Harrogate Borough Council

Climate Change Action Plan

Climate Change Action Plan Report

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Purpose of the action plan

The purpose of this report is present the results of modelling carbon emissions from activity in Harrogate Borough and to identify the actions that need to be implemented to achieve the following carbon dioxide (CO_2) emissions reductions from consumption: 40% by 2020 and 80% by 2050 compared with 2005 levels. This report also documents how the emissions reductions associated with different actions have been calculated as well as the approach used to model the likely levels of future emissions against which emissions reductions have been compared.

Why use a consumption based approach?

Currently, there are two distinct approaches to calculating and describing the CO_2 emissions associated with our activities: production based and consumption based carbon footprinting. Production based carbon footprinting measures all of the CO_2 emissions that occur within a given spatial boundary. For this action plan the production based footprint would include all of the CO_2 emitted within HBC's boundary. This would include emissions from all of the transport that moves within the boundary, the emissions from the use of grid electricity and direct gas or other fuel use for heating as well as, commercial and industrial emissions.

Consumption based carbon footprinting uses the same basis for calculating CO_2 emissions from fossil fuel use, grid electricity use and transport. However, in addition to these emissions, a consumption based carbon footprint also includes the emissions associated with providing all of the goods and services we use as individuals as well as the embodied impacts associated with capital investment and maintaining existing infrastructure such as road-building schemes. For example, the emissions associated with buying a pint of milk will include those from processing and transport. Consequently it is easier to relate individuals' actions to emission reductions and provides a sound basis for identifying the actions that Harrogate Borough Council (HBC) and the residents of the borough to implement.

How we developed the action plan

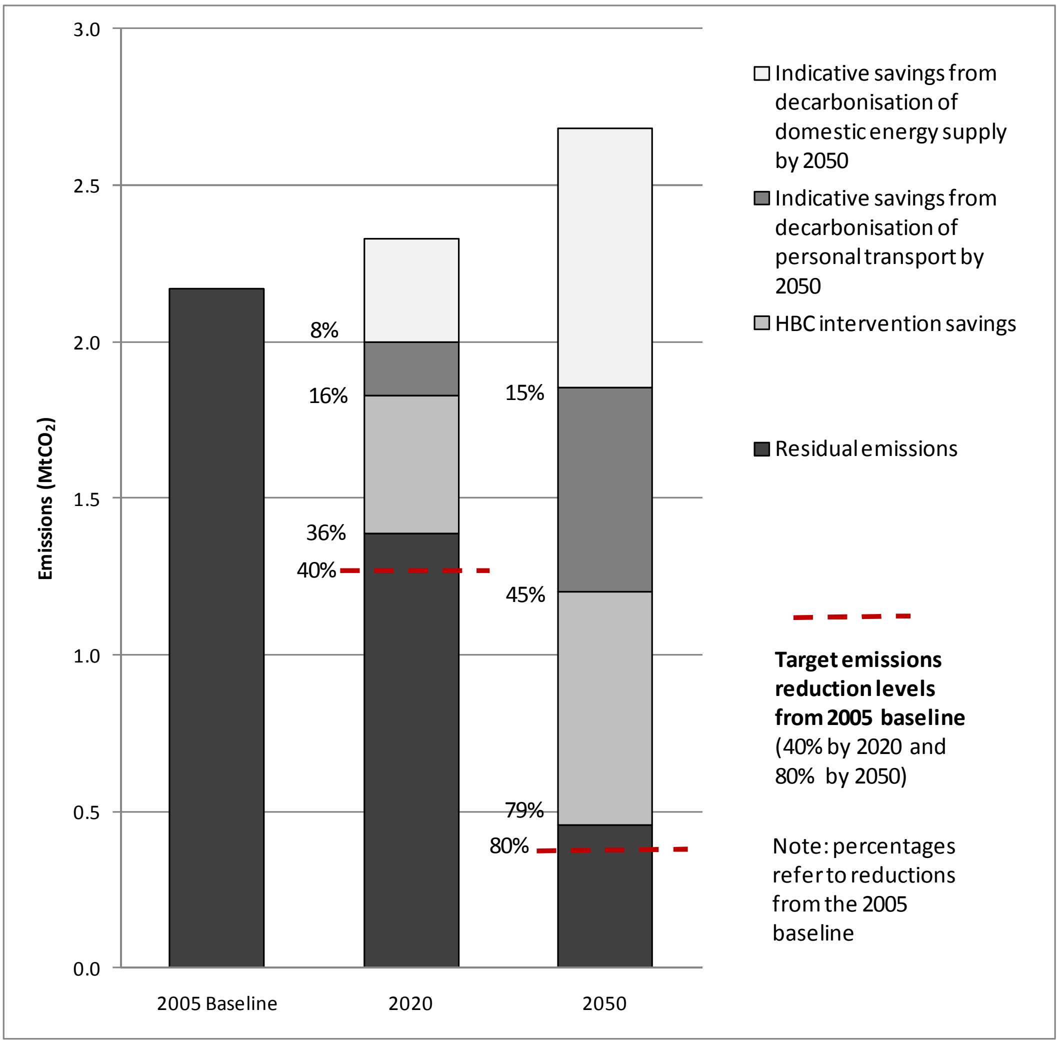
The action plan has been developed modelling the future CO_2 emissions based on a continuation of the 'business as usual' scenario. This assumes that the housing numbers identified in the Local Development Framework Core Strategy are built to the relevant Code for Sustainable Homes standard. It also assumes that population growth will follow the trends in the population forecasts predicted by the Office of National Statistics. From this baseline we have modelled the potential emission reductions that could occur if HBC and other partner organisations implement the interventions that have been identified.

To model the reductions in CO_2 emissions the Resource and Energy Analysis Programme (REAP) Version 2.14 has been used. This software tool has been developed by the Stockholm Environment Institute (SEI) at the University of York. Using this and an additional tool to predict changes in energy usage from different housing energy interventions the CO_2 emission reductions from the different interventions have been calculated.

The CO_2 emissions reduction measures

Using the tools described above the CO_2 emission reductions illustrated in the graph below have been calculated. The results show clearly that the emission reduction interventions identified in this action plan are vital if we are to even get close to the targets for 2020 and 2050. It also helps to illustrate the fact that in order to get close to these targets there needs to be a combined effort from national Government, local government, residents, transport and energy suppliers and cannot be left to one organisation or sector.

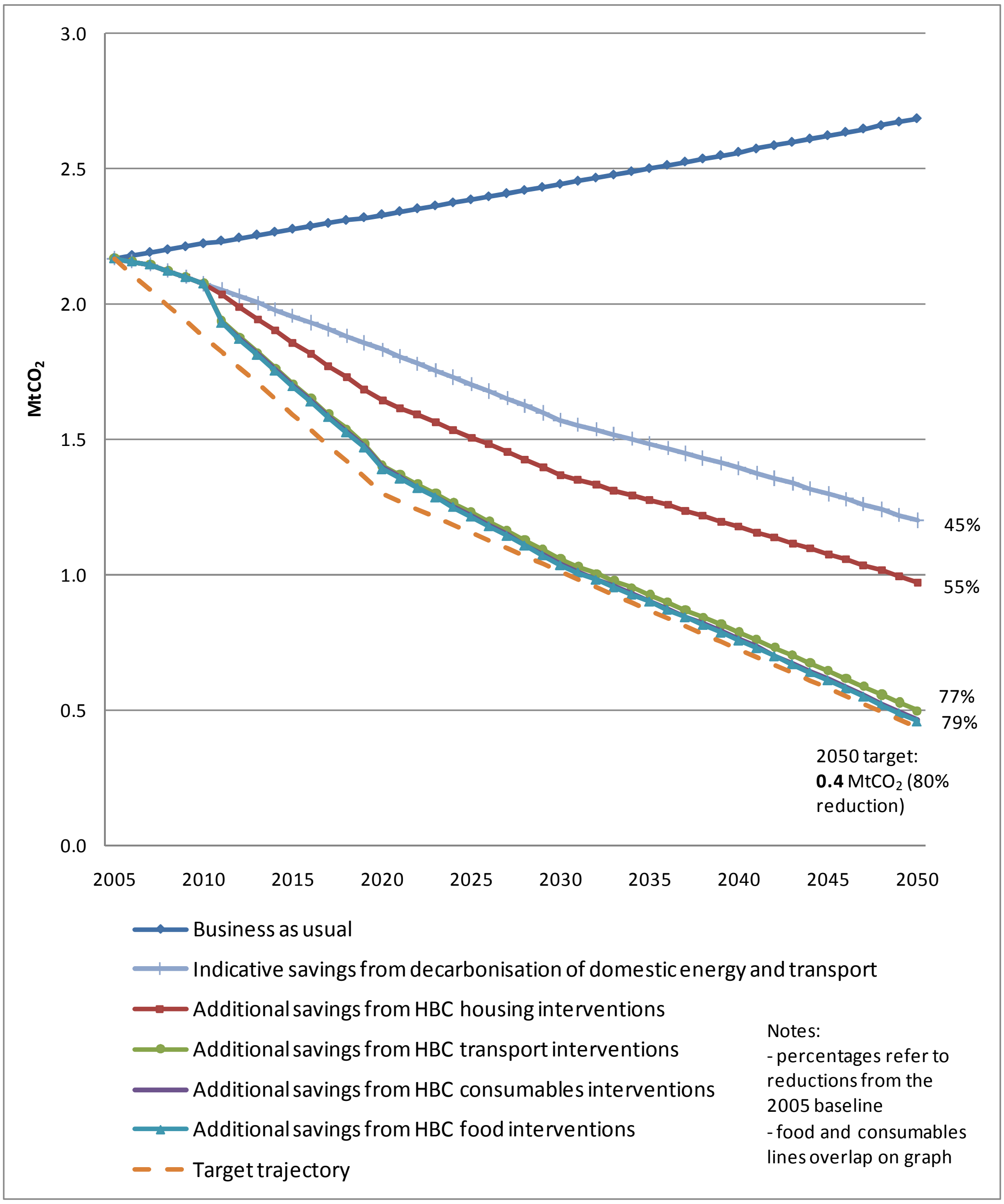
Modelled CO_2 emission reductions in 2020 and 2050 compared against the emissions baseline in 2005 for the population of Harrogate Borough.



The emission reduction measures associated with the interventions in this action plan have also been broken down further and are illustrated in the graph on the next page. The reductions are split as follows:

- housing interventions are:
  - (Retrofitting cavity wall insulation, loft insulation, double glazing, new boilers and energy efficient lights and domestic appliances to existing homes.
  - Installing micro-renewable energy supplies that include solar photovoltaic panels, solar water heaters and ground source heat pumps to existing homes.
  - Behaviour change activities consisting of running a campaign to get people to change their behaviour e.g. reducing the temperature on their heating thermostats by 1 °C and turning off appliances when they are not being used);
- transport interventions are:
  - Facilitating the Department for Transport's 'Smarter Choices' scheme,
  - extending the successful car share scheme already running in Harrogate to achieve an 18% increase in private car occupancy rate to 50% by 2020 (or an average of 2.5 people per car as compared with 1.6 current occupancy level).
  - Activities to encourage residents to take one less flight per year as part of a sustainable lifestyle campaign.
- consumables intervention which aims to achieve a 10% reduction in expenditure on consumables and durables through reduce and re-use campaign work (as part of a sustainable lifestyles campaign).
- food intervention which promotes one meat and poultry free day per week (also as part of a sustainable lifestyle campaign).

Contribution of HBC interventions to overall emissions reductions.



Of these interventions it is transport interventions that have the potential to contribute the most towards achieving the action plan targets (see table overleaf). It should however be noted that the modelling represents a 'best case' implementation of interventions. The interventions assume that maximum uptake of all retro-fit and behaviour change is achieved. Therefore, the modelling represents the highest possible carbon savings that the borough could expect to achieve from implementing the interventions.

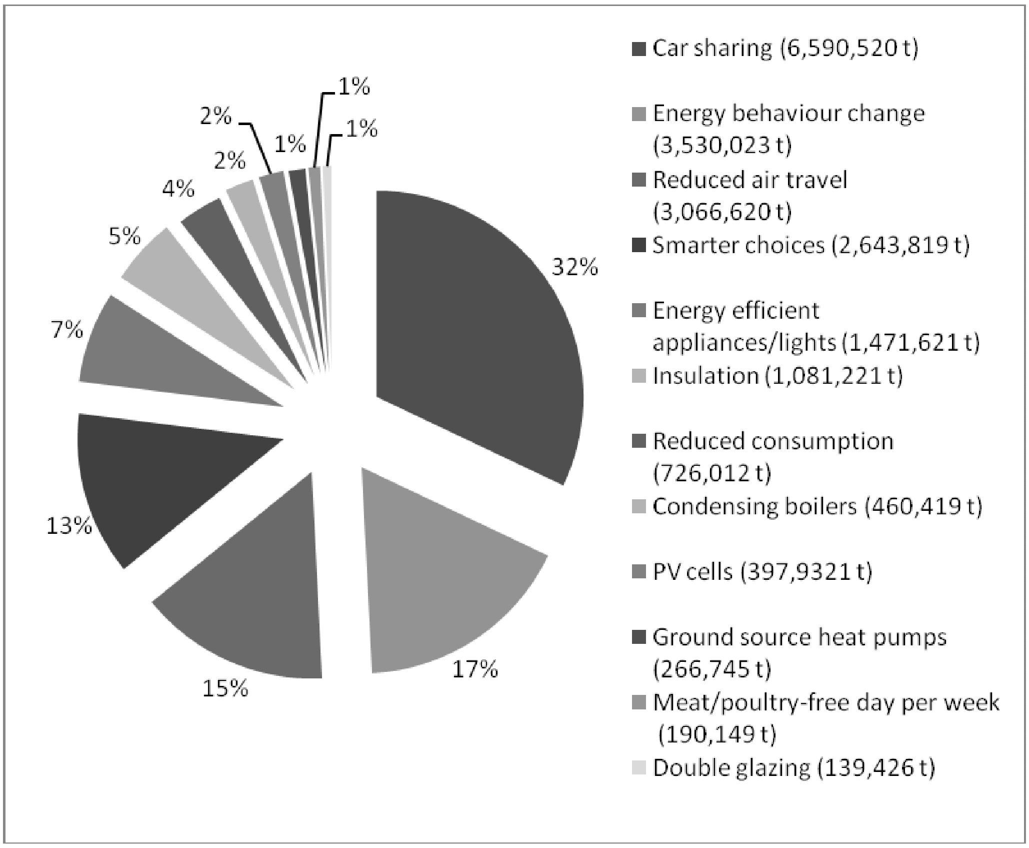
Contribution of national and HBC measures compared to 2005 baseline.

	2020	**2050**
Baseline emissions (2005) (Mt CO_2)	**2.3**	**2.7**
Targets (Mt CO_2)	**1.3 (40%)**	**0.4 (80%)**
Emissions with decarbonisation of domestic energy (Mt CO_2)	**2.0 (8%)**	**1.9 (15%)**
Emissions with decarbonisation of domestic energy and personal transport (Mt CO_2)	**1.8 (16%)**	**1.2 (45%)**
Emissions with decarbonisation measures and HBC interventions (Mt CO_2)	**1.4 (36%)**	**0.5 (79%)**

Note: values in ( ) represent the % reduction against the 2005 baseline and includes the predicted increases in population and traffic over the 40 year timeframe from 2010.

The measures described above that are directly attributed to HBC can also be broken down further according to the categories set out on page iii. The proportion of total CO_2 reductions in 2050 from these interventions is also illustrated in the pie chart below.

Proportion of total CO_2 reductions (2011 to 2050) from all of HBC's interventions.[1]



[1] Only the Solar PV intervention is shown as the other two solar interventions use the same resource. .

Indicative costs and priority for implementation

In order to prioritise the interventions that have been identified their costs over the 40 year lifetime of this Action Plan have been calculated. This has then allowed the cost per tonne of CO_2 saved to be calculated. This combined with the ranked score for total CO_2 saved and total costs to 2050 have been used to generate the sum ranked score for each action. The lower the score the greater the priority for action in terms of CO_2 reduction and costs. The costs include positions for HBC officers as well as the capital investment required to fund energy efficiency retrofitting measures and micro-renewables. The prioritised list of actions is set out in the table overleaf.

Prioritised action plan interventions, total emission savings over 40 years and total cost per tonne of CO_2 saved (ranked by cost/tonne CO_2saved).

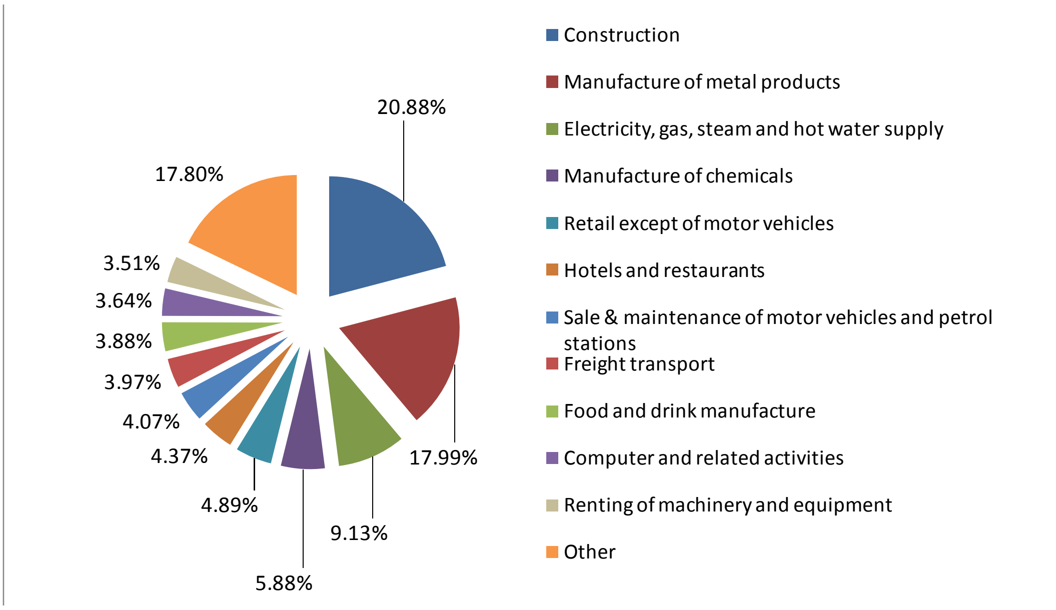
CO_2 saving to 2050 (t)	Total cost/tonne CO_2 saved	Total cost (2011-2050)	Sum of Ranked Scores	Prioritised list of Carbon Reduction Action
3,530,023	£0.20	£703,980	4	Energy consumption behaviour change
6,590,520	£0.32	£1,386,600	8	Car sharing
3,066,620	£0.68	£1,386,600	12	Air travel behaviour change (part of a sustainable lifestyle intervention).
726,012	£1.43	£1,039,950	15	Reduced overall consumption (part of a sustainable lifestyle action)
2,643,819	£0.79	£1,386,600	15	Smarter Choices (modal shift and no growth in travel) (part of a sustainable lifestyle action)
1,471,621	£54.90	£703,980	16	Energy efficient appliances/ lights
190,149	£5.47	£1,039,950	22	Promote 1 meat/poultry-free day per week per person (part of a sustainable lifestyle action)
1,081,221	£8.90	£9,627,980	22	Insulation (loft/ cavity)
460,419	£105.96	£48,783,980	29	Condensing Boilers
139,426	£16.98	£2,367,980	30	Double Glazing
266,745	£126.29	£33,687,586	32	Ground source heat pumps
397,921	£409.13	£162,799,950	36	PV cells
268,594	£418.77	£112,479,950	37	Combined solar (PV/HW)
148,715	£332.45	£49,439,950	37	Solar hot water

Actions for business

The consumption based footprint is concerned with the CO_2 emissions associated with the things we consume and do as individuals. As a result the emissions associated with business and industry is accounted for in the footprint as the 'embodied emissions' within the goods and services we buy and use.

