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"Carbon intensity of UK Household Consumption: Scenarios to 2030"

Submitted for the Degree of Doctor of Philosophy, May 2011

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Abstract

As part of the Research group on Lifestyles, Values and Environment (RESOLVE), at the University of Surrey, UK, this PhD study involves the development of a set of scenarios depicting the carbon intensity of UK household consumption over the next 20 years.

A set of four scenario narratives are developed, accompanied by illustrative quantitative figures. The thesis sets out some of the background factors pertinent to this study, including economic, energy and environmental uncertainties, and establishes how household consumption is framed and understood in the present work. Accordingly, emissions embedded within goods and services imported from abroad are included in the accounting. A review of the scenario planning literature is provided, an investigation is conducted into the epistemological contribution that these scenarios might make, and the methodology adopted for this study is described, before the scenarios themselves are laid out.

Key lessons from the scenarios are discussed, including: the importance of a coordinated international approach (if households are to be expected to engage proactively in environmental behaviour change); the increasing dominance of embedded emissions in imports (as a share of total household emissions) in the event of significant decarbonisation in the UK; the centrality of social movements in driving political outcomes either for or against a low carbon transition; and the economic impact of energy and resource depletion and the divergence of subsequent responses according to the socio-political uncertainties used to frame these scenarios.

Acknowledgements

I would like to thank my supervisors Professor Lester Hunt and Dr Michael Peters, for their guidance and encouragement through the various stages of the PhD. I am grateful also to the members of RESOLVE who formally contributed their time on the scenario (advisory) panel: Professor Tim Jackson, Dr Yacob Mulugetta and as interviewees in the data gathering process: Kate Burningham, Mona Chitnis, Angela Druckman, Shane Fudge and Birgitta Gatersleben. I am indebted to the other members of the group whose informal support and advice has proved invaluable, in particular Ian Christie, Gemma Cook, Bronwyn Hayward, Claire Livingston and my fellow PhD students Alison Armstrong, Catherine Bottrill, Peter Bradley, Alexia Coke and Chris Kukla. Many colleagues in the wider Centre for Environmental Strategy and the School of Economics were also immensely supportive, and I owe particular thanks to Marilyn Ellis, Barbara Millington and Maureen Newman.

The contributions of various external experts were crucial to the successful completion of this research, and I would like to thank Chris Foster, David Kempton, Francesco Sindico, Nicholas Howarth, Nick Eyre, Ruairi O'Connell, Nick Robins and Matt Leach for their insightful input.

Finally, this thesis is dedicated to my late friend Alex Carmichael, for never ceasing to think clearly, question sincerely and battle cheerfully.

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Glossary

CCC - Committee on Climate Change; an independent body established as part of the UK Climate Change Act (2008) to advise government on climate action.

COICOP - Classification of Individual Consumption According to Purpose; United Nations classification scheme for household expenditure on goods and services.

Consumption perspective - accounting and attributing responsibility for emissions according to where the associated goods and services are finally consumed. See also 'Production perspective'.

Deductivism - A method of reasoning whereby speculative hypotheses may be tested against the evidence. Begins with hypothesised general laws and proceeds towards explanation or prediction of specific instances. See also 'Inductivism'.

Direct Emissions - Those emissions associated with use of electricity, gas, vehicle fuels and other fuels by households.

ELESA - Econometric Lifestyle Environmental Scenario Analysis; A model that explores the role of income, price and non-economic factors in driving changes in UK household expenditure. Employed as the basis of the scenario quantification in this research.

Embedded Emissions - Those emissions which arise 'upstream' in the production of goods and services eventually consumed by households.

Environmental Scanning - A stage in the scenario planning process involving scanning for key factors, trends and uncertainties in the domain of interest. May involve interviews, literature review, surveys etc.

Epistemological monism - The position that all (scientific) disciplines are to be treated equally with respect to the verification of knowledge claims.

Epistemological pluralism - The position that different (scientific) disciplines necessarily involve different standards in the verification of knowledge claims.

EU ETS - European Union Emissions Trading Scheme; a carbon trading scheme covering selected sectors of the European Union economy, such as energy production and heavy industry (as of 2011).

ExNEF - exogenous non-economic factors; a term used in relation to the econometric model applied in the quantification of the scenarios in this study. Refers to those factors other than income and price that have an impact on household expenditure.

Idiographic - refers to those disciplines whose object is the description of individual events, rather than general laws applicable to all events of a type. See also 'Nomothetic'.

Inductivism - A method of reasoning whereby observation of specific events lead to general laws. See also 'Deductivism'.

Instrumentalism - A method of reasoning in which theories are treated as mere instruments for the delivery of predictions to be tested against empirical data. The 'realism' of the assumptions used in those theories is regarded as unimportant.

Intuitive logics - the term applied to the qualitative scenario planning approach developed at Shell.

Methodological monism - the position that, within a given (scientific) discipline, there is one school of thought best able to account for all the phenomena of interest.

Methodological pluralism - the position that, within a given (scientific) discipline, different schools of thought may have different strengths in relation to different phenomena of interest.

Nomothetic - refers to those disciplines whose object is the positing of general laws about all events of a type, as opposed to description of individual instances only. See

also 'Idiographic'.

Production perspective - accounting and attributing responsibility for emissions according to the country where those emissions are produced. See also 'Consumption perspective'.

Rational choice theory - an approach to understanding human economic behaviour that assumes people always act to maximise utility, prefering more of a good rather than less.

RESOLVE - Research group on Lifestyles, Values and Environment; an ESRC funded research group at the University of Surrey, comprising members from the Centre for Environmental Strategy and the Departments of Economics, Psychology and Sociology.

Scenario planning - The technique of developing informed narratives of the (business) environment over a given period into the future, in order to use these as the basis of strategic planning.

UKERC - UK Energy Research Centre; funded by the UK Research Councils' Energy Programme to conduct research into 'sustainable future energy systems' and inform UK policymakers.

1. Introduction

This PhD study is taking place within the Research group on Lifestyles, Values and Environment (RESOLVE), at the University of Surrey, UK[1]. The inter-disciplinary nature of the research group provides the framework for this PhD research, which examines the possible impact of social, technological, economic and political factors on the carbon intensity of UK lifestyles through to 2030.

The overarching aim of RESOLVE is:

> *"to develop a robust understanding of the links between lifestyles, societal values and the environment, and to provide informed advice to policy-makers seeking to understand and to influence the behaviours and practices of energy consumers"*[2].

Within that context, the specific objective of this PhD is to develop a range of coherent and plausible scenarios depicting the carbon intensity of UK household consumption over the next 20 years. The scenarios can be used to assist policy- and decision-makers in considering the implications of their decisions under alternative conditions in the future. In this way, the scenarios can help to challenge entrenched thinking and unconscious assumptions associated with a business-as-usual mentality.

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1 RESOLVE is funded by the Economic and Social Research Council (ESRC) as part of the Research Councils' Energy Programme. The group comprises academics, researchers and PhD students from the Centre for Environmental Strategy and from the Economics, Psychology and Sociology departments at the University of Surrey.

2 "About RESOLVE", http://resolve.sustainablelifestyles.ac.uk/about-resolve

1.1 Energy, economic and environmental uncertainty

A range of uncertainties relevant to this study are explored in some detail later in the thesis. It is perhaps useful though to provide a brief context for the current study by exploring some of the fundamental issues shaping the world today. Three such issues are the energy, economic and environmental uncertainties facing the UK and the wider world.

A recent report on global oil depletion by the UK Energy Research Centre reviewed over 500 studies, concluding that: *"a peak in conventional oil production before 2030 appears likely and there is a significant risk of a peak before 2020"* (UKERC, 2009a, p. x). The chief economist to the International Energy Agency (IEA), Fatih Birol, has also stated that demand for oil could outstrip supply by 2020. This assessment brings forward the IEA's previous estimate of 2030, due in part to revised estimates of output decline, but also due to the effects of the recent economic crisis in reducing expenditure on new exploration and extraction projects (Macalister & Monbiot, 2008). While the dynamics of oil depletion are complex, including uncertainties over the true extent of OPEC reserves, the level of investment in exploration, the availability of non-conventional oil supplies, domestic consumption in the oil producing nations and the desire for energy security in oil importing nations, it is clear that a decline in oil availability is a significant medium to long term risk for the UK economy.

The impact of the economic crisis has not been confined to investment in the oil and gas industry. The events that have unfolded since July 2007 have been described in the Wall Street Journal as the worst financial crisis since the Great Depression (Hilsenrath *et al.*, 2008). The crisis has resulted in governments taking unprecedented steps to prevent a

collapse of the global financial sector, including the nationalisation of banks, and wholescale bailouts of nation states in Europe. A drop in the value of housing, increased unemployment and shortage of credit have all contributed to the economic uncertainty for UK households. A contraction of the economy by 0.5% in the last three months of 2010 led to renewed fears of a double dip recession, and while the following three months saw growth of the same magnitude, at the time of writing (early 2011) significant uncertainty remains around the strength of the recovery.

In the midst of this economic crisis, global leaders were also tasked with delivering progress on tackling climate change. An unprecedented level of expectation was placed on global leaders to secure a deal at the Copenhagen climate summit in December 2009. In the end, the UNFCCC negotiating process barely survived, with the non-legally binding commitments that were made falling far short of the levels necessary to avoid the risk of catastrophic climate change (Fudge *et al.*, 2011). One year on, in Cancun, the climate talks achieved little more than a political agreement to continue holding talks, with little if any further improvement on commitments by individual member states. In addition to the political and economic uncertainties around an international agreement, the extreme weather events of 2010 serve as a reminder of the potential direct impacts of climate change, even in the short term, as a result of increased average global temperatures (Black, 2010).

In the midst of such overarching global uncertainties it might appear that individual and voluntary behaviour change will have little role to play in determining the carbon intensity of UK lifestyles through to 2030. Clearly, the transition to a low carbon society will require substantial technological innovation. Many of these innovations

will occur out of sight of consumers going about their day-to-day lives, e.g. supply side innovations in electricity supply, new agricultural methods for low carbon food production etc. However, in addressing these challenges, significant change may also be required on the part of citizens and consumers more directly. In many cases the changes may be subtle, e.g. where economic (dis)incentives influence consumption patterns towards less energy intensive versions of the same goods and services. In other cases, more radical behaviour change may be called for, such as modal shifts in transport use, installation of micro-generation technologies or retraining for green collar jobs. Ultimately, it may be that individuals' values and behaviours hold the key to ensuring a low carbon transition can be made in an ordered and proactive fashion, rather than a disordered and reactive one. Therefore, while global uncertainties should certainly frame the landscape of change to 2030, and technological innovations will play an enormous role in the way society responds to those uncertainties, these should not be treated in a deterministic way, independent of the will of individuals. This study therefore aims to explore the opportunities and constraints for householders in the UK in shaping and responding to this future.

1.2 Research questions

The primary research question to be addressed is:

> *How could the carbon intensity of UK lifestyles be affected by social, technological, economic, political, psychological and environmental factors through to 2030?*

In addition, two secondary research questions were identified, a prelimenary question which required to be addressed ahead of the main body of work, and an epistemological question regarding the value of the contribution made by this scenario building study:

> ***Prelimenary question**: Can a RESOLVE consensus on a definition of 'lifestyle' be reached? If so, what would this definition be? If not, what alternative definition of 'lifestyle' should be adopted for use in determining the parameters of this research?*
>
> ***Epistemological question**: What epistemological contribution can be offered by a set of scenarios detailing the carbon intensity of lifestyles under different conditions in the future?*

1.3 Thesis structure

The remainder of this thesis is organised as follows:

Chapter 2 - Background sets out the historical development of UK legislation on climate change and describes how carbon emissions are accounted for, where a distinction is made between the production and consumption perspectives. There follows a summary of how the prelimenary research question on the definition of lifestyles was addressed.

Chapter 3 - The 'scenario' technique gives a description of the technique of scenario building and scenario planning, defining key terms and offering an historical account of different schools of practice associated with the technique. A scenario typology is then adopted in order to highlight some of the key features of the scenarios developed in this

study. Finally, a series of scenario studies are drawn from the literature as they relate to the present work.

Chapter 4 - Epistemology addresses the secondary research question focused on the contribution to the knowledge space made by a study of this nature, and is organised in two parts. The first section considers what lessons might be drawn from the discipline of history, to inform a qualitative, narrative scenario building approach. The second part focuses on economics, delving into the history of the discipline to show how the concept of rational choice has informed mainstream economic theories of consumer behaviour. A summary of the various criticisms of this concept is provided, before outlining how the quantitative modelling approach followed in this study might offer new insights in this area.

Chapter 5 - Methodology describes the process of conducting the research. First there is a summary of how the methodology was designed, then revised in light of feedback from experts and practitioners. Then the various stages are explained in detail, including: the design, running and analysis of a series of internal interviews; an analysis of the key uncertainties these produced; the provisional scenario framework generated; a description of the external expert interview process; the drafting of the scenario narratives; and details of the quantitative modelling process.

Chapter 6 - Scenarios depicts the key outcome from the study, including a primer or introduction to the four scenarios, the four scenario narratives each with a summary of the quantitative figures for expenditure and emissions, and a summary section comparing and contrasting the outcomes from each scenario and drawing lessons for

decision makers.

Chapter 7 - Conclusions offers a series of reflections in two broad categories: methodological conclusions drawn from the scenario/modelling process itself, and epistemological conclusions reflecting on the earlier discussion in light of the scenario outcomes.

2. Background

2.1 UK legislation on carbon emissions

As a result of the Rio Earth Summit in Rio de Janeiro in 1992, an international treaty was signed known as the United Nations Framework Convention on Climate Change (UNFCCC). This treaty included provisions for further updates, or Protocols, that would include mandatory targets for reduction of greenhouse gas (GHG) emissions. After lengthy negotiations, the Kyoto Protocol was adopted by the UNFCCC in December 1997.

Along with the other EU member states, the UK ratified the Kyoto Protocol, agreeing to a 12.5% reduction on 1990 UK emissions over the period 2008-2012 (averaged annually). Moreover, the UK Government believed that a stronger reduction was both possible and desirable, leading to a voluntary domestic target of a 20% reduction by 2010 (DEFRA, 2006).

Later, the UK Government passed the world's first legally binding framework on climate change with the Climate Change Act 2008 (DEFRA, 2008). Key provisions of the Act include:

- GHG emission reduction targets of at least 80% by 2050, CO_2 emission reduction of at least 26% by 2020, against 1990 levels;
- A series of five year carbon budgets;

- Establishment of a Committee on Climate Change (CCC), an independent body set up to advise the Government on appropriate measures for achieving targets;
- Plans to include emissions from international aviation and shipping by 2012.

