* – of this report.

Within the DEFRA report, reference is made to updated targets and projections, due in 2008 (Figure 1) . No updated targets or projections could be found on DEFRA's website. DEFRA launched a consultation in December 2009 entitled *Saving Energy Through Better*

Products and Appliances[4], which closed in early March 2010. This consultation covered a large number of different sectors, including both domestic and non-domestic, and sought feedback on a variety of policy measures intended to drive greater efficiency in products and appliances.

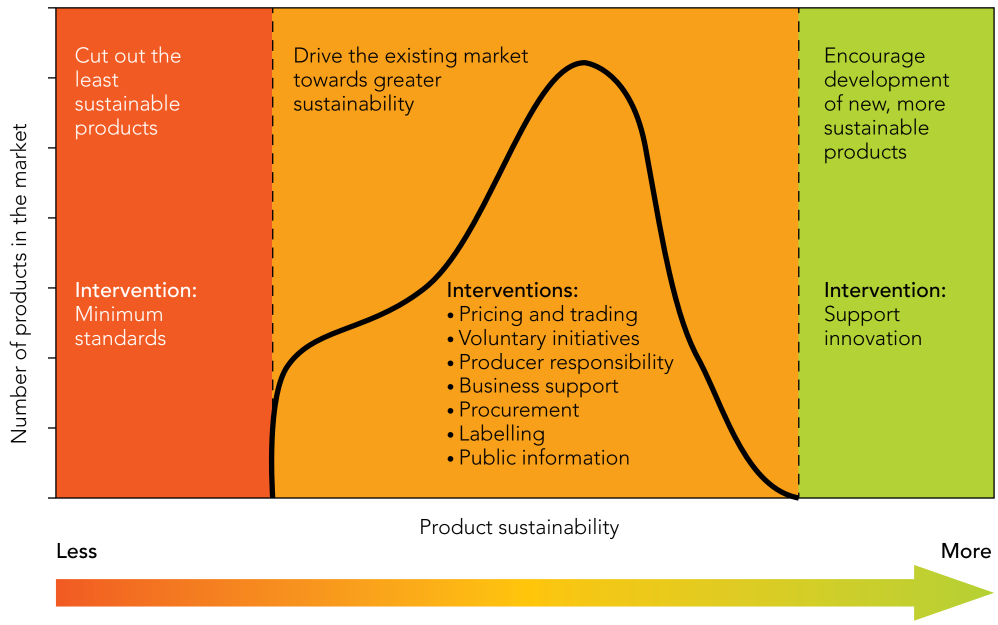


Figure 1 DEFRA graphic showing interventions to increase product efficiency

Domestic cooking appliances are included in the consultation as a mini annex, and DEFRA acknowledges it has limited information on the sector. As a result, the consultation set out an approximate framework for measures and savings in this area. Future policy interventions are proposed to be the EU Energy Using Product Policy (EU EuP), EU Energy Labelling (EL), the Carbon Emissions Reduction Target (CERT), and the ESTR scheme. The potential overall energy saving arising by 2020 from these interventions is estimated to be approximately 10%. These figures in the consultation document are again underpinned by work carried out by the MTP.

3.2.2 Market Transformation Programme

The MTP produced figures that underpinned the DEFRA policy brief referenced above, which can be found in *BNCK01: Assumptions Underlying the Energy Projections of Cooking Appliances*[2]. This document sets out projected trends in appliance ownership by fuel, and efficiency. Note that the impacts of National Grid decarbonisation and alternative fuel sources are not included in the analysis. Key numbers from this report underpin results in Section 4 – *Energy modelling and CO_2 impacts* – of this report.

3.2.3 Energy Saving Trust Recommended scheme

The ESTR scheme was launched in 2000 by the Energy Saving Trust to identify the most energy-efficient products on the market. Where product groups can be differentiated by their energy-saving characteristics, the scheme aims to endorse the top 20% of products on the basis of their energy performance. Recognised products carry the ESTR label, for easy identification by consumers (Figure 2).

Figure 2 Energy Saving Trust Recommended logo

To gain certification, a product must meet a set of strict criteria. These are developed with the involvement of a wide range of stakeholders, and are reviewed on an annual basis to ensure the scheme continues to drive market improvements in energy performance. The ESTR scheme currently operates across 38 product groups, with manufacturers and suppliers providing over 2000 certified products.

In May 2009, electric ovens were added to the ESTR scheme, and are currently the only cooking appliance product represented.

3.2.4 Building regulations

Because emissions from cooking appliances are classed as 'unregulated' emissions, they are not addressed within the building regulations. Since 2011 Budget announcements, unregulated emissions are not expected to be included as part of the 2016 zero carbon building regulations for new housing.

In terms of current regulatory compliance, a small benefit is available to electrical pre-wired plug-in hobs, which achieve simplified compliance under Part P of the building regulations. This benefit is likely to be carried forward to future electric cooking technologies, and may present a key advantage to developers seeking the simplest and least time-consuming low carbon cooking option.

3.2.5 Code for Sustainable Homes

There are currently no plans to offer credits for low carbon cooking technology within the Code for Sustainable Homes, although this may change within future iterations of the methodology. In terms of awareness-raising, inclusion within the Code would be an important step; the response of the Department for Communities and Local Government (DCLG) to this issue could be central in determining market uptake of low carbon cooking appliances.

3.2.6 EU Energy Labelling Scheme

Of common cooking appliances, the EU Energy Labelling Scheme currently only covers electric ovens. The label has been successful in driving efficiency within the product group, with the majority of purchases now falling into the A (35%) or B bands (54%)[5]. Within the recent DEFRA consultation document, there is a suggestion to increase the scope of the labelling scheme to include gas ovens, and clearly both the electric and gas hob sectors would also benefit from labelling.

Experience from Brazil[6] shows that energy labelling for gas ovens, as well as electric and gas hobs (referred to as cooking tables), is both possible and useful in driving up efficiency standards. The Brazilian Association for Technical Standards (ABNT – Associacao Brasileira de normas Tecnicas) has set standards for safety and efficiency in domestic electric cooking appliances since 1985, and domestic gas cooking appliances since 1999, with comparative labelling being compulsory since 2003. The labelling scheme has been successful in driving up efficiencies, with effective minimum hob efficiency rising from 52% (2003) to 56% (2008), and oven minimum efficiency indices going from unlimited (2003) to 67% (2008). Improvements have led to classes F and G being eliminated from the label in 2006, and a current push to eliminate class E. Availability of high-rated products dominates the marketplace, with 69% of hobs and 80% of ovens being A-rated.

3.3 Technical research conclusions

Low carbon cooking appliances are gaining increasing significance in Government policy research, but there remains some way to go before a compelling evidence base is gathered. Fundamentally a requirement for EU energy labelling of all cooking appliances, for all fuels, seems a clear prerequisite for driving improvements in efficiency, and experience from Brazil is encouraging. Once energy and CO_2 savings can be quantified, scope for including efficiency savings within the Code for Sustainable Homes becomes more feasible.

There is limited publicly available information on the future technical development of cooking appliances, due to reasons of commercial confidentiality. Nevertheless, patents reveal that research into new technologies is ongoing, and involves mainstream manufacturers who are equipped to bring new and potentially more efficient products to market. Changes to the legislative or commercial environment would encourage the investment of further resources into this area, accelerating progress and bringing the widespread availability of low carbon cooking appliances closer to reality.

4 Energy modelling and CO_2 impacts

4.1 Policy scenario

Currently, emissions from cooking make up only a small part of a typical new build dwelling's CO_2 emissions. However, with dwelling construction standards set to radically improve under the current and forthcoming revisions to Building Regulations (Part L1A which in England is linked to the Energy and CO_2 emissions section of the Code for Sustainable Homes), the percentage emissions from cooking will increase. This section of the research investigates how significant this increase may be, by looking at cooking CO_2 emissions in relation to the kind of dwelling which may be typical in the future. The Energy and CO_2 performance levels as set out in the Code for Sustainable Homes have been used to indicate the likely performance levels such a dwelling would achieve.

The Code for Sustainable Homes is now well established in England and Wales as a major driver in the delivery of sustainable homes.

Emissions from cooking are currently only included in the Code at Level 6, as they fall within the 'unregulated emissions' bracket (which includes emissions from other household appliances). The methodology for calculating cooking emissions uses a standardised equation, and currently there is no officially sanctioned way to reflect enhanced efficiencies within the assessment.

The Code for Sustainable Homes has recently undergone a major consultation. One of the main proposed changes was a relaxation in the necessity to achieve all emissions reductions on-site, using a broad set of approaches known as allowable solutions. These might include, for example, improving the energy efficiency of surrounding buildings or infrastructure, to achieve total CO_2 reductions equivalent to the required Code level target. The allowable solutions approach is yet to be fully defined, and one interpretation might allow efficiency reductions from low carbon cooking appliances to be included. Alternatively, the standardised equation currently used to calculate unregulated emissions could be enhanced to allow increased appliance efficiencies to be reflected in the assessment.