Nevertheless a review of the contribution that different business sectors present in Harrogate borough make towards CO_2 emissions in general has been undertaken. The majority of the emissions (approximately 82%) come from manufacturing, construction, agriculture, the hospitality sector, retail (wholesale trade), utility supplies and the transport of freight. The remaining 18% of emissions (classified as other in this analysis) includes a variety of sectors such as the financial and professional services and some niche manufacturing sectors. The total emissions calculated for businesses in Harrogate is approximately 2.7 million tonnes of CO_2.The following chart displays percentage contributions from individual sectors.

Contribution of sectors to overall business emissions



Specific recommendations for actions by businesses include improved monitoring of energy and fuel consumption, undertaking energy audits and use of sustainable construction materials.

Actions for waste management.

Similarly, waste is treated as an industrial sector, it doesn't have a discrete footprint separate from the footprint of consumption because as individuals we don't buy or use waste directly. The waste sector's impact is taken into account as an indirect or supply chain impact. It is also important to understand that the way household waste is disposed of will have a very small impact on the total footprint of an area. Only measures taken at the top of the waste hierarchy (e.g. avoiding waste creation within manufacturing and food processing) will have a significant impact on the size of an area's footprint because they help to prevent CO_2 emissions from occurring in the first instance when products are manufactured or processed.

HBC in its role as a waste collection authority has already investigated the CO_2 savings that can be achieved from changing the collection regime. Likewise, the emission reductions from North Yorkshire County Council's proposed Energy from Waste plant should also help to reduce greenhouse gas emissions associated with waste by increasing recycling rates and reducing the amount of waste that is sent to landfill.

Conclusions – main findings and next steps

The modelling that has been carried out to quantify the reductions in the CO_2 emissions related to the energy and transport that people living Harrogate Borough use and the embodied CO_2 highlights the following:

- To achieve the targets set by the Committee on Climate Change everybody needs to contribute if we are to get anywhere close to where we need to be in 2020 and 2050.
- Even with national interventions such as decarbonising electricity supply and transportation we cannot achieve the 2020 or 2050 targets. Therefore interventions that are facilitated by local authorities, partners and communities are also critical.
- Without any interventions (i.e. with ‚'business as usual') population growth and increased road traffic mean that the baseline CO_2 emissions in 2020 and 2050 (against which the CO_2 reductions are measured) are greater than in 2005 (*2.3Mt CO_2 by 2020 and 2.7Mt CO_2 by 2050)* and therefore it is more difficult to achieve the 40% and 80% reductions.
- The emission reduction interventions that offer the greatest reductions per pound invested are all grouped under behaviour change However, there is significantly less certainty whether or not these interventions will actually deliver the predicted emission reductions. Conversely, the capital investment measures offer less value for money but are not reliant on behaviour change and therefore are more likely to deliver the predicted emission reductions
- The models show that by 2020 an estimated 36% CO_2 reduction can be achieved and by 2050 an estimated 79% CO_2 reduction can be achieved.
- If HBC is to maximise its chances of achieving the 40% target by 2020 the action in the early years is essential.

During the process of analysing the potential emission reductions from different interventions it has become clear that HBC will need to gain access to funding because many of the interventions identified do not form part of core services. It is recommended that HBC investigates this further. The cost of implementing these changes is given in the table below overleaf.

Total and annual intervention costs

Action	Total cost (2011-2050)	Annual cost (averaged to 2050)
Energy consumption behaviour change	£703,980	£17,600
Energy efficient appliances/ lights	£703,980	£17,600
Reduced overall consumption (par t of a sustainable lifestyle action)	£1,039,950	£25,999
Promote 1 meat/poultry-free day per week per person (par t of a sustainable lifestyle action)	£1,039,950	£25,999
Car sharing	£1,386,600	£34,665
Air travel behaviour change (part of a sustainable lifestyle intervention).	£1,386,600	£34,665
Smarter Choices (modal shift and no growth in travel) (part of a sustainable lifestyle action)	£1,386,600	£34,665
Double Glazing	£2,367,980	£59,200
Insulation (loft/ cavity)	£9,627,980	£240,700
Ground source heat pumps	£33,687,586	£842,190
Condensing Boilers	£48,783,980	£1,219,600
Solar hot water	£49,439,950	£1,235,999
Combined solar (PV/HW)	£112,479,950	£2,811,999
PV cells	£162,799,950	£4,069,999

HBC itself may be able to secure public sector funding for the interventions. If this is not possible HBC may instead be able to help residents make applications to sign up to a FIT scheme or obtain grants for retrofitting insulation. It is recommended that HBC explores whether or not there are opportunities to secure investment from the private sector and other funders such as the Green Infrastructure Bank.

The above actions can feed into the development of a risk based costed action plan that builds on this action plan with a view of identifying which partners can contribute finances or staff resources to achieve the actions that have been identified. It is also recommended that any such business plan also considers the economic implications of not taking action so that the costs of the interventions described in the table above can be viewed in context.

1 Introduction

1.1 Purpose of this report

The purpose of this report is to present the results of modelling carbon emissions from activity in Harrogate Borough and to identify the actions that need to be implemented to achieve the following carbon dioxide (CO_2) emissions reductions from consumption: 40% by 2020 and 80% by 2050 compared with 2005 levels. This report also documents how the emissions reductions associated with different actions have been calculated as well as the approach used to model the likely levels of future emissions against which emissions reductions have been compared. Finally, the report makes recommendations as to how progress towards intervention implementation can be monitored.

1.2 Report Structure

This report has two main sections. The first section looks at the context for the study and basis for calculating the CO_2 emission reductions. The second section reviews the results of the modelling, identifies actions and prioritises them. The content of each chapter is described in more detail below:

- *Context for the study (Chapter 2).* This chapter identifies the need for the study and defines consumption based CO_2 emissions. It also sets out the range of actions that are considered in the Action Plan.
- *Methodology (Chapter 3).* This chapter describes the modelling software and processes that have been used to model the current and future baseline emissions. It also describes how CO_2 emission reductions from different proposed actions have been modelled, including any assumptions that have been made. This also includes how actions to reduce emissions from waste management and businesses within the borough have been analysed.
- *Action plan – for reducing consumption based emissions (Chapter 4).* This chapter discusses the results of the modelling including the likely CO_2 emissions reductions from different actions, the cost and priority for implementation.
- *Action plan - emissions not modelled in REAP (Chapter 5).* This chapter reviews the CO_2 reduction actions that waste management and businesses could implement. This is addressed in a separate chapter because these measures cannot be modelled directly within the REAP software tool.
- *Conclusions (Chapter 6).* This chapter summarises the main findings of the modelling results. It also identifies the actions most likely to generate the greatest emissions reductions, those that will help to facilitate greater emissions reductions from other actions and those that are reliant on other parties such as central government.

2 Study Context

2.1 The need for action

As a result of rising concentrations of greenhouse gases (GHG) in the earth's atmosphere, our climate is changing and will continue to do so into the future. Records have shown that eleven of the past twelve years (1995 – 2006) were amongst the twelve warmest years on record since records began in 1850.[2] A global average warming of 2°C is currently viewed as a critical threshold beyond which human well-being is irreversibly negatively affected[3]. Targets set in the UK to reduce emissions of greenhouse gases are therefore set at a level which represents the country's contribution to avoiding a global rise of 2°C.

In a 'business as usual' scenario, with emissions continuing to rise, there is at least a 50% risk of exceeding 5°C global average temperature change during the rest of the century. This 5°C increase would result in catastrophic impacts on the human population as we know it. An illustration of the scale of such an increase is that globally we are now only around 5°C warmer than during the last ice age.[4]

Assuming that we are able to act now to avert the worst impacts of climate change in the future, there will still be unavoidable changes to our climate in the next 40-50 years. While there will be global trends, not all parts of the world will be affected in the same way. Here in the UK, we are most likely to see the following climatic trends[5]:

- The UK will continue to get warmer;
- Summers will continue to get hotter and drier;
- Winters will continue to get milder and wetter;
- Some weather extremes will become more common (heat waves & winter flooding), others less common (winter cold snaps); and
- Sea level will continue to rise.

Specific work has also been done to understand how these general trends will particularly affect the Yorkshire and Humber region up to 2050 as part of a regional adaptation study.[6]

Because of these potential impacts and the need for action the UK Government has established policies to reduce CO_2 emissions. On signing the Kyoto Protocol, which came into force in 2005, the UK Government made a legally binding agreement to reduce emissions of GHGs to 12.5% below 1990 levels by the year 2012. The UK's Climate Change Act (2008), the first national legislation of its kind, sets out the Government's commitment to reducing carbon dioxide emissions to 80% below 1990 levels by 2050. This national legislation is being supported by a host of regional, local and sectoral policies and initiatives.

In 2009, Harrogate Borough Council adopted a climate change strategy and action plan and set targets to achieve a 40% reduction by 2020 (and 80% by 2050) for

[2] HM Treasury (2006) Stern Review: The Economics of Climate Change
[3] *Ibid.*
[4] *Ibid.*
[5] UK Climate Impacts Programme (UK CIP) Climate Projections 2009 (UK CP 09) Key Findings. Available at: http://ukclimateprojections.defra.gov.uk/content/view/515/675/
[6] Yorkshire and Humber Adaptation Study (2009). Full report available at: http://www.adaptyh.co.uk/

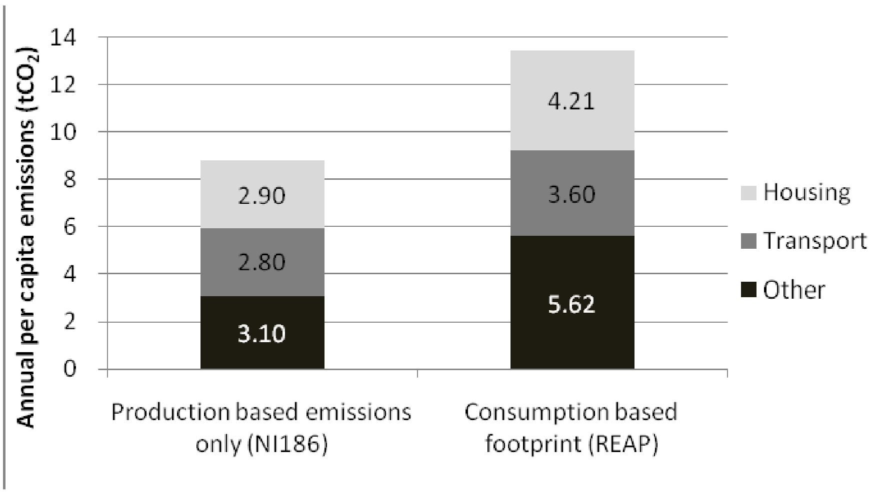
the Harrogate district and also the Council's own estate. The purpose of this study is to identify what actions the Council could take to achieve these targets and the likely cost of implementation.

2.2 Carbon dioxide emissions from production and consumption

Currently, there are two distinct approaches to calculating and describing the CO_2 emissions associated with our activities: *production based* and *consumption based* carbon footprinting. Production based carbon footprinting measures all of the CO_2 emissions that occur within a given spatial boundary. For this action plan the production based footprint would include all of the CO_2 emitted within HBC's boundary. This would include emissions from all of the transport that moves within the boundary, the emissions from the use of grid electricity and direct gas or other fuel use for heating as well as, commercial and industrial emissions (Figure 1 below).

Consumption based carbon footprinting uses the same basis for calculating CO_2 emissions from fossil fuel use, grid electricity use and transport. However, in addition to these emissions, a consumption based carbon footprint also includes the emissions associated with providing all of the goods and services we use as individuals as well as the embodied impacts associated with capital investment and maintaining existing infrastructure. As a consequence the consumption based emissions for Harrogate on a per capita basis are greater than production based emissions.

Figure 1. Production based and consumption based emissions for Harrogate Borough area in 2006[7].



[7] Note: The per capita production based CO_2 emissions for a resident of Harrogate was 8.8 tonnes in 2006[7]. However the per capita consumption based CO_2 emissions for resident of Harrogate was 13.43 tonnes in 2006Source: SEI - REAP v2 Experimental release: 15-10-08. Published by SEI 2008. This is based on data from 2006.

2.3 Scope of the Action Plan

This Climate Change Action Plan is primarily concerned with identifying the actions that HBC can implement over the next 40 years (starting in 2011) to reduce the CO_2 emissions associated with the energy, goods and services that residents in the Borough consume and the trips they take using transport that involves the combustion of fossil fuels.

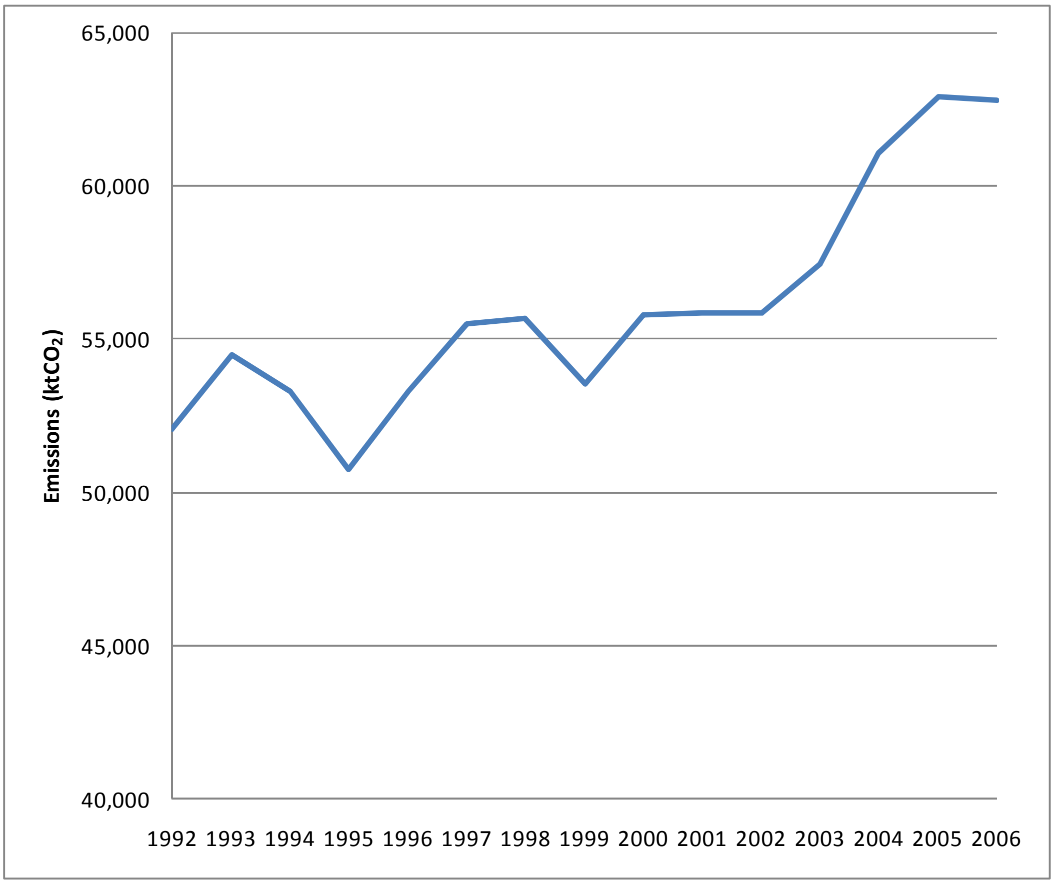
The two targets years of 2020 and 2050 and the targets for reducing CO_2 emissions are taken from the Climate Change Act (2008). Likewise the targets for reducing emissions by 40% and 80% by these years are also drawn from the Climate Change Act. However, a different baseline year has been selected instead of 1990 because baseline emissions data for Harrogate in 1990 does not exist. 2005 (the baseline year for this action plan), is the first year that HBC began collecting the detailed data on which our assessment is based. Using the 2005 baseline instead of the 1990 baseline does however mean that the level of emissions reductions is not as large as a 1990 baseline would require, because consumption based CO_2 emissions have been increasing over the period 1990-2005 (Figure 2 overleaf). Over the same time period, production-only emissions in the UK have fallen slightly[8] due to a number of factors, including uptake of efficiency measures and the increased export of manufacturing industries.

The Climate Change Act is designed to cover emissions occurring within the set UK boundary so does not include emissions resulting from the consumption of goods and services in the UK that occur abroad[9].

[8] Source:DECC, 2010 GHG Inventory Summary Factsheet http://www.decc.gov.uk/assets/decc/Statistics/climate_change/1217-ghg-inventory-summary-factsheet-overview.pdf

[9] Source: Climate Change Act, http://www.legislation.gov.uk/ukpga/2008/27/part/6/crossheading/territorial-scope-of-provisions-relating-to-greenhouse-gas-emissions

Figure 2. Consumption based CO_2 emissions in Yorkshire and the Humber since 1992 (source Stockholm Environment Institute – REAP Version 2.14).



3 Methodology

3.1 Resource and Energy Assessment Programme

3.1.1 The tool

The Resource and Energy Assessment Programme (REAP) has been developed by the Stockholm Environment Institute (SEI) at the University of York. It is a software tool that assists Government, agencies and other organisations assess the footprint impacts of a population in a given area. In addition it provides scenario modelling and policy assessment capabilities on the issues of sustainable consumption and production[10].

REAP's underlying methodology is an economy-wide environmental input-output analysis providing a number of indicators including: carbon dioxide, greenhouse gas emissions[11], air pollutants and heavy metals, the Ecological Footprint of consumption and material flows. These indicators are consumption-based, region-specific, comparable between geographic areas, standardised, and measure the significant flows of constrained resources which have to be managed in order to achieve sustainability. The indicators all include the direct and indirect effects of the consumption of products and services throughout the economic supply chain.

In addition to the benefits described above the consumption based approach to carbon footprinting can also provide the basis for helping people to live more sustainable lifestyles.

Version 2.14 of the REAP software was used in the analysis for the Action Plan. In addition to the REAP software, an additional 'Housing Calculator' was also used to analyse the contributions that different housing energy interventions could have on domestic energy consumption. This calculator was produced as part of work that SEI undertook on behalf of the Leeds City Region (LCR) in 2008[12].

3.1.2 Emissions associated with business and waste management

The consumption based footprint is concerned with the CO_2 emissions associated with the things we consume and do as individuals. As a result the emissions associated with business and industry is accounted in the footprint as the 'embodied emissions' within the goods and services we buy and use.

Similarly, waste is treated as an industrial sector, it doesn't have a discrete footprint separate from the footprint of consumption because as individuals we don't buy or use waste directly. *Waste arises from consumption and this is therefore how the* CO_2 emissions are calculated in the REAP programme. The

[10] For further information see http://www.resource-accounting.org.uk/

[11] These emissions factors are based on the Defra emission factors for 2006. These emission factors can be found in the reporting the Guidelines to Defra's GHG Conversion Factors for Company Reporting.

[12] Barratt, J and Dawkins, E. (2008). Carbon Footprint of Housing in the Leeds City Region – A Best Practice Scenario Analysis.

waste sector's impact is taken into account as an indirect or supply chain impact. It is also important to understand that the way household waste is disposed of will have a very small impact on the total footprint of an area. Only measures taken at the top of the waste hierarchy (e.g. avoiding waste creation within manufacturing and food processing) will have a significant impact on the size of an area's footprint because they help to prevent CO_2 emissions from occurring in the first instance when products are manufactured or processed.