The newly formed CCC then recommended a revised 2020 emissions reduction target of 34% on 1990 levels, which was accepted by Government and announced alongside the 2009 Budget (CCC, 2008). The CCC also proposed that in the event of a global deal on emissions, the UK should improve its reduction targets to 42% by 2020, and 90% by 2050. However, the failure to secure a sufficiently robust deal at Copenhagen meant that the UK target remained unchanged through 2010.

In spite of the lack of progress at a global level, there have been calls from within Europe for the EU to voluntarily adopt a stronger target of 30% by 2020 (above the present target of 20%). Three arguments have been given: lower economic activity resulting from the global recession has set back emissions levels such that a 20% target is no longer ambitious (Kinver, 2010); it is also argued that the move would give the EU a more commanding position in the development of emerging low carbon technologies (Harvey, 2011a); and finally, some commentators believe that post-Copenhagen, the only card left for Europe to play is a voluntary move intended to coax the US and China into adopting targets of their own (Dimsdale & Findlay, 2010). Whatever the merits of these arguments, any strengthening of the EU target, voluntary or otherwise, would require the adoption of stronger targets across member states, including the UK, thus a target of 42% by 2020 remains a possibility.

Having adopted the interim emissions targets recommended by the CCC, the UK

Government launched its Low Carbon Transition Plan, outlining specific measures to achieve the goals set out in earlier legislation (DECC, 2009). The plan includes several targets to 2020:

- More than 1.2 million people in green jobs;
- 7 million homes to undergo 'pay-as-you-save' energy retrofits;
- More than 1.5 million households supported in producing clean energy;
- 40% of electricity from renewables, nuclear and clean coal;
- UK gas imports 20-30% lower than they would be without intervention;
- New cars will emit on average 40% less carbon than today's models.

The CCC continues to publish advice to UK Government, establishing appropriate short term carbon budgets as required under the Climate Change Act, and recommending specific sectoral targets and policy measures for achieving these. The UK carbon budgets are divided between the traded and non-traded sectors. The traded sector includes those businesses already part of the EU Emissions Trading Scheme (EU ETS) including power generation and energy intensive industry e.g. iron and steel, cement, refining. Because EU allowances (EUAs) traded through the EU ETS are capped, any savings achieved through trading represent a real contribution to emissions reductions. In contrast to EUAs, offset credits (generated through Joint Implementation and Clean Development Mechanism projects under the Kyoto Treaty) are not part of a capped trading system and thus may not reliably count towards emissions reduction in the same way. Nevertheless, the EU ETS allows member states to secure a proportion of their emissions reductions through such offset credits (CCC, 2008).

The non-traded sector covers direct CO_2 emissions from buildings, transport and less energy-intensive industry, as well as non-CO_2 emissions. By definition, the non-traded sector does not form part of the EU ETS, and thus has no access to emissions reductions through trading of EUAs. Limited use of offset credits in the non-traded sector are allowed under EU rules, however the CCC has advised against using these to meet the interim budget, and the government has made a legally binding commitment to this effect, for the first budget only (2008-2012).

Clearly, for a study exploring UK carbon emissions through to 2030, the CCC recommendations might act as a powerful framework through which to develop alternative visions of implementation. However, in accounting for carbon emissions, the present study takes an approach quite different to that used in the government figures and targets. The two approaches are discussed below.

2.2 Production versus consumption

The method used by government to assess historical emissions levels and to establish legally-binding targets is known as the production perspective. This method counts emissions arising from all goods and services produced within the UK, regardless of whether they are consumed domestically or exported for consumption abroad. With manufacturing and other energy intensive industries having shifted away from the UK in recent decades, this production perspective has accordingly shown a reduction in UK emissions of around 15% between 1990-2004 (Druckman *et al.*, 2007). However, this

approach ignores emissions from goods and services that must now be imported – perhaps from countries with less energy efficient manufacturing industries, and requiring increased transportation to reach the UK market.

Recent work has attempted to assess GHG emissions from a 'consumption perspective'. In this approach, exported goods and services are excluded from the accounting while emissions from imported goods and services are attributed to the UK. In other words, it is the consumers of goods and services who are deemed responsible for any associated emissions, regardless of where they are produced. Following a consumption approach, emissions in the UK actually increased by 7% between 1990-2004 (Druckman & Jackson, 2009).

While the production perspective is employed for global accounting of emissions as part of the Kyoto Protocol, it has long been argued that the consumption perspective represents a more egalitarian approach (Bastianoni *et al.*, 2004, Jackson *et al.*, 2007, Munksgaard & Pedersen, 2001, G. P. Peters & Hertwich, 2006). Indeed, in 2009 the BBC published comments by Professor David Mackay, the newly appointed Chief Scientist at the Department of Energy and Climate Change (DECC), in which he argued that apparent reductions in UK emissions since 1990 were "an illusion", failing to account for embedded emissions in imported goods and services (Harrabin, 2009). A spokesman for DECC, declining to challenge the principles or figures quoted by Professor Mackay, argued simply that the production perspective was the official recognised mechanism for international accounting of emissions.

It seems likely that a production perspective will continue to dominate international

accounting of emissions for the foreseeable future. Nevertheless, in assessing the true carbon intensity of UK lifestyles as opposed to UK industry, a consumption perspective is arguably more appropriate and insightful. For these reasons, the consumption perspective is adopted in this study.

2.3 Characterising lifestyles

Although the remit of RESOLVE is to examine the links between lifestyles, values and the environment, there was – as of November 2008 – no consensus on how the term 'lifestyle' was actually understood by members of the research group. This presented several challenges for the present scenario research. For example, a clear understanding of the term would be a useful tool when attempting to interview external experts regarding their views on how lifestyles may be affected by different factors. In addition, without an understanding of what constitutes a lifestyle, it would be difficult to establish the issues that should be explored in the scenario narratives. As a result, those narratives would risk being unfocused and counter-productive as a means of engagement with policy-makers. On a more practical note, the ability to provide measures of the carbon intensity of lifestyles would be severely diminished if the activities to be examined could not be clearly defined. So, it was seen as desirable to have a definition of lifestyles in order that the research could be relevant, focused and engaging, thus giving rise to the prelimenary research question identified earlier. To begin to address this question, a discussion was organised at one of the RESOLVE research meetings around 'a definition of lifestyles'.

2.3.1 RESOLVE discussion on a definition of lifestyles

Prior to the discussion, a representative of each research strand in RESOLVE had been invited to prepare a short statement describing their understanding of lifestyles. The economics/modelling contributor explained that the focus of their work was consumption, i.e. how people spend their money. Thus lifestyles are understood in terms of consumer demand for goods and services. Interestingly, the psychology contributor said that psychologists 'don't do lifestyles'. Rather, their research is concerned with the relationship between independent variables. If the focus is on consumption behaviour, this does not take account of lifestyles *per se*. Lifestyles are not just what people do, but also why they do it. The sociology contributor suggested that defining lifestyles is deeply problematic, but that they might be best understood as bundles of social practices. In addition, they argued that the term lifestyles could be applied to individuals or to groups. The psychology contributor added that identifying lifestyle groups is itself problematic and depends very much on the approach taken. From the policy and governance strand, the contributor also described the term lifestyles as problematic, arguing that it was a recent, western-centric construct. Other issues to arise during the discussion included:

- consideration for the relationship between individual agency and institutional structures;
- issues of social equity; regarding some individuals, the question is not are they consuming too much, but rather are they consuming enough?
- the role of lifestyles in establishing our social status and identity.

From this short summary it can be seen that there are a variety of approaches to understanding lifestyles across the disciplines. Also, a common theme throughout the

session was the hesitance of the participants to attempt a definition, at least one that would be satisfactory across the inter-disciplinary team. Instead, the discussion often focused on the perils of attempting a definition.

When it became obvious that a definition was not going to be achieved, a contingency plan was then followed, whereby the discussion was steered towards the more practical task of identifying individual issues that the group thought should be addressed through the scenarios. Some examples of relevant issues were introduced, i.e. food, housing, transport. The Shell Group scenarios were also summarised, wherein the scenario team had identified four key areas: Demand, Resources, Technology, Environment including specific issues such as (for Resources): Oil & Gas, Coal, Nuclear, Electric Renewables, Biomass (Shell, 2008). Despite this contingency approach, comments continued to focus on the shortcomings of various understandings of lifestyles. As a result, it was not possible to identify any issues that people felt should be addressed in the scenarios.

With hindsight, an alternative approach might have been to begin the discussion with this identification of issues, by explaining that the session aimed to develop a framework of issues around lifestyles, rather than a strict definition. Doing this might have resulted in some useful insights that could have subsequently contributed to a discussion on establishing a definition. Nevertheless, it is believed that the approach taken was appropriate, given the intention of avoiding 'contaminating' the discussion too early on with suggestions and examples of issues, preferring instead to see if these would emerge out of the discussion.

Following the discussion session, further research was then carried out to investigate

how lifestyles are characterised in the literature on sustainable consumption. The remainder of this section details the development of a suitable framework drawing on the literature as well as points from the discussion.

2.3.2 Lifestyles

In understanding how lifestyles might be characterised, a useful starting point is the United Nations Environment Programme (UNEP) Marrakech Task Force on Sustainable Lifestyles (MTFSL). In its concept paper on Sustainable Lifestyles, the Task Force argues that:

> *"Lifestyles is a way we live our lives that allows us to fulfil our needs and aspirations. They serve as "social conversations", in which people signal their social position and psychological aspirations to others. Since many of the signals are mediated by goods, lifestyles are closely linked to material and resource flows in the society."* (UNEP, 2007a, p. 2)

Elsewhere, in a 2004 report on Sustainable Lifestyles, the Centre for Sustainable Development at the University of Westminster argued:

> *"what this term [lifestyle] describes is an accumulation of patterns of behaviour, resource use and consumption, as well as choices about employment and the best ways to live... ...As patterns of consumption replace employment type as the primary social marker, the goods and services that individuals and households consume become the most*

important elements in demonstrating social class, wealth and identity. They become the means by which individuals express their values and their desires as well as the way individuals are judged by others." (Bedford *et al.*, 2004, pp. 3-4)

For Bedford *et al.* then, consumption is central to the notion of lifestyles. Although values and attitudes may be key to understanding the motivations behind any act of consumption, the present study is interested in the actual and potential carbon intensity of lifestyles, thus it seems appropriate that consumption should play a central role in any framework on lifestyles.

2.3.3 Consumption

Bedford *et al.* (2004, pp. 7-8) use the notion of 'consumption clusters' to group together patterns of actions along with the goods and services associated with a particular area of consumption. This was based on work elsewhere that had identified the following ten clusters where households can make a difference in reducing environmental impact: clothing, education/training, food, healthcare, construction/housing, hygiene, cleaning, recreation, social life and transport (Lorek & Spangenberg, 2001). These clusters were estimated to account for over 95% of environmental impacts from household consumption (environmental impacts being material extraction, energy consumption and land use). Bedford *et al.* made a series of amendments:

- removing three clusters that consist primarily of public consumption, namely education/training, healthcare and social life (where social life is understood as the police, military and other public services, as distinct from recreation);
- adding financial investments, domestic appliances and domestic durables;

- returning education and healthcare to the list, under the heading 'social choices';
- disaggregating recreation into leisure activities and holidays.

The resulting clusters can be seen in Figure 2.1:

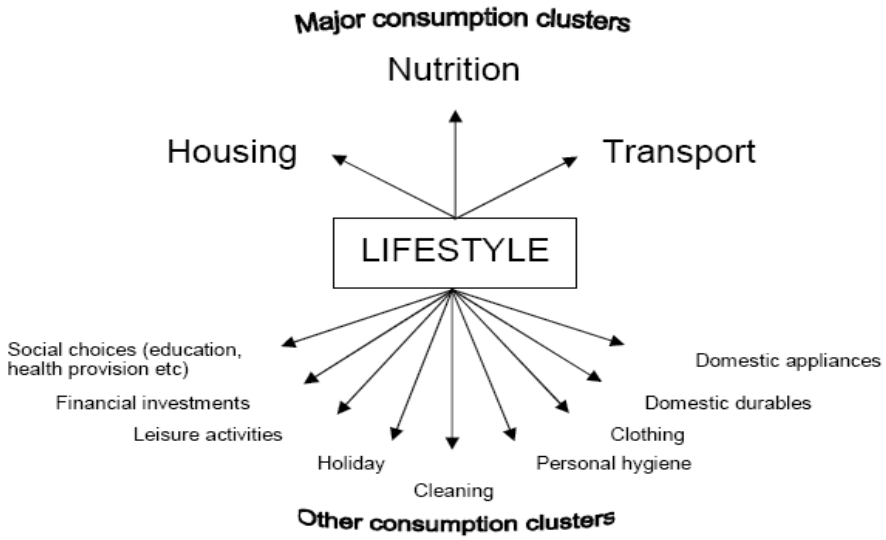


Figure 2.1: Bedford et al's Consumption Clusters for Lifestyles

Of these consumption clusters, it is estimated that housing, nutrition and transport account for around 70% of environmental impacts (Lorek & Spangenberg, 2001).

In 2006, the Sustainable Consumption Roundtable produced a report investigating opportunities for more sustainable consumer lifestyles (Sustainable Consumption Roundtable, 2006). The Roundtable organised a consumer forum involving over a hundred people, inviting them to discuss their aspirations and how these related to policies for sustainable consumption. Arising out of these discussions were four areas of our lives where significant change could begin to take place:

- how we run our homes;
- the food we eat;
- how we get around;
- how we get away.

These equate neatly with the main three consumption clusters identified earlier (Bedford *et al.*, 2004, Lorek & Spangenberg, 2001), with transport being disaggregated into day-to-day travel and holiday travel. In addition, the fact that these four categories arose out of the expressed aspirations of forum participants makes this framing of consumption activities more accessible in terms of communicating potential future lifestyles to stakeholders. For this reason, these four categories were adopted as the primary means of communicating the notion of lifestyle consumption in the scenario development process.

2.3.4 External factors or drivers of consumption

As discussed previously, lifestyles are 'not just what we do, but why we do it'. In developing a lifestyles framework for scenario development then, it is also necessary to consider those external factors responsible for driving consumption. In the initial planning stage of this research, a standard set of five external factors used in scenario planning were used to frame the problem space, namely: social, technological, environmental, economic and political (STEEP). A further examination of the literature provides another perspective on these external factors.