4.2 Modelling approach

In order to model the potential savings from the inclusion of low carbon cooking appliances, we used the following approach:

1. Model a representative house type using SAP (Standard Assessment Procedure) software:
   - A representative house type was chosen as being typical of an existing dwelling. This was achieved by reference to the English Housing Survey, a national stock survey which contains real survey data from thousands of existing homes. A semi-detached built form was chosen.
2. Increase the specification to be typical of a 70% Fabric Energy Efficiency Standard and Carbon Compliance level dwelling, as is expected to be required for Code Levels 5 and 6:
   - In order to ensure that the fabric energy efficiency requirements were met, the dwelling was modelled using a typical Passivhaus specification, linked to a gas CHP, with additional photovoltaic electricity generation as required to achieve the 70% emission reduction when compared to ADL1A 2006 requirements.
3. Take the existing unregulated emissions equation and alter so that increased cooking appliances efficiency can be reflected:
   - The equation was expanded to split out appliances and cooking emissions. The default efficiency within the equation was then altered to reflect different appliance efficiencies, and fuel CO_2 factors.
4. Determine the percentage difference in CO_2 emissions between a 70% compliant dwelling with standard cooking appliances, and more efficient cooking appliances:
   - This calculation was carried out by contrasting:
     - total regulated energy dwelling emissions, plus the standard unregulated emissions equation.
     - total regulated energy dwelling emissions, plus altered unregulated emissions equation to reflect higher cooking appliance efficiencies.

4.3 Modelling results

Figure 3 shows the baseline percentage emissions in a 70% compliant dwelling with electric cooking:

- Unregulated emissions (from appliances and cooking) now make up 75% of the total emissions, with cooking-specific emissions accounting for 18%.
- To take such a design to Code Level 6 would require a further 2.5 tonnes CO_2 reduction per dwelling. In terms of the average UK person's lifestyle, this 2.5 tonnes of CO_2 saving is equivalent to not watching television for nearly 22 years.

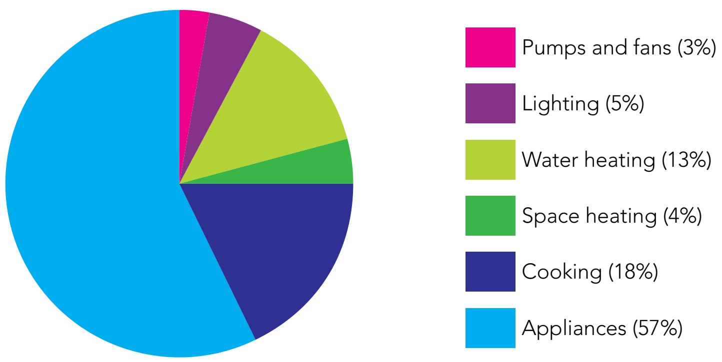


Figure 3 Baseline percentage CO_2 emissions from a 70% compliant dwelling

4.3.1 Analysis of different cooker and fuel types

Next the impact of other cooking fuels and improved efficiencies was investigated. Due to the lack of data available from manufacturers, it was not possible to model specific low carbon cooking appliances. To overcome this, three fuel types (electricity, gas and biogas), and three theoretical improved efficiencies for electricity (30, 50 and 70%) were modelled. The three additional electricity scenarios were indicative only and were chosen to reflect potential future improvements in electric cooking technology efficiency. Because standard electric cooking showed the highest CO_2 emissions, it was chosen as a baseline against which to compare other options.

Figure 4 shows percentage cooking CO_2 emission savings, relative to the baseline using electric cooking described above. In simple terms, the higher the bar, the greater the percentage saving the particular fuel or technology achieves relative to standard electric cooking.

Returning now to the 70% compliant dwelling, where standard electric cooking was responsible for 18% of total regulated plus unregulated emissions (see Figure 3), we can see that by switching fuel or increasing electrical cooking efficiency, cooking's percentage contribution to overall dwelling CO_2 emissions shrinks (Figure 5).

- Figure 5 indicates that the most carbon efficient technology currently available (currently available technologies being shown in blue) is standard gas cooking.
- Note that LPG, biogas, and 30/50/70% enhanced efficiency electrical cooking appliances are not currently available, and have been modelled to show potential CO_2 savings.

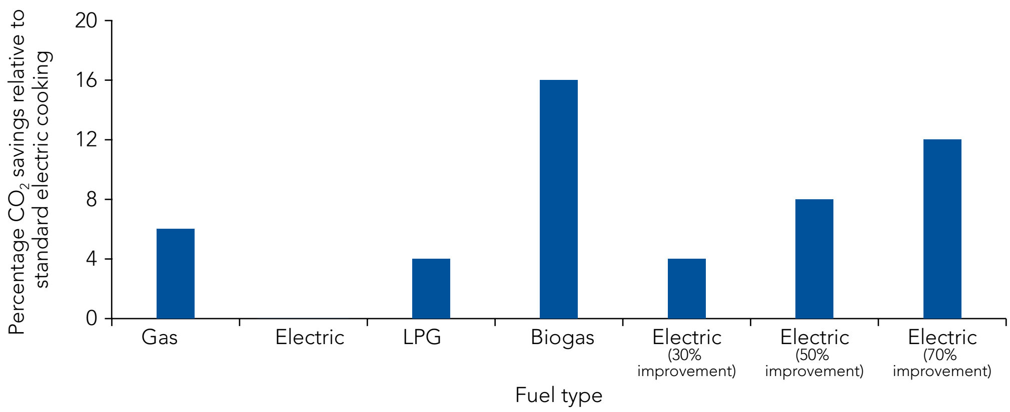


Figure 4 Percentage fuel CO_2 emissions savings relative to standard electricity

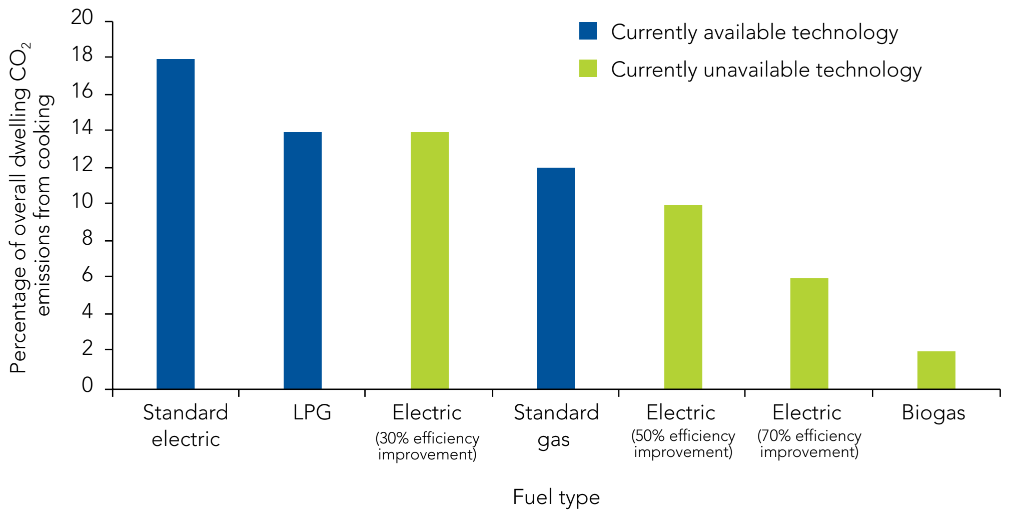


Figure 5 Percentage of overall dwelling CO_2 emissions from cooking (70% compliant dwelling, total of regulated plus unregulated emissions)

- Electrical induction hobs are currently available which achieve claimed percentage efficiency improvements of 20% over standard electric cooking (these are manufacturer's figures and have not been verified as part of this report). The modelling results in Figure 5 show that the 'Electric (30% efficiency improvement)' scenario would emit more CO_2 than standard gas cooking; this means that at 20% more efficient than standard electrical cooking, induction cooking technology remains more carbon intensive than standard gas cooking. The modelling indicates that electrical cooking technology would need to achieve a 40% improvement in efficiency to be equivalent in CO_2 terms to standard gas cooking.
- To illustrate the most dramatic improvement potential over standard electricity, the biogas option was investigated further (see Figure 6):

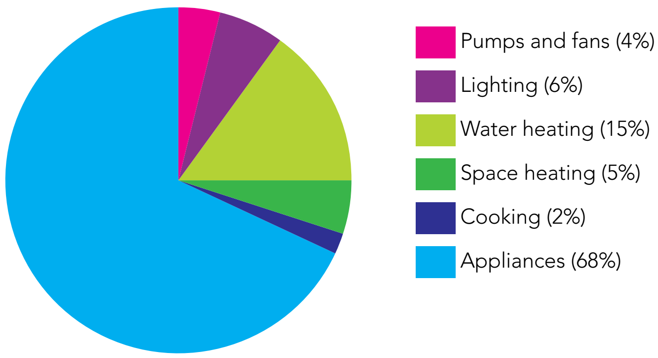


Figure 6 Percentage CO_2 emissions from a 70% compliant dwelling with biogas cooking

- Unregulated emissions (from appliances and cooking) now make up 70% of the total emissions from a dwelling with emission reduction of 70% when compared to the requirements of ADL1A 2006, with cooking-specific emissions accounting for 2% (a reduction of 16% over standard electric cooking).
- To take such a design to Code Level 6 would require a further 2.0 tonnes CO_2 reduction (a saving of 0.5 tonnes per dwelling when compared to a 70% compliant dwelling with electric cooking).
- Scaled up over a development of 400 new dwellings, this would mean a 200 tonne CO_2 saving.
- In terms of allowable solutions and achieving CO_2 reduction from surrounding buildings, assuming a 5 tonne CO_2 saving per refurbished dwelling, this would mean that 40 fewer existing dwellings would need to undergo major refurbishment.