3.2 Establishing a baseline

HBC's emissions targets are for a 40% reduction by 2020 and an 80% reduction by 2050, based on a 2005 baseline. This report displays savings from HBC interventions both in the context of a static 2005 baseline and a 'continuing trends' scenario. This is because to meet the targets, future reductions may also have to overcome any increases that are predicted due to current trends (see section 4.1. page 14).

Therefore, to place potential emissions reductions in this context, a business as usual (BAU) or 'continuing trends' scenario was also modelled. This provides an estimate of CO_2 emissions over time if present trends continue and no action was taken (see section 4.1. page 14).

Where data on existing trends were available, they have been incorporated into the BAU scenario. The BAU scenario is informed by population and transport growth forecasts from national sources as well as data provided by HBC. The following sections describe what is included in the BAU scenario.

Version 2.14 of the REAP software uses a 2006 baseline year. Therefore in order to report against a 2005 baseline for HBC's reduction targets, it was necessary to manipulate the findings of the BAU scenario to obtain a total emissions value for 2005. This was done by simply applying the BAU trend back one year to 2005. Full details of the approach and assumptions in the BAU scenario can be found in Appendix A.

3.3 Identifying interventions and actions

REAP enables the modelling of different interventions over time under the categories of domestic energy, personal transport, demographics, consumables and durables and food. The SEI Housing Calculator tool (see 3.1.1 on the previous page) enables more refined modelling of specific housing retro-fit interventions. Specific interventions were defined by the options in REAP and the Housing Calculator Tool and informed by Harrogate-specific data provided by the council.

3.3.1 Front-loading actions to kick-start the emissions reduction programme

Originally, the retro-fit and renewables interventions were modelled to achieve full capacity by 2050. This is ambitious but realistic given the annual numbers of installations required and the necessary levels of capital investment. However, once results from this modelling were analysed, it was clear that even with national decarbonisation measures, the Borough would fall short of its 2020 target. In order to see whether the 2020 target is achievable when using consumption-based modelling, these interventions were front-loaded in order that capacity for renewable technologies and energy efficiency measures is fully exploited by 2020 instead of 2050. The energy behaviour change and car sharing interventions were also altered to achieve increased emissions savings. It must be noted that these represent incredibly ambitious interventions for which there is no precedent. However, they help to illustrate the challenge posed by HBC's targets, especially if a consumption-based approach is taken.

This sections that follow briefly describe the interventions that have been modelled, including the 'front-loading' of implementation. Detailed methods, assumptions and sources for each intervention are included in Appendix B and the original methods and interventions modelled over 40 years (along with a summary of results) are briefly described in Appendix D.

3.3.2 Housing interventions

The SEI Housing Calculator Tool enables the modelling of various micro-renewable and retro-fit interventions[13]. The tool provides an output in the form of energy consumption per person for each intervention which can be imported into REAP to model the CO_2 saving. The exact details of each intervention were informed by Harrogate-specific data from a number of sources. The scale and type of micro-renewable interventions modelled, including solar PV, solar hot water and ground source heat pumps, were informed by a recent report entitled 'Harrogate Planning and Climate Change Study', commissioned by HBC to determine the renewable energy potential of the Borough[14]. This report provides an estimate of the Borough's total potential capacity for technologies such as solar PV and ground source heat pumps. Retro-fit interventions were informed by data within the Homes Energy Efficiency Database (HEED) gathered by the Energy Savings Trust[15]. Information on current levels of energy efficiency enabled the modelling of interventions that fully exploit the potential for retro-fitting the existing housing stock by 2050. Table 1 describes the housing interventions. More detailed methods and assumptions for each intervention are included in Appendix B.

Table 1: Housing Interventions

Intervention	Description
Solar PV	Potential CO_2 savings from exploiting the Borough's full solar potential by 2020 by using PV cells to generate electricity at a household level.
Solar hot water	Potential CO_2 savings from exploiting the Borough's full solar potential by 2020 by using solar panels to heat water at a household level. This scenario retains the existing rate of PV uptake included in the BAU scenario.
Combined solar	Potential CO_2 savings from exploiting the Borough's full solar potential by 2020 with a mix of PV and hot water installations. The solar capacity is

[13] The term "micro-renewables" refers to small scale renewable energy generation systems such as photo voltaic cells and solar water heaters that can provide electricity, hot water and heating for domestic property. In the context of this Action Plan retro-fit refers to the installation of insulation to existing properties. Full details of the retro-fit and micro-renewable measures considered can be found in Table 1 above.

[14] Draft report produced for HBC: AECOM, 2010. Harrogate Planning and Climate Change Study - Stage One.

[15] http://www.energysavingtrust.org.uk/business/Business/Information/Homes-Energy-Efficiency-Database-HEED/Find-out-more-or-register

Intervention	Description
	split equally between the two technologies.
Ground source heat pumps	Potential CO_2 savings from exploiting the full potential for GSHPs for off-grid[16] properties by 2020[17].
Home insulation	Potential CO_2 savings from insulating every domestic property that can be insulated to current building regulations standards by 2020 (both loft and cavity).
Condensing boilers	Potential CO_2 savings from installing condensing boilers in all properties on the gas network that currently have conventional systems, by 2020.
Double glazing	Potential CO_2 savings from installing double glazing in all suitable properties by 2020
Energy efficiency appliances and lights	Potential CO_2 savings from installation of energy efficient appliances and lights[18] in all properties by 2020
Energy consumption behaviour change	Potential CO_2 savings resulting from changes in energy consumption behaviour – models an ambitious 15% reduction in domestic energy consumption by 2020 and an annual 0.6% reduction thereafter to 2050.

3.3.3 Transport interventions

There is no transport equivalent to the SEI Housing Calculator Tool which means the potential for modelling transport interventions is more limited. Personal transport data in REAP is in the form of passenger kilometres (PKMs) per year split by mode. It is also possible to edit the occupancy rates of transport modes in REAP. Therefore, when modelling transport interventions in REAP the impacts of different actions were represented as either a change in PKMs or % occupancy rates by mode of transport. The selected interventions were based on a mixture of continuing to roll out existing interventions and emulating the success of 'Smarter Travel Choices'[19] initiatives elsewhere in the country. Table 2 below describes the transport interventions that have been modelled and Appendix B provides more detail on specific methods and assumptions.

Table 2: Transport Interventions

Intervention	Description
Smarter Travel Choices	Potential CO_2 savings from a 4% modal shift from private cars to bus and train by 2020 and no increase in per capita PKMs to 2050.
Car Sharing	Potential CO_2 savings from an 18% increase in the private car occupancy rate by 2020 with levels staying static thereafter. In reality, this means that between now and 2020, all private vehicles will go from carrying an average of 1.6 to 2.5 people.
Air travel	Potential CO_2 savings from all residents taking 1 less flight per year

[16] Off-grid properties in this context consist of those that do not have access to natural gas grid and therefore use either fuel oil or bottled gas.
[17] GSHPs were modelled for off-grid properties only in line with guidance from the Energy Savings Trust which recommends the technology only for properties not covered by the gas network. http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF
[18] This intervention has been modelled as straight swap for normal lighting and less efficient appliances. Where possible these would replace appliances at the end of their useful lifetime.
[19] See the following website for further information about Smarter Choices http://www.dft.gov.uk/pgr/sustainable/smarterchoices/

3.3.4 Consumables intervention

REAP includes detailed per capita expenditure data for a range of consumables and durables (e.g. white goods, magazines and newspapers, tobacco) in order to measure the supply chain impacts of consumption. The extent to which these data can be manipulated in REAP is limited and there are few existing studies suggesting expected levels of expenditure reduction as a result of behaviour change interventions. However, in order to estimate the potential CO_2 savings from reduced overall consumption, a ‘sustainable lifestyles’ intervention was included which modelled a 10% per capita reduction in expenditure on consumables and durables by 2050. This was applied in a linear way with equal decreases in consumption each year to achieve a 10% reduction in 2050.

3.3.5 Food interventions

REAP also includes information on per capita expenditure on different food types. In the same way as consumables, it is possible to model the carbon implications of changes in per capita expenditure on different food types. After consultation with HBC, it was decided to model the implications of changes to personal diets. Table 3 describes the three interventions that were modelled and more detailed assumptions are detailed in Appendix B.

Table 3. Food interventions.

Intervention	Description
1 meat-free day per week	Potential CO_2 savings if every resident had one meat-free day per week
1 poultry-free day	Potential CO_2 savings if every resident had one poultry-free day per week
1 meat-free day and 1 poultry-free day per week	Potential CO_2 savings if every resident had one day per week free of both meat and poultry

3.4 Modelling the change in emissions from actions

Having identified the various CO_2 emission reduction packages each one was modelled as a separate scenario in REAP. The scenario editor in REAP allows the user to specify changes to variables over time and determine what happens to CO_2 emissions in that scenario. The BAU scenario was modelled first and each subsequent intervention used this scenario as a baseline to which the relevant changes were made.

3.4.1 Modelling the BAU scenario

Due to a bug[20] being encountered in REAP at the start of the project, a ‘workaround’ method was developed in order to enable the modelling of interventions within the timescale of the project. This method meant the

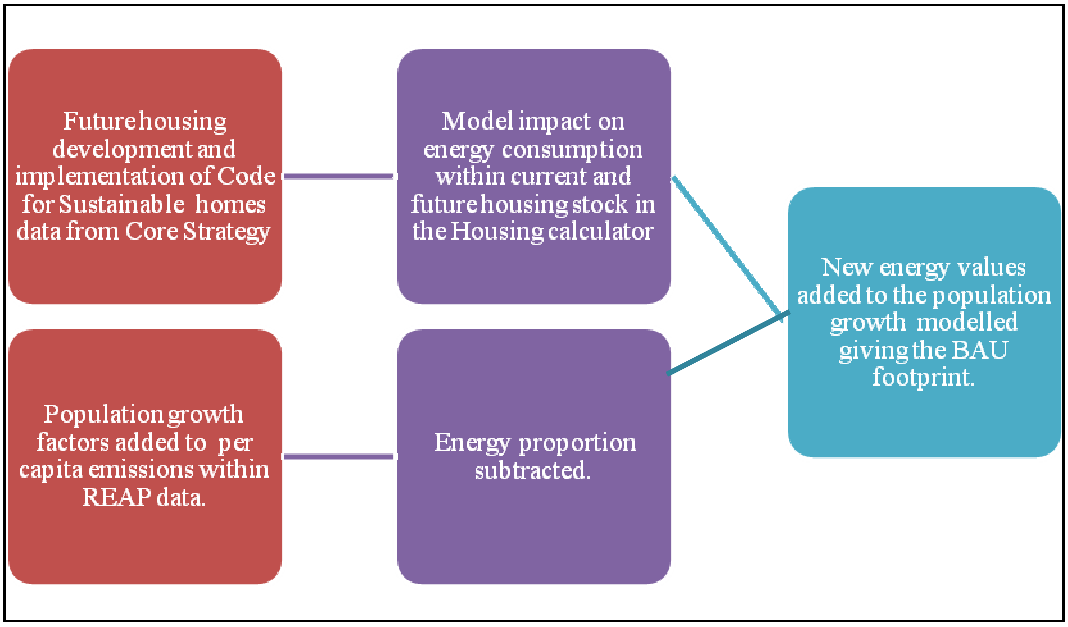
[20] The bug in the REAP software meant that the impact of population growth over time could not be modelled directly within the software. However it was possible to model the impact of other interventions on emissions within REAP. So the impact of an increasing population over time was calculated by multiplying the per capita emissions by the forecast population for each year.

production of two scenarios in REAP which were then manipulated to account for population growth and combined to account for the aspects of the BAU scenario outlined in Section 3.2.

The first of these included the transport growth factors gathered from national sources but excluded all personal energy consumption. To account for population growth, per capita emissions from this scenario were exported from REAP and multiplied by the forecast population[21] in each year to 2050 to get total emissions on an annual basis.

The second scenario was prepared to account for the housing aspects of the BAU scenario[22] (the increase in housing numbers and the roll out of the Code for Sustainable Homes expected in the Harrogate Core Strategy). The SEI Housing Calculator produced the second scenario which was subsequently modelled in REAP. The energy portion of this scenario was separated out by subtracting total emissions in the baseline year from the first BAU scenario. This figure was then added on an annual basis to the first portion to determine the total BAU emissions for Harrogate to 2050 (see Figure 3 below).

Figure 3. Modelling process for the business as usual scenario.



If there had been no bug in REAP, there would have been no need to combine two BAU scenarios; a single scenario would have been created which would have been edited to determine the impact of each intervention. The SEI intends to debug the programme by March 2011.

[21] See Appendix A, section A1 for more detail.
[22] This consisted of the increase in housing numbers and the roll out of the Code for Sustainable Homes as applied to new development as set out in the Harrogate Core Strategy.

3.4.2 Modelling individual interventions

Each intervention was modelled and the resulting emissions subtracted from the BAU scenario to calculate savings to 2020 and 2050 and the contribution that each intervention could make to meeting HBC's targets. Emissions savings are presented from a static 2005 baseline value and in the context of the BAU scenario in Chapter 4 (page 14).

Not all emissions reductions measures can be facilitated by HBC. Some rely on sub-national or national activity. Specifically, the national Climate Change Committee highlighted the importance of decarbonising national energy supply and transport infrastructure interventions in its 2008 report Building a Low-Carbon Economy[23]. The contribution of decarbonising energy supply and personal transport were also indicatively modelled in order to show the contribution of HBC's interventions in the context of wider national interventions. (Detail on the methods used to do this are also included in Appendix B).

3.5 Costing and prioritising the interventions

An estimate has been made for the cost of each intervention in order to help identify the most cost-effective actions in terms of the tonnes of CO_2 saved. This allows the actions in the plan to be prioritised. Full methods and assumptions used to cost each intervention are included in Appendix C.

Intervention costs were split into three parts; capital cost, HBC staff time cost and potential income. Capital cost refers to the upfront cost of an intervention for materials and installation (e.g. the cost of purchasing and installing PV cells on a property). Capital costs have been estimated based on a number of sources including HBC publications such as the recent Planning and Climate Change Study[24] and the 2003 Private Sector Stock Condition Report[25].

HBC time cost refers to the salary cost to HBC of employing officers to promote and implement the interventions. Salary costs were supplied by HBC for a typical Project Officer, Campaign Officer and Manager. Assumptions were made in consultation with HBC on the number of employees required to implement the interventions. Appendix C details these assumptions.

For several interventions, there is potential for income to be earned as a result of capital investment. The Feed in Tariff (FiT) pays a fixed rate to householders for every kWh they produce from a number of renewable electricity generation technologies. The Renewable Heat Incentive will start in April 2011 offering a similar incentive to householders who install renewable heat technologies such as ground source heat pumps. If the capital cost for installation is met by the householder they will receive the income but there is also potential for HBC to fund installations and receive the subsequent payment. Feed in Tariff payments will be paid for 25 years from the date of installation and RHI payments will last 20 years. Where there is potential for these payments, estimates were made based on average sized installations. Appendix C details these methods.

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[23] UK Climate Change Committee (2008) Building a Low-Carbon Economy, available at: http://www.theccc.org.uk/reports/building-a-low-carbon-economy

[24] Draft report produced for HBC: AECOM, 2010. Harrogate Planning and Climate Change Study - Stage One.

[25] Harrogate Borough Council (2004), 2003 Private Sector Stock Condition Survey.

3.6 Contributions from business and waste management

As described in section 3.1.2 previously, emissions from business and waste management are not expressed as individual elements within the consumption based carbon footprint. However, the CO_2 emissions from both make significant contributions towards the nation's total emissions. As a consequence it is important that CO_2 emissions reduction actions are identified for businesses and waste management in Harrogate.

To provide an overview of the CO_2 emissions from businesses in the borough annual turnover data was provided by the HBC Economic Development Unit. This data was aggregated according to the UK Standard Industrial Classification of Economic Activities (UK SIC) codes[26] and then Defra / DECC's "*Greenhouse Gas Conversion Factors for Company Reporting*" for supply chains were applied[27]. This analysis provides us with a picture of the total CO_2 emissions from these industrial sectors based on the amount of money that other businesses and individuals spend to buy goods or services from these organisations.

Waste management has been included as a separate element of this study because it is an important function for HBC (as the municipal waste collection authority) and also North Yorkshire County Council (as the waste disposal authority for municipal waste arising within HBC's boundary). No specific modelling has been undertaken as part of this study to calculate the greenhouse gas emissions from different waste management approaches because this has already been calculated by both waste authorities using the Waste and Resources Assessment Tool for the Environment (WRATE) developed by the Environment Agency. WRATE allows the environmental life cycle impacts of a wide range of waste management processes and waste transport measures to be calculated. The modelling carried out by both HBC and NYCC for their planned waste transport and management proposals have been reviewed to identify potential actions that could be implemented to achieve even greater reductions in greenhouse gas emissions. This modelling is only concerned with the collection, treatment and disposal of domestic and municipal waste. As a consequence, construction, demolition, commercial and industrial waste management does not contribute towards the emissions modelling described above.

[26] For more information see: http://www.statistics.gov.uk/methods_quality/sic/downloads/SIC2007explanatorynotes.pdf

[27] 2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Defra, UK - The Environment - Business & the environment - Reporting environmental impacts

4 Modelling Results and Action Plan

This section presents the findings of the modelling work and cost estimates which have informed the prioritised action plan included in Section 4.3. Section 4.1 displays the headline findings, including the overall potential impact of HBC interventions. Section 4.2 covers the potential carbon savings delivered by each intervention in more detail. The action plan in Section 4.3 presents the total costs of each intervention to 2050 and the costs per tonne of CO_2 saved over the 40 year period at present day rates. This information is then used to inform a prioritisation of actions and the identification of interventions to focus upon in the short and long term. *It is not clear how this is achieved by using the two tables which are in different orders.*

4.1 Overview of emissions reductions

4.1.1 Total emission reductions

The emissions savings from all HBC interventions were added together to determine the full extent of potential CO_2 savings from council actions in relation to the BAU scenario and the target trajectory. These findings are summarised in Table 4 (below) and displayed graphically in Figure 4 (overleaf) in the context of indicative potential savings from national decarbonisation measures[28]. Modelled HBC interventions alone were calculated as delivering total cumulative savings of 2.8MtCO_2 by 2020 and 20.6 MtCO_2 by 2050, when compared with the BAU scenario. The contributions of each category and individual interventions are outlined in Section 4.2.