The UNEP MTFSL list five external factors, broadly similar to the STEEP factors listed above but with some variation (UNEP, 2007a). These factors are: economic,

technological, policy, socio-psychological, cultural/historical. The first three of these are covered within the STEEP factors. MTFSL have used the term policy rather than political, but in the context of this research, these terms may be regarded as interchangeable. Interestingly for a sustainability task force, MTFSL have omitted the term environment. Although some environmental factors e.g. climate change, may impact on lifestyles indirectly through other categories, many environmental changes such as deforestation, resource and water scarcity could affect lifestyles more or less directly. For scenarios through to 2030 then, it is important to retain an explicit recognition of possible environmental factors.

The remaining difference between the original list of STEEP factors and those put forward by MTFSL is the sub-categorisation of social factors into socio-psychological and cultural/historical. In this scenario exercise, it would be possible to use the term social to cover both the psychological and the cultural/historical. Within the RESOLVE group however, there exist two separate strands covering the psychological and the sociological. Thus dealing with these two areas as important factors in their own right would mean that each of these two strands within RESOLVE had a clear opportunity to contribute to the building of the scenarios.

Incorporating this amendment to the original list of external factors, we now have Social (i.e. Sociological, Cultural/Historical), Technological, Economic, Political, Psychological, Environmental. These may be referred to as the STEPPE factors, for convenience. These external factors and the consumption clusters identified previously can be seen in Figure 2.2, with examples of issues within each factor based on the MTFSL model presented in their Fact Sheet (Government Offices of Sweden, 2007).

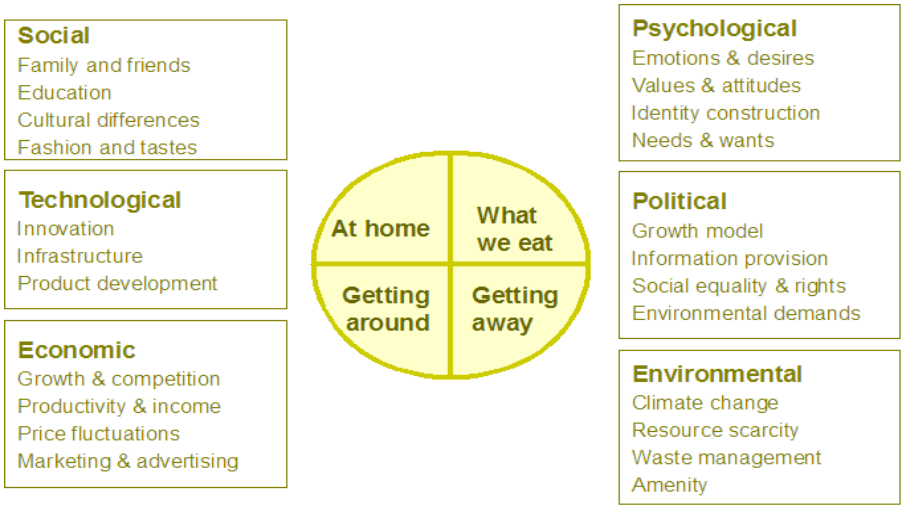


Figure 2.2: Consumption Clusters and External Factors

2.3.5 Lifestyles framework

The prelimenary question was formulated as follows:

> *Can a RESOLVE consensus on a definition of 'lifestyle' be reached? If so, what would this definition be? If not, what alternative definition of 'lifestyle' should be adopted for use in determining the parameters of this research?*

As to the first part, a consensus on a definition of 'lifestyle' across the disciplines within RESOLVE was not achieved. Instead, a framework has been devised in which consumption plays the central role, divided into four broad categories and placed within the context of the various external factors described above.

The framework is intended as a guide during the interview of key experts, rather than as a strict model of how lifestyles should be understood more generally. The actual trends,

issues, impacts and shocks that are deemed to be relevant to this study may not fall neatly into these categories. The purpose of identifying such categories is therefore to stimulate broad reflection and not to act as a limiting factor on the environmental scanning process. The use of this framework may ensure a better understanding of what constitutes a relevant insight when engaging with interviewees, and will help to make it clear where the conversation may be drifting away from the areas of core interest.

2.4 Summary

The emergence of an international approach to the management of GHG emissions in the form of the Kyoto Protocol has led to reduction targets for specific member states including the UK. With the establishment of the Climate Change Act, the UK is committed to long term emissions reduction, although the precise level of domestic emissions targets remains subject to uncertainty as key states continue to negotiate a more substantive global deal. Whatever the eventual targets, those are likely to be specified in terms of emissions produced in the member states, while the consumption perspective adopted here attempts to account for emissions by attributing responsibility to the consumer, irrespective of where the emissions are produced. This approach enables a more meaningful consideration of the carbon intensity of individual lifestyles. The concept of lifestyle is problematic though, and no single definition is sufficient to satisfy the various disciplines represented within RESOLVE. Instead, a working framework has been developed with consumption at its heart, divided into four broad categories and surrounded by various external factors that might influence consumption.

The next chapter introduces the technique of scenario planning and offers a review of the scenario planning literature relevant to the present study.

3. The 'scenarios' technique

3.1 A definition of 'scenarios' and 'scenario planning'

Various definitions of "scenario planning" were identified in a review of the literature by Chermack and Lynham (2002). A total of 18 definitions were identified, the earliest being from 1985, despite scenarios being used since the 1960s. Almost half of the definitions had been published in the five years since 1997, suggesting increased attention to scenario planning in academic literature over recent years. A sample of these definitions from Chermack and Lynham (2002) is reproduced here:

> *"An internally consistent view of what the future might turn out to be—not a forecast, but one possible future outcome"* (Porter, 1985, p. 63)
>
> *"A tool for ordering one's perceptions about alternative future environments in which one's decisions might be played out"* (Schwartz, 1991, p. 45)
>
> *"A disciplined methodology for imagining possible futures in which organizational decisions may be played out"* (Schoemaker, 1995, p. 25)
>
> *"That part of strategic planning which relates to the tools and technologies for managing the uncertainties of the future"* (Ringland, 1998, p. 83)
>
> *"Creating stories of equally plausible futures and planning as though any one could move forward"* (Tucker, 1999, p. 70)
>
> *"A series of imaginative but plausible and well-focused stories of the future"* (Kahane, 1999, p. 511)
>
> *"Scenarios are literally stories about the future that are plausible and based on analysis of the interaction of a number of environmental variables"* (Kloss, 1999, p. 73)

> *"A scenario is simply a means to represent a future reality in order to shed light on current action in view of possible and desirable futures"* (Godet, 2001, p. 63)

After analysing these definitions, Chermack and Lynham extracted what they saw as the four major outcome categories of scenario planning, before building an 'integrative definition' incorporating each of these categories which reads:

> *"Scenario planning is a process of positing several informed, plausible, and imagined alternative future environments in which decisions about the future may be played out for the purpose of changing current thinking, improving decision making, enhancing human and organization learning, and improving performance"* (Chermack & Lynham, 2002, p. 376)

Commenting on Chermack and Lynham's analysis, Nicol (2005, p. 35) points out that their list includes definitions of both scenario planning and scenarios themselves and concludes that their integrative definition told us *"a lot about what scenarios were and the purposes to which they were put, but about scenario planning only that it was a process"*. Nicol followed a similar approach involving a study of existing definitions, analysis of key elements and creation of a new definition, but was clear on seeking a definition of 'scenarios' specifically. The following twenty elements were found repeatedly in the definitions reviewed by Nicol:

i. internally consistent	xi. time-limited
ii. coherent	xii. ordering perceptions
iii. plausible	xiii. based on assumptions
iv. interconnected events	xiv. different possibilities
v. relevance	xv. based on past/present
vi. challenging	xvi. based on pre-determined events
vii. representative	xvii. trend outcomes
viii. external	xviii. imagined
ix. narrative	xix. decision-making tools
x. boundaries/framework	xx. progressive

(Nicol, 2005)

Nicol then constructed a four-part statement incorporating each of these elements, which reads:

> 1. Scenarios are descriptive narratives (ix). They need to be internally consistent (i), coherent (ii) and plausible (iii), about interconnected events (iv) and relevant to the organisation (v), which are all characteristics that help make narratives meaningful and acceptable. These characteristics concern communication of the scenarios.
>
> 2. Scenarios provide boundaries or frameworks (x) for considering the future, by encompassing a range of representative possible futures (vii) but limiting the number of different possibilities for the future to be considered (xiv) and by relating to a defined time period (xi). Usually they describe the progress of events (xx), not just an end state. They concern the environment

external (viii) to the organisation. These characteristics all concern the substance of scenarios.

3. Scenario narratives are imaginative accounts (xviii) grounded in predetermined events (xvi) and trends (xvii) discerned from the past and present (xv). The stories reflect and order the varied perceptions (xii) of the participants in the process and are grounded in the present knowledge. These characteristics concern what scenarios are based on.

4. The narratives provide a structure, i.e., a framework, for the participants to explore (xiii) assumptions about and make sense of the otherwise incomprehensible multiplicity of possible future events. However, to be effective as a decision-making tool (xix) scenarios should challenge (vi) the mindsets – entrenched thinking – and assumptions of the participants. These characteristics concern the effect of scenarios. (Nicol, 2005)

Finally, Nicol provides a summarised definition:

> *"Scenarios are narratives, grounded in present knowledge, that have the purpose of communicating bounded possibilities for the future, challenging entrenched thinking and providing a framework for decision-making."* (Nicol, 2005, p. 33)

Taking account of Nicol's critique that the definition provided by Chermack and Lynham is more appropriate for a definition of scenarios than scenario planning, these

two definitions give a broadly similar account of how scenarios are understood in this research, i.e. as:

> *Informed narratives describing plausible alternative futures in which decisions can be played out, helping to challenge current thinking and assist decision making.*

The difficulty in reaching a consensus on what constitutes 'scenario planning' is evident from Nicol's literature review, where several writers are quoted as expressing discomfort with the term, suggesting alternatives including: scenario learning, scenario-based learning, scenario-driven planning, scenario building, scenario analysis, scenario process and scenario method. Nicol gives further examples of authors offering 'definitions' of scenario planning that fall short of providing any real meaning and argues that *"scenario planning has become a label, a term that can mean different things to different people"* (Nicol, 2005, p. 36).

It is certainly useful to make a distinction between the process of *building* scenarios and that of *using* scenarios to inform decision making. Scenario planning has been used to describe each of these and both of them together. In this research, no actual planning will be undertaken on the basis of the scenarios, rather it is intended that the scenarios will be disseminated for use by the target audience of policy- and decision-makers in their own planning processes. Instead, the term scenario building more accurately describes what will be conducted in the present study. Nevertheless, the term scenario planning is so pervasive in the literature that the proceeding discussion of the method uses these terms interchangeably according to the literature being discussed.

3.2 A history of futures thinking

Long before the term scenarios came into use, humans have been imagining possible future worlds. Since the advent of the written word in early civilisations, these imagined worlds have been recorded. A long tradition of utopian writing in Western culture begins with Plato's *Republic* (c. 360 B.C.E.), including works such as Augustine of Hippo's *The City of God* (413) and Thomas More's *Utopia* (1516) as well as various dystopian works such as Aldous Huxley's *Brave New World* (1932) and George Orwell's *Nineteen Eighty-Four* (1949).

As a tool for strategic planning, scenarios were first employed in a military context (Bradfield *et al.*, 2005). The earliest written works which might be said to constitute scenario planning are those of the Prussian military strategist Carl von Clausewitz in the 19th Century. Published posthumously in 1832, von Clausewitz's *On War* deals with the complexity and uncertainty inherent in real world events.

In one of the seminal works in the scenario literature, Kahn and Wiener (1967) document some of the early attempts at future thinking from the 20th Century, in the introduction to which Bell discusses a series of books entitled *"Today and Tomorrow"* written in the 1930s. These numbered around 80 books in total, covering a wide range of topics including *"food, clothes, architecture, war, peace, Jews, India, labor, machines, and even crime"* (Bell, in: Kahn & Wiener, 1967, p. xxi). According to Bell, these works took a playful attitude towards future thinking:

> *"What is striking about these volumes is their fanciful character, the*

personal and even prejudiced judgments, the airy and even comical tone, as if the idea of speculating about the future had a somewhat absurd but pleasant quality – in effect, a lack of seriousness." (Bell, in: Kahn & Wiener, 1967, p. xxi)

The serious use of scenario thinking beyond a military context would not emerge until the mid-20th Century. Bradfield *et al.* (2005, p. 797) detail two concurrent developments which they term 'The USA Centre' and 'The French Centre'. Numerous similarities and cross-overs occur between these centres, with certain methodological approaches having been pursued independently by both. Nevertheless, the geographical distinction is useful in tracing the origins and history of different schools of thought and their associated branches.

3.2.1 The USA Centre

The emergence of scenario thinking in the USA can be traced back to Herman Kahn in the 1960s. Kahn had worked since the late 1940s as a physicist and mathematician at the RAND Corporation, a defence research group which emerged in 1946 from a project originally sponsored by the US Air Force and the Douglas Aircraft company (Bradfield *et al.*, 2005, p. 798). It was here that Kahn pioneered 'future-now' thinking: *"to combine detailed analyses with imagination and produce reports as though they might be written by people in the future"* (Chermack *et al.*, 2001, p. 10).

In his role as head of Civil Defense and Strategic Planning, Kahn began developing scenarios for the Air Defense System Missile Command. The resulting scenarios led

him to the conclusion that the current US military strategy was deeply flawed, and he used the scenarios to explore alternatives to annihilation and surrender, work that Bradfield *et al. (2005, p. 798)* claim had a major influence on military planning in the 1950s. Aligica (2007) supports this claim, adding that Kahn had *"a profound impact on the US nuclear and military strategy and on strategic thinking in general"*. Kahn published his results in his book *On Thermonuclear War* (1960), believing that *"the best way to prevent nuclear war was to think through in detail what would happen if the war did occur, and publicise the results"* (Ringland, 2006, p. 13). Aligica writes that Kahn's book *"was the first book to systematically analyze the possible effects of nuclear war and the possible strategic options under various circumstances"* (Aligica, 2007). Kahn is credited as having coined the term *"thinking about the unthinkable"* in relation to his work of this period (Aligica, 2007, Bradfield *et al.*, 2005, p. 798).