These results demonstrate that, whilst the market for low carbon cooking appliances is currently in its infancy, the impacts on future regulatory compliance could be significant.

4.4 Modelling conclusions

This section of the report has investigated the impact that low carbon cooking appliances could potentially have on overall dwelling emissions. Given proposals in the Code for Sustainable Homes consultation document for allowable solutions, coupled with proposed revised levels of dwelling CO_2 reduction, a dwelling that achieves 70% reduction in CO_2 emissions was chosen as a baseline, against which to model various types of cooking appliances. The modelling was carried out against Part L1A 2006 using SAP software, and a modified version of the standardised cooking and appliances emissions equation (as found within the Code for Sustainable Homes) was used to estimate cooking CO_2 emissions.

The modelling indicated that, in a 70% compliant dwelling with standard electric cooking, 18% of CO_2 emissions result from cooking. In an equivalent dwelling with standard gas cooking, 12% of CO_2 emissions result from cooking. A variety of fuels and efficiencies were modelled, with the greatest reduction in CO_2 emissions being achieved by biogas. In a 70% compliant dwelling with biogas cooking, a 16% improvement over standard electric appliances was achieved, with only 2% of CO_2 emissions resulting from cooking.

5 The potential for biogas-fuelled cooking

Anaerobic digestion (AD) provides a method of turning food waste into biogas, which can then be combusted in a combined heat and power (CHP) plant[7]. Such plants are rare in the UK, but examples exist which provide enough renewable electricity to power approximately 4000 houses. This section of the report investigates the role that AD could potentially play in reducing emissions from cooking appliances.

Because the economics of biogas production are currently marginal, using biogas to fuel individual cooking appliances is not a feasible solution at present. Even if this situation improves significantly, the high cost of distribution infrastructure to individual dwellings is likely to make direct supply a secondary choice for developers.

However, given suitable circumstances, using renewable electricity produced from biogas CHP may present an attractive option to developers wishing to reduce the overall emissions associated with new developments. See Figure 7 for indicative operation of anaerobic digestion linked to CHP. Such plants can generate renewable heat and electricity, which could be supplied back to the development via private wire, or a straight 'like for like' offset against National Grid electricity. In either case, a heat main would be necessary should the development require renewable heat from the plant.

Given current economics, an AD plant requires between 20 000 and 25 000 tonnes of waste per year to be feasible. To take advantage of a local AD plant, food waste from the new development would need to be segregated by occupants and collected before being sent to the plant. Given a typical recoverable food waste production of 2.1 kg per week per dwelling, this means that approximately 182 000 dwellings would be necessary to feed an AD plant, although the presence of industrial food waste would reduce this figure significantly. Such a situation is only likely to arise where a new development is built on the edge of an existing area where the Local Authority has opted to embrace AD for all existing buildings, thus providing a suitable feedstock for the plant. Discussions with members of the AD industry indicated that the current feed-in tariff for AD-produced electricity is unlikely to provide a serious stimulant to the market, although the Renewable Heat Incentive may go some way to increasing the feasibility of AD-driven biogas CHP.

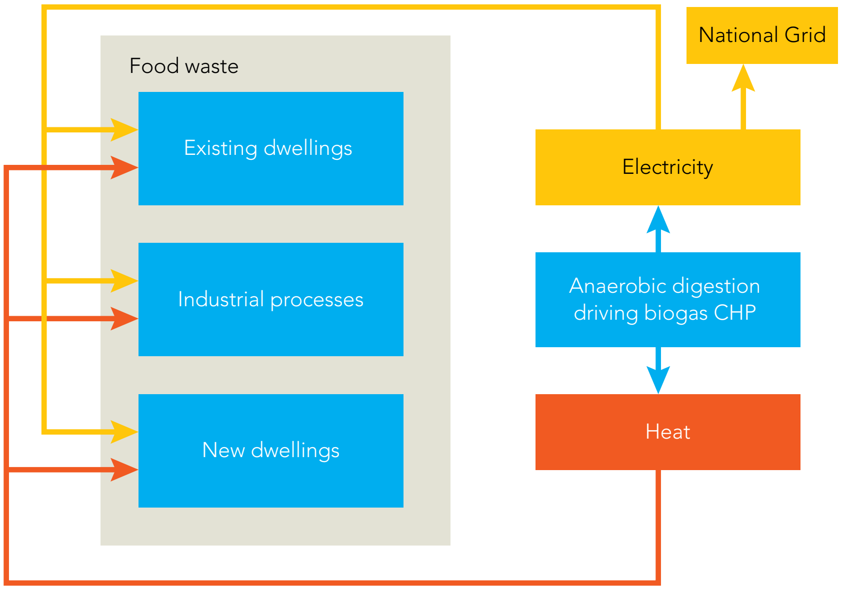


Figure 7 Indicative operation of anaerobic digester linked to combined heat and power (CHP)

6 Consumer research

6.1 Methodology

The population of interest for this piece of consumer research comprised people who had recently purchased or built a new build property. The aim was to target properties that had been built within the previous 18 months prior to the distribution of the questionnaire. The researchers identified 22,514 new build properties that had been registered across England in the 12 months prior to the distribution of the questionnaire. From this population, a random sample of 6000 properties representing all regions was selected. Name and address data for these properties were purchased from CACI Ltd.

An electronic web-based questionnaire and an identical paper form were created using BRE's Teleform software. The content and questions were refined through feedback from the NHBC Foundation and those who attended the low carbon cooking appliances workshop at RIBA in January 2010. To enable the comparison of the response rates associated with each distribution method, the information provided to recipients was kept as consistent as possible across formats.

The paper questionnaire, an information sheet and a prepaid return envelope were sent to 2000 households. The people in this sample were also given the option of completing the form online if they preferred. A further 2000 households were sent a letter that outlined the purpose of the questionnaire and pointed them to the website where they could complete the form. The final 2000 households were sent a flyer that outlined the purpose of the questionnaire and pointed them to the website where they could complete the form. Entry into a prize draw with a prize of £500 was offered as an incentive to recipients. Respondents were given two weeks to complete the questionnaire.

6.2 Findings

6.2.1 Sample demographics

In total, 262 respondents completed the questionnaire. Of these, 128 (49%) completed and returned the paper form, while the remainder chose to complete the form online. Ten (4%) respondents who received the paper form chose to complete the form online, 50 (19%) completed the online form after receiving the flyer, and 74 (28%) completed the online form after receiving the letter. A significant difference was found in terms of the number of responses associated with the different distribution methods ($\chi^2 = 111.4$, df = 3, $p < 0.001$). The findings indicate that when contacted via the post, people are much more likely to respond to a paper-based version of a questionnaire than complete a web-based version of the same form.

Figure 8 shows the proportion of respondents who lived in each type of property. The largest proportion of respondents (32%) lived in low rise flats, 22% lived in terraced houses, 20% lived in detached houses and 18% lived in semi-detached houses.

In a third of cases (36%), there was just one adult living in the property whereas in the majority of cases (57%), there were two adults living in the property. Just 7% had three or more adults occupying the property. The majority (61%) of respondents had no children living in the property, 23% had one child, 13% had two children and 3% had three or more children living in the property.

Figures 9 and 10 show how frequently respondents used their hobs and ovens. The majority of those who responded to the questionnaire were frequent users of both their hobs and ovens; 70% of respondents said they used their hob every day and 40% said they used their oven every day; 95% indicated they used their hob at least three times a week and 85% indicated they used their oven at least three times a week.

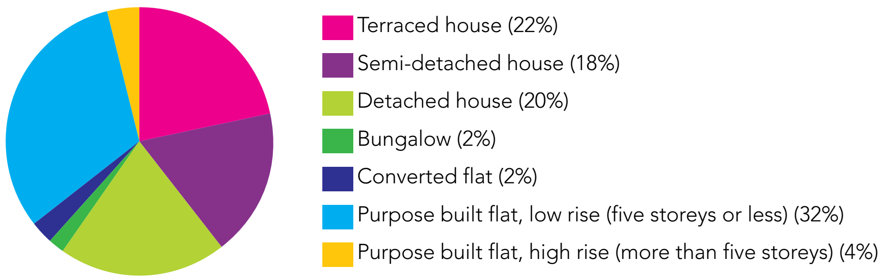


Figure 8 Proportion of respondents living in each type of property

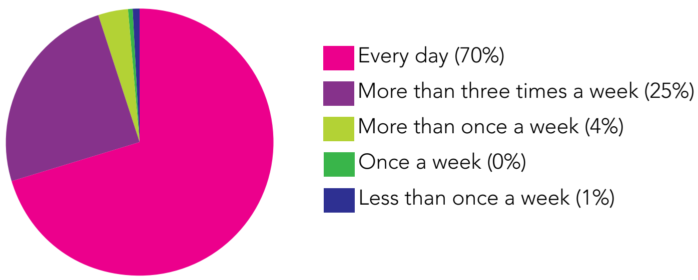


Figure 9 Hob use

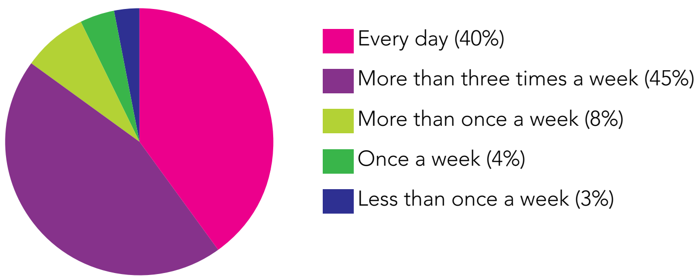


Figure 10 Oven use

6.2.2 Hobs – awareness and preference

Figure 11 shows the proportion of respondents who had heard of, and cooked on, each of the different hob types. The majority of respondents had heard of ceramic, halogen and gas hobs, but the majority had only actually cooked on gas (92%) and ceramic (52%). 'Other' refers to a hob type not listed. Less than half the respondents had heard of sealed plate or electric coil hobs and less than a third had heard of the more recent induction, gas on glass, or dual fuel hobs. The findings indicate that few people are aware of the hob options available and even fewer have experienced using many different types of hobs.