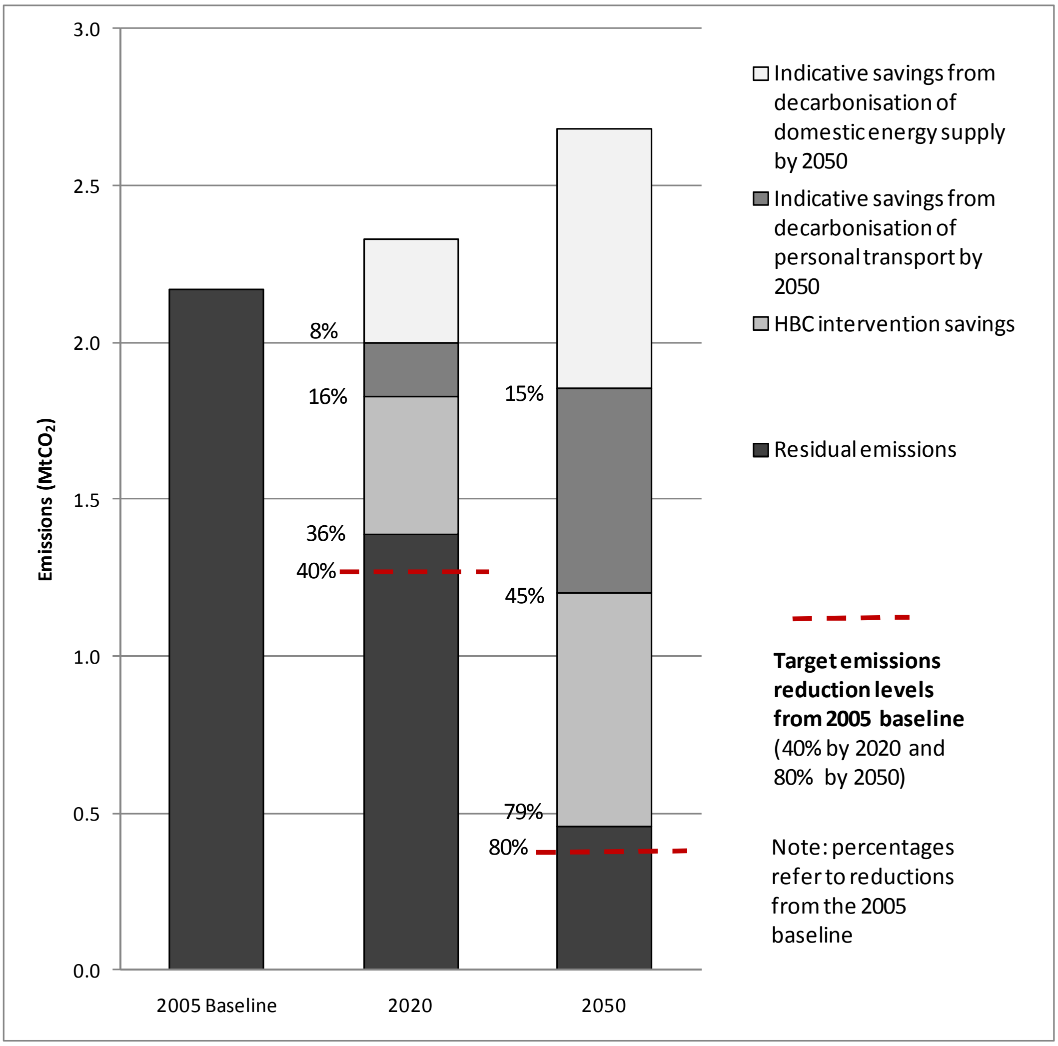
Table 4. Emissions reductions against the 2005 baseline.

	2020	2050
Baseline emissions (2005) (Mt CO_2)	**2.3**	**2.7**
Targets (Mt CO_2)	**1.3 (40%)**	**0.4 (80%)**
Emissions with decarbonisation of domestic energy (Mt CO_2)	**2 (8%)**	**1.9 (15%)**
Emissions with decarbonisation of domestic energy and personal transport (Mt CO_2)	**1.8 (16%)**	**1.2 (45%)**
Emissions with decarbonisation measures and HBC interventions (Mt CO_2)	**1.4 (36%)**	**0.5 (79%)**

Note: values in ( ) represent the % reduction against the 2005 baseline and includes the predicted increases in population and traffic over the 40 year timeframe from 2010.

[28] Indicative estimates have been modelled in line with the most recent report Committee on Climate Change report: 90% decarbonisation of the energy sector by 2030 along with a decarbonisation of the surface transport sector by 2050. Appendix B covers mothds used. See http://downloads.theccc.org.uk.s3.amazonaws.com/4th%20Budget/CCC_4th-Budget_interactive.pdf

Figure 4. Modelled CO_2 emission reductions in 2020 and 2050 compared against the emissions baseline in 2005 for the population of Harrogate Borough.



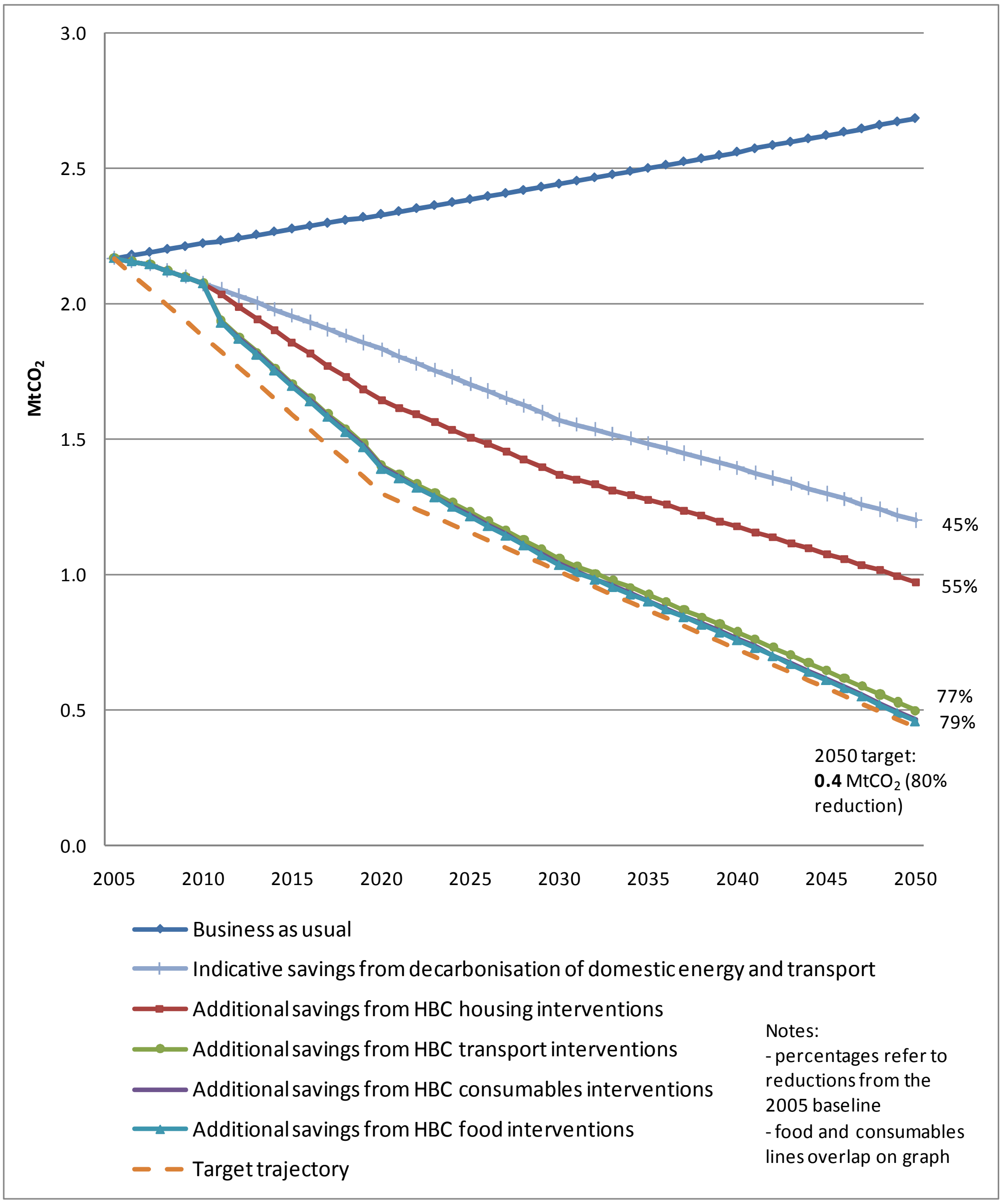
These results show that the combined reductions from the interventions along with indicative estimations of the Committee on Climate Change's energy supply and transport decarbonisation measures could achieve a reduction of up to 36% by 2020. The interventions will continue to deliver savings after 2020 and by 2050 could reduce emissions by 79%. It must be noted that interventions are extremely ambitious and have been 'front-loaded' to deliver the maximum possible savings by 2020. Appendix D describes the original set of interventions that were modelled over a longer time-frame to 2050.

What is clear from these findings is that national decarbonisation interventions alone will not be sufficient for targets to be met and local–level consumption-based intervention is necessary to make up the remaining savings. Equally, local action alone is not sufficient to meet the target and HBC will need to actively support the full implementation of national measures suggested by the Committee on Climate Change.

4.2 Emission reductions from HBC interventions

Figure 5 below focuses in on the reductions that can be attributed to the emission reductions identified in this action. plan. As detailed in the methodology section, interventions were split into four footprint categories; housing and domestic energy, transport, consumables and food.

Figure 5 Contribution of HBC interventions to overall emissions reductions[29].



29 Note: the 'Additional savings from HBC consumables interventions' is obscured by the 'Additional savings from HBC food interventions'.

These results show that the biggest portion of potential HBC emissions reductions come from transport interventions (a further 21% reduction in 2050). The second biggest contribution comes from housing interventions (13% of target emissions savings in 2050) and a small contribution is delivered by consumables and food (approximately 1%). Table 5 (below) presents cumulative emissions savings for each of the intervention categories and the percentage of required savings delivered by each when compared to the projected BAU.

Table 5. Emission savings from intervention categories.

Intervention category	Cumulative emissions savings by 2020 ($MtCO_2$)	% of required saving over BAU by 2020	Cumulative emissions savings by 2050 ($MtCO_2$)	% of required saving over BAU by 2050
Housing (including and domestic energy)	1.05	12.8%	7.3	12.7%
Transport	1.6	19.5%	12.3	21.3%
Consumables and durables	0.06	0.7%	0.7	1.3%
Food	0.04	0.5%	0.2	0.3%

It is important to note that although transport interventions appear to deliver the largest portion of carbon savings, they are all behaviour change interventions that rely on commitment from all Harrogate residents. This means that modelled savings should be viewed as being towards the higher end of what is achievable. Further discussion about the confidence with which to attribute to savings is included overleaf. The following sections present emissions savings from each intervention in turn.

4.2.1 Housing – domestic energy use

The potential emissions savings delivered by each housing intervention are displayed in Table 6 overleaf. As mentioned in chapter 3 they are based on data from the Energy Savings Trust on the numbers of existing dwellings in Harrogate Borough that still do not have energy efficiency retrofit measures. These measures include the installation of cavity wall insulation, loft insulation and double glazing in properties that are suitable but do not currently have these measures in place[30]. The amount of energy generated from micro-renewable generation is also represented here and is based on the capacities identified within the Draft Renewable Capacity study being prepared for the Borough's Core Strategy.

The energy consumption behaviour change intervention delivers most savings. As noted above for transport behaviour change interventions, this figure should be treated as a maximum potential saving as it is very ambitious and requires significant commitment from all residents in the Borough. Investment by HBC and partners in supporting behaviour change does not necessarily ensure behaviour change and the desired impacts.

[30] There were insufficient data on homes with external insulation in HEED to model inform an intervention. However, this is an option in the SEI housing calculator so if new data become available, this can be modelled in future.

Table 6: Cumulative emissions savings from retro-fit housing interventions and behaviour change across Harrogate Borough.

Intervention	Cumulative savings by 2020 (tCO_2)	Percentage contribution to 2020 target	Cumulative savings by 2050 (tCO_2)	Percentage contribution to 2050 target
Solar PV	71,967	0.9%	397,921	0.7%
Solar hot water	25,189	0.3%	148,715	0.3%
Combined solar	50,061	0.6%	268,594	0.5%
Ground source heat pumps	45,179	0.6%	266,745	0.5%
Home insulation	184,688	2.2%	1,081,221	1.9%
Double glazing	23,614	0.3%	139,426	0.2%
Condensing boilers	77,988	1%	460,419	0.8%
Energy efficient appliances/ lights	250,112	3%	1,471,621	2.5%
Energy consumption behaviour change	398,303	4.8%	3,530,023	6.1%
TOTAL[31]	1,051,851	13%	7,347,376	13%

Note: Displayed in tonnes rather than Mt as some values are relatively small. Percentages are rounded.

4.2.2 Transport

Potential emissions savings from transport interventions are displayed in Table 7 (overleaf). Given that HBC is not the highways authority for the borough, the extent of the interventions that HBC can actively lead on is limited to those that do not rely on significant investment in infrastructure. As a result they focus on the Department for Transport's 'Smarter Choices' framework, expanding the existing car-share scheme and, as part of a sustainable lifestyle intervention, encouraging residents to take one less flight (on average) per year.

All of the transport interventions are focussed on behaviour change rather than capital investment. As a consequence this figure should be treated as a maximum potential saving as it is very ambitious and requires significant commitment from all residents in the Borough. Investment by HBC and partners in supporting behaviour change does not necessarily ensure behaviour change and the desired impacts.

[31] Note that this total figure does not include 'solar hot water' or 'combined solar' as they use the same solar potential as the PV intervention.

Table 7: Cumulative savings from transport interventions

Intervention	Cumulative savings by 2020 (tCO_2)	Percentage contribution to 2020 target	Cumulative savings by 2050 (tCO_2)	Percentage contribution to 2050 target
Smarter travel choices (modal shift and no increase in mileage)	204,655	2.5%	2,643,819	4.6%
Car sharing	699,086	8.5%	6,590,520	11.4%
Air travel behaviour change	700,977	8.5%	3,066,620	5.3%
TOTAL	1,604,719	19.5%	12,300,959	21.3%

4.2.3 Consumables, Durables and Food

The potential savings from the consumables intervention is shown in Table 8 below and the potential savings from food interventions are shown in Table 9 below. These emission reductions interventions form part of a wider 'sustainable lifestyles' intervention that aims to encourage and support residents in the Borough to lead more sustainable lifestyles.

Table 8: Cumulative savings from consumables interventions

Intervention	Cumulative savings by 2020 (tCO2)	Percentage contribution to 2020 target	Cumulative savings by 2050 (tCO2)	Percentage contribution to 2050 target
Reduced overall personal consumption (10% reduction by 2050)	58,509	0.7%	726,012	1.3%

Table 9: Cumulative savings from food interventions[32]

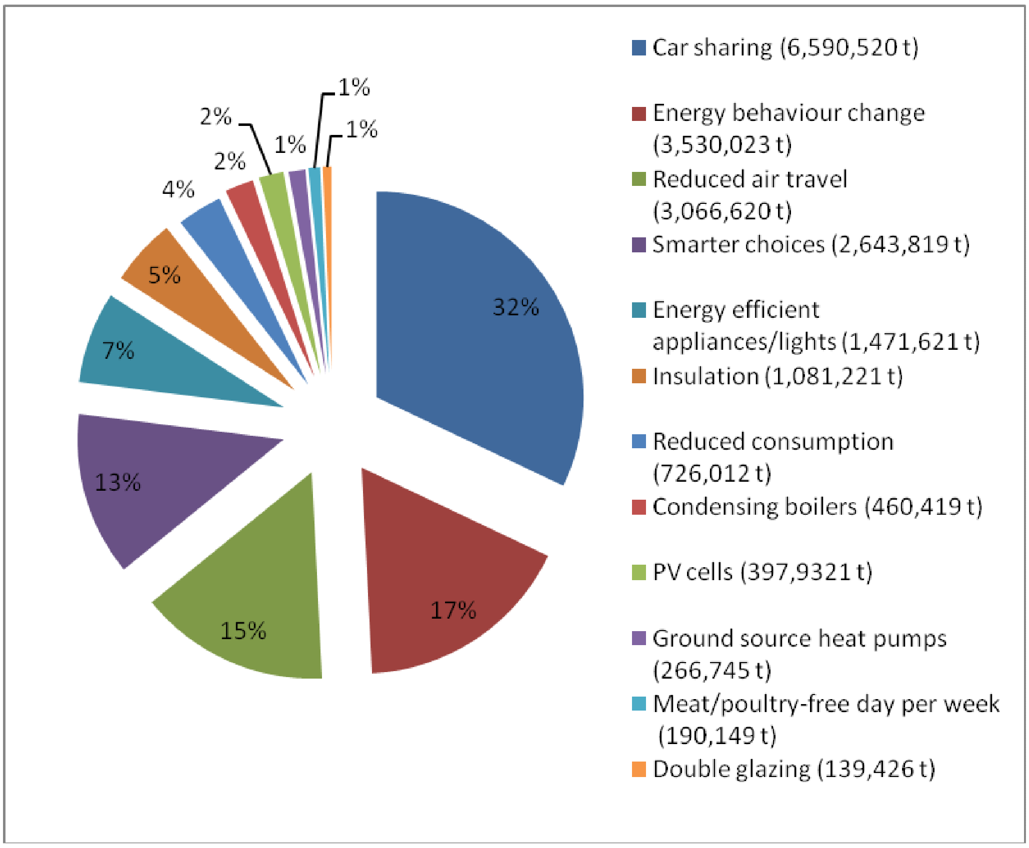
Intervention	Cumulative savings by 2020 (tCO_2)	Percentage contribution to 2020 target	Cumulative savings by 2050 (tCO_2)	Percentage contribution to 2050 target
1 meat-free day per week (per person)	30,978	0.4%	135,282	0.2%
1 poultry-free day per week (per person)	12,541	0.2%	54,615	0.1%
1meat-free day per week and 1 poultry-free day per week (per person)	43,519	0.5%	190,149	0.3%
TOTAL	43,519	0.5%	190,149	0.3%

[32] Note that total only includes the last intervention as including others would lead to double-counting.

4.2.4 Relative CO2 emission reductions of the action plan interventions.

The emission reduction interventions described on the previous make varying contributions towards HBC's total CO_2 emissions reductions. This is illustrated in Figure 6 below. In broad terms the measure that avoid energy use and therefore CO2 emissions generate the greatest benefits where as renewables and energy efficiency measures provide much smaller benefits. This information, along with the cost of implementation has been used to prioritise these interventions and this is discussed further in section 4.3.

Figure 6. Proportion of total CO_2 reductions (2011 to 2050) from all of HBC's interventions. [33]



4.2.5 Uncertainty in the results

Although the workaround method adopted to overcome the bug in REAP has succeeded, it introduced more scope for modelling errors and uncertainty. Furthermore, the emissions savings figures for behaviour change interventions should be treated with caution. These interventions are very ambitious and assume the successful involvement and response of all residents in the Borough. As such, the savings figures for the energy behaviour change, the three transport interventions and the consumables and food interventions should be considered as best-case scenarios.

33 Only the Solar PV intervention is shown as the other two solar interventions use the same resource.

4.3 Prioritised interventions

Using the approach set out in Chapter 3 and Appendix C the cost of implementing each intervention has been calculated. This has then been used to calculate the total cost and annual costs (see Table 11 below and Table 12overleaf). It must be noted that behaviour change interventions only involve a HBC time cost and no capital cost. This generally accounts for their lower total costs. Staff allocated to each intervention are summarised in Table 10.

Table 10: Suggested staff requirements for each intervention

Intervention	Staff Time and level	Notes
PV Cells	0.5 FTE Project Officer	Note that only one of the solar interventions can be implemented as they each exploit the same resource. The other half of the PO's time is allocated tothe GSHP intervention
Solar Hot Water		
Combined Solar		
Ground Source Heat Pumps	0.5 FTE Project Officer	
Double Glazing	0.2 FTE Project Officer, 0.2 FTE Campaigns Officer	Two members of staff are allocated across these five interventions; a Project Officer and a Campaigns Officer. This effectively means that there will be 2 staff spending 1 day per week on each intervention.
Insulation	0.2 FTE Project Officer, 0.2 FTE Campaigns Officer	
Condensing Boilers	0.2 FTE Project Officer, 0.2 FTE Campaigns Officer	
Energy Efficient Applicances	0.2 FTE Project Officer, 0.2 FTE Campaigns Officer	
Energy Consumption Behavior Change	0.2 FTE Project Officer, 0.2 FTE Campaigns Officer	
Car sharing	1 FTE Project Officer	The very ambitious nature of these intverventions means they have each been allocated a fulltime PO.
Smarter Travel Choices	1 FTE Project Officer	
Air Travel behaviour Change	1 FTE Project Officer	
Meat/Poultry-Free Day	0.5 FTE Project Officer	These two interventions are packaged into a sustainable lifestyles role for one PO.
Reduced Overall Consumption	0.5 FTE Project Officer	

Note: FTE – Full time equivalent

Table 11: Total and annual intervention costs

Action	Total cost (2011-2050)	Annual cost (averaged to 2050)
Energy consumption behaviour change	£703,980	£17,600
Energy efficient appliances/ lights	£703,980	£17,600
Reduced overall consumption (par t of a sustainable lifestyle action)	£1,039,950	£25,999
1 meat/poultry-free day per week per person (part of a sustainable lifestyle action)	£1,039,950	£25,999
Car sharing	£1,386,600	£34,665
Air travel behaviour change (part of a sustainable lifestyle intervention).	£1,386,600	£34,665
Smarter Choices (modal shift and no growth in travel) (part of a sustainable lifestyle action)	£1,386,600	£34,665
Double Glazing	£2,367,980	£59,200
Insulation (loft/ cavity)	£9,627,980	£240,700
Ground source heat pumps	£33,687,586	£842,190
Condensing Boilers	£48,783,980	£1,219,600
Solar hot water	£49,439,950	£1,235,999
Combined solar (PV/HW)	£112,479,950	£2,811,999
PV cells	£162,799,950	£4,069,999

Note: Costs are stated at current (2010) levels; inflation has not been accounted for.