In 1961 Kahn left RAND and founded the Hudson Institute think-tank, where he expanded his interests beyond military and strategic issues to encompass economics, politics and public policy. It was in this context that Kahn:

> *"became one of the founding fathers of the Futures Studies (futurology) movement contributing to the highest degree to its methodological and theoretical foundations: he developed the scenario method, the application of systems analysis and of mathematical and scientific tools to forecasting, and the organizational bases of interdisciplinary and future-oriented research"* (Aligica, 2007)

Kleiner (2003) reports that it was during this period that film-maker Leo Rosten

suggested to Kahn that he adopt the term 'scenarios', which had recently been abandoned by the film industry in favour of 'screenplay'. Ringland (2006, p. 13) explains that Kahn liked the term because of its emphasis on creating a story or myth, rather than on forecasting. The term was then introduced into the literature through his book *The Year 2000 (Kahn & Wiener, 1967)*. According to Bradfield *et al.* (2005, p. 799) the book *"has since come to be regarded as a landmark in the field of scenario planning"*. Not only did the book introduce 'scenarios' and provide one of the earliest definitions of the term, it also *"demonstrated the use of scenarios as a methodological tool"* and inspired the development of scenario techniques by other practitioners (Bradfield *et al.*, 2005).

Two other RAND employees, Theodore Jay Gordon and Olaf Helmer, also left the corporation to form the Institute for the Future in 1968. Described as having been *"encouraged by the publicity and controversy caused by Kahn's books"* (Bradfield *et al.*, 2005, p. 799), Gordon and Helmer began working with Stanford Research Institute (SRI) Futures Group and California Institute of Technology, experimenting with scenarios and becoming *"pioneers in the field of future studies"* (Bradfield *et al.*, 2005, p. 799).

The SRI, founded in 1946, was engaged in planning which incorporated operations research, economics, political strategy, science and military consulting (Ringland, 2006, p. 13). In 1958, the SRI inaugurated its Long-Range Planning Services, an environmental scanning service which later became the Scan Program operated by the spin-out company SRI Consulting Business Intelligence.

The collaboration between the Institute for the Future and SRI was originally concerned with public policy, but their work began to influence the business community where the experience of Shell provides the earliest documented use of scenarios (Bradfield *et al.*, 2005, p. 799).

According to Ringland (Ringland, 2006, p. 20), after a decade of physically-oriented planning at Shell following the Second World War, financial planning began to play a larger role between 1955-1965. By 1965, the company had developed a tool called Unified Planning Machinery (UPM) which allowed integrated planning across all of Shell's operations, from oil extraction to point-of-sale at petrol stations. However, it eventually became apparent that the results of UPM could not be relied upon as a basis for action, and Shell *"considered itself in a state of mild crisis"* (Heijden *et al.*, 2002, p. 132).

Heijden *et al.* (2002, p. 132) document how in 1967, Pierre Wack – an employee of the Group Planning team at Shell – is said to have expressed criticism of UPM, complaining that it applied statistical techniques to what were essentially unpredictable variables. As a Frenchman, Wack was familiar with the French school of scenario planning, but believed their method to be too technocratic, preferring instead the approach pioneered by Herman Kahn (Heijden *et al.*, 2002, p. 132). So, Wack teamed up with Shell colleague Ted Newland in 1971 to conduct a scenario exercise (Kleiner, 2003). Inspired by the book of the same name by Kahn, Wack persuaded the Shell Group to conduct a 'Year 2000' scenario exercise of their own, specifically for the oil industry (Heijden *et al.*, 2002, p. 132). Numerous commentators, including Kleiner, have claimed that this process demonstrated early success in foreseeing the oil crisis of

the early 1970s, enabling Shell to respond decisively, gaining an advantage over its competitors. Kleiner also argues that in future scenario planning exercises, further competitive advantage was gained from the Group's foresight of the oil price shock resulting from the Iranian revolution of 1979 and from seeing that the oil industry bubble of the early 1980s would collapse, with oil becoming more of a commodity product (Kleiner, 2003).

According to Bradfield *et al. (2005, p. 800)*, General Electric (GE) also began to experiment with scenarios around the same time. In 1971, the company produced four alternative scenarios depicting global and US economic and socio-political conditions in 1980 (Millett, 2003). However, Bradfield *et al.* (2005, p. 800) point out that Shell remain the only company whose scenario work from this period is widely documented in the literature.

3.2.2 Key methods of the USA Centre

The scenario model discussed above – pioneered by Kahn and refined by Wack and Newland at Shell – has come to be known as the 'Intuitive Logics' approach (Bradfield *et al.*, 2005, p. 799). Bradfield *et al.* detail a number of proprietary scenario models based on this approach, and suggest that *"when it comes to the intuitive logics model, a large part of the 'methodological chaos'... arises from the observation that there are almost as many ways of developing scenarios as there are practitioners in the field"* (Bradfield *et al.*, 2005, p. 800).

Along with the Intuitive Logics approach, two other significant methods evolved out of the USA Centre, in particular from the work of Gordon and Helmer, during their time at

the RAND Corporation and subsequently at the Institute for the Future. These methods are described as involving *"the probabilistic modification of extrapolated trends"* (Bradfield *et al.*, 2005, p. 800).

Gordon (1994a, p. 1) explains that 'Trend Impact Analysis' (TIA) was developed in the late 1970s to answer *"a particularly difficult and important question in futures research"*. Gordon argued that quantitative methods such as time-series techniques and econometrics were based on extrapolating historical data into the future, failing to take into account the impact of unexpected future events. Such methods, Gordon claimed, resulted in *"surprise-free projections"* which were unlikely to occur (Gordon, 1994a, p. 1). TIA was designed to enhance this process by supplementing the time-series forecast with a qualitative stage where unprecedented future events that could affect the original forecast are listed, before expert judgement is sought regarding the probability of these events occurring and their expected impact.

According to Nicol (2005, p. 38) however, TIA is focused on the impact of events on a single forecast variable and does not take into account the *"dynamic interactive interplay of interdependent events"*. As noted by Bradfield *et al.*, Gordon claims that *"the TIA method is used frequently"* (Gordon, 1994a, p. 1), however there are very few references in the literature relating to TIA in the context of scenarios.

Cross Impact Analysis (CIA) was developed in 1966 by Gordon and Helmer while still working at the RAND Corporation (Gordon, 1994b, p. 1). CIA was initially designed as a game for Kaiser Aluminum and Chemical Company. A summary of the game, provided by Gordon, helps explain the CIA method. The game, called Future, consisted

of a set of cards each depicting a future event. These events were given a probability value by Gordon and Helmer, and players would roll a die which displayed probability values rather than numbers. If the probability value shown on the die was equal to or greater than the probability of the event occurring, then the event 'occurred'. If an event occurred, the card was turned over to reveal a set of cross impacts i.e. changes to the probability of other events in the game.

In 1968, Gordon and Hayward built a computer program of the CIA method (Gordon, 1994b, p. 1). They were now able to run through many iterations of the game, with events being selected in a random order each time such that different outcomes were obtained. By keeping a record of the number of times an event occurred across a large number of iterations, a final probability could be assigned to each event.

According to Gordon (1994b, p. 2), numerous variations of CIA have since been developed by other teams. Some of these go beyond the forecasting of specific events to incorporate a scenario element, such as EXPLOR-SIM developed at the Battelle Institute in Geneva, and SMIC (Cross Impact Systems and Matrices) developed by Duperrin and Gabus in France. Other CIA variations emerged as part of the French Centre, discussed below.

3.2.3 The French Centre

Bradfield *et al.* (2005, p. 802) write that the development of the French Centre of scenario thinking began with philosopher Gaston Berger in the 1950s at the Centre d'Etudes Prospectives, a school which he had founded. Berger developed a scenario method for long-term planning which he called 'la prospective'. According to Bradfield

et al., la prospective – as in the case of the USA Centre – was developed in response to the failure of conventional forecasting techniques:

> *"Berger was concerned with the long-term political and social future of France and the underlying philosophical premise of his work was that the future is not part of a 'predetermined temporal continuity' but something which is to be created and which can be 'consciously modeled to be humanly beneficial'. The primary objective of the Prospectives centre was to formulate an acceptable scenario-based methodology for developing positive images or 'normative scenarios' of the future and to lead these images into the political arena where they could serve as a guiding vision to policy makers and the nation, providing a basis for action."* (Bradfield *et al.*, 2005, p. 802)

Despite Berger's death in 1960, the Centre d'Etudes Prospectives continued to apply la prospective to public policy and planning issues. Scenario thinking was introduced into the Fourth French National Plan (1960-1965) by Pierre Masse, then director of French National Economic Planning (Bradfield *et al.*, 2005, p. 802). Bertrand de Jouvenel then joined the Centre d'Etudes Prospectives in 1966, having previously founded the Comite Internationale Futuribles (Futuribles International Committee) which would lead to the formation in 1967 of the Association Internationale de Futuribles. According to Bradfield *et al. (2005, p. 802)*, De Jouvenel contended that the future of a nation was often determined by small, dominant political groups, but that this could be avoided if positive scenarios were developed to serve as a blueprint for a better future for ordinary people.

Michel Godet became head of the Department of Futures Studies at defence firm SEMA in 1974 (Chermack *et al.*, 2001, p. 19). He soon began developing scenarios for several large French groups including Électricité de France (EDF) and Elf Aquitaine (Elf). Chermack *et al.* write that Godet's scenario work was based on la prospective, however he began to establish his own method, developing various mathematical and computational tools to bring a more probabilistic approach to scenario thinking.

Chermack *et al.* (2001, p. 19) describe the approach pioneered by Godet, which took the form of a structural analysis in three phases. Phase One involves building a system of interrelated elements by identifying internal and external variables. These elements are quantified and compiled into a database. A cross-impact matrix is then used to study the interactions between variables. Phase Two identifies key variables and strategies. Software, detailed below, is used to estimate the subjective probabilities of different combinations of variables and thus reduce uncertainty. Phase Three involves the development of the scenarios. These begin as sets of hypotheses which are tested against the data before being fleshed out to describe the path that would lead from the present to this future scenario. The software tools developed by Godet to assist in this included: Micmac to identify key variables, Mactor to analyse actors' strategies and Smic-Prob-Expert to determine the probability of scenarios (Bradfield *et al.*, 2005, p. 803).

3.2.4 Futures thinking summary

Scenario planning can be traced back to the middle of the 20th century, where two schools emerged independently. The USA Centre initiated by Herman Kahn involved

the development of the popular Intuitive Logics approach, as well as Trend Impact Analysis and Cross Impact Analysis. The French Centre and its 'la prospective' approach, was established by Gaston Berger and continued after his death by Bertrand de Jouvenel at the Centre d'Etudes Prospectives, before being modified by Michel Godet to form a more probabilistic approach to scenario development.

The approach adopted for the qualitative scenario narrative development in this research is the Intuitive Logics approach, pioneered by Shell Group, which traces its existence back to the work of Herman Kahn. As explained by Bradfield *et al.*: *"when it comes to the intuitive logics model... there are almost as many ways of developing scenarios as there are practitioners in the field"* (Bradfield *et al.*, 2005, p. 800). The particular methodology developed for this research is therefore explained in detail later. In addition, this research also includes a quantitative component, intended to complement the qualitative narratives by providing illustrative figures for key economic variables. As explained later, the quantitative approach involves the use of a time-series model, with assumptions for the variables informed by the qualitative storylines. In this sense, the approach is reminiscent of the Trend Impact Analysis technique developed by Gordon and Helmer.

Although the French Centre also developed tools to synthesize qualitative and quantitative methods, these took a more probabilistic turn after Michel Godet, a controversial approach given the deep uncertainty inherent in any scenario process. These probabilistic approaches have therefore been avoided in this research. In summary, the methodology adopted in this study is more closely aligned with the methods and techniques developed as part of the USA Centre, rather than those of the

French Centre.

3.3 Relevant Scenario Studies

During an early literature scanning exercise in 2008, a range of scenario and futures studies from within the previous ten years were examined for their potential role in informing an appropriate methodological approach for the present study. A selection of these (in chronological order of publication) is listed below:

- Which World?: Scenarios for the 21st Century - Global Destinies, Regional Choices (Hammond, 1998).
- China's Futures: Scenarios for the Worlds Fastest Growing Economy, Ecology, and Society (Ogilvy & Schwartz, 2000).
- Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change (Nakicenovic & Swart, 2000).
- Energy for Tomorrow: Powering the 21st Century (DTI, 2001).
- Tyndall Centre, Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report (Hulme *et al.*, 2002).
- Foresight Futures 2020: Revised scenarios and guidance (DTI, 2002).
- Tyndall Centre, UK Electricity Scenarios for 2050 (Watson, 2003).
- Surrey in 2020 (SAMI Consulting, 2004).
- Scenarios for Europe in 2020 (Ringland, 2004).
- UKSHEC Hydrogen Visions (Eames & McDowall, 2005).
- Tyndall Centre, World Transport Scenarios project (Timms *et al.*, 2005).
- Using energy scenarios to explore alternative energy pathways in California (Ghanadan & Koomey, 2005).
- Decarbonising the UK: Energy for a Climate Conscious Future (Tyndall Centre, 2005).

- Program on Technology Innovation: Electric Power Industry Technology Scenarios (Electric Power Research Institute, 2005).
- Decentralising UK Energy (Greenpeace, 2006).
- Energy Technology Perspectives: Scenarios and Strategies to 2050 - In Support of the G8 Plan of Action (OECD/IEA, 2006).
- Electricity Network Scenarios for 2020 (SuperGen, 2006).
- The Role of Electricity: A new Path to Secure and Competitive Energy in a Carbon-Constrained World (eurelectric, 2007).
- Technology & Policy Implications of Global Energy Scenarios that Stabilize Climate Change (Hummel, 2007).
- Japan Scenarios towards Low-Carbon Society (LCS): Feasibility study for 70% CO2 emission reduction by 2050 below 1990 level (NIES, 2007).
- GEO-4 Global Environmental Outlook: environment for development (UNEP, 2007b).
- Shell Energy Scenarios to 2050 (Shell, 2008).
- Long Term Electricity Networks Scenarios (LENS) (OFGEM, 2008).
- Environmental Outlook to 2030 (OECD, 2008).

Many of these studies were informative during the development of an appropriate methodological approach in this research, described in Chapter 5, although a detailed account of each of these scenario studies is beyond the scope of this research. Instead, the next section provides an insight into the evolution of ideas that can occur through scenario planning by focusing on a series of scenario studies produced by one organisation in particular.