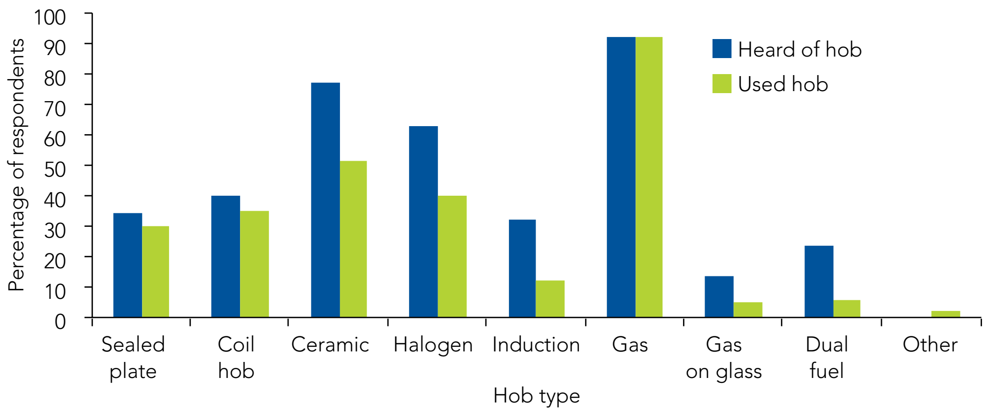


Figure 11 Percentage of respondents who had heard of, and actually used, each hob type

Figure 12 shows respondents' current, preferred and least preferred hob types. As can be clearly seen from the graph, the vast majority of respondents (72%) currently use gas hobs. Surprisingly, the next highest proportion of respondents (10%) were currently using electric sealed plate hobs followed by ceramic (9%) and halogen (6%). This was surprising as the sample of new build properties were all built within the last 18 months. This finding suggests that electric sealed plate hobs are still being installed in new properties. 'Other' refers to a hob type not listed.

Over two-thirds of respondents (69%) said that a gas hob would be their preferred hob choice. The next most frequent choice was electric halogen hobs (14%). Respondents' least preferred choice was electric sealed plate hobs (33%) and the next least preferred hob type was electric ceramic (24%).

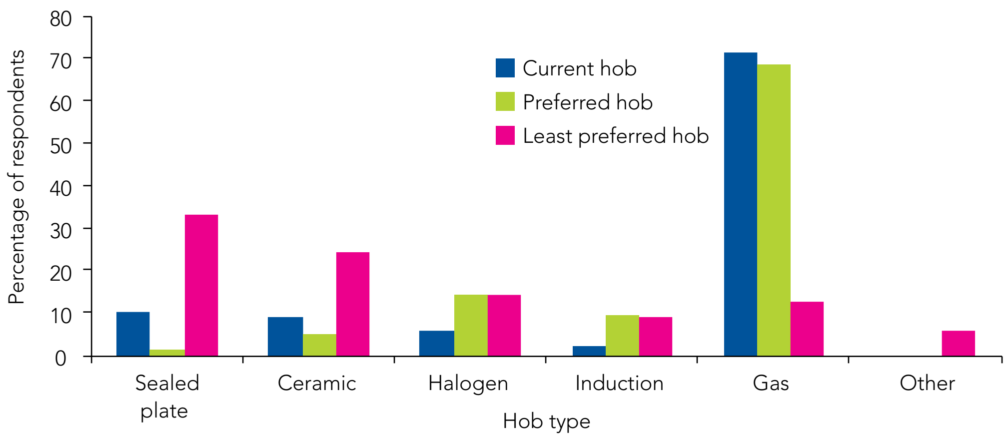


Figure 12 Respondents' current, preferred and least preferred hob types

6.2.3 Hobs – likes and dislikes

Table 1 shows the most frequently selected features that respondents said they particularly liked about their preferred hob. As reported above, the most frequently selected preferred hob types were gas, followed by electric halogen. Table 1 shows that the features that respondents particularly liked about the gas hobs were the level of control over the exact temperature, the ease of cleaning and the visible flame. In addition, respondents particularly liked the appearance, ease of cleaning and quality of heat distribution across the base of pans offered by the halogen hobs.

Table 2 shows the most frequently selected features that respondents said they particularly disliked about their least preferred hob. The most frequently selected least preferred hob types were electric sealed plate and electric ceramic hobs. Table 2 shows that the features respondents particularly disliked about the sealed plate hobs were the lack of control over the exact cooking temperature, appearance, time taken to reach desired cooking temperature and the increased risk of accidental burning of the user. In reference to the electric ceramic hobs, respondents said that they particularly disliked the time taken to reach the desired cooking temperature, speed of cooling after use, and appearance.

Table 1

Preferred hob: most mentioned likes

Preferred hob	Likes	No.	Percentage of cases
Ceramic	Appearance	4	67
	Ease of cleaning	3	50
	Energy efficiency	2	33
	Cost to run	2	33
Gas	Level of control over exact temperature	36	44
	Ease of cleaning	29	35
	Visible flame	24	29
Halogen	Appearance	12	71
	Ease of cleaning	11	65
	Quality of heat distribution across the base of pans	5	29
Induction	Less risk of accidental burning of the user	7	58
	Ease of cleaning	6	50
	Energy efficiency	4	33
Sealed plate	Ease of cleaning	2	100

Table 2

Least preferred hob: most mentioned dislikes

Least preferred hob	Dislikes	No.	Percentage of cases
Ceramic	Time taken to reach desired cooking temperature	8	33
	Speed of cooling after use	8	33
	Appearance	7	29
Gas	Difficulty of cleaning	5	36
	Appearance	4	29
	Visible flame	4	29
	More risk of accidental burning of the user	4	29
Halogen	Speed of cooling after use	5	29
	Cost to run	5	29
	More risk of accidental burning of the user	5	29
Induction	Speed of cooling after use	3	30
	Cost to buy	3	30
	Level of control over exact temperature	3	30
	Unreliability	3	30
Sealed plate	Level of control over exact temperature	15	39
	Appearance	13	34
	Time taken to reach desired cooking temperature	12	32
	More risk of accidental burning of the user	12	32

6.2.4 Hobs – perceived running cost, energy use, and environmental impact

Overall, the majority of respondents felt that gas hobs would use less energy (71%) and would be cheaper to run (73%) than electric hobs. However, when asked, 'which type of hob would you expect to be more environmentally friendly?' more respondents (56%) answered electric than gas.

Additional analysis revealed that respondents' perceptions of the relative energy use and running costs of gas and electric hobs were significantly influenced by their preference for either gas or electric hobs. For example, over twice as many respondents who showed a preference for electric hobs said they expected electric hobs to use less energy (Table 3) and be cheaper to run (Table 4) than those who showed a preference for gas hobs.

Table 3

Hob type expected to use less energy, split by hob type preference

			Expected to use less energy		Total
			Electric	Gas	
Preferred hob type	Electric hob	Count	18	22	40
		% within preferred hob type	45.0	55.0	100
	Gas hob	Count	20	72	92
		% within preferred hob type	21.7	78.3	100
Total		Count	38	94	132
		% within preferred hob type	28.8	71.2	100

Table 4

Hob type expected to be cheaper to run, split by hob type preference

			Expected to be cheaper to run		Total
			Electric	Gas	
Preferred hob type	Electric hob	Count	17	22	39
		% within preferred hob type	44	57	100
	Gas hob	Count	19	73	92
		% within preferred hob type	21	79	100
Total		Count	36	95	131
		% within preferred hob type	27	73	100

6.2.5 Oven – awareness and preference

Figure 13 shows the proportion of respondents who had heard of, and used, each of the oven types. The majority of respondents had heard of, and experienced, using gas, conventional electric, and electric fan assisted ovens. Less than 20% had heard of electric steam ovens and less than 5% had actually used one. Interestingly, respondents seemed to be more aware and experienced in using different oven types than the different hob types. 'Other' refers to an oven type not listed.

Figure 14 shows respondents' current, preferred, and least preferred oven type. The vast majority of respondents (86%) who had electric fan assisted ovens selected electric fan assisted ovens as their preferred choice (70%). In contrast, less than 5% had gas ovens and less than 20% said gas would be their preferred choice. The oven type most frequently selected as least preferred was gas (44%) followed by conventional electric (28%) and electric steam ovens (22%). 'Other' refers to an oven type not listed.