4.3.1 Prioritised interventions

In order to prioritise the interventions that have been identified their costs over the 40 year lifetime of this Action Plan have been calculated. This has then allowed the cost per tonne of CO_2 saved to be calculated. This, combined with the ranked score for total CO_2 saved and total costs to 2050 has been used to generate the sum ranked score for each action. The lower the score the greater the priority for action in terms of CO_2 reduction and costs. The costs include positions for HBC officers as well as the capital investment required to fund energy efficiency retrofitting measures and micro-renewables. The prioritised list of actions is set out in the table below in Table 12.

Table 12: Estimated costs and potential income per tonne of CO_2 saved

Actions	CO_2 saving to 2050 (t)	Total cost/ tCO_2 saved £	Capital cost/ tCO_2 saved £	HBC time cost /tCO_2 saved £	Total cost (2011-2050) £	Potential income/ tCO_2 saved[34]	Sum of ranked Scores	Timeframe for action	Likelihood of the action delivering the benefit	Other comments
Energy behaviour change	3,530,023	0.20	NA	0.20	703,980	NA	4	Most behaviour change occurs by 2020 with steady improvements continuing to 2050	Uncertain *(it is reliant on the effectiveness of behaviour change campaigns and individual officers to get residents to change their behaviour).*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits'.
Car sharing	6,590,520	0.32	NA	0.32	1,386,600	NA	8	increase in occupancy rate ooccurs by 2020 but benefits felt continuously thereafter	Uncertain/neutral *(the magnitude of any saving is uncertain however, given that the borough already has scheme up and running it is felt that it is more likely to result in the emission*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits' and to support the continued

[34] Although these actions are more expensive because of their capital element the potential revenue value has been kept separate because it might not be feasible for HBC to claim this money back to reinvest in other schemes.

Actions	CO_2 saving to 2050 (t)	Total cost/ tCO_2 saved £	Capital cost/ tCO_2 saved £	HBC time cost /tCO_2 saved £	Total cost (2011-2050) £	Poten-tial income/ tCO_2 saved[34]	Sum of ranked Scores	Timeframe for action	Likelihood of the action delivering the benefit	Other comments
									savings than some of the other behaviour change actions).	administration of this action.
Aviation behaviour change (as part of sustainable lifestyle action)	3,066,620	0.68	NA	0.68	1,386,600	NA	12	Behaviour change achived immediately and maintained to 2050	Uncertain *(it is reliant on the effectiveness of behaviour change campaigns and individual officers to get residents to change their behaviour).*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits'.
Reduced consump-tion	726,012	1.43	NA	1.43	1,039,950	NA	15	All benefits occur by 2050	Uncertain *(it is reliant on the effectiveness of behaviour change campaigns and individual officers to get residents to change their behaviour).*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits'.
Smarter choices/ no growth in travel	2,643,819	0.79	NA	0.79	1,386,600	NA	15	Modal shift achived by 2020 and maintained to 2050	Uncertain/neutral *(the magnitude of any saving is uncertain however, four pilot studies have been completed there is greater confidence in the magnitude of the predicted savings than some of the other behaviour change actions).*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits' and to support the continued administration of this action.
Energy Efficient Appliances and lights	1,471,621	54.90	54.42	0.48	703,980	NA	16	Full roll out by 2020	Certain *(the reduction in domestic energy demand from retrofitting insulation, double glazing, energy efficient appliance, lights and condensing boilers is well documented and as a result there is a high level of certainty about the ability of this action to deliver emission reductions).*	It has been assumed that this capital investment and officer time is spread evenly to 2020.

Actions	CO_2 saving to 2050 (t)	Total cost/ tCO_2 saved £	Capital cost/ tCO_2 saved £	HBC time cost /tCO_2 saved £	Total cost (2011-2050) £	Poten-tial income/ tCO_2 saved[34]	Sum of ranked Scores	Timeframe for action	Likelihood of the action delivering the benefit	Other comments
1 meat / poultry-free day per week	190,149	5.47	NA	5.47	1,039,950	NA	22	Full roll out in 2011and behaviour maintained to 2050	Uncertain *(it is reliant on the effectiveness of behaviour change campaigns and individual officers to get residents to change their behaviour).*	Officer time is included to 2050 in order to implement campaigns etc to help residents from slipping back into 'old habits'.
Insulation	1,081,221	8.90	8.25	0.65	9,627,980	NA	22	Full roll out by 2020	Certain *(the reduction in domestic energy demand from retrofitting insulation, double glazing, energy efficient appliance, lights and condensing boilers is well documented and as a result there is a high level of certainty about the ability of this action to deliver emission reductions).*	It has been assumed that this capital investment and officer time is spread evenly over the 40 year period to 2050.
Condensing Boilers	460,419	105.96	104.43	1.53	48,783,980	NA	29	Full roll out by 2020.	Certain *(the reduction in domestic energy demand from retrofitting insulation, double glazing, energy efficient appliance, lights and condensing boilers is well documented and as a result there is a high level of certainty about the ability of this action to deliver emission reductions).*	It has been assumed that this capital investment and officer time is spread evenly over the 40 year period to 2050.

Actions	CO_2 saving to 2050 (t)	Total cost/ tCO_2 saved £	Capital cost/ tCO_2 saved £	HBC time cost /tCO_2 saved £	Total cost (2011-2050) £	Poten-tial income/ tCO_2 saved[34]	Sum of ranked Scores	Timeframe for action	Likelihood of the action delivering the benefit	Other comments
Double Glazing	139,426	16.98	11.93	5.05	2,367,980	NA	30	Full roll out by 2020	Certain *(the reduction in domestic energy demand from retrofitting insulation, double glazing, energy efficient appliance, lights and condensing boilers is well documented and as a result there is a high level of certainty about the ability of this action to deliver emission reductions).*	It has been assumed that this capital investment and officer time is spread evenly over the 40 year period to 2050.
Ground source heat pumps (GSHP)	266,745	126.29	122.39	3.90	33,687,586	295	32	Full roll out by 2020 in off gas properties	Certain *(GSHP, and solar hot water heaters are a mature technologies that are well understood. The total capacity is based on the renewable capacity study for the borough.)*	Potential income is based on the values in the renewable heat incentive consultation document which could be subject to change following consultation and also during the 40 year timeframe of the action plan.
Photo Voltaic (PV) panels.	397,921	409.13	406.51	2.61	162,799,950	641	36	Full roll out by 2020	Certain *(PV panels are well documented and understood technology. The total capacity is based on the renewable capacity study for the borough).*	The predicted income is based on the current Feed in Tariff. However, this rate may change over the period of this action plan and as a consequence may not generate as large an income.
Combined Solar (50/50 water heater and PV)	268,594	418.77	414.90	3.87	112,479,950	669	37	Full roll out by 2020	Certain (see solar water heaters and PV).	The revenue from this type of intervention is subject to the caveats listed above for solar water heaters and PV.

Actions	CO_2 saving to 2050 (t)	Total cost/ tCO_2 saved £	Capital cost/ tCO_2 saved £	HBC time cost /tCO_2 saved £	Total cost (2011-2050) £	Poten-tial income/ tCO_2 saved[34]	Sum of ranked Scores	Timeframe for action	Likelihood of the action delivering the benefit	Other comments
Solar hot water heaters	148,715	332.45	325.45	6.99	49,439,950	492	37	Full roll out by 2020	Certain *(GSHP, and solar hot water heaters are a mature technologies that are well understood. The total capacity is based on the renewable capacity study for the borough.)*	Potential income is based on the values in the renewable heat incentive consultation document which could be subject to change following consultation and also during the 40 year timeframe of the action plan.

Notes: For simplicity, officer time has been kept at the same level as originally modelled for front-loaded interventions (i.e. over the 40 year timeframe) even though the interventions involving capital investment will be complete by 2020. This reflects the increased challenge of implementation over a shorter timescale and remains valid as the same number of units will be installed (requiring more up-front work). It may be that HBC would have to increase staff numbers further beyond what is suggested in this report to fully implement the interventions.

4.3.2 Confidence levels

The interventions requiring no capital cost appear to be most cost effective. However, as noted previously, these interventions have a higher level of uncertainty in achieving the desired emissions reductions as they rely on the successful engagement and response of all Harrogate residents. The CO_2 savings (and associated costs) are therefore much more difficult to accurately predict from this type of intervention.

4.4 Implementing the Interventions

4.4.1 Behaviour Change

In order to be able to deliver the benefits identified in the table overleaf HBC needs to have the agreement and support of Members and senior managers if any of the interventions are going to be implemented and achieve their challenging objectives. The behaviour change interventions, in light of their relatively low costs per tonne of CO_2 saved, are likely to be the first interventions that are implemented. This is particularly true given the current economic climate in the public sector. However, on their own some of the behaviour change interventions will seem abstract at best to the wider public. As a consequence it is recommended that the behaviour change interventions are packaged up as part of co-ordinated project or campaign focussed on sustainable living.

The objective of this ‘sustainable living’ campaign could be twofold; to implement the behaviour change interventions and also raises awareness of wider sustainability issues amongst borough residents. There are a number of examples that could be followed, but perhaps the most relevant regional example is the ‘Green Street Challenge’ study that the Stockholm Environment Institute ran with the City of York Council[35].

The Green Street Challenge identifies neighbourhoods which can do more to reduce their carbon emissions, and challenges them to take part in a city-wide competition to achieve a measurable reduction in their carbon footprint. The lessons from this project are likely to be transferrable to a behaviour change interventions / sustainable lifestyles project. Harrogate Borough Council undertook a similar project with a group of local volunteers who worked with their neighbours, youth groups and clubs to cut their carbon by well over 600 tonnes – about the same as putting solar panels on 640 homes. This or a similar approach could provide the stimulus that would inspire residents to change their behaviour.

Regardless of the method used to drive behaviour change, continued support to promote the schemes throughout the 40 year life of the action plan is required to prevent people from slipping back into old habits.

[35] See http://www.york.ac.uk/sei/projects/current-projects/green-streets/ for further information.

4.4.2 Capital Investment

The emissions reductions from the retro-fitting and micro-renewable interventions assume that they are implemented at an even rate over the 40 years of the Action Plan. Clearly this is dependent upon funding being available for their implementation and it is noted that the majority of this funding is unlikely to be sourced directly from HBC. As a result finding funding streams will be a critical factor before any of the potential emission reductions can be realised. However, there are funding options available that other partners such as the Energy Savings Trust and energy suppliers can advise on and/or provide access to. The scale of the interventions being proposed might also appeal to some larger private sector investors. However, this would require further investigation.

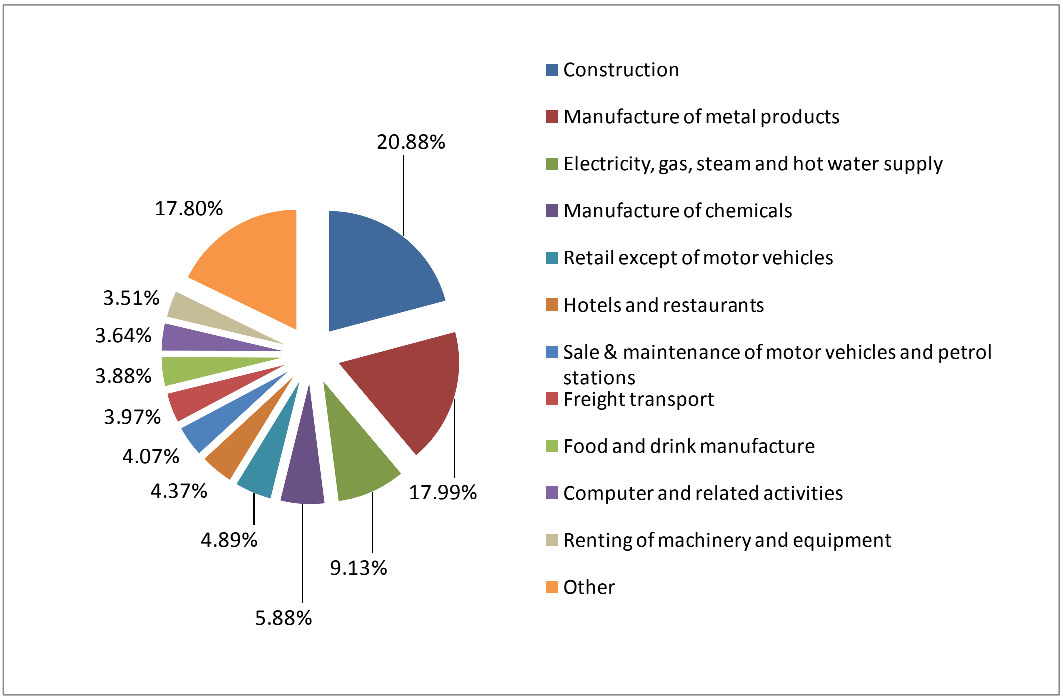
Feed-in-tariffs may also provide a useful means to cover the cost of investment in micro-renewables with any revenue that exceeds the original capital investment costs being re-invested in energy efficiency measures and/or further renewable energy generation. HBC is currently developing plans to use feed in tariffs and the renewable heat incentive as a means of paying for capital investment and ring fencing savings for further energy efficiency investment.

5 Action Plan – emissions not modelled in REAP

5.1 Business

By adopting the modelling approach described in Chapter 3 the CO_2 emissions for the various industrial sectors represented within Harrogate Borough have been calculated. The results from this modelling are illustrated in Figure 7 below.

Figure 7. Embodied carbon dioxide emissions associated with expenditure in the economy of Harrogate Borough (measures in tonnes of CO_2) based on data from HBC Economic Development Unit and Defra / DECC greenhouse gas emissions factors.



The majority of the emissions (approximately 82%) come from manufacturing, construction, agriculture, the hospitality sector retail (wholesale trade) utility supplies and the transport or freight. The remaining 18% of emissions (classified as other in this analysis) includes a variety of sectors such as the financial and professional services and some niche manufacturing sectors.

In order to provide an example of the types of actions that businesses in Harrogate Borough could implement to reduce their emissions we have focused on the three sectors whose emissions make the greatest contribution to the commercial sector's CO_2 emissions.

5.1.1 Construction

The emissions associated with the construction sector (21%) include direct emissions from transporting construction materials to construction sites, the fuel and energy consumed during construction works and the embodied emission associated with the materials that are used during construction and the waste arising from construction. Having carried out a brief literature review it appears that there are no case studies or data that breaks down the sources of CO_2 emissions within a typical construction sector business. However, from our experience of carrying out carbon footprinting for construction projects, we know that the majority of emissions are associated with the use of materials – particularly concrete based building products and metals. In comparison the emissions from energy use are generally much smaller. On the basis of this knowledge the following actions are recommended for the construction sector:

- Develop a better understanding of the emissions associated with construction schemes – particularly during the design stage when it is easier to alter the design of a scheme to reduce CO_2 emissions. This can be achieved by using carbon calculators that have been developed to help designers and construction contractors to calculate the emissions associated with a development[36]. These calculators can also be used to compare the emissions of different options or design iterations and help the construction make choices that reduce the total construction phase emissions of a project.
- Reduce the total amount of materials used in construction by adopting lean design and construction processes. This can also include the use of pre-fabricated building materials and elements that tend to be more resource efficient because they help to reduce wastage and therefore also the total quantity of materials used is also smaller.
- Use alternative materials with lower embodied carbon. In some situations construction projects can use completely different materials e.g. using timber instead of steel to provide a structural frame for a building. However, in some situations this is not possible. Where this is the case options such as ensuring that steelworks contain recycled metals or specifying a concrete that uses recycled aggregates and other waste materials such as pulverised fly ash will also help to reduce the embodied carbon associated with the construction sector[37].

No specific actions have been identified for HBC for the reduction of the sector's CO_2 emissions because other partners and organisations are taking a lead e.g. the Carbon Trust and WRAP (Waste and Resources Action Programme). Website information on a range of resources and funding opportunities are also available from co2sense[38].

However, it is recommended that HBC should lead by example by ensuring that the actions and principles described above are applied to all the construction works that they implement directly or fund. This recommendation is particularly relevant to the extensions built to the Harrogate International Centre and also future Council office accommodation plans.

[36] The Environment Agency, for example, has developed a carbon calculator that can be used to calculate the construction emissions, including the embodied emissions in construction materials. This can be accessed at: http://www.environment-agency.gov.uk/business/sectors/37543.aspx (last accessed on 26/11/2010).

[37] The Inventory of Carbon and Energy (produced by the University of Bath) provides data on the embodied carbon and energy of different materials generally used in construction projects. See the following link for further information:
http://wiki.bath.ac.uk/display/ICE/Home+Page;jsessionid=8B8E9AB29980875EDFEE7D06C0DC22D3

[38] For information see: http://www.co2sense.org.uk

5.1.2 Manufacture of metal products

As for construction our literature review could not find a breakdown of the typical embodied CO_2 footprint for a business in this sector. However, given the temperatures required to heat metals in order to manufacture metal products it is assumed that direct energy use will be a greater part of their footprint than other sectors. Nevertheless the embodied CO_2 of the metals that they use will still account for a significant proportion of their emissions due to the vast amount of energy required to covert raw materials (ores) into metal products ready for manufacturing. To reduce their CO_2 emissions businesses in this sector should consider applying the following actions to their business activities:

- Monitor their energy consumption by taking regular meter readings to establish a benchmark for monitoring the success of other emission reduction measures;
- Undertake an energy audit to try and identify opportunities to reduce energy consumption and therefore CO_2 emissions. Undertake a resource efficiency audit to also assess the impacts of their wider use of materials. Manufacturers can obtain free initial audits, advice and support from external organisations such as the Manufacturing Advisory Service and CO_2Sense in Yorkshire and the Humber[39].
- Use materials more efficiently e.g. by employing measures to reduce wastage within the manufacturing process and increase the proportion of recycled metals in the raw material used in the manufacturing process.

As above no specific actions have been identified for HBC. However, these actions do present the council with an opportunity to ensure that it engages with other partners that could deliver support to the sector e.g. MAS, Business Link, CO_2Sense and the Chambers of Commerce and promotes the service available.

5.1.3 Electricity generation and gas supply

This sector is the next largest in the electricity generation and gas supply sector. Their emissions are high because their activities directly result in CO_2 emissions during electricity generation and indirectly as a result of transmission or distribution of gas and electricity.

The Climate Change Committee's recommendations for this sector are focussed on reducing demand for energy followed by 'decarbonising' the electricity supply. This combined approach will make a significant contribution towards reducing CO_2 emissions from these sources.