3.3.1 Scenarios at Shell

The emergence of scenario planning at Shell in the 1970s was documented above.

Since 1992, Shell have published a set of scenarios roughly every three years. As the organisation often attributed with the leading role in popularising the scenario method, a short summary of the Shell scenarios to date provides a useful insight into the shifting focus of their scenario planners in response to an ever changing business environment.

In 1992, Shell published a set of two scenarios to 2020 influenced by global political events, most notably the fall of the Berlin Wall. The scenarios pivoted around whether economic and political liberalisation would be embraced across the world, or resisted; these scenarios were named 'New Frontiers' and 'Barricades' respectively (Shell, 1992).

By 1995, the forces of globalisation, liberalisation and technology seemed irresistible and the Shell study of that year echoed the words of Margaret Thatcher: There Is No Alternative (TINA) (Shell, 1995). A new pair of 2020 scenarios were published, termed 'Just Do It!' and 'Da Wo (Big Me)'. The first scenario describes a world characterised by US-style capitalism, rewarding innovation and creating a space for individual creativity. The alternative scenario describes a world in which companies and governments recognise the need for longer-term relationships of trust, a world in which Asian societies are at an advantage due to existing social and business structures of this nature.

Just as the 1995 scenarios had assumed a 'winner' from the 1992 set (New Frontiers), in 1998 Shell developed two new 2020 scenarios, based upon the success of Just Do It! (Shell, 1998). In 'The New Game' the world would be shaped more by strengthened global institutions and global rules favouring *"open and transparent markets, globalisation, commoditisation" (Shell, 1998, p. 8)*. In 'People Power' the world would

be dominated more by the individual forces of wealth, choice and education, with *"consumer choice, rising personal expectations, and grassroots pressure groups [able to] overwhelm attempts to impose rules and overshadow old institutions"* (Shell, 1998, p. 9).

The scenarios published in 2001 built on the economic and political dimensions of earlier scenarios, but added a social dimension (Shell, 2001). The two scenarios presented were 'Business Class', characterised by *"a globally interconnected meritocracy based on individual freedom and the American dream"* and 'Prism', with *"many networks reflecting the persisting power of culture and history"* (Shell, 2001, p. 1).

In Global Scenarios to 2025 (Shell, 2005), Shell explored the interplay between three forces: market incentives, state coercion or regulation, and communities. These forces were seen to have competing objectives: efficiency, security, and social cohesion and justice respectively. Shell visualised these forces as corners of a 'Trilemma Triangle' (Figure 3.1). The interplay between these forces then defined the scenarios, i.e. each scenario represented an edge of the triangle, characterised by *"two wins, one loss"* (Shell, 2005).

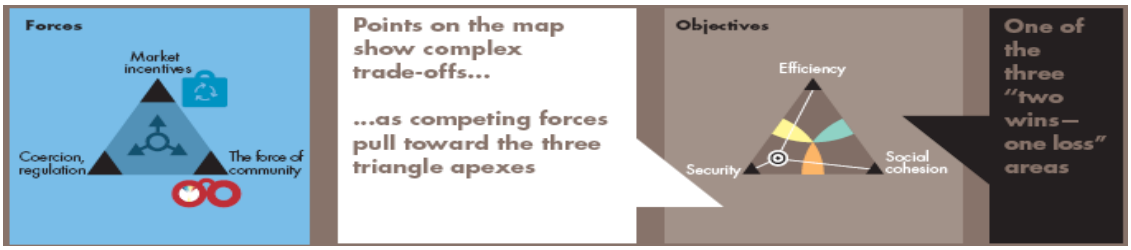


Figure 3.1: Shell's Trilemma Triangle (Shell, 2005)

The three scenarios were as follows: 'Low Trust Globalisation' represented a compromised between the efficiency of market incentives and the security of state coercion/regulation (with communities losing out); in 'Flags', a compromise was reached between state coercion/regulation and the social cohesion/justice of communities (with market incentives losing out); while 'Open Doors' was characterised by a compromise between market incentives and communities (with state coercion/regulation losing out).

In 2007, Shell published "Signposts", a supplement to the 2005 scenarios which discussed a selection of recent global developments, attempting to make sense of these through the framework of the Trilemma Triangle (Shell, 2007). The impacts of two particular events – 9/11 and Enron – had led to an increased demand for physical security along with tighter market regulation. Additionally, the collapse of the Doha trade negotiations was seen as indicative of national identity and social cohesion overruling economic efficiency. The team interpreted this combination of events by arguing: *"we are therefore currently living in a world that predominantly reflects the Low Trust Globalisation scenario, with a strong component of Flags"* (Shell, 2007, p. 4). Nevertheless, *"significant fault-lines and opposing pressures"* between the three forces had been revealed, meaning that the future path *"remains highly uncertain"* (Shell, 2007, p. 4).

In the introduction to the 2008 scenarios, the fault-lines identified in Signposts were said to be adding to the pressures on energy supply, energy demand and the environment, brought on by population growth and economic development (Shell, 2008). According to Shell, there were *"three hard truths"* that could no longer be

ignored, namely: Step-change in energy use; Supply will struggle to keep pace; Environmental stresses are increasing (Shell, 2008, p. 8). These three areas – demand, supply and the environment – are seen as the key drivers of the energy world. The scenarios through to 2050 reflect the *"revolutionary transitions and considerable turbulence"* (Shell, 2008, p. 10) that will result from the enormous changes affecting these. In the first scenario, 'Scramble', policy-makers fail to address energy efficiency and greenhouse gas emissions until forced into action due to severe supply shortages and climate shocks respectively. In the alternative scenario, 'Blueprints', local organisations at grassroots, city and regional levels take the initiative. As these gain momentum, they are brought together at a national level, resulting in effective market-based mechanisms to address energy efficiency and emissions.

In their most recent publication at the time of writing, Signals & Signposts, Shell provide an update to the 2008 scenarios to take account of new uncertainties arising from the 2008 financial crisis (Shell, 2011). A range of economic outlooks are provided in light of the crisis, including 'Deeper and longer', 'Severe-yet-sharp', and 'Depression 2.0', although this latter outlook is described as unlikely.

Different lessons might be drawn from this chronological summary. On the one hand, the sequence makes clear that many of the scenario studies begin by selecting a 'winner', i.e. one of the possible worlds envisioned in a previous study. Although this is a judgement made by the Shell team themselves, this observation might support the claim that scenario planning can prove successful in identifying broad 'themes' emerging or solidifying within the global landscape. On the other hand, it is clear that however well-resourced, scenario practitioners are generally incapable of detecting the major 'events'

that will retrospectively come to be considered as world changing. Although the Shell scenario team of the 1960s and 1970s were credited with foreseeing the risk of oil crises during that period (Kleiner, 2003), in this more recent series of studies two of the most pivotal moments in history - 9/11 and the 2008 financial crisis - have instead led to a rethink and revisioning of earlier scenarios. These game-changing events are often referred to as 'Black Swans', although some analysts would argue that the financial crisis was perfectly detectable if only the correct economic model had been applied to the analysis (Taleb, 2011). Thus, in any scenario study, although some key themes may well prove to have been identified correctly, by missing key events that change the landscape so profoundly, other emerging themes will necessarily go undetected. All of which goes to support the argument, explored later, that scenarios should never be an exercise in prediction, but rather in sensemaking of the uncertainties of the present.

In terms of providing further background to the particular areas of interest to this study, it is worth turning attention to two reports which were published in 2009, once this study was underway.

3.3.2 A critique of low carbon energy scenarios

The first report offers a critique of low carbon energy scenarios, with a review and analysis of 21 such scenario studies (Hughes *et al.*, 2009). Hughes *et al.* argue that these studies have made an important contribution by beginning to imagine and articulate a range of low carbon futures, thus prompting consideration of the necessary first steps. Nevertheless, the critique identified several shortcomings that must be addressed if low carbon energy scenarios are to move beyond this imaginitive stage to

offer strategic insight regarding appropriate actions to be undertaken by specific actors. The authors identified three main obstacles to be overcome.

Exogenous constraints

Many of the studies reviewed by Hughes *et al.* portray scenarios that are bounded by a 'normative exogenous constraint', typically a carbon emissions reduction target. The authors warn that such a constraint *"creates an illusion of inevitability"* regarding the achievement of that goal, which can *"diminish and underestimate the significance of certain potentially highly significant obstacles"* (Hughes *et al.*, 2009, p. 39). Crucially, by imposing a target as an exogenous constraint, it is removed from the interplay of actors and their motivations, and elevated to a realm where it is no longer clear how that goal might be brought about by particular actors and institutions within the system. The authors compare this to the ancient Greek concept of 'deus ex machina', a storytelling device where *"the characters within the drama are unable to resolve a situation through their own efforts, but are saved by a force completely external to the previously established plot, and thus completely implausible within the structure of the drama previously established"* (Hughes *et al.*, 2009, p. 40).

If scenarios are to portray the transition towards certain goals, then these should first be attributed to particular actors in the scenario, such that the supporting and conflicting forces that might affect the achievement of these goals can be explicitly drawn out.

High level trends

Hughes *et al.* argue that the scenario studies reviewed are *"overly reliant on high level trends... [including] ...consumerism, environmentalism, globalisation, fragmentation*

etc" (Hughes *et al.*, 2009, pp. 4, 40). Typically, two of these trends are selected as bisecting axes to form a 2x2 matrix.

The authors question the ability of high level trends to generate meaningful representations of the world. In any ongoing social/technical/economic/political development, a multitude of conflicting forces operate simultaneously. Over time, some of these forces will dominate, some will fade, others will adapt and yet more will emerge. With the benefit of hindsight, it may be possible to identify and isolate those dominant forces for the purposes of summarising key historical developments. Thus, high level trends may be useful in developing narratives intended to provide a broad retrospective summary of events. However, the dynamic interplay of a multitude of forces is precisely what is required in thinking prospectively, for only then is it possible to identify points of intervention and gain strategic insight for future action. Therefore, *"an actor-based perception of the evolution of events would be much more useful than one based in high-level trends"* (Hughes *et al.*, 2009, p. 41).

Co-evolution of social, technological, economic and political factors

In the 21 scenario studies investigated by Hughes *et al.*, the focus is predominantly on the development of the technological energy system, at the expense of other considerations such as social, political and environmental factors. Where social and political dynamics are included, this is done either in a post-hoc manner, where a technology mix is proposed with a socio-political landscape then painted around this, or else a socio-political system is described first and a technology mix chosen as deemed appropriate. In both cases, such descriptions can fail to account for the dynamic co-evolution of these systems.

In reality, social systems are not constructed independently of technological systems. Instead, the various systems (social, technological, economic, political) develop in an *"iterative and reflexive"* manner (Hughes *et al.*, 2009, p. 44). Thus, what is politically feasible depends on what is socially acceptable, technologically possible and so on. Similarly, what is technologically (and economically) feasible depends on policy interventions, social trends and more.

Hughes *et al.* stress again the importance of understanding the role of different actors in this co-evolution process, a demand that is all the more important in the present research given the explicit consideration of psychological factors among those other systems.

Lessons for lifestyle scenarios

A common theme across all three characteristics described above is the need to better portray the role of actors in bringing about change. Whether as citizens, consumers, communities, firms, local authorities or governments, the developments that will shape the future should be attributable to these actors, and not merely abstracted to megatrends, if scenarios are to provide opportunities for strategic insight. If previous scenario developers might be forgiven for focusing on technology given the supply-side nature of their studies, any scenarios depicting the carbon intensity of lifestyles must clearly incorporate the role of actors in society if they are to achieve credibility among decision-makers.

As well as the actors themselves, the social, technological, economic and political systems should be represented in terms of a process of dynamic co-evolution. This

representation will be aided from the outset by efforts to portray actors and their motivations. However, special care should be taken to ensure this co-evolution of systems is represented explicitly.

3.3.4 UKERC lifestyle scenarios

The second report of interest is a scenario study conducted by the UK Energy Research Centre (UKERC). Whereas the focus of previous energy scenarios has tended to be on the technological system, the UKERC scenario study also attempts to portray the role that lifestyles might play in reducing energy demand to 2050 (UKERC, 2009b). The focus of these lifestyle scenarios is on household energy use and personal transport, *"the forms of energy most directly controlled by the individual"* (UKERC, 2009b, p. 104).

The report details a series of assumptions regarding changes in energy behaviour by 2050. For household energy use, these include: a high standard of insulation; social unacceptability of over-heating; low-carbon heating systems; phasing out of incandescent lighting; improved efficiency of appliances; rolling out of smart meters.

For personal transportation, assumptions include: social norms demoting large cars, single occupancy, speeding and air travel; efficient, low-energy transport systems replacing petrol and diesel car-based systems; increased localism resulting in shorter average distances; new models of car ownership; increased role of information and communication technology in making cost and energy use transparent; radical changes in work patterns and business travel including teleworking and video conferencing; the appeal of air travel fading due to social unacceptability and inconvenience.

These assumptions are then used to investigate energy demand for 2050 using three different models. The report explains how the general assumptions listed above are translated into more specific assumptions suitable for input into these models.

This scenario complements the range of earlier scenarios focusing more on the technological energy system and makes an important contribution to the discussion on energy systems, energy policy and economics by thinking about the opportunities for reducing energy demand (and thus carbon emissions) through lifestyle change. What is absent in this scenario though, is a meaningful reflection on how lifestyle change might come about. The report states that: *"If Government is pursuing ambitious carbon emissions, this is likely to be consistent with social acceptance, and therefore it is probable that attitudes and personal behaviour will change."* (UKERC, 2009b, p. 103). By way of an explanation for the assumptions given for 2050, the following brief synopsis is provided:

> *"The basic storyline of the scenario is of steadily changing social attitudes to the environment, with increasing understanding leading to a widely held belief that human activity is having a serious impact on the global climate. This is followed by a broad social consensus that personal consumption is a key driver and needs to change. We do not assume complete social agreement, nor widespread frugality, but majority support geared to improving quality of life without increased material consumption in rich countries. Starting with some key opinion leaders, social norms emphasise 'green housing'; and 'community living' and 'accessibility' replace 'mobility'*

as aspirations." (UKERC, 2009b, p. 104)

In the executive summary, the report makes it clear that further work remains to be done:

> *"There is little existing evidence of how to bring about comprehensive changes in people's lifestyle and behaviour that will lead to reduced energy demand and CO2 emissions... ...Research is needed to understand the conditions under which people would voluntarily take on lifestyles embodying these types of behaviour."* (UKERC, 2009b, p. 7)

It therefore remains an aim of this research to add to this literature by exploring the specific conditions under which lifestyle change might occur, and in which directions. In this way, it will be possible to examine the intricacies of behaviour change in relation to other socio-technical systems and to better inform policy and decision-makers on possible points of intervention en route to a low carbon future.