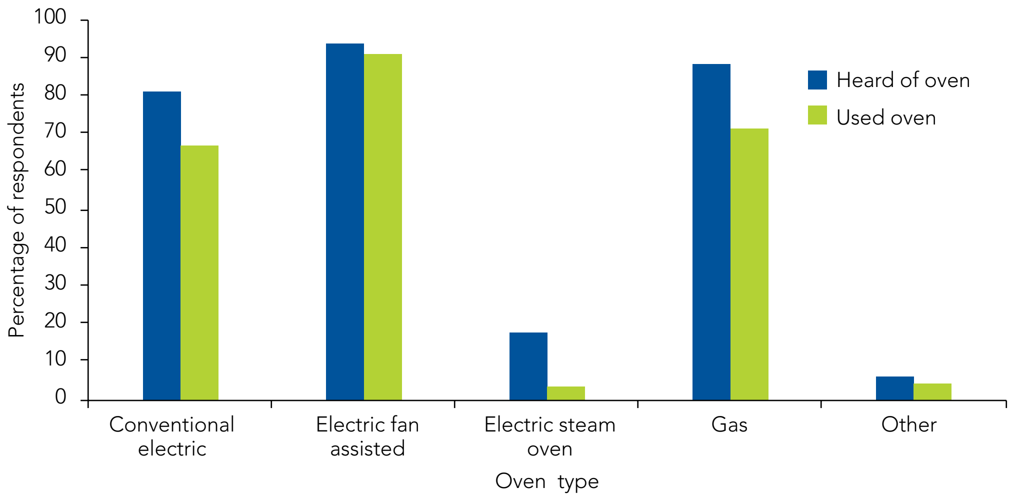


Figure 13 Percentage of respondents who had heard of and used each oven type

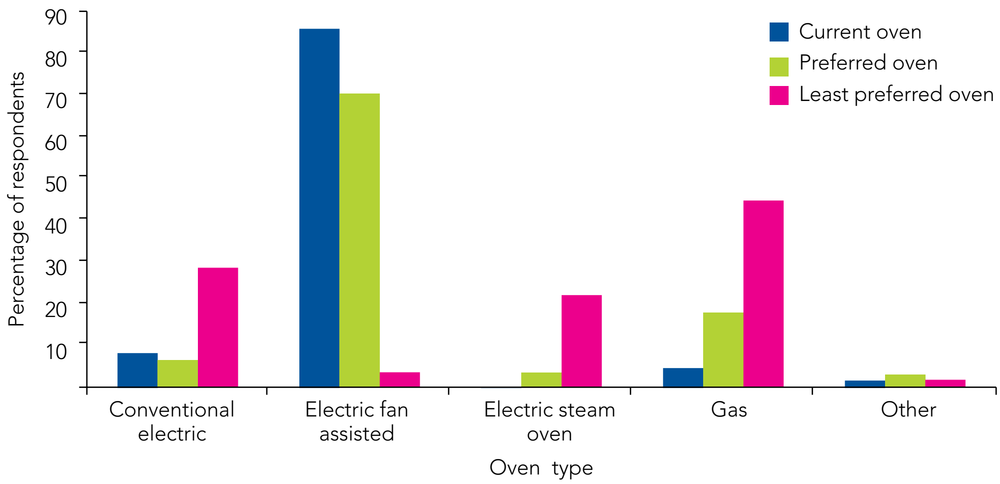


Figure 14 Respondents' current, preferred, and least preferred oven type

6.2.6 Ovens – likes and dislikes

Table 5 shows the most frequently mentioned features that respondents said they particularly liked about their preferred oven. The most frequently selected preferred oven type was the electric fan assisted oven. Table 5 shows that the features respondents particularly liked about the electric fan assisted ovens were the even temperature across the oven, time taken to reach desired cooking temperature, and ease of cleaning.

Table 6 shows the most frequently mentioned features that respondents said they particularly disliked about their least preferred oven. The most frequently selected least preferred oven type was the gas oven. Table 6 shows that the features respondents particularly disliked about gas ovens were the risk from harmful fumes, difficulty of cleaning, and the increased risk of explosions.

Table 5

Preferred oven: most mentioned likes

Preferred oven	Likes	No.	Percentage of cases
Conventional electric	Cost to buy	6	50
	Cost to run	6	50
	Reliability	4	33
Electric fan assisted	Even temperature across the oven	56	42
	Time taken to reach desired cooking temperature	48	36
	Ease of cleaning	46	35
Electric steam oven	Appearance	3	38
	Ease of cleaning	2	25
	Reliability	2	25
	Lifespan	2	25
	Even temperature across the oven	2	25
	No risk from harmful fumes	2	25
Gas	Even temperature across the oven	13	35
	Energy efficiency	12	32
	Time taken to reach desired cooking temperature	12	32
	Cost to run	10	27
	Level of control over exact temperature	10	27

Table 6

Least preferred oven: most mentioned dislikes

Least preferred oven	Dislikes	No.	Percentage of cases
Conventional electric	Uneven temperature across the oven	17	39
	Time taken to reach desired cooking temperature	12	27
	Difficulty of cleaning	11	25
	Energy efficiency	10	23
Electric fan assisted	Time taken to reach desired cooking temperature	2	50
Electric steam oven	Cost to buy	12	32
	Cost to run	10	26
	Difficulty of cleaning	10	26
Gas	Risk from harmful fumes	34	40
	Difficulty of cleaning	33	38
	More risk of explosions	29	34

6.2.7 Ovens – perceived running cost, energy use, and environmental impact

As was also found for hobs, the majority of respondents felt that gas ovens would use less energy (59%) and would be cheaper to run (57%) than electric ovens. However, when asked, 'which type of oven would you expect to be more environmentally friendly?' more respondents (64%) answered electric than gas.

As was found with the hobs data, additional analysis revealed that respondents' perceptions of the relative energy use and running costs of gas and electric ovens were significantly influenced by their preference for either gas or electric ovens. Of those respondents who preferred electric ovens, almost half expected electric ovens to use less energy and be cheaper to run, whereas the vast majority (over 88%) of those who preferred gas expected gas ovens to use less energy (Table 7) and be cheaper to run (Table 8).

The biggest effect of preference was found for respondents' perceptions of how environmentally friendly the respective ovens were; 64% of those respondents who preferred gas ovens expected gas ovens to be more environmentally friendly than electric ovens. Conversely, 70% of those who preferred electric ovens expected electric ovens would be more environmentally friendly (see Table 9).

Table 7

Oven type expected to use less energy split by oven type preference

			Expected to use less energy		Total
			Electric	Gas	
Preferred oven type	Electric oven	Count	93	101	194
		% within preferred oven type	48	52	100
	Gas oven	Count	5	39	44
		% within preferred oven type	11	89	100
Total		Count	98	140	238
		% within preferred oven type	41	59	100

Table 8

Oven type expected to be cheaper to run split by oven type preference

			Expected to be cheaper to run		Total
			Electric	Gas	
Preferred oven type	Electric oven	Count	97	97	194
		% within preferred oven type	50	50	100
	Gas oven	Count	5	38	43
		% within preferred oven type	12	88	100
Total		Count	102	135	237
		% within preferred oven type	43	57	100

Table 9

Oven type expected to be most environmentally friendly split by oven type preference

			Expected to be most environmentally friendly		Total
			Electric	Gas	
Preferred oven type	Electric oven	Count	135	58	193
		% within preferred oven type	70	30	100
	Gas oven	Count	15	27	42
		% within preferred oven type	36	64	100
Total		Count	150	85	235
		% within preferred oven type	64	36	100

6.2.8 The importance of having gas supplied to the kitchen

Respondent were asked, 'When buying your home, how important was it that your kitchen was connected to the gas?' Figure 15 shows the proportion of respondents who said it was not at all important (29%), desirable (41%), or essential (30%). The findings indicate that for 70% of respondents, it was not essential that their kitchen was connected to a gas supply when they bought their house. However, for many it was desirable.

As would be expected, a significantly higher proportion of those respondents who showed a preference for gas said it was desirable or essential for there to be a gas connection in the kitchen (Table 10). Of those respondents who showed a preference for gas cooking appliances, having a gas connection was essential for over a third (35%). However, surprisingly, over a quarter (26%) of those respondents who showed no preference for gas cooking appliances stated it was essential that the kitchen was connected to the gas and over a third (36%) said it would be desirable. It may be that these respondents were considering the ease of resale and the preferences of other future buyers when answering this question. Table 10 shows the breakdown of responses by preference for gas.