Direct actions that HBC could take to support this sector is to publish the renewables capacity study that is currently being finalised to inform the Local Development Framework. Using this evidence and developing policies that will allow this sector follow the Government policy and implement the Climate Change Committee's recommendations will help to reduce potential planning constraints that may currently restrict wider growth in renewables.

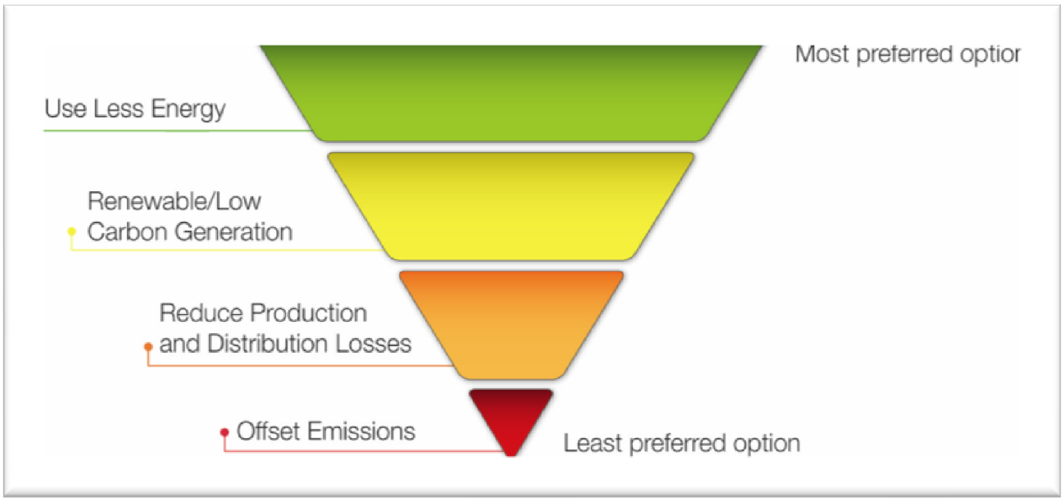
[39] For find out more information about the Manufacturing Advisory Service (MAS) follow this link: http://www.mas-yh.co.uk/. For more information about the services provided by CO2Sense please follow this link: http://www.co2sense.org.uk/default.aspx?tabId=25.

5.1.4 General recommendations for business

Regardless of the sector concerned, there are a number of actions that businesses in Harrogate Borough can implement in order to reduce their CO_2 and other greenhouse gas emissions. These are summarised below:

- Monitor and review activities. Some businesses will now be recording data as part of the Carbon Reduction Commitment[40]. However, there are benefits for businesses to monitor and regularly review things such as electricity and fossil fuel usage and vehicle mileage as well as wider resource usage and waste generation. By collecting and reviewing this data businesses can gain an understanding about the areas of their activities that generate the greatest CO_2 emissions. Collecting data also provides businesses with a benchmark against which they can compare the impact of different actions on their energy consumption and CO_2 emissions.
- Apply a hierarchical approach towards reducing emissions. A hierarchical approach firstly involves avoiding or minimising energy consumption where possible (e.g. turning lights and electrical machinery off when not being used, walking or using public transport instead private cars for staff travel). The second level involves the use of renewable or low carbon energy. The third level involves changing the way energy generation is distributed by opting for localised and district scale generation to reduce the energy losses that occur when electricity is distributed across the national grid. The fourth and final level inolves offsetting emissions by making financial contributions towards projects elsewhere that reduce net CO_2 emissions from existing activities. This hierarchy is illustrated in Figure 8 below.

Figure 8. Carbon reduction hierarchy.



- Consider the emissions associated with supply chains. Every business and organisation has a supply chain through which it procures the goods and services required to operate. The emissions associated with the supply chain

[40] It is unfortunately not possible to state exactly how many businesses in the district are covered by the CRC

can be calculated using Defra / DECC greenhouse gas emissions factors for supply chains[41]. From this organisations can work with their suppliers in order to reduce their emissions as well as improving resource efficiency by cutting wastage and identifying opportunities to use alternative and less carbon intensive suppliers and/or materials. Arup have already undertaken similar studies for the NHS and higher education sectors and as a result have been able to identify opportunities to cut CO_2 emissions and reduce operating costs as by also carrying out resource efficiency audits of the organisations concerned.

The Carbon Trust, Business Link and CO_2Sense all provide information aimed at businesses and public sector organisations to help them reduce their CO_2 emissions. HBC should look at opportunities to influence these partners and businesses through the Economic Development Unit and the Leeds City Region and also set a good example in demonstrating the action to be taken for business to reduce CO_2

[41] Defra, UK - The Environment - Business & the environment - Reporting environmental impacts.

5.2 Waste

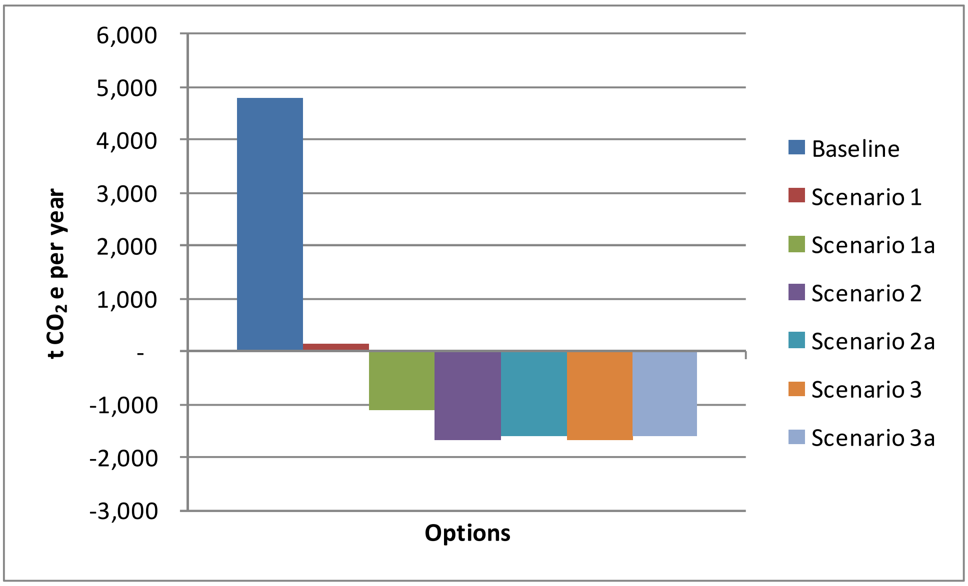
5.2.1 Waste collection

As described in section 3.6 (page 13) greenhouse gas emissions modelling for waste collection and future waste treatment have been carried out for the Borough and County Councils respectively. In 2008 the impacts of changing the waste collection regime in the Borough were modelled using WRATE[42] in order to predict the likely change in greenhouse gas emissions associated with waste disposal. Seven scenarios were assessed and compared to the emissions associated with the existing collection regime. These were broken down into two main groups. Scenarios 1, 1a and 1b consisted of an expanded kerbside collection in terms of the numbers of houses served and the range of materials collected (to include mixed paper and plastic bottles). Scenarios 2, 2a, 3 and 3a are all variations on alternate weekly collections. The alternate weekly collections allow a greater variety of materials to be collected. The different sub-options consist of different coverage of the borough area.

The results are illustrated in Figure 9 overleaf. Scenarios[43] 2 and 3 provided the greatest savings in greenhouse gas emission per year (1,682 and 1,678 tonnes of CO_2 equivalents). This is represents a saving of approximately 35% against the current baseline situation. The key message from this modelling is the importance of providing people with the infrastructure that helps them change their behaviour, in this case increase the proportion of their waste that they segregate for recycling.

[42] WRATE is a tool developed by the Environment Agency to assess the environmetnal implications of different waste collection and treatmetn options.
[43] See explanation of scenarios overleaf

Figure 9. Greenhouse gas emissions reductions associated with the different waste collection scenarios compared with the baseline scenario.[44]



Explanation of scenarios

Scenarios refer to the modelled 'options'. Scenario definitions are listed below:

1: expanded kerbside collection scheme increasing number of households served (just under 90% for dry recyclables and just under 60% for garden waste) and range of material collected (extended to include all mixed paper plus plastic bottles). Two kerbside boxes and a reusable sack are used for the extended collection. In addition the number of black sacks collected from each household for residual waste would be limited to 2 per week.
1a: as per scenario 1 but covering 100% of households.
1b: as per scenario 1a but uses biodegradable sacks instead of black plastic sacks.
2: alternate week collection scheme for 90% of all households. Residual waste, garden waste and dry recyclables collected fortnightly. The households involved will receive a 240 litre wheeled bin for dry recyclables (all paper and card, cans and plastic bottles), and a 240l wheeled bin for residual waste. Glass will be collected separately using the kerbside box, and garden waste will be collected using a wheeled bin from just under 60% of all households.
10% of the population not taking part in the alternate week collection scheme will receive the same service as the base case. Transfer of the recyclables to a Materials Recycling Facility (MRF) for sorting is an additional requirement of this scenario.
2a: same as scenario 2 but distance to MRF is extended from 20 miles to 50 miles.
3: same as scenario 2 for dry recyclables, residual waste and glass collection. But garden waste collection scheme is expanded to just over 70% of households. Transfer distances to the MRF remain the same as Scenario 2.
3a: same as scenario 3 but distance to MRF is extended from 20 miles to 50 miles.

[44] Source: BeEnvironmental Ltd (2008). Climate Change Impacts of Household Waste Management in Harrogate (page 13).

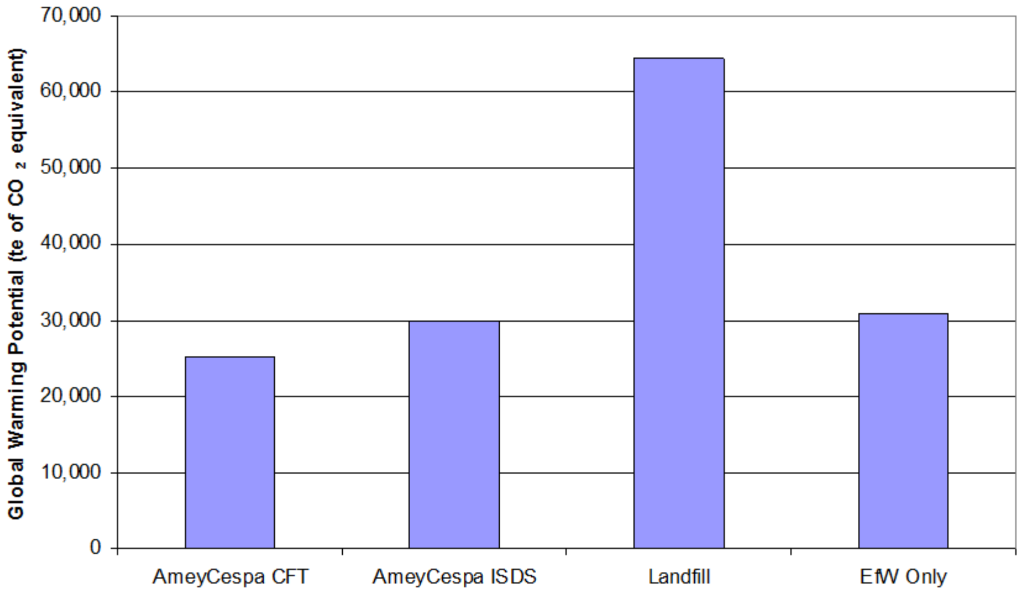
The following actions have been identified for HBC to consider implementing in order to reduce the volume of greenhouse gas emissions associated with the operation of collection of waste prior to treatment:

- Promote the scheme prior during and post the launch of an intensified recyclables kerbside collection scheme. This will help to make people aware of the scheme and to help them understand why it is necessary.
- Develop a waste avoidance scheme for domestic, commercial and industrial waste within in the Borough. Waste avoidance is the single most effective measure to reduce the greenhouse gas emissions associated with waste management. It achieves this by avoiding the emission associated with collecting and sorting the waste as well as the energy used to re-process the recyclate once it has been collected.
- In addition to the general actions listed above the 2008 report also identifies the diversion of food waste from landfill as an opportunity for greenhouse gas emission reductions. If it is treated in an anaeorobic digestion plant (AD) it can then be used to provide heat and/or power, for example, through a CHP plant.

5.2.2 Waste treatment and disposal

Domestic waste is disposed of by North Yorkshire County Council. They are currently in the process of procuring (via a private finance initiative) a facility to treat all of the domestic waste arisings in York and North Yorkshire. This procurement process has now arrived at a final technical solution which involves pre-processing using mechanical pre-treatment to separate out recyclables and materials that can be processed with an anaerobic digester before treating the remaining waste in a furnace.

Figure 10. Global warming potential comparison of different technological solutions that were considered for the Allerton Waste Recovery Park.[45].



Note: AmeyCespa Call for Final Tenders (CFT) is a refined version of the AmeyCespa Invitation to Submit Detailed Solution (ISDS) that consists of mechanical pre-treatment, anaerobic digestion and then energy from waste. The differences are based on slightly different operating specifications.

As part of the tendering process the greenhouse gas emissions associated with the preferred scheme, landfill and energy from waste (EfW) without pre-treatment were modelled using WRATE (see Figure 10 above). This analysis clearly shows that by diverting 95% of waste arisings from landfill the AmeyCespaCFT scheme reduces annual greenhouse gas emissions by 38% when compared with landfill. In terms of the emissions that can be attributed towards the waste treated at the facility that is generated within Harrogate Borough Council's area it is predicted to be approximately 63,137 tonnes of CO_2 per year[46]. The total annual emissions from the facility are predicted, as a result of the WRATE modelling, as 303,290 tonnes of CO_2 per year.

[45] Source: AmeyCespa & Fichtner (2008) York & North Yorkshire PFI - WRATE Report (Note: AmeyCespa Call for Final Tenders (CFT) is a refined version of the AmeyCespa Invitation to Submit Detailed Solution (ISDS) that consists of mechanical pre-treatment, anaerobic digestion and then energy from waste. The differences are based on slightly different operating specifications).
[46] A breakdown of the emissions from waste treated at the facility by local authority was not available. Instead emissions have been calculated on a pro rata basis using population proportions for the City of York and North Yorkshire local authoritites from the 2001 Census.

It has been assumed that the process design has been optimised to make it as efficient as possible. As a result there are only a limited number of actions that HBC can directly follow up which are listed below:

- Implement the waste collection actions described above (5.2.1) in order to increase the proportion of recyclable waste that is segregated from the residual domestic waste stream. By doing this, the mechanical pre-treatment (MPT) EfW facility will be able to work more efficiently by only recovering recyclables that are present within the residual waste a greater quantity of material for recycling which will help to offset the CO_2 emissions associated with extracting and processing virgin resources to create metals, plastics and glass.
- Encourage the NYCC waste team to drive AmeyCespa to make year on year reductions to the Facility's CO_2 emissions through the PFI contract.

6 Conclusions and recommendations

6.1 Main findings

The modelling that has been carried out to quantify the reductions in the CO_2 emissions related to the energy and transport people living Harrogate Borough use and the embodied CO_2 highlights the following:

- To achieve the targets set by the Committee on Climate Change everybody needs to contribute if we are to get anywhere close to where we need to be in 2020 and 2050.
- Even with national interventions such as decarbonising electricity supply and tranasportation we cannot acheive the 2020 or 2050 targets. Therefore interventions that are facilitated by local authorites, partners and communities are also critical.
- Without any interventions (i.e. with ‚'business as usual') population growth and increased road traffic mean that the baseline CO_2 emissions in 2020 and 2050 (against which the CO_2 reductions are measured) are greater than in 2005 and therefore it is more difficult to achieve the 40% and 80% reductions.
- The emission reduction interventions that offer the greatest reductions per pound invested are grouped under behaviour change. However, there is significantly less certainty whether or not these interventions will actually deliver the predicted emission reductions. Conversely, the capital investment measures offer less value for money but are less reliant on behaviour change and are therefore more likely to deliver the predicted emission reductions.

6.2 Next Steps and implementation

During the process of analysing the potential emission reductions from different interventions it has become clear that HBC will need to gain access to funding because many of the interventions identified do not form part of core services. As a consequence this needs further investigation.

The first step would be the development of a business case for implementing the action plan interventions. This should determine the economic costs of not implementing the action plan i.e. the cost to society and the economy of the baseline CO_2 emissions[47]. An initial analysis of the social costs associated with not reducing emission compared with the cost of implementing the HBC interventions suggests that the benefits will be greater than the costs. Cost benefit analysis would also need to be carried out to support a HBC business case for further investment.

HBC itself may be able to secure public sector funding for the interventions. If this is not possible HBC may instead be able to help residents make applications

[47] To quantify the social costs of not implementing the HBC actions the emission savings for each year from 2011-50 were multiplied by the ‚Shadow Price of Carbon' (SPC). The SPC is based on estimates of the lifetime damage costs associated with greenhouse gas emission known as the Social Cost of Carbon. See The Social Cost Of Carbon And The Shadow Price Of Carbon: What They Are, And How To Use Them In Economic Appraisal In The UK (Defra 2007) http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/shadow_price/shadow_price.aspx

to sign up to a FIT scheme or obtain grants for retrofitting insulation. HBC could explore whether or not there are opportunities to secure investment from the private sector and other funders such as the Green Infrastructure Bank. The above actions can feed into the development of a risk based costed action plan that builds on the plan in Chapter 4 with a view of identifying which partners can contribute finances or staff resources to achieve the actions that have been identified.

The following list summarises the actions that would be required to fully achieve the potential reductions in consumption based CO_2 emissions documented in this report by 2020 and 2050:

- Install 1,348 PV installations on domestic properties per year until 2020 to exploit full resource, or exploit the same resource by installing 968 solar hot water installations per year, or split between the two technologies (672 PV per year and 617 hot water).
- Install 278 ground source heat pumps in properties off the gas network per year until 2020 to exploit the full resource.
- Install loft insulation in 2,113 properties per year until 2020 that currently have no/poor loft insulation and fill 1,880 unfilled cavity walls per year until 2020.
- Install 2,405 condensing boilers per year to 2020 in properties currently with a conventional model.
- Install double glazing in 1,787 properties that currently have single glazing per year to 2020.
- Encourage the uptake of energy efficient lights and appliances in households (5,414 installing energy efficient lights per year to 2020, and 6,577 installing energy efficiency appliances per year to 2020).
- Project Officer to promote micro-renewables, split between solar installations and ground source heat pumps.
- Two staff (a Project Officer and Campaigns Officer) responsible for other retrofit and energy behaviour change interventions.
- Project Officer responsible for promoting car sharing.
- Project Officer responsible for promoting smarter travel choices.
- Project Officer with responsibility for promoting air travel behaviour change.
- Project Officer with responsibility for promoting sustainable lifestyles, to cover meat/poultry and overall consumption interventions.

6.3 Approach to monitoringprogress

The table overleaf (Table 13) sets out how HBC could monitoring progress towards implementing the interventions outlined in this report. Many of the retro-fit interventions, if implemented, are likely be undertaken with funding sourced by the council which will make monitoring the number of installations achieved much easier. However, HBC will have to rely on undertaking surveys or using external data sources to monitor progress in other areas. It should be noted that these data (such as HEED) are not comprehensive and are not necessarily updated annually.

Table 13. Recommendations for monitoring the implementation of the action plan interventions.