Having drawn lessons from the literature for this research, the following section discusses some of the key characteristics of the scenarios developed here.

3.4 Scenario characteristics

A scenario typology can offer a comprehensive and comprehensible framework for communicating the nature and characteristics of the proposed scenario study (van Notten *et al.*, 2003, p. 423). This has the added advantage of allowing heterogenous scenario studies to be compared to one another in order to draw out similarities and

differences. The use of a scenario typology can also assist in informing stakeholders on why a particular approach has been chosen over the alternatives.

An early typology for scenarios was proposed by Ducot and Lubben (1980, p. 51), consisting of three axes with the following poles:

> *Exploratory – Anticipatory:* this axis considers the temporal view. An exploratory scenario begins with a set of basic hypotheses in the present and traces the effects of these into the future, while an anticipatory scenario begins with a set of basic hypotheses about the future and works backwards to identify which key events could be responsible for this situation unfolding.
>
> *Descriptive – Normative:* this refers to the inclusion of values in describing the scenarios. A descriptive scenario attempts to represent a 'value-free' account of how events might unfold, while a normative scenario explicitly takes into account the values of the scenario developer in describing a desirable future world.
>
> *Trend – Peripheral:* this final axis considers the conventionality of the scenarios. A trend scenario is based on current trends extrapolated into the future, while a peripheral scenario is derived from the consequences of more extreme and unlikely events.

The 3-axis model also allows for midpoints, so that any given scenario could be based in one of three categories for each axis, allowing a total of 27 'types' of scenario (3x3x3)

(Ducot & Lubben, 1980, p. 54). This model is represented by a cube with 27 points of intersection, as in Figure 3.2:

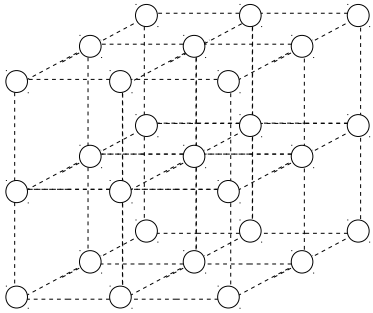


Figure 3.2: Ducot and Lubben's Typology Cube (1980, p. 54)

Other scenario theorists have proposed broadly similar models, with some variation. Some 23 years after Ducot and Lubben, a significantly updated scenario typology was proposed by van Notten *et al.* (2003). Explaining why an updated scenario typology was necessary, the authors argued that *"existing typologies do not sufficiently capture the diversity in contemporary scenario analysis*" (van Notten *et al.*, 2003, p. 424). In particular, the existing typologies were criticised for being too broad, such that a variety of distinct scenario types are often clustered together within the same category. To develop their updated scenario typology, van Notten *et al.* reviewed approximately 70 scenario studies from the literature, using these to *"distil the features common to most scenario development processes"*. These common features were then used to compose the new typology. The typology consists of three overarching themes, each with a set of characteristics. The three themes are the project goal (why), the process design (how) and scenario content (what). The Scenario Characteristics identified within each of these themes are detailed in Table 3.1.

Themes	Scenario Characteristics		
Project Goal (Exploration vs Decision Support)	I	Inclusion of Norms	Descriptive vs Normative
	II	Vantage Point	Forecasting vs Backcasting
	III	Subject	Issue-based, Area-based, Institution-based
	IV	Time Scale	Long Term vs Short Term
	V	Spatial Scale	Global/Supranational vs National/Local
Process Design (Intuitive vs Formal)	VI	Nature of the Data	Qualitative vs Quantitative
	VII	Method of Data Collection	Participatory vs Desk Research
	VIII	Resources	Extensive vs Limited
	IX	Institutional Conditions	Open vs Constrained
Scenario Content (Complex vs Simple)	X	Temporal Nature	Chain vs Snapshot
	XI	Nature of the Variables	Heterogeneous vs Homogeneous
	XII	Dynamics	Peripheral vs Trend
	XIII	Level of Deviation	Alternative vs Conventional
	XIV	Level of Integration	High vs Low

Table 3.1: van Notten et al.'s (2003) Updated Scenario Typology

This scenario typology is not without its shortcomings, as articulated below. However, it has been adopted as a contingent framework for communicating the characteristics of the scenarios to be developed in this research.

3.4.1 Project goal

The first set of scenario characteristics relate to the project goal, or 'why' the scenarios are being developed. These consist of: Inclusion of Norms, Vantage Point, Subject, Time Scale and Spatial Scale.

Inclusions of Norms

This first characteristic is perhaps also the most contentious, for it may be argued that scenario development is inherently normative. For van Notten *et al.*:

> *"[It] can be justifiably argued that all scenarios are normative as they consist of the interpretations, values, and interests of the scenario developers. Consequently, for our typology we distinguish between descriptive scenarios that explore possible futures, and normative scenarios that describe probable or preferable futures."* (van Notten *et al.*, 2003, p. 429)

This distinction is problematic however, for it is repeatedly argued in the literature that the very definition of scenarios requires that they be plausible (see for example Chermack & Lynham, 2002, Nicol, 2005 for a review of definitions). Accordingly, all scenarios (not just descriptive scenarios) should share the characteristic of being possible. Additionally, whereas van Notten *et al.* define normative scenarios as describing probable futures, this is a quality we might instead expect to find associated with descriptive scenarios. Thus, a better distinction might have been made between exploratory (probable) futures and normative (preferable) futures. A similar distinction is made by Rotmans *et al. (2000)*:

> *"Descriptive scenarios state an ordered set of possible events irrespective of their (un)desirability, whereas normative scenarios take values and interests into account, often reasoning from specific targets to be reached."* (Rotmans *et al.*, 2000, p. 812)

The issue of probability remains contentious, some practitioners aim to imbue descriptive scenarios with an assessment of their probability, while others prefer to avoid this altogether. Either way, the distinction of interest here is the sense of 'directedness', i.e. descriptive scenarios may be said to 'unfold' from knowledge about the present and about the driving forces involved, without any preconceived end-state on the part of the scenario developers; meanwhile, normative scenarios begin with the (un)desirable end-states and focus on finding those paths which it is believed will lead there. In terms of the inclusion of norms then, descriptive scenarios are influence by the norms of the scenario developers only implicitly (and as little as possible), while normative scenarios are influenced explicitly by the norms of the developers.

In developing scenarios of the carbon intensity of UK lifestyles for this research, in particular considering their potential role in influencing policy- and decision-makers, it is tempting to opt for the normative approach, enabling clear recommendations for paths to a low carbon society. At the same time though, it may be argued that the best way to enable clear thinking on suitable policy alternatives is to provide an impartial assessment of the different paths that our lifestyles might take under a variety of conditions. Moreover, it may be that a set of normative scenarios would engender a sense of complacency regarding the prospects of reaching such a low carbon society, thus having the opposite effect from that intended.

In light of these considerations, a descriptive approach can be seen to hold two main advantages over a normative one. Firstly, the effort of following a scenario building process that prizes objectivity over subjectivity (even if true objectivity can never be fully attained) helps to ensure the legitimacy and acceptability of the scenarios among

an academic audience which may hold some scepticism towards the scenario technique. Secondly, any scenarios resulting from a normative approach may be seen as prescriptive, and may fail to engage policy-makers in the intended fashion, i.e. as artefacts to be used to challenge existing thinking rather than as forthright recommendations. Instead, descriptive scenarios merely provide a 'sandpit' or testbed for policy- and decision-makers, enabling a sense of ownership over any agreed policy outcomes.

Based on these considerations, this research will involve ***descriptive scenarios***.

Vantage Point

This characteristic tends to go hand-in-hand with the previous one, as the vantage point is largely determined by the inclusion (or otherwise) of norms. Normative scenarios are typically backcasting scenarios, beginning with the horizon year and working backwards from there. Descriptive scenarios are typically forecasting scenarios, in that they begin from the present and work out the implications of interactions between various forces over time until the horizon year. Indeed, so inextricably linked are these two characteristics that van Notten *et al.* acknowledged that *"some of the [typology] characteristics overlap... For example, a backcasting scenario is invariably normative"* (van Notten *et al.*, 2003, p. 439). Nevertheless, these characteristics have been retained as distinct entries in the typology, thus in the interests of thoroughness it is necessary to establish that the scenarios developed in this research shall be ***forecasting scenarios***.

Subject

This characteristic is somewhat self-selecting in the case of this research. Although it has been estabished that the focus is on the UK, the predominant concern here is with lifestyles, thus these scenarios are to be ***issue-based***, rather than area- or institution-based.

Time Scale

According to van Notten *et al.*, a short term scale is 3-10 years, while a long term scale is anything over 25 years. Thus the scenarios developed here are on a ***medium-term*** scale.

Spatial Scale

The spatial scale refers to the geographical extent of the scenario study. This can be global, international, national, regional, local etc. In this research, the geographical area of interest is the UK, thus the scenarios developed here will be at a ***national scale***, even if global factors will play a significant role.

3.4.2 Process Design

This second set of characteristics addresses the process design, in other words 'how' the scenarios will be developed. These characteristics are: Nature of the Data, Method of Data Collection, Resources, Institutional Conditions.

Nature of the Data

This characteristic distinguishes between qualitative and quantitative data. The nature of the data used depends on the object of the study, and van Notten *et al.* write:

> *"Qualitative or narrative scenarios are appropriate in the analysis of complex situations with high levels of uncertainty and when relevant information cannot be entirely quantified. For example, information that relates to human values, emotions, and behaviour is invariably incorporated in qualitative rather than quantitative scenarios"* (van Notten *et al.*, 2003, p. 431)

The wide range of factors to be investigated in this study (including human values and behaviour) makes it clear that the nature of the data will be ***qualitative***. Nevertheless, a quantitative model will also be employed to provide illustrative emissions and expenditure figures.

Method of Data Collection

In this characteristic, van Notten *et al.* distinguish between a participatory approach and desk research. These two approaches are not mutually exclusive though. Different stages in this research will involve participatory approaches and desk research alternately. The first stage of data collection will involve interviews with experts for example, while a later stage involves desk research on candidate scenario uncertainties. Therefore this study does not adhere to either pole of this characteristic but involves both ***participatory*** **and** ***desk research*** methods, in a complementary role.

Resources

The resources available in a scenario study include finance, time and competencies, and van Notten *et al.* distinguish between extensive and limited resources. While the period

of time given over to this research might exceed that of some other scenario studies, many of those studies will involve more than one scenario 'developer' as part of a larger team, perhaps supported by considerable organisational financing. A direct comparison between studies for this characteristic is therefore difficult.

Institutional Conditions

The institutional conditions describe the (internal) political environment of the organisation, and the freedom that can be exercised by the scenario team in conducting the scenarios. Institutional conditions may be constrained if there is pressure on the team to produce particular results, for example. In the case of this research, there is no such 'controlling organisation' and so the institutional conditions can be said to be ***open***.

3.4.3 Scenario Content

This final set of characteristics describes the scenario content, or 'what' the scenarios look like. These characteristics are: Temporal Nature, Nature of the Variables, Dynamics, Level of Deviation, Level of Integration. These characteristics are necessarily less concrete at the outset, as the nature of the scenario narratives only become clear once the process is underway, so there must be sufficient leeway to allow the scenarios to be developed in a way that reflects the outcomes of the earlier stages.

Temporal Nature

This characteristic is concerned with whether the narratives describe the chain of developments of each scenario over the course of time, or instead provide a snapshot of the end-state. It was the intention in this research to provide not just the end-state of each scenario, but also the story of how these may have developed, and this objective

was indeed achieved. This research therefore provides a set of ***chain scenarios***.

Nature of the Variables

A scenario study may address a multitude of variables of different types, or the variables may instead be limited in both number and type. The terms homogenous and heterogenous are used here by van Notten *et al.*, even though these terms seem to address only the type of variables in relation to each other and not the number of variables. Nevertheless, we can say that the variables in this study are varied in type, addressing the external factors and consumption categories of interest. As such, this research will involve a ***heterogenous set of variables***.

Dynamics

This is yet another problematic characteristic, for it refers to the extent to which the scenarios deviate from a business-as-usual scenario. Clearly, in a context where the value of scenarios is considered to be their ability to challenge conventional thinking, there is a value judgement implicit in this characteristic. Consequently, trend scenarios, those which extrapolate in a linear fashion from existing trends, are less useful than peripheral scenarios, which are discontinuous and often include extreme events. In some ways it would be disingenuous to make a deliberate effort to push the scenarios in either direction, as the dynamics should be something that emerge as a consequence of the interaction between scenario inputs, unknown at the outset. However it can be useful, once the scenario narratives have been developed, to reflect on the dynamics portrayed therein and to ask what their role might be in challenging entrenched thinking. In the event, the coordinator of a scenario building process may not be the most appropriate person to pass judgement on the dynamic nature of their work, however:

this research makes an attempt to portray ***peripheral*** scenarios.

Level of Deviation

The level of deviation reflects the variation between the scenarios produced. Conventional scenarios involve little deviation from one another, and may be used where the scenario team wishes to fine-tune a particular strategy. Alternative scenarios on the other hand present markedly different views of the future, thus providing a series of distinct testbeds for considering the implications of decision making. As with Dynamics, there appears to be an implicit value judgement here in favour of alternative scenarios and similarly it seems inappropriate for a scenario coordinator to judge the level of deviation apparent in their own work. Nevertheless, the attempt in this research was to develop ***alternative*** scenarios.

Level of Integration

The level of integration describes the extent to which the various scenario inputs are interwoven over the course of the scenario timeline. A high level of integration would involve a great deal of interaction between these inputs, while a low level of integration might portray the inputs as distinct developments without attempting to offer any insight into how these might effect each other in the process. In the case of this scenario study, a ***high level of integration*** between the scenario inputs was attempted in order to achieve a series of interwoven narratives rather than a list of discrete developments for each scenario.

3.4.4 Typology summary

Although the typology has its flaws, the adoption of a framework for thinking through

each characteristic and the alternatives available helps to clarify and guide the process of scenario building. In addition, using a typology such as this enables more effective communication and dissemination of the process to stakeholders. The characteristics of the scenarios developed in this research are summarised in Table 3.2.