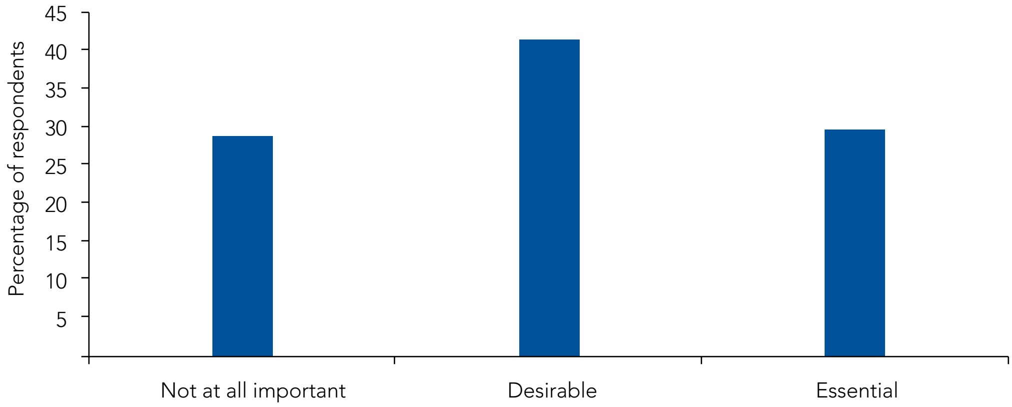


Figure 15 Importance of having a gas connection in the kitchen

Table 10

Importance of having a gas connection in the kitchen broken down by preference for gas

		Importance of kitchen being connected to the gas			Total
		Not at all important	Desirable	Essential	
No preference for gas	Count	50	47	34	131
	% within preference for gas	38	36	26	100
Preference for gas	Count	19	56	40	115
	% within preference for gas	17	49	35	100
Total	Count	69	103	74	246
	% within preference for gas	28	42	30	100

Respondents were asked, 'would you buy a home if the kitchen could not be connected to the gas supply?' The majority of respondents (65%) said they would buy, however, 35% said they would not. No significant difference was found between those respondents who showed a preference for gas cooking appliances and those who did not.

Next, respondents were asked to consider the following scenario: 'You are looking to buy a new house, you have found a property you like and can afford; however, it is impossible to supply gas to the kitchen of this property.' They were asked, 'Would you still want to buy the property?' The vast majority (70%) said they would still want to buy the property, less than a third (30%) said they would not (Figure 16). They were then asked, 'Would you expect to pay less for this property than if it had gas supplied to the kitchen?' The majority of respondents (58%) said they would not expect to pay less for the property, although 42% said they would expect to pay less (Figure 17). On average, these respondents said they would expect to pay 12% less, although most (73%) said they would expect to pay up to 10% less. Of those who said that in this scenario they would not want to buy the property, 64% said they would expect to pay less, however, of those who said they would still want to buy the house, 67% said they would not expect to pay any less.

The findings show that, for the majority of respondents (70%), not having gas supplied to the kitchen would not put them off buying a house they liked, and of this group, two-thirds would not expect to pay less for the property. However, for a minority of respondents (30%), not having gas supplied to the kitchen would put them off buying a house they liked and of this group, almost two-thirds would expect to pay less for the property.

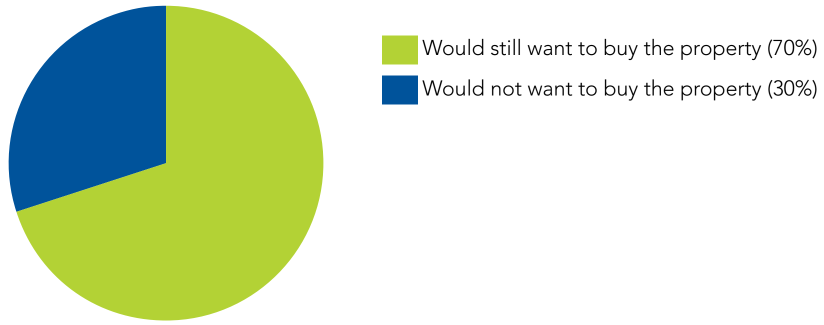


Figure 16 Proportion of respondents who would still want to buy a house they liked even though the kitchen could not be connected to the gas supply

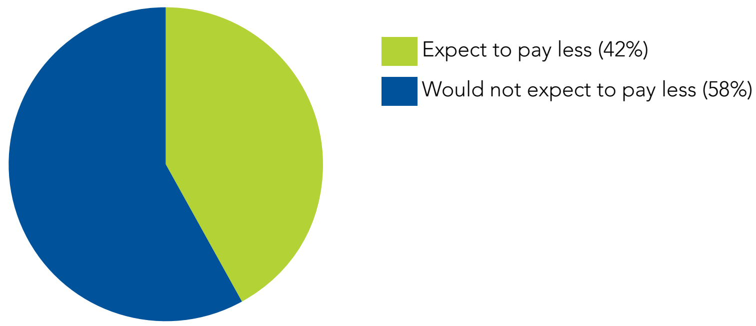


Figure 17 Proportion of respondents who would expect to pay less for a house if the kitchen could not be connected to the gas supply

6.2.9 Consumer differences

It was hypothesised by some developers that consumers in the South West would show a greater preference for gas and that they would be less likely to buy a house if the kitchen could not be connected to the gas than consumers from other parts of England. In order to test this hypothesis, a series of chi-square tests were run comparing the responses of those respondents from the South West with the rest of the sample.

The tests revealed no significant statistical differences between respondents from the South West and those from other regions in terms of:

- general preference for gas cooking appliances
- the importance of having a gas connection in the kitchen
- whether respondents would buy a house if the kitchen could not be connected to the mains gas supply
- whether respondents would expect to pay less for a property if gas could not be supplied to the kitchen.

It was also hypothesised that consumers of different house types (eg detached, semi-detached, flats, etc) may differ in terms of their general preference for gas, how highly they rate the importance of having a gas connection to the kitchen, and their likelihood of buying a house that could not be connected to gas. In order to test this hypothesis, a series of chi-square tests were run comparing the responses of those who lived in each of the different house types.

The tests revealed no significant statistical differences between respondents from different house types in terms of:

- general preference for gas cooking appliances
- whether respondents would buy a house if the kitchen could not be connected to the mains gas supply
- whether respondents would expect to pay less for a property if gas could not be supplied to the kitchen.

However, a significant difference was found in terms of the importance of having a gas connection in the kitchen ($\chi^2 = 22.22$, df = 12, $p < 0.05$). Those consumers living in detached or semi-detached houses were most likely to say that having a gas connection to the kitchen was desirable or essential. Almost half (47%) of those living in semi-detached houses said that, when buying their current home, it was essential that the kitchen was connected to gas. This was far higher than any other group of consumers including those in detached properties.

The findings indicate that respondents living in houses (terrace, semi-detached and detached) would be less likely to buy a house if the kitchen could not be connected to gas than those living in other types of property. However, this difference was not statistically significant and even for those living in these houses, the majority said they would still buy houses where the kitchens could not be connected to gas.

6.3 Consumer research conclusions

The population of interest for this piece of consumer research comprised people who had recently purchased a new build property. The majority of those who responded to the questionnaire indicated that they used both their hob and their oven at least three times a week.

The findings also indicate that the majority of this population are not very aware of the variety of hobs available and even fewer have experience using different types of hobs. Most respondents had only actually cooked on gas and electric ceramic hobs. This finding supports previous work done by the MTP that predicted the percentage of all households with an electric hob would fall over the coming years due to a preference for gas. This finding supports previous work done by the MTP that predicted that the percentage of all households with an electric hob is expected to fall over the coming years due to a preference for gas. Respondents least preferred choice was electric sealed plate hobs followed by electric ceramic. Most felt that gas hobs would use less energy and would be cheaper to run than electric hobs. However, the majority felt electric hobs would be more environmentally friendly than gas.

Respondents seemed to be more aware of different oven types and experienced in using them than different hob types. The majority of respondents had heard of, and experienced using, gas, conventional electric, and electric fan assisted ovens. Well over three-quarters of the respondents currently had electric fan assisted ovens and over two-thirds indicated that electric fan assisted ovens were their preferred choice. In contrast, very few had gas ovens and less than a quarter said that gas would be their preferred choice. The oven type most frequently selected as least preferred was gas, followed by conventional electric and electric steam ovens. As was also found for hobs, the majority of respondents felt that gas ovens would use less energy and would be cheaper to run than electric ovens. However, the majority also felt that electric ovens would be more environmentally friendly than gas.

The findings showed that, for the vast majority of respondents (70%), not having gas supplied to the kitchen would not put them off buying a house they liked and of this group, two-thirds would not expect to pay less for the property. However, for a minority of respondents (30%), not having gas supplied to the kitchen would put them off buying a house they liked and of this group, almost two-thirds would expect to pay less for the property.

7 Workshop

7.1 Background information

A half-day industry workshop was held in January 2010 to explore issues and opinions around the potential adoption of low carbon cooking appliances. Delegates were present from a variety of industry sectors and were chosen to represent a range of experience levels in working with low carbon cooking appliances.

The event was carefully structured to first draw out and record delegates' initial perceptions of the issues surrounding wider uptake of low carbon cooking appliances, via a facilitated discussion session. As part of this, each delegate was invited to briefly explain their perceptions to the floor, before adding them in note form to a display board. The board was divided into 'barrier' and 'opportunity' sides, allowing delegates to place their feedback into the appropriate section.

The initial discussion session was followed by a series of presentations by key industry stakeholders, which explored a variety of issues in more depth. These included technical developments and possibilities, CO_2 impacts relative to whole house performance, and infrastructure and planning. The day was concluded by a second facilitated discussion session, to explore delegates' opinions of the issues in more detail.

7.2 Outputs

The primary outputs from the workshop day were two mind maps, listing delegates' detailed responses to the two facilitated discussion sessions.