Intervention(s)	Monitoring Recommendations
PV cells, solar hot water and GSHPs	It is possible to monitor the number of PV installations registered for the Feed in Tariff on the Ofgem website. It is assumed that a similar service will operate for the Renewable Heat Incentive once operational in April 2011.
Insulation, double glazing and condensing boilers	If HBC is to implement a programme aiming to achieve maximum uptake of these measures by 2020 it will likely have to seek external funding. Monitoring the number of properties completed would likely be part of this process. The HEED will also give an indication of insulation levels over time although this is not comprehensive and may not be regularly updated.
Energy efficient lights and appliances	Uptake should be monitored and estimated by the Project Officer with responsibility for this area. It may be necessary to undertake surveys to estimate uptake amongst the general public.
Transport interventions	Uptake and use of car sharing schemes is currently monitored by HBC and this will likely have to be used as a proxy for occupancy rate (as data is formatted in REAP). The extent of modal shift and air travel behaviour change achieved through campaigns can be monitored through transport surveys.
Energy consumption behaviour change, food and general consumption interventions	Behaviour change as a result of energy consumption and sustainable lifestyles campaigns should be monitored through surveys of household energy consumption and consumption behaviour

Appendix A

The basis for modelling a changing business as usual scenario

A1 Population growth

Population growth forecasts published by the Office for National Statistics (ONS) were used to inform the BAU scenario. The latest ONS 2008-based sub regional population forecast dataset was used which predicts the Harrogate Borough population until 2033. It was originally intended to use national annual population growth forecasts to predict the Harrogate population between 2033 and 2050 but this method was not compatible with the SEI Housing Calculator Tool used to model retro-fit interventions. The Housing Calculator Tool applies the growth rate from 2006 to 2026 through to 2050 as the tool was developed when population forecasts were only available until that year. However, this method predicts a population in 2050 very close to that which is calculated using the latest national forecast figures. The population of Harrogate in 2050 is predicted to be 199,529.

Population data points

2005 baseline	154, 524
2011	159,509
2050	199,529

A2 Transport growth

Forecast growth in personal transport was integrated into the BAU scenario using data in the Department for Transport's (DfT) TEMPRO software[48]. Data were extracted from the TEMPRO website in the form of predicted growth in the number of trips by each mode. Given that personal transport data in REAP is formatted in passenger kilometres (PKMs) per year, these growth factors were applied to baseline 2005 PKM figures in REAP to estimate growth in personal transport to 2050. Note that in REAP, the baseline year is 2006. No growth in air travel is assumed in the baseline.

Transport growth data points

Mode	2006 baseline (pkm per year)	2050 (pkm per year)
Walking	264	316
Cycling	62	72

[48] DfT TEMPRO Software: transport growth forecasts. Available at: http://www.dft.gov.uk/tempro/

Mode	2006 baseline (pkm per year)	2050 (pkm per year)
Private and rented vehicles	9850	12824
Public road transport	623	675
Public rail transport	472	571
Other public transport	300	325

A3 Housing (new build)

Predicted housing numbers have been informed by an annual figure from the Harrogate Core Strategy[49]. The Core Strategy states the policy to make provision for 390 new homes each year in the Borough. It has been assumed that this annual rate will apply through to 2050.

The Core Strategy also brought forward the introduction of Code for Sustainable Homes (CSH) Levels 3 and 4 ahead of their national introduction. This is reflected in the BAU scenario.

House numbers data points

2006 baseline	**66,430**
2011	**68,380**
2050	**83,590**

A4 Photovoltaics (PV)

The current rate of uptake of PV cells under the Government's Feed in Tariff (FiT) scheme has also been included in the BAU scenario. Data on the number of installations in the Borough since the FiT came into place in April 2010 were

[49] Policy SG1 of Harrogate Core Strategy, Settlement Growth: Housing Distribution

extracted from Ofgem's 'FIT Installations Statistical Report' tool[50]. The same rate of uptake is assumed in the BAU scenario to 2050.

PV uptake data points (number of installations under Feed in Tariff)

2006 baseline	**0**
2011	**114**
2050	**2,649**

A5 Housing Energy Efficiency Database (HEED)

The Energy Savings Trust's Homes Energy Efficiency Database[51] (HEED) provides information on the energy efficiency of the UK housing stock at a local authority level. This includes data on property types, insulation levels, central heating type and main heating fuel. It must be noted however that data are only available for approximately 45% of houses in the Borough and for each of the HEED categories, many households fall into the 'unknown/no data' group. For example, for 'loft insulation' data are only available in the HEED for approximately 20% of Harrogate's housing stock. Data from the HEED were inputted into the BAU scenario and assumed to stay static throughout the period.

Two sets of HEED data were provided to Arup throughout the project. One referred to an older version of HEED and the second was a more up to date version. The second set of data was unfortunately received too late to be incorporated into all interventions. However, the figures were very similar in both datasets. Data entered into the baseline section of the SEI Housing Tool is not in the same format as data exported from the HEED. There was therefore uncertainty as to the accuracy of data in the HEED on condensing boiler levels in the Borough; the two sets of exported HEED data reported very different levels. This uncertainty was increased by the small sample size in the database. For these reasons, the default national average figures for condensing boilers included in the SEI tool were used in the modelling of this intervention.

[50] Ofgem FIT Installations Statistical Report, available at: https://www.renewablesandchp.ofgem.gov.uk/Public/ReportManager.aspx?ReportVisibility=1&ReportCategory=0
[51] HEED, available at: http://www.energysavingtrust.org.uk/business/Business/Information/Homes-Energy-Efficiency-Database-HEED.

Appendix B

Interventions - methods and assumptions

B1 Interventions - methods and assumptions

This section describes the methods and assumptions used to arrive at input data for the REAP model for each intervention. This describes the method used to 'front-load' interventions in order to maximise the chance of achieving the 2020 target.

B1.1 Housing Interventions

B1.1.1 Solar PV

Total potential installed solar resource figures for the Borough were taken from the recent Harrogate Planning and Climate Change Study undertaken by AECOM[52] . The average size of installation in the Borough was calculated from data on existing PV installations from Ofgem. An allowance was made for the existing PV installations in the Borough. The total number of installations necessary to exploit the full solar resource by 2020 was divided by 10 to determine an annual number. This method assumes a linear rate of uptake of PV from 2011 to 2020. These assumptions are documented in Table 14 below.

Table 14. Assumptions for the solar PV intervention.

Data	Value	Source
Total potential installed resource (existing domestic properties)	34,534 kW	AECOM Report (2010)[64]
Average installation size in Harrogate	2.55kW	Calculated from existing PV installations (Ofgem data)
Total number of installations to exploit solar capacity	13529	Total capacity divided by average installation capacity
Annual installations to exploit full resource by 2020 (this is the number used in the SEI Housing Calculator).	1348	Total number divided by 10 (years between 2011-2020). Note that existing installations have been subtracted.

[52] Draft report produced for HBC: AECOM, 2010. Harrogate Planning and Climate Change Study - Stage One.

B1.1.2 Solar hot water

Potential installed resource is assumed to be the same whether PV or solar hot water technology is used. This is an assumption also made in AECOMs report. The average size of a solar hot water installation was also taken from the AECOM report. An allowance was made for the continuing trend of PV uptake assumed in the baseline and the remaining solar capacity exploited by solar hot water installations. Again, a linear trend of annual installations is assumed between 2011 and 2020. Further details about these assumptions and references can be found in Table 15 below.

Table 15. Assumptions for the solar hot water intervention.

Data	Value	Source
Total potential installed resource (existing domestic properties)	34,534 kW	AECOM Report (2010)[64]
Average installation size	2.8kW	AECOM's report [64] (Table 21). Figure for existing buildings.
Total number of installations to exploit solar capacity	9685	Total capacity divided by average installation capacity
Annual installations to exploit full resource by 2020 (this is the number used in the SEI Housing Calculator).	968	Total number divided by 10 (years between 2011-2020). Note that existing installations have been subtracted.

B1.1.3 Combined solar (PV/hot water)

This intervention splits the total solar resource between PV and solar hot water installations in order to fully exploit the Borough's solar potential by 2020. The existing number of PV installations was subtracted. These assumptions are documented in Table 16 below.

Table 16. Assumptions for the combined PV/hot water intervention.

Data	Value	Source
Total potential installed resource (existing domestic properties)	34,534 kW	AECOM Report (2010)[64]
Average installation size	2.55kW (PV) 2.8kW (hot water)	See above.
Total number of installations to exploit solar capacity	6715 (PV) 6167 (hot water)	Total capacity halved and divided by average installation capacity for both PV and hot water. Note that the PV number includes an allowance for existing installations.
Annual installations to exploit full resource by 2020 (this is the number used in the SEI Housing Calculator).	672 (PV) 617 (hot water)	Total number divided by 10 (years between 2011-2020).

B1.1.4 Ground source heat pumps

A total potential installed capacity figure for ground source heat pumps in the Borough was sourced from AECOM's 2010 report[64]. The figure for off-grid domestic properties was used as this is where the technology offers most potential. The Energy Saving Trust currently recommends GSHPs only for off-grid properties. Average installation size was taken from the AECOM report and this figure divided by the total capacity to determine the total number of installations. This was then applied on an annual basis to 2020 assuming a linear uptake rate. Further details about these assumptions and references can be found in Table 17 below.

Table 17. Assumptions for ground source heat pump intervention.

Data	Value	Source
Total potential installed resource (existing domestic properties)	29,927 kW	AECOM Report (2010)[64]Figure for off-grid domestic properties.
Average installation size	11kW	AECOM Report (2010)[64] (figure for existing properties)
Total number of installations to exploit potential resource	2721	Total capacity divided by average installation capacity
Annual installations to exploit full resource by 2020 (this is the number used in the SEI Housing Calculator).	272	Total number divided by 10 (years between 2011-2020).

B1.1.5 Home insulation

Data on current levels of insulation in the Borough were available in the HEED. This included estimates of the number of properties with unfilled cavity walls and those with no or poor levels of loft insulation. These data were inputted into the Housing Calculator. It was then possible to see the number of properties remaining with no cavity wall insulation or with no or poor levels of loft insulation. The Housing Calculator than allows the user to specify an annual number of properties to be insulated in each category. For both cavity and loft insulation, the total number of properties requiring insulation was split on a yearly basis to 2020 in order to model the emissions savings achieved by fully insulating all domestic properties by 2020. Further details about these assumptions and can be found in Table 18 below.

Table 18. Assumptions relating to retrofitting wall and loft insulation.

Data	Value	Source
Number of homes requiring insulation retro-fit	4,916 (no loft insulation) 16,209 (poor loft insulation – < 75mm) 18,800 (unfilled cavity walls)	Calculated in Housing Tool from HEED information[53]. Data exported from HEED by HBC and provided to Arup.
Annual number of homes to be insulated until 2050	492 (no loft insulation) 1,621 (poor loft insulation <75mm) 1,880 (unfilled cavity walls)	Total numbers applied across 10 year period.

Due to a lack of detailed data within the HEED dataset and the limited range of categories in the SEI Housing Tool it has not been possible to carry out a more detailed assessment of the contribution from insulating cavity walls as well as solid walls.

[53] Source: Energy Saving Trust – HEED Online Data Pack prepared for Harrogate Borough Council Edition 1 October 2009 – page 4.

B1.1.6 Condensing boilers

Data on the number of condensing boilers are provided in the HEED database. Two versions of HEED output data were supplied to Arup by HBC during this work. These datasets included contradictory figures on the number of condensing boilers in the Borough. Data entered into the baseline section of the SEI Housing Tool is not in the same format as data exported from the HEED and so a certain level of manipulation is required so that figures are in the correct format. There was therefore increased uncertainty as to the accuracy of data in the HEED on condensing boiler levels in the Borough. This uncertainty was increased by the small sample size in the database. For these reasons, the default national average figures for condensing boilers included in the SEI tool were used for this intervention. Further details about these assumptions and references can be found in Table 19 below.

Table 19. Assumptions regarding the opportunities to install condensing boilers.

Data	Value	Source
Number of homes on the gas network with no condensing boiler	24,045	Calculated in Housing Tool from HEED information [54]. Data exported from HEED and provided to Arup by HBC.
Annual number of homes to be retro-fitted until 2020	2,405	Total number applied across 10 year period.

[54] Source: Energy Saving Trust – HEED Online Data Pack prepared for Harrogate Borough Council Edition 1 October 2009 – page 6.

B1.1.7 Double glazing

Data on the number of properties partially and fully double glazed are included in HEED (see Table 20). These data were inputted into the Housing Calculator Tool. The intervention models the installation of full double glazing in all properties by 2020 with a small allowance for listed properties. Data on the number of listed buildings in the Borough were provided to Arup by HBC. In order to account for these properties the following assumptions were made:

- It would not be possible to install double glazing in Grade I listed buildings or Grade II* listed buildings.
- It would be possible to install double glazing in half of all Grade II listed buildings. This was deemed appropriate after discussions with the planning team at HBC. Double glazing planning decisions are on a case-by-case basis.

Table 20. Assumptions regarding opportunities to install double glazing.

Data	Value	Source
Number of homes with less than 50% double glazing	17,870 (including 1,211 listed homes assumed to be unsuitable for double glazing)	Calculated in Housing Tool from HEED information[55]. Data exported from HEED and provided to Arup by HBC.
Annual number of homes to be retro-fitted until 2020	1,787	Total number applied across 10 year period.

[55] Source: Energy Saving Trust – HEED Online Data Pack prepared for Harrogate Borough Council Edition 1 October 2009 – page 6.

B1.1.8 Energy efficient appliances

The housing tool enables modelling of the impact of the uptake of energy efficient lights and appliances by households (see Table 21). No data are included in the HEED report for Harrogate on current levels of energy efficient appliances and lights so the default values in the tool were used. The default values state that 18.5% of properties have energy efficient lights and 1% have energy efficient appliances. The intervention was modelled such that all houses in the Borough will have energy efficient lights and appliances by 2020.

Table 21. Assumptions regarding the implementation of energy efficient appliances.

Data	Value	Source
Number of homes with no energy efficient technologies	54,140 (lights) 65,766 (appliances)	Default values in SEI Housing Tool applied to Harrogate.
Annual number of homes to be retro-fitted until 2020	5,414 (lights) 6,577 (appliances)	Totals number applied across 10 year period.

B1.1.9 Energy behaviour change

The housing tool also includes a function which enables the modelling of energy behaviour change interventions. Data is edited in the tool by applying a percentage change to household energy consumption over time. It is estimated that a third of carbon savings in the domestic household sector will have to come from personal behavioural change[56]. Measures to encourage these changes will include smart meters, energy monitoring and improvements to billing information. There are few studies estimating the level of reduction in energy consumption that can be expected as a result of such interventions. However, an SEI report on housing in the Leeds City Region[57] cites a study suggesting that a 10% reduction in energy consumption is possible, if very ambitious. This 10% reduction in demand was originally modelled to 2020. However, in order to demonstrate the scale of change required to achieve the 2020 target, the intervention was further front-loaded and modelled top achieve a 15% reduction by 2020 (equivalent to a 1.5% annual decrease in household energy consumption). In order to continue reductions thereafter, a 0.6% annual decrease in energy consumption was applied from 2020 to 2050, again based on similar assumptions in the SEI study. It should

[56] Boardman (2007), cited in SEI (2008) Carbon Footprint of Housing in the Leeds City Region
[57] Darby (2006) cited in SEI (2008) Carbon Footprint of Housing in the Leeds City Region

be recognised that these are very ambitious reductions so the intervention gives an indication of savings towards the higher end of what might be achieved from energy behavioural change.

B1.2 Transport Interventions

This section describes the methods and assumptions used to arrive at input data for transport interventions. These interventions were modelled by editing data on passenger kilometres and occupancy rates in REAP.

B1.2.1 Smarter choices

Smarter Travel Choices refers to a package of 'soft' measures to encourage better use of existing transport infrastructure, including school and workplace travel plans and information provision. Previous schemes introduced in Sheffield, Bristol and Nottingham produced, on average, a 4% modal shift away from car use[58] (i.e. 4% fewer overall trips by car. In these cases it is not possible to determine the proportion of the shift attributed to other modes). The assumption was made that a similar shift could be expected in Harrogate. After discussion with HBC, it was decided to allocate the 4% equally to bus and train travel given the high proportion of people commuting from Harrogate to Leeds and York. This change was applied in REAP to passenger kilometre figures (this is the only unit REAP includes for transport scenarios) and the 4% shift is completed in 2020. In order to simplify modelling, it was also assumed that implementing a smarter travel choices programme would keep personal travel distances static, effectively cancelling out assumed growth in the BAU scenario. This means that for all modes in this scenario, total personal annual 'passenger kilometres' travelled stays the same from the baseline year to 2050, for all modes. The only aspect that changes is the mode that makes up this total.

B1.2.2 Car sharing

The impacts of car share schemes can be modelled in REAP by editing the parentage occupancy rate of private vehicles. Data were provided to Arup on current sign-up rates of individuals and businesses in the Borough. However, it was unfortunately not possible to convert these data into a format that could inform the baseline occupancy rate in REAP. For this reason, the default occupancy rate of 32% was used. Evidence suggests that car share schemes could potentially deliver a 10% increase in private vehicle occupancy rates, taking the average number of people per car to just over 2 people[59]. It should be noted that this rate of occupancy change is at the higher end of what can be expected from car sharing initiatives. In order to model the impacts of such a change, a 10% increase in occupancy was originally applied between the years of 2011 and 2020. However, in a similar way to the energy consumption behaviour change intervention, to demonstrate the size of the overall task, the occupancy rate was

[58] Department for Transport, Evaluation of 14 projects part-funded by DfT, available at: http://www.dft.gov.uk/pgr/sustainable/travelplans/ptp/personalisedtravelplanningev5774?page=6
[59] Friends of the Earth, Car sharing and car clubs, available at: http://www.foe.co.uk/living/articles/car_sharing.html; Liftshare (2006) Why car sharing should be taken seriously and funded appropriately, available at: https://www.liftshare.com/download/case-for-car-sharing.pdf.

further increased to 50% by 2020 (meaning the average car on the road would carry 2.5 people). The occupancy rate was kept static at 50% from 2020 to 2050.

B1.2.3 Air travel

This intervention was included to indicate the potential savings from a reduction in the number of flights residents take. In the same way as the smarter choices intervention, this was modelled by altering the annual passenger kilometres figure in REAP for air travel.

The impact of every resident taking one less flight per year was modelled. It was therefore necessary to arrive at an average flight distance figure and subtract this distance from the annual passenger kilometres figure in the REAP baseline. Average flight distance data was sourced from the GHG Protocol Initiative[60]for short, medium and long haul journeys (see Table 22). In order to simplify data input to REAP, these figures were averaged to arrive at an average flight distance. This figure was then subtracted from the annual passenger kilometre figure in REAP for all years from 2011 to 2050. As no allowance was made for the number of short, medium and long-haul flights, this has likely resulted in an overestimate of the impacts of taking one less flight per year. However, it gives an indication of potential CO_2 savings from air travel behaviour change.

Table 22. Assumptions regarding air travel.

Data	Value	Source
Average flight distances	437 km (short-haul) 1,651km (medium-haul) 5,684 km (long-haul) 2,590 km (averaged)	GHG Protocol Initiative data averaged.
Annual passenger kilometres	5,287 (REAP baseline figure) 2,695 (With 1 less flight per year [applied from 2011-2050])	REAP baseline figure minus calculated average flight distance.

[60] GHG Protocol Initiative average flight distance values, available at: http://www.whatsmycarbonfootprint.com/faq.htm

B1.3 Consumables and Durables Intervention

B1.3.1 Reduce overall consumption (sustainable lifestyles)

REAP includes data on personal expenditure on consumables and durables and models the carbon impact of changes to levels of personal expenditure. There are no real precedent studies suggesting levels of reduction in personal expenditure on consumables that can be expected as a result of sustainable lifestyles behaviour change initiatives. Therefore, in order to indicatively model the impacts of reduced consumption, it was assumed that such an intervention would result in a 10% reduction in personal expenditure on consumables and durables between 2011 and 2050.