Themes	Scenario Characteristics		
Project Goal (Exploration vs Decision Support)	I	Inclusion of Norms	***Descriptive***
	II	Vantage Point	***Forecasting***
	III	Subject	***Issue-based***
	IV	Time Scale	***Medium Term***
	V	Spatial Scale	***National***
Process Design (Intuitive vs Formal)	VI	Nature of the Data	***Qualitative (and Quantitative)***
	VII	Method of Data Collection	***Participatory and Desk Research***
	VIII	Resources	*unspecified*
	IX	Institutional Conditions	***Open***
Scenario Content (Complex vs Simple)	X	Temporal Nature	***Chain***
	XI	Nature of the Variables	***Heterogeneous***
	XII	Dynamics	***Peripheral***
	XIII	Level of Deviation	***Alternative***
	XIV	Level of Integration	***High***

Table 3.2: van Notten et al.'s typology with characteristics for this study highlighted

3.5 Chapter summary

The scenario planning technique emerged in the 1950s and 1960s, through two distinct schools. In the USA, the term 'scenarios' was introduced and pioneered by Herman Kahn, before Shell popularised the method through its use in planning exercises which helped the organisation foresee the oil crises of the 1970s. Meanwhile in France, another school developed in parallel, eventually being modernised by Michel Godet into a more probabilistic approach. The scenario planning actitivies at Shell continue to the

present day, and an examination of the group's scenario studies since 1992 gives an insight into the evolution of ideas within the team. Meanwhile other publications in the scenario literature point more directly to some of the key lessons for a study focussed on the carbon intensity of lifestyles, lessons which are articulated above. Finally, through the use of a scenario typology, the characteristics of the scenarios developed in this research have been outlined to better enable cross comparison with similar studies now or in the future.

In the next section, the secondary research question regarding the epistemological contribution of scenarios is addressed.

4. Epistemology

The present research includes qualitative and quantitative components. The qualitative component consists of a series of scenario narratives through to 2030, while the quantitative component seeks to provide illustrative expenditure and emissions figures to accompany these. It therefore seemed appropriate to consider:

> *What epistemological contribution can be offered by a set of scenarios exploring the carbon intensity of UK household consumption under different conditions in the future?*

This chapter begins by exploring the traditional 'soft' defence of scenario planning as a tool for learning. This is followed by a discussion of the nature of explanation and prediction in the sciences generally, and how this has developed over time. The next section examines what insights might be drawn from history in terms of constructing plausible narratives to describe sequences of events and the behaviour of individuals. The final section in this chapter explores historical developments in economics related to the modelling of consumer behaviour, including various criticisms from the psychological and sociological traditions, before the modelling approach used in this research is introduced.

4.1 The 'soft' defence of scenario planning

In approaching the scenario planning literature, it is immediately evident that this technique has its roots in the applied fields of management and strategic planning. This emphasis on scenario planning as an applied technique, as opposed to a more theoretical

approach based on a body of scientific knowledge, may explain why scenarios are described as having been historically marginalised in academia (Aligica, 2005, p. 816). It may also go some way to explaining why the predominant focus of the scenario literature has been on the craft of scenario building, with relatively little reflection on epistemology – that is, the contribution of scenarios to the knowledge space.

Anyone engaged in a futures thinking process such as scenario planning will frequently encounter the view, implicitly or explicitly, that thinking about the medium to long-term future is purely speculative, a kind of guess work, and thus has little or no place in an academic setting. After all, academic activities are concerned with advancing our understanding of the world, or contributing to the knowledge space. Surely speculating about the future lies in the realm of fiction? And if so, then doesn't the introduction of futures thinking into a research project undermine the aims of that project to provide evidence-based advice to decision makers?

An initial defence of scenario planning is that it is not concerned with predicting the future, but rather with assisting our decision-making in the present by raising awareness of the range of possible futures that lie before us. Furthermore, even if we cannot know what the future holds, we nevertheless have to make some kind of contingency plans for the future. Therefore, since people will *inevitably* plan for the future, it is surely better to do so in a systematic way by thinking explicitly about the range of possibilities that await us. For proponents of this view, it is sufficient to show that by envisioning a series of possible futures, we challenge our preconceptions and mental models and are therefore able to make less biased judgements about the path ahead. Thus, scenarios are intended to play a 'propaedeutic' role, a learning role, which in turn may facilitate the

emergence of other kinds of knowledge, but are not designed as knowledge artefacts in their own right (Aligica, 2005, p. 817).

That scenario planning can help challenge preconceptions and raise awareness of alternate futures from those implicitly held in the minds of decision makers seems a reasonable claim to make. Yet, in its dealing of the epistemological question, this line of defence seems almost tantamount to sophistry. As Aligica has pointed out: *"Learning involves by definition a growth of knowledge and thus on the one hand, a claim to knowledge is softly downplayed while at the same time another identical claim is made in a disguised form"* (Aligica, 2005, p. 817).

The 'soft' defence often asserts that by refraining from assigning probabilities to alternate futures, the scenario planner is not seeking to offer an assessment of the likelihood of the various outcomes. However, important questions must still be raised around the validity of the alternate futures such as they are. Specifically, it must be asked: what basis can there be for describing a set of alternate futures as 'possible'? The use of the word 'possible' implies that a particular set of circumstances in the future may conceivably arise. Thus, without claiming to know that a particular outcome *will* occur, it is implicitly claimed that it *could*. Ultimately then, each possible future rests on a series of assumptions regarding causality in human affairs and the natural world.

So, it seems that even if a range of alternate futures are never treated as knowledge artefacts themselves, they are nevertheless grounded in knowledge (or assumptions) about discernible patterns in the past that form the basis of an extrapolation (quantitative or otherwise) into the future. Indeed, perhaps upon inspection trends or tendencies can

be identified that have characterised our progress to date and which seem, if not immutable, then certainly dominant and persistent. It may reasonably be argued that such 'mega-trends' are likely to have a presence and influence in our medium or even long-term future. However, identifying mega-trends from historical data is one thing, but understanding the causal processes which have given rise to those is another matter entirely. Thus, to assess whether scenarios might claim an epistemological status beyond that of a 'prodaedeutic' tool, it is necessary to first examine the epistemological nature of patterns discerned from the past, i.e. the generalisation of historical events. This will involve thinking about the scientific nature of historical explanations, an enquiry which begins here by turning the question around and looking at the history of scientific explanation.

4.2 Developments in the philosophy of science

Whereas particular scientific disciplines are concerned with phenomena within their domain and how these can be explained in relation to one another, the philosophy of science is concerned with explanation itself. Over the centuries, as various thinkers have contributed to this branch of philosophy, the accepted view of what constitutes the 'scientific method' has changed significantly. In addition, the birth of ever more distinct areas of inquiry that might be considered ‘sciences’ has led to a plethora of diverse methodologies, such that it is difficult to discern a pattern that transcends them all and which could be meaningfully described as a universal scientific method.

Up until the mid-nineteenth century, the standard view of scientific method was one of inductive reasoning. It was believed that science began with the objective observation of facts in the real world, based on which the scientist could first infer universal laws,

and subsequently more general theories. Those laws and theories could then be tested against further observations (Blaug, 1992, p. 4). However, the inductive approach had been challenged as early as the second century by the Pyrrhonian philosopher Sextus Empiricus. Perhaps more famously, the Scottish philosopher David Hume challenged the justification for inductive reasoning (Hume, 1748). Put simply, the problem with induction is that although we might observe a series of events demonstrating some consistent property, we have no guarantee that our subsequent observations will also exhibit this property. Therefore any general law inferred from these observations must be contingent. Bertrand Russell famously made the point using the example of a chicken having been fed every day, expecting this day to be like any other, only to have the farmer wring its neck (Russell *et al.*, 1992, pp. 150-151).

Despite Hume's challenge, this inductive approach held until the second half of the nineteenth century when it began to break down (Blaug, 1992, p. 4). In its place came a model of scientific method based on deduction, eventually formalised by Hempel and Oppenheim (1948). Blaug summarises this 'deductive-nomological model' as follows:

- A scientific explanation consists of the *explanans* and an *explanandum*.
- The *explanans*, or premises, are made up of:
    - one or more universal law(s), i.e. statements of the form: 'if A is true, then B is also true'; and:
    - details of relevant initial conditions.
- From these premises, and with the use of deductive logic (such as 'if A is true, then B is true. A is true, therefore B must be true'), it is possible to derive an *explanandum* - a statement about some phenomenon which needs explaining (Blaug, 1992, p. 4).

Blaug writes:

> *"The point of the model is that it employs no other rules of logical inference than that of deduction...The universal laws that are involved in explanations are not derived by inductive generalization from individual instances; they are merely hypotheses, inspired conjectures if you like, that may be tested by using them to make predictions about particular events but which are not themselves reducible to observations about events."* (Blaug, 1992, p. 5)

An important consequence of this model for Hempel and Oppenheim is that scientific explanation involves the same logical structure as scientific prediction, the only difference being that one is concerned with past events and the other with future events. This has been termed the symmetry thesis (Blaug, 1992, p. 5).

To reiterate, the deductive-nomological model considers scientific explanation and prediction to have the same form. An explanation begins with an event that has occurred and establishes premises to account for it. Prediction instead begins with the premises and posits the occurrence of an event. In principle then, if an explanation can be achieved for a given phenomenon, then future occurrences may be predicted by identifying the presence of the relevant initial conditions.

However, Helmer and Rescher (1959) contested this received view, arguing that explanation and prediction are in fact *asymmetrical*: an explanation must state *why* a given event occurred, while a prediction need only state *that* a given event will occur. Helmer and Rescher therefore argued that whereas an explanation must establish its

conclusion beyond reasonable doubt, a prediction has only to demonstrate itself as *"more credible than any comparable alternative"* (Helmer & Rescher, 1959, p. 32). A similar view is expressed by Blaug, arguing that *"prediction only requires a correlation, whereas explanation cries out for something more"* (Blaug, 1992, p. 5). Indeed, history provides many examples of scientific laws which provide either strong explanatory or predictive power, but not both. Newton's inverse square law is often cited as an example of the latter. The law offers remarkable predictive power relating to the movement of bodies, however Newton himself felt that this law failed to explain *why* gravity acts in the way it does (Blackburn, 2001, p. 226).

Blaug also discusses the converse situation, i.e. a scientific explanation lacking predictive power. With the theory of evolution, Darwin provided an account of how relatively simple forms of life develop into more specialized forms through natural selection. Nevertheless, the theory of evolution is unable to predict in advance which specialised forms will evolve under given conditions (Blaug, 1992, p. 7). Blaug cites other examples of theories offering explanations without predictive power, including an entire class of theories discussed later, namely historical laws.

It seems then that there may be a reasonable case to be made for the rejection of the symmetry thesis, as called for by Helmer and Rescher. For Blaug though, the Hempel-Oppenheim model of scientific method withstands the explanation-without-prediction criticism, for where explanatory power is not matched by predictive power this is either due to a lack of sufficient information about initial conditions (as in the case of biological evolution), or due to the explanation not having being suitably based on any universal law, in which latter case the scientific nature of the explanation should be

called into question (Blaug, 1992, p. 10). Furthermore, the symmetry thesis says only that scientific explanation and prediction are *logically* symmetrical, i.e. an explanation for a given event *would* look the same as a prediction of the same event if one were to be proposed. If, in practice, one is not accompanied by the other, the principle of logical symmetry would remain unaffected (Ruben, 1990, p. 124). Thus, it seems reasonable to argue the case for a 'specifically predictive method' on purely pragmatic grounds, but without having to reject the symmetry thesis altogether.

However, if explanation and prediction are still held to be 'logically' symmetrical, then it holds that predictions about the future should take the form proposed by Hempel and Oppenheim, comprising one or more universal laws and a description of initial conditions, prior to the statement that a particular type of event will occur if these conditions are met. Thus, even if a purely predictive approach is undertaken, if this is to be described as 'scientific' then it ought still to be founded in universal laws. And in searching for universal laws applicable to the social, technological, economic and political transitions of interest to this study, we now turn to the discipline which might be described as logically symmetrical to futures thinking, namely history.

4.3 Insights from history

If scenarios are concerned with explaining possible events and circumstances in the future, how do historians account for events that have actually occurred in the past? Specifically, (how) do historians depict causal relationships between events? And (how) do they offer generalisations of those events such that they could help us envisage the future?

This section presents a chronological account of how historians have reflected on history-as-science. Next, the issue of causality and general laws is examined to see how historians approach the task of explaining past events. Finally, the question of agency, or the role of the individual in history, is explored. The implications of the determinism vs free will debate in explaining historical events are drawn out.

If, as shall be shown, historians view their work as more of a craft than a science, then futures thinking may be seen in a similar light, as expressed by Heijden (1996). However, this turn away from making strong epistemological claims has implications for both fields, namely: why should one account of the past or future be considered any more worthy of attention than another? Exactly how historians attempt to answer this question is explored here.

4.3.1 A history of historical explanations

The first question that must be addressed here is whether historians themselves see theirs as a scientific discipline. Evans addresses the challenges that have been mounted against history since the 1980s by postmodernists, by first giving an account of historians' views on the nature of historical enquiry throughout the ages (Evans, 2000, pp. 15-44). This account explains a great deal about the state of history in the present day, and is summarised here.

In 1862 the French historian Coulanges stated: *"History is, and should be, a science"* (Evans, 2000, p. 20). As discussed earlier, scientific enquiry at that time was carried out through inductive reasoning. For Coulanges and his contemporaries, the 'facts' were out there, all that was required of the historian was to accumulate them. Evans recounts that

the physicist Max Planck, at the beginning of his studies in the 1870s, was advised against a career in physics by his professor, who insisted there was nothing left to discover. But just as Planck and others would revolutionise their own areas of enquiry with new breakthroughs and discoveries, the same was to happen in the field of historical enquiry where archaeological advances led to further discoveries about the distant past. Thus, by the end of the nineteenth century the notion that all the facts could be gathered up was already beginning to look questionable. In the early twentieth century too, historians began to pursue a range of different approaches in their endeavours, branching out from the traditional focus on the nation-state to consider economic history, social history and more: *"New questions, it seemed, could render previously neglected areas of evidence freshly meaningful"* (Evans, 2000, p. 21). Moreover, the rapid development of new technologies was leading to ever more material sources to be 'gathered up' such as newspapers, photographs and films. Thus, *"the notion of a truly scientific history, began to seem more than a little shaky by the turn of the century"* (Evans, 2000, p. 22).