7.2.1 Mind map 1

What are the issues around increased uptake of low carbon cooking appliances?

Mind map 1 contains responses from the first discussion session, which were gathered before the industry presentations. The responses are therefore 'gut level' and independent of any specific technical information that was presented later in the day. Note that where similar responses were received from multiple delegates, they have been merged.

Mind map 1: What are the issues around increased uptake of low carbon cooking appliances?

	Barriers	Opportunities
Perception	▪ Widespread uptake of low carbon appliances requires significant change to current consumer preferences ▪ Consumers unfamiliar with low carbon appliances and potentially sceptical ▪ Consumers' prevailing negative views of electric hobs may affect uptake ▪ Perception that home owners prefer gas hobs may lead to resistance from buyers ▪ Perceived risks associated with unknown technology ▪ Public resistance to change in general ▪ Consumers' perception of cost difference between fuels	▪ The demand for low carbon from consumers is expected to grow year-on-year, and roll-out of low carbon appliances can capitalise on: – their potential feel-good factor – clean, modern, and green – perceived outdated consumer view of electric hobs – opportunity to change this? – the aspirational/lifestyle market (one-upmanship)
Performance	▪ Consumer preference for gas hobs based on: – instant heat up – greater versatility – greater controllability ▪ Certain low carbon fuels may not be capable of providing an instant heat source ▪ Experience of present electric systems are negative – lack responsiveness	▪ New electric models provide flexibility and responsiveness
Behavioural	▪ Unfamiliar and potentially less intuitive than current technology – potential for incorrect usage ▪ Need for consumers to relearn cooking methods? ▪ End users may remove low carbon units in preference for more traditional appliances	▪ Possible changes in cooking practices/diet to accommodate low carbon cooking: – cooking at 80°C – communal kitchens – decrease in home cooking beneficial for low carbon agenda
Cost	▪ New technology potentially carries a price premium ▪ Will low carbon fuel/running cost necessarily be lower? ▪ Cost to consumer of changing equipment – eg induction-ready pans ▪ Maintenance cost unknown	▪ Possible running cost savings ▪ Incentives ▪ Rising energy costs ▪ Potential for minimal/zero maintenance with electric cookers
Safety	▪ Gas safety issues – risk of explosion ▪ Gas health issues – airborne particulate contamination	▪ Electric cooking removes gas explosion risk – particularly relevant for elderly occupants ▪ Possibility of getting gas out of property generally seen as a positive move
Developers	▪ Cost and regulation/compliance issues were raised (see Cost and Technical sections in this mind map) ▪ Lack of awareness of low carbon cooking and potential impacts	▪ Use of electric low carbon cooking could increase build simplicity, by reducing services to be considered ▪ Significant avoided cost of gas network ▪ Low carbon appliances increase feasibility of zero carbon homes ▪ Possible selling angle for open minded buyer

Mind map 1 continued

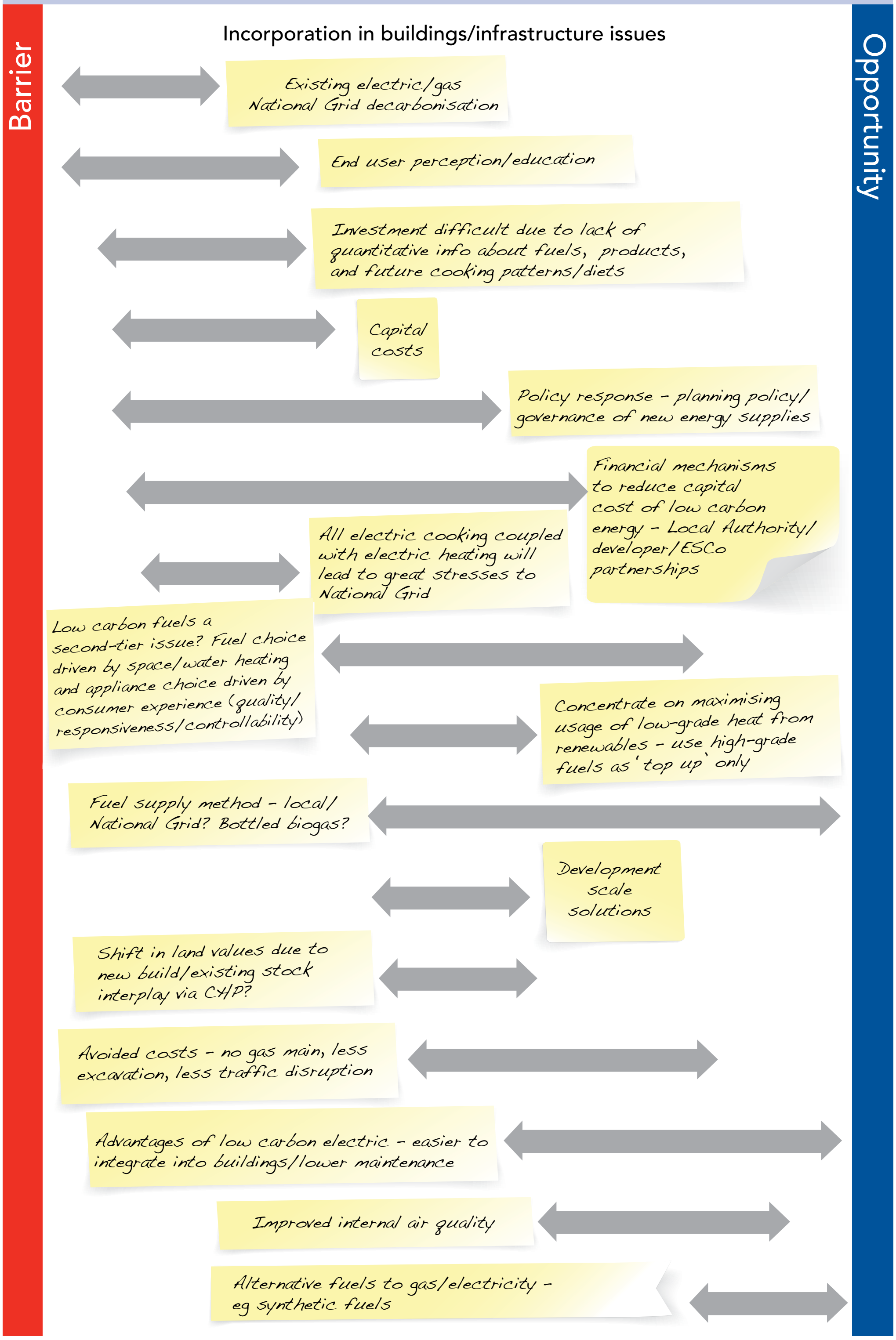
	Barriers	Opportunities
Technical	• Integrating low carbon cooking appliances within SAP • Potentially complicated installation and maintenance routines • Current gas/electric split provides a convenient 'back up' if one service fails • Low carbon fuels may require flue/chimney • Gas cooking creates steam – potentially problematic for airtight homes	• Energy and carbon savings • Gas has a large existing knowledge base – can biogas tap into this? • Balanced flue gas ovens remove ventilation requirements – aiding integration into airtight new homes • Changing carbon intensity of National Grid electricity means standard electric cooking is likely to get greener • Market is wide open for new ideas: – using base heat from CHP with solar thermal to raise water final few degrees – cooking using a number of low-carbon, single-use gadgets (steamer/fryer etc), rather than multipurpose oven/hob – vacuum insulated pans with integrated electric elements instead of hobs • Potential for wider energy labelling • Potential independence from Naitonal Grid • Low carbon appliances could provide heating and hot water too
Supply chain	• Future availability of zero carbon energy sources unclear • Certain low carbon fuels may have localised storage requirements (eg wood) • Low carbon fuel supply chain may be less streamlined than current gas/electricity delivery • Lack of availability of new technologies • Small skills base • Industry slow to change production, with no incentive to alter the status quo • Training requirements for installers and maintenance staff • Timescale for decarbonising National Grid electricity is unclear • Without manufacturer input we do not have a clear idea what technologies are out there, so planning roll-out is impossible	• Opportunity to roll out supply of cleaner fuels – biogas or solar • Potential for greater fuel security if widespread roll out of low carbon fuels/appliances • New market created for low carbon cooking appliances • Develop low carbon appliances market by targeting new build – to aid eventual roll-out to all homes

7.2.2 Mind map 2

What are the barriers and opportunities regarding low carbon cooking appliance integration into buildings, and associated infrastructure impacts?

Mind map 2 contains responses from the second discussion session, which were gathered after the industry presentations. The responses are therefore partially informed by the information that was presented earlier in the session. Again, where similar responses were received from multiple delegates, they have been merged. Delegates were asked to place their post it notes relative to the 'barrier' and 'opportunity' sides of Mind map 2.

Mind map 2: Barriers and opportunities regarding low carbon cooking appliance integration into buildings.



So for example, if a particular issue was seen as a major barrier, it would be placed to the far left of the scale. Major opportunities would be placed to the far right, with less clear-cut issues occupying the central area. The grey arrows indicate the spread of positions each individual issue occupied.

7.3 Workshop conclusions

These conclusions have been based on a survey of the delegate feedback received, as well as conversations and debates on the workshop day itself.