B1.4 Food Interventions

B1.4.1 Behaviour change: meat and poultry free days

In the same way as consumables and durables, REAP includes personal expenditure data for different food categories. Following discussions with the client, it was decided to indicatively model the carbon savings resulting from three changes in food expenditure as a proxy for reduced meat and poultry consumption. The following scenarios were modelled:

- All residents have one meat-free day per week
- All residents have one poultry-free day per week
- All residents have one meat-free day and one poultry-free day per week

To model these scenarios one seventh of personal annual expenditure was removed from baseline poultry and meat data. Due to the fact that data in REAP are monetary, a decision was made not to re-distribute the removed expenditure as the calorific content for £1 spent varies between foodstuffs. These interventions therefore provide only an indicative idea of potential carbon savings from dietary changes.

B1.4.2 Problems encountered during the development of the Action Plan

A lack of useful examples regarding emissions reductions from sustainable lifestyle interventions (e.g. not eating meat or poultry for 1 day per week and taking on average 1 less flight per year) could not be found. Therefore the magnitude of the reductions from these interventions is uncertain.

B1.5 Indicative national decarbonisation measures

Once all of the HBC interventions were modelled it was important to show these emissions reductions in the context of other national infrastructural interventions. Decarbonisation of energy supply and transport infrastructure will enable residents in Harrogate to further reduce their emissions. Both of these scenarios are indicative only as it is not possible to directly alter the national energy supply mix or transport emissions factors in REAP. Given the nature of the scenarios, it is thought that there is a certain amount of double counting in these scenarios; national decarbonisation would undoubtedly cancel out some savings achieved through interventions made in Harrogate against a BAU scenario. The following methods were used to indicatively show the contribution of decarbonising domestic energy supply and personal transport.

B1.5.1 Domestic energy consumption

The percentage contribution of domestic energy consumption to the overall Harrogate carbon footprint in 2006 was taken from SEI's publicly available footprint information. This contribution was then steadily removed from the BAU scenario to 2050, indicating the impact of removing emissions from this sector. In order to front-load this decarbonisation, the latest Committee on Climate Change recommendations were used which suggest that a 90% decarbonisation of the energy sector is necessary by 2030[61]. The final 10% was then removed by 2050, achieving carbon neutrality.

B1.5.2 Personal transport

A scenario was run in REAP which steadily reduced passenger kilometres for private and public transport (assumed to be fuelled by fossil fuels) to zero in 2050, indicating the impact of decarbonising transport infrastructure over time. This attempts to mirror the effect of complete decarbonisation of the personal transport sector by 2050.

[61] Committee on Climate Change (2010) The Fourth Carbon Budget, reducing emissions through the 2020s, available at: http://downloads.theccc.org.uk.s3.amazonaws.com/4th%20Budget/CCC_4th-Budget_interactive.pdf

Appendix C

Cost estimates: methods and assumptions

C1 Cost estimates: methods and assumptions

This section describes the methods and assumptions used to estimate the cost of implementing each intervention. Costs were calculated as totals over the period to 2050, on an annual basis and as cost per tonne of CO_2 saved for each intervention. Costs for certain interventions should be treated with caution; spending on behaviour change initiatives will not necessarily guarantee the modelled outcome. For behaviour change interventions, the cost in reality will be determined by levels of available funding and the number of roles assigned to each intervention. All HBC time costs are applied out to 2050. Where an intervention is 'front-loaded' to 2020 as is the case for car-sharing for example, it is assumed that an employee will be required after that date in order to help maintain behaviour changes.

Section C1.1 describes how costs for HBC time were allocated between interventions and Section C1.2 describes methods used to calculate costs for interventions that involve an element of capital cost.

C1.1 HBC time cost assumptions

HBC was able to provide Arup with annual salaries for three bands of council employee. These are as follows:

- Project Officer: £34,655
- Campaigns Project Officer: £22,723 – £26,034 (average taken of £24,000 for simplicity)

In order to reflect the additional costs to HBC from overheads such as office space, the staff rates have been multiplied by a factor of 1.5.

The following staff numbers were applied to the interventions modelled for this project. It was assumed that these staff would work under an existing manger.

- **1 x Project Officer split between the micro-renewables retro-fit interventions** (solar and ground source heat pump interventions). The solar interventions exploit the same total resource so only one can be implemented. This means that each of the solar interventions has been allocated half of the cost of a Project officer (0.5 FTE). The other half of the project officer's time (0.5 FTE) is applied to the ground source heat pump intervention. **1 x Project Officer and 1 x Campaigns Officer assigned to remaining domestic energy interventions** (home insulation, condensing boilers, double glazing, efficient appliances, and energy behaviour change). This translates to 0.2 FTE (1 day per week) for both staff on each of these interventions. This was thought to be a realistic remit for two staff and would involve identifying funding sources and encouraging the uptake of retro-fit measures.
- **1 x Project Officer for each of the transport interventions.** Given the lack of capital cost in implementing the transport interventions and their ambitious nature, it was thought that one staff member should be assigned to each in order to more accurately reflect the cost to the council. This

translates as 1 FTE project officer for each transport behaviour change intervention.

- **1 x project officer split between the consumables and food interventions.** Given their focus on sustainable consumption, these interventions lend themselves to being packaged as one role for a project officer, focused on consumption behaviour change. This translates as 0.5 FTE project officer for the food intervention and 0.5 FTE project officer for the consumables intervention.

C1.2 Interventions with capital cost

C1.2.1 Photovoltaics

C1.2.1.1 Cost

The cost of an average household PV system is estimated by the Energy Savings Trust at £12,000[62]. This figure was multiplied by the number of installations necessary as part of the intervention. The HBC time cost to 2050 was added to this figure.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

C1.2.1.2 Potential Income

Solar Century estimates that the average PV installation in Harrogate will earn approximately £784 per year from the Feed in Tariff[63]. This figure was applied to the annual number of installations required for the intervention to 2050. The payment was continued for 25 years from the data of installation in line with the period FiTs will be paid for. Note that potential income is capped at 2050 even though some installations may keep earning after that date. This calculation must be treated with caution as the scheme's terms are due to be reviewed by Government in early 2013 and payments may be revised downwards.

C1.2.2 Solar hot water

C1.2.2.1 Cost

The cost of a solar hot water system on an existing building is estimated at £5,000[64]. This was multiplied by the number of installations necessary as part of the intervention. The HBC time cost to 2050 was added to this figure.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

[62] Energy Savings Trust, http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-electricity#Costs,savingsandmaintenance
[63] Solar Century, http://www.solarcentury.co.uk/estimate/?postcode=HG2+3EP
[64] Harrogate Planning and Climate Change Study – stage 1, produced by Aecom for HBC, 2010

C1.2.2.2 Potential Income

The proposed Renewable Heat Incentive (RHI) will pay a set income per kWh generated from solar hot water systems from April 2011. The potential income from this scheme in Harrogate was calculated using average heat generation figures[65] and proposed payment levels set out in the Government's RHI consultation document[66]. This resulted in an estimated annual payment of £378 per installation. This was applied for each installation for 20 years as is proposed under the RHI. Note that potential income is capped at 2050 even though some installations may keep earning after that date.

C1.2.3 Combined solar intervention

C1.2.3.1 Cost

The costs of installing solar PV and hot water systems were taken from calculations done for the previous two interventions and applied to the relevant number s of new installations for this intervention. HBC time cost was added.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

C1.2.3.2 Potential Income

Figures for potential income from the FiT and RHI were taken from the previous interventions and applied as necessary.

C1.2.4 Ground source heat pumps

C1.2.4.1 Costs

The cost of installing ground source heat pumps to existing properties was sourced from the report produced for HBC by Aecom[64] which is verified by a figure from the Energy Savings Trust[67]. These sources suggest a cost of approximately £12,000. This figure was applied to the number of installations required for the intervention. HBC time cost was added.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

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[65] Average generation is taken as 750kWh per kWp installed, from: http://www.climatechangeandyourhome.org.uk/live/small_scale_electric_energy.aspx
[66] DECC (2010) Renewable Heat Incentive Consultation Document, available at: http://decc.gov.uk/assets/decc/Consultations/RHI/1_20100204094844_e_@@_ConsultationonRenewableHeatIncentive.pdf
[67] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Ground-source-heat-pumps

C1.2.4.2 Potential Income

The RHI proposes a rate of 7 pence per kWh for ground source heat pumps. It was assumed that the system would replace 100% of fuel use for heating which is taken as 21,587 kWh[68] for Harrogate. These figures were multiplied to give an annual income per installation and applied for 20 years to each installation throughout the period to 2050.

C1.2.5 Home insulation

C1.2.5.1 Costs

Best estimate costs to install cavity and loft insulation were taken from the Harrogate Private Sector Stock Condition Report and compared with figures supplied by Kirklees Council from their experience. The following figures were used:

- Loft insulation - £200 (this is a cost averaged between properties with poor existing lost insulation and those with none)
- Cavity insulation - £250 (the Kirklees number was lower but this assumes a current level of existing cavity insulation. £250 was thought to be a good estimate based on available data).

These figures were applied to the number of properties receiving insulation in the intervention to 2050. HBC time costs were added.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

C1.2.6 Condensing boilers

C1.2.6.1 Costs

The cost of installing a condensing boiler was sourced from the Private Sector Stock Condition Report as £2,000. This refers to upgrading an existing system. A sense check was carried out by conducting a short web search of installers to compare condensing boiler prices and this figure was thought to represent a fair average. This cost was applied to the number of new boilers required under the intervention to 2050. HBC time costs were added.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

[68] DECC (2010) Sub-national gas sales for Harrogate.

C1.2.7 Double glazing

C1.2.7.1 Costs

The cost of installing double glazing in an average property has been taken as £4,000. This is a figure quoted in the Private Sector Stock Condition Report. Costs obviously vary depending on the size of the property and can sometimes rise to as much as £10,000. However, although it may be a conservative estimate, the figure of 4,000 was used in the absence of a more accurate average figure. This figure was applied to the number of houses requiring double glazing under the intervention. HBC time costs were added.

The total cost to 2050 was then divided by total CO_2 savings to 2050 to estimate the cost per tonne of CO_2 saved.

C1.2.8 Energy efficient appliances

C1.2.8.1 Costs

The housing tool does not clearly define what is meant by energy efficiency appliances. An assumption was made that the following costs will be incurred for new appliances for every household covered by the intervention:

- Washing machine – £350
- Fridge – £400
- Dishwasher – £420
- Kettle – £30

These assumptions were made by consulting the Energy Savings Trust's approved appliances database[69]. As costs vary significantly, a best guess average was taken having looked up several models for each appliance. These costs were then applied to the number of properties included in the intervention.

Costs for energy efficient light bulbs were estimated by applying a per bulb cost of £0.99[70] to the average number of bulbs per house[71]. This cost was then multiplied up for the relevant number of properties.

[69] http://www.energysavingtrust.org.uk/Home-improvements-and-products/Home-appliances
[70] http://www.nigelsecostore.com/acatalog/Eco_Kettle3.html
[71] http://www.staffordarea.saveyourenergy.org.uk/how/lighting/lowenergylightbulbs

Appendix D

Original approach – modelling interventions over 40 years to 2050

D1 Original Approach to modelling

D1.1 Original interventions

The interventions described above include significant front-loading in order to demonstrate how the targets can be achieved using a consumption-based approach. The following interventions differed from those outlined above when originally modelled:

- All three solar interventions: these were originally modelled to exploit full solar potential by 2050
- GSHP: originally modelled to exploit full off-grid potential by 2050
- Insulation: originally modelled to exploit full potential by 2050
- Double glazing: originally modelled to exploit full potential by 2050
- Energy efficient appliances/lights: originally modelled such that every household has energy efficient appliances and lights by 2050
- Condensing boilers: originally modelled to exploit full potential by 2050
- Energy consumption behaviour change: this intervention was originally modelled to achieve a 10% reduction in consumption by 2020 with a 0.6% year on year reduction thereafter.
- Car sharing: originally modelled to achieve a 10% increase in occupancy rate by 2020 (from 32% to 42%)

The method used to indicatively show emissions savings form decarbonisation of domestic energy consumption was also slightly different. Instead of front-loading decarbonisation as described above (90% occurring by 2030), the sector was decarbonised on a linear trajectory from 2011 to 2050.

D1.2 Original results

This section briefly covers the results of earlier modelling which spread renewable and retro-fit interventions over the 40 years period. It should be noted that costs have been kept the same in both sets of modelling.

Figure 11: Modelled CO_2 emission reductions in 2020 and 2050 compared against the emissions baseline in 2005 for the population of Harrogate Borough (original modelling approach).

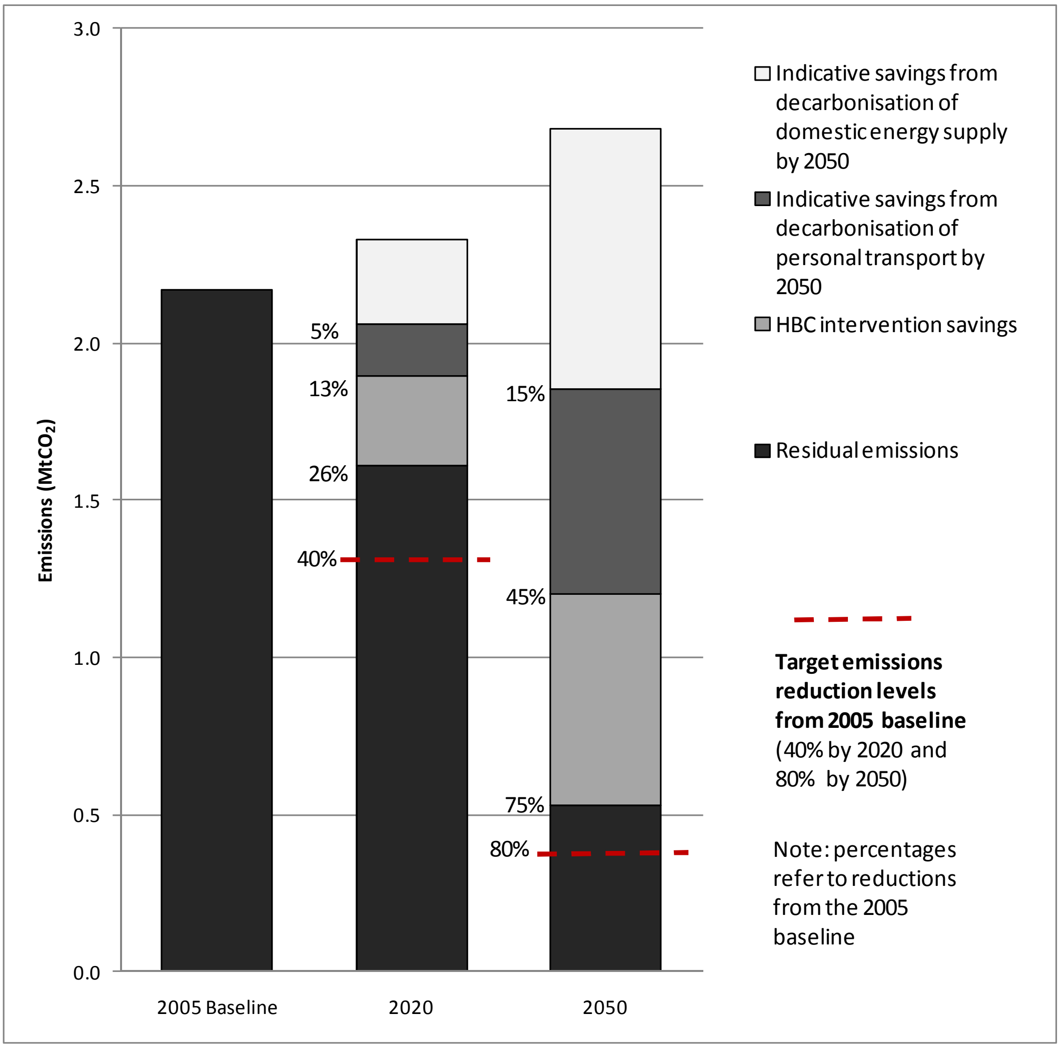
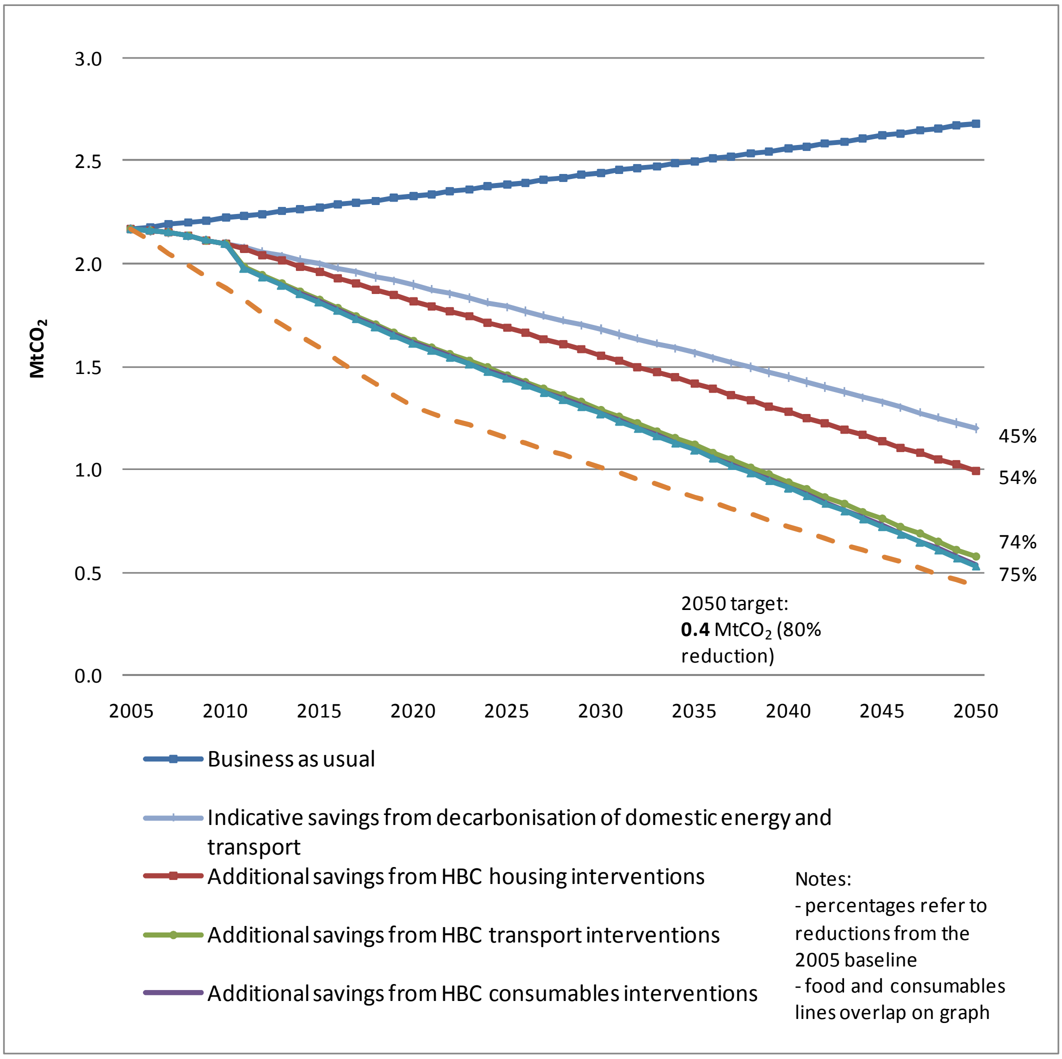


Figure 12: Contribution of HBC interventions to overall emissions reductions (original modelling approach).



The front-loading approach (as described in the report body) brought forward emissions savings, delivering increased cumulative savings over the BAU scenario. Seeing as capital and time costs have remained the same between the two approaches, this had the effect of decreasing the cost per tonne of CO_2 saved.