For those such as Trevelyan, it was wrong to consider history to be analogous to the physical sciences (Evans, 2000, p. 25). For Trevelyan, the sciences were of value regardless of whether or not the general public could engage in them. History, on the other hand, had to be disseminated to be of any value. In addition, whereas the natural sciences were capable of deducing laws of cause and effect, no general laws had ever been derived from history in such a way that they could lead to predictions about the future. Trevelyan believed that certain activities conducted by historians could be described as scientific, i.e. the gathering of facts, assessing the evidence, but the attempt to uncover the causes and effects of historical events could never be described as such.

Similarly, Ranke had earlier made a distinction between the *"rigorous principles of source-criticism"* required to assess historical documents, and the more intuitive approach of identifying the thread that connects different events together (Evans, 2000, p. 25). For Trevelyan, history was *"a mixture of the scientific (research), the imaginative or speculative (interpretation) and the literary (presentation)"* (Evans, 2000, p. 25).

In the wake of the First World War, the belief in history as essentially objective and scientific was dealt a further blow, as historians' accounts of the causes of the conflict became highly partisan. Moreover, the belief in an overriding pattern of progress throughout history was shattered: *"if unpredictable and uncontrollable forces were shaping the present, it seemed, then the previous belief of historians that they could understand by a simple process of induction the forces that shaped the past now seemed dangerously naïve."* (Evans, 2000, p. 29).

Evans writes that the early part of the twentieth century, with the publication of Einstein's General Theory of Relativity in 1913, saw a shift towards *"an intellectual climate in which it was thought that the 'aspect of things' changed with the position of the observer"* (Evans, 2000, p. 30). As well as in the physical sciences, this view was brought to bear on historical enquiry. The effect of this incursion of relativity into history was to *"blur the distinction... between fact and interpretation"* (Evans, 2000, p. 31).

The 'reassertion of objectivity' would take place in the 1950s and 1960s in both history and the sciences. Famously, Popper put forward his arguments for falsification -

arguing that the pursuit of objective knowledge involved putting forth propositions in such a way that it was possible to discern the conditions under which they could be proved false. Elsewhere, in France, a more scientific and objective approach was emerging among a group of historians who incorporated methods from economics, sociology, geography and statistics (Evans, 2000, pp. 38-39). The resurgence of history-as-science culminated in the emergence of 'social science history' and cliometrics, in the United States in the 1960s and 1970s. As seen by their proponents, these new approaches distinguished themselves from traditional history through the use of *"explicitly elaborated, sometimes mathematical models that could be rigorously tested by quantitative means"* (Evans, 2000, p. 39). However, Evans delivers a rebuke of this movement, stating that it only ever delivered results on a very small number of very specific questions: *"When it came to the really big issues in history, it had to remain silent, because they could not be solved by quantitative methods"* (Evans, 2000, p. 41).

Evans writes that this resurgence of 'scientific history' was set back further by developments in the philosophy of science, where the falsification of Popper had given way to Kuhn's model, which held that the scientist worked within a 'paradigm' of assumptions and theories which guided their work and *"ensured that their observations matched the theories they held"* (Evans, 2000, p. 42). Although Kuhn restricted the application of his model to the natural sciences, Evans suggests that those historians who were influenced by Kuhn's ideas nevertheless saw parallels in their own endeavours, resulting in a sense of relativism: "*By the 1980s, therefore, the long search for a scientific method of history had failed to yield any definitive results"* (Evans, 2000, p. 43).

Evans' chronological account of historians' reflections on their discipline makes it clear that – even allowing for the differing views among historians at any given point in time – the broad case for history-as-science has been oscillating back and forth between strong and weak views, often informed by developments outside the field, primarily in the philosophy of science. It seems uncontroversial to claim for history that it at least employs a great number of scientific methods in its approach towards ancient documents, artefacts and so on. The gathering of 'facts' then, might be said to be a properly scientific aspect of the work of historians. Things become more problematic when discussion turns to the ways in which such facts are employed in the weaving together of causal narratives, or more controversially, the positing of general laws from history.

4.3.2 Causation and General Laws in History

In a 1942 paper, Hempel gave an account of the function of general laws in history (Hempel, 1942). The paper includes many of the ideas on causation and explanation that would be formalised in the 1948 paper introducing the deductive-nomological model, discussed above. Describing the form of a scientific explanation for an event *E*, Hempel writes that this consists of:

1. *a set of statements asserting the occurrence of certain causes (C_1, C_2, ... C_n)*
2. *a set of universal hypotheses*

   where: both are reasonably well confirmed by empirical evidence, and the occurrence of event *E* can be logically deduced from these. (Hempel, 1942)

Hempel also explains that the '*C*' and '*E*' here refer to types of events, not individual instances of that type. Hempel's proposed structure is, of course, deductive. That is, if the first two sets of conditions are true, then the conclusion (or event) is necessarily true also. Thus, Hempel asserts that causal explanation in history can and does exhibit the same form as a scientific explanation. However, even for the sciences, this approach to causal explanation has been seen as problematic.

McClelland argues that to understand the nature of causal explanation, it is necessary to understand how such statements are put together, and the terms used therein (McClelland, 1975). The first issue is whether causal explanations should be qualified with 'Necessarily', 'Always' or 'Probably'. Even if it is assumed that all causes of a certain type *C* can be specified, and that these are invariably followed by an event of type *E*, it is still unclear whether the explanation deserves the preface 'Necessarily' or merely 'Always'. This depends on whether causation consists of anything other than observed correlations (McClelland, 1975, pp. 22, 35). For Hume, an observer may repeatedly witness the conjunction of one event with another, but never a connection between them (Hume, 1748, p. 58). If this approach is adopted, then causal explanations must be preceded by the term 'Always', and not 'Necessarily'. But for McClelland there are further difficulties.

The second difficulty relates to the grouping of individual instances of events into homogenised 'types' of both causes and effects. But reality can only be organised into such homogenised sets through a process of abstraction in which some of the unique characteristics of individual events are ignored. Thus, the result is frequently unsatisfactory either because too much has been lost in the abstraction, and/or because

the resulting set of events is still insufficiently homogeneous (McClelland, 1975, pp. 24, 42). This is problematic enough for the scientist analysing e.g. the lighting of a match, but is many times more complicated for the historian dealing with types of events such as 'assassinations' or 'revolutions'.

The final problem for McClelland is that, even if events could be grouped satisfactorily into 'event types', the task of identifying a complete list of antecedent causes – *known* to be complete – would be impossible. This is true for the historian and is widely accepted as such in that field. Evans elucidates further:

> *"it is obvious enough what a cause is; we can have necessary causes (if A had not happened, then B could not have happened) and sufficient causes (A happening was enough to make B happen). Within the first category at least, we can have a hierarchy of causes, absolute causes (if A had not happened, then B definitely could not have happened) and relative causes (if A had not happened, then B probably could not have happened). Accustomed as they are to stating their arguments in a careful gradation of assessment of probability and plausibility, historians do not in practice approach the discussion of causation in concrete historical instances in such a schematic way."* (Evans, 2000, p. 157)

But even in the sciences, for seemingly precise statements of the form 'If (C1,..., Cn), then E', it can never be known with certainty that all – and only – the relevant causes have been enumerated (McClelland, 1975, pp. 24, 42). Thus, rather than applying the preface 'Always', causal explanations ought to be qualified with 'Probably'. The

consequence of this qualification is that inferences based on such probabilistic laws can no longer be described as deductive. Where probabilistic premises are present, then conclusions drawn from those are necessarily probabilistic also (McClelland, 1975, p. 48).

A further problem arises for the historian in that, in order to establish the causes of an event, a scientist may conduct experiments where possible causes are removed one at a time to determine their role in inducing the effect. The historian however, has no means of isolating candidate causes and repeating sequences of events.

The very notion of deriving generalised explanations from historical events begins to appear futile. Indeed, Evans writes that *"Most historians have always felt the establishment of general laws to be alien to the enterprise in which they are engaged"* (Evans, 2000, p. 56). However, there have been notable exceptions. Evans describes how Carr put forward the case for history-as-science by arguing that even if history dealt with unique events, the objects of interest to scientists – atoms, stars, living organisms – were similarly unique, and yet scientists frame general laws all the same. But as Evans points out, the differences between two human beings are far more complex that those of two atoms, making general laws equally more difficult to achieve at this level. This point relates to the homogenisation of individual instances into 'types', as discussed above. While the abstraction of two atoms for the purpose of homogeneity would incur some loss of detail, the abstraction of two political revolutions would present vastly greater losses to the point that – for either of the two reasons McClelland has discussed – the resulting groupings would be unsatisfactory for the positing of general laws. The cliometricians attempted to eliminate this problem by

dealing only with statistically significant numbers of people. Yet again though, Evans expresses scepticism: *"history clearly includes the study of individual people, events and structures as well as groups and collectives"* (Evans, 2000, p. 57).

The tendency among some historians to imbue their works with explanatory power, indeed holding this to be the goal of history over and above 'mere description', has been termed the *"explanatory bias"* (Megill, 1989, p. 632). For Megill, this bias has been supported by the 'prejudice for universality'. This prejudice regards historical description as being tied to individual events and instances, to the mere particular, while explanation is seen as universal. Megill points to the work of Windelband who, in 1894, described the dichotomy between the 'nomothetic' sciences concerned with general laws, and the 'idiographic' disciplines concerned with particular events and entities (Megill, 1989, p. 632).

This polarisation of approaches, and particularly the elevation of the nomothetic sciences above the idiographic, has obscured an alternative understanding of the term 'generalisation' that would go a long way towards resolving many of the seemingly intractable disputes over the scientific nature of history discussed above. This understanding of generalisation refers not to universal laws applicable across all time and space, but to a broad statement applied to a particular historical context:

> *"In historians' language, the following invented statement counts as a generalization: "As a result of the growth of towns and trade, feudalism gave way to incipient capitalism in late medieval and early modern Europe." The "problem of generalization," as historians conceive of it, is*

> *usually the problem of how to get from fragmentary and confusing data to such larger assertions. But such assertions are not what the logical positivists, or Windelband before them, had in mind when they spoke of general laws. In "nomothetic" science, the desired generalizations transcend particular times and places, as in, for instance, this invented statement: "Whenever, within a feudal system, towns and trade begin to grow, then feudalism gives way to capitalism.""* (Megill, 1989, p. 633)

Following this definition, a generalisation need not be universally applicable to be of value to the historian. Adopting this revised understanding of what constitutes a generalisation leads to a parting of ways between the historian and the scientist. As Kaplan explains, the scientist begins with empirical observations, knowledge about what is going on in the world, but is not content with this. Instead, the scientist aims to discover what *must* be true, not simply what happens to be true at a particular time and place, hence the effort to uncover universal laws (Kaplan, 1964, p. 123). The historian however, in providing a contextual generalisation, makes no claim to universality – the commonalities between the events they describe need not hold for events occurring beyond the temporal or geographical boundaries that they have drawn. Helmer and Rescher nevertheless argue that historical generalisations constitute laws that carried counterfactual force and could be applied to other situations (Helmer & Rescher, 1959, pp. 27-28). But as Dray points out, it is impossible to test whether these generalisations would have held true even for other posited events in the *same* time and place, let alone those outside the original historical context (Dray, 1964, pp. 16-17).

Evans seems to support a contextual understanding of generalisation, arguing that

history can in this way identify *"patterns, trends and structures"* with *"a high degree of plausibility"* (Evans, 2000, p. 60). Yet he concedes that history cannot generate universal laws with strong predictive power:

> *"History, in the end, may for the most part be seen as a science in the weak sense of the German term Wissenschaft, an organised body of knowledge acquired through research carried out according to generally agreed methods, presented in published reports, and subject to peer review. It is not a science in the strong sense that it can frame general laws or predict the future."* (Evans, 2000, p. 73)

Indeed, *Wissenschaft* is precisely the term Windelband used to described his two categories of enquiry, the nomothetic and the idiographic. The description was intended to mark these approaches as equals. It was only later, as the logical positivists restricted the use of the term 'science' to the nomothetic pursuits, that the 'prejudice for universality' led to the nomothetic being elevated in status above the idiographic, a bias which significantly influenced – and still holds sway over – the historical discipline (Megill, 1989, pp. 632, 636).

So, while historians may not seek to derive universal laws from the observation of past events, they nevertheless deal with contextual generalisations, ones which are intended to help make sense of a particular period or process without claiming to explain events beyond that. So long as these generalisations are understood in this way, they may be a useful and constructive part of the 'craft' of history. Similarly, causality – even if it may not be dealt with in a 'schematic' way – can be a part of the sense-making approach

undertaken by practitioners of this craft. No discussion of causality would be complete though, without dealing with the question of agency.

4.3.3 The role of the individual in history

Of particular interest in this research on lifestyles and environmental behaviour, is the historians' discussion on the role of the individual in causal explanations. Evans quotes Roberts who calls for a *"human action approach"* in which the freedom of the individual is central and where historical events are reconstructed from the actors' point of view (Evans, 2000, p. 137). But Evans criticises this position arguing that historians generally do not assume that individuals have 'unfettered freedom' to act. Indeed, at the opposite end of the spectrum historians such as Carr discussed causation in a way that has been described as determinist, where historical events are typically brought about by external factors independent of the will of the actor(s) involved (Evans, 2000, p. 138). But this position too has been attacked, accused of having *"trapped human beings... in an inescapable net of causation and robbed them of freedom of action in the present"* (Evans, 2000, p. 138, summarising White, 1966).

It was Tolstoy who wrote:

> *"As the sun and each atom in the ether is a sphere complete in itself, and yet at the same time only a part of a whole too immense for man to comprehend, so each individual bears within himself his own aims and yet bears them to serve a general purpose incomprehensible to man."* (Tolstoy, 1997, p. 1255).

Some might read the claim that humans exist to serve a general purpose as being essentially a religious statement, but even those who do not share such beliefs might appreciate the notion of purpose here in a biological context as one geared towards reproduction and survival of the species and/or in a social context as part of some collective geared towards a 'greater good'. So, if individuals have some capacity for conscious self-determination, but are at the behest of external forces and constraints and crucially, are also biological beings driven by internal forces, then the interplay between individual agency and those internal and external forces must be explored.

Causal analysis of human behaviour is of course qualitatively different from that of inanimate objects. Humans have *"internal response mechanisms that mediate between external stimuli and resulting overt action"* (McClelland, 1975, p. 66