Low carbon electrically-powered cooking dominated the conversation, and there was a general feeling that developments in this area would be by far the most feasible and useful potential outcome. These could lead to reduced humidity/pollution problems (relative to gas) for airtight homes, no additional infrastructure requirements or pipework, and reduced risks to safety. In addition, maintenance costs were felt to be potentially lower.

Despite the enthusiasm for low carbon electric cooking, it was felt that there is a large amount of work to do in changing consumers' negative perception of typical electric cooking technology (plate or halogen), despite the fact that new electric models provide greater flexibility and responsiveness. Delegates felt that running cost savings, whilst beneficial, may not figure in consumer choices due to lack of perceived impact on overall bills. In addition, the lack of energy rating for hobs or gas ovens means that improvements in efficiency may not be noted. Nevertheless, delegates believed that a strong 'feel good' factor would be associated with new low carbon cooking technology, which manufacturers and developers could tap into to make their products more attractive to consumers.

Moving away from electricity, alternative fuels also figured in the debate, but delegates generally felt that it was too early to tell what fuels might be suitable, what their availability would be, how supply would be regulated by Government, and how developers would incorporate new technology into their plans. The range of alternative fuels suggested included biogas, biomass and synthetic fuels. It was noted that in many respects, these seem to lack the ease of delivery and enhanced safety that makes electric cooking so attractive.

A general difficulty in catalysing the low carbon cooking appliances market is the perceived lack of importance relative to other emissions. Adding to this is the proposed decarbonisation of the National Grid, which although it would also go some way towards reducing the carbon intensity of electric cooking, could also potentially also act as a disincentive to manufacturers increasing the efficiency of their appliances. To exacerbate this problem, the majority of appliance manufacturers have product ranges in both gas and electric models, and hence there is a potential disincentive to shift the market too far towards one fuel over the other.

There was also discussion of potential CO_2 savings to be made by new cooking techniques, or 'doing more with less': for example, cooking at 80°C instead of 100°C. These kinds of behavioural techniques might contribute to overall energy efficiency, but are effectively outside the interest of developers, who require robust energy-saving technologies to contribute to CO_2 reductions thus assisting regulatory compliance.

In terms of wider impacts, it was acknowledged that electric cooking coupled with electric heating (eg heat pumps) will lead to significantly greater stresses on the National Grid in terms of heightened peak loads at key demand times throughout the day.

8 Conclusions

With the increased focus on CO_2 reduction in new developments via the Code for Sustainable Homes, housing developers are now required to look in more detail at every aspect of their designs. In recognition of this, the Homes and Communities Agency (HCA) has recently launched a funding stream for low carbon infrastructure. It is against this background that this report was commissioned, and it is intended to provide guidance to developers who wish to understand the role that low carbon cooking appliances can play in reducing CO_2 emissions within new dwellings.

In seeking to investigate current technological developments in low carbon cooking appliances, information was not forthcoming via liaison with manufacturers and trade bodies due to commercial sensitivities. However, a patent search did reveal that a number of mainstream manufacturers have recently patented several innovative cooking mechanisms that could potentially reach the marketplace and bring potential CO_2 savings. To investigate potential CO_2 savings, a variety of scenarios were modelled to represent different types of cooking appliance and fuels, and to determine the overall difference these would make to overall dwelling CO_2 emissions. Modelling of a 70% carbon compliant dwelling (a dwelling that abates 70% CO_2 emissions relative to ADL1A 2006 requirements) was carried out to reflect future on-site construction practice. Standard electric cooking was shown to account for 18% of total modelled dwelling CO_2 emissions, with the best available alternative option, biogas, cutting the contribution of CO_2 emissions from cooking to just 2%. Food-waste driven biogas production, and integration with new housing developments was investigated, but given marginal economic returns, only in very particular circumstances would biogas lend itself to new developments. Given this situation, standard gas cooking remains the most CO_2 efficient option available, with standard electrical cooking needing to improve efficiencies by approximately 50% to take the lead. Existing electric induction technologies can only be applied to hobs, and according to manufacturers' figures, they improve over standard electrical efficiency by just 20%, meaning they remain more CO_2 intensive than standard gas cooking.

The regulatory drive to improve efficiencies further is currently weak. Cooking appliances have very limited inclusion in the building regulations, and no mention in the revised Part L1A. They do figure in the Code for Sustainable Homes Level 6, but a standardised equation is used to assess emissions, and there is no officially sanctioned method to reflect efficiency savings. There is currently no plan to offer a credit for low carbon cooking appliances in the Code for Sustainable Homes. The EU Energy Labelling scheme currently only covers electric ovens, which are also the only cooking appliance covered by the Energy Saving Trust Recommended scheme. However, in Brazil, energy rating for both electric and gas cookers and hobs has been mandatory since 2003, with the result of driving up efficiencies and removing poorly performing products from the marketplace. Despite this, there are positive signs that low carbon cooking appliances are moving up the Government's agenda, and DEFRA has recently held a consultation seeking additional information on the sector.

Assuming that new technologies and cooking appliances become available, a key question remains around consumer acceptability. To investigate this, a consumer questionnaire was sent out to the occupants of 6000 new build properties. An important issue for developers is dwelling fuel type, and the findings show that, for the majority of respondents (70%), not having gas supplied to the kitchen would not put them off buying a house they liked, and of this group, two-thirds would not expect to pay less for the property. However, for a minority of respondents (30%), not having gas supplied to the kitchen would put them off buying a house they liked, and of this group, almost two-thirds would expect to pay less for the property. In terms of consumer preference, over two-thirds of respondents preferred gas hobs and electric fan-assisted ovens. Interestingly, the majority of respondents thought that electric cooking would be more environmentally friendly in both cases, a conclusion at odds with the technical research carried out for this report.

Overall it appears that, whilst the carbon emissions associated with cooking are currently a minor consideration at best, future build practice will mean their minimisation will be a significant aspect of design. There are signs that Government is beginning to recognise this, and the housing industry should seek to engage with this process at an early stage to ensure that its voice as a key stakeholder is heard. Allied to this, whilst appliance manufacturers are understandably reluctant to share commercially sensitive data, closer links between manufacturers and developers with a view to developing stronger supply chains for 2016 onwards would be beneficial in driving forward innovation. Consumer acceptability remains a key consideration, but with the likelihood that significant innovation will occur within the traditional gas/electric appliance sector rather than via adoption of any new fuel source, the outlook for managing risk appears to be encouraging.

Please note that this report was written prior to the Government's March 2011 Budget announcement regarding the altered zero carbon homes definition, which indicates that unregulated emissions from cooking and appliances will no longer be included within the compliance metrics for zero carbon.

The current expectation is that unregulated emissions will not form part of the requirements for 2016 building regulations compliance. However, it is expected that they will continue to be included within Code for Sustainable Homes Level 6.

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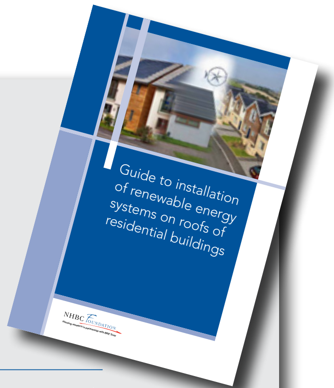
NHBC Foundation recent publications



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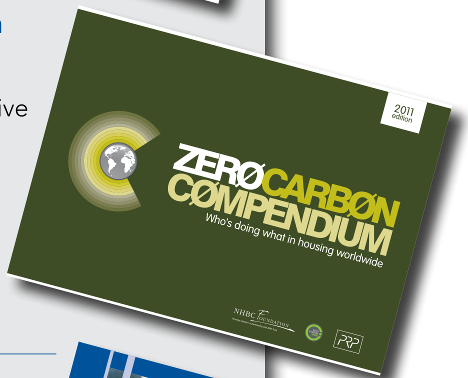

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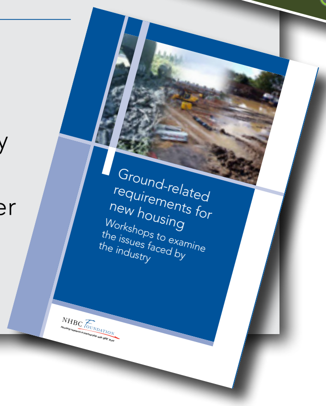

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In 2010 the NHBC Foundation undertook workshops and a survey to look at the issues facing the housebuilding industry in potentially conflicting requirements for ground-related works. This report provides the responses and draws together the common themes arising from the discussion at the seminars. ***NF32*** June 2011

NHBC Foundation publications in preparation

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- Operational and embodied CO_2 in new build housing
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Low carbon cooking appliances

With the increased focus on CO_2 reduction in new developments via the Code for Sustainable Homes, housing developers are now required to look in more detail at every aspect of their designs.

This report provides guidance to developers who wish to understand the role that low carbon cooking appliances can play in reducing CO_2 emissions within new dwellings.

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The NHBC Foundation has been established by NHBC in partnership with the BRE Trust. It facilitates research and development, technology and knowledge sharing, and the capture of industry best practice. The NHBC Foundation promotes best practice to help builders, developers and the industry as it responds to the country's wider housing needs. The NHBC Foundation carries out practical, high quality research where it is needed most, particularly in areas such as building standards and processes. It also supports housebuilders in developing strong relationships with their customers.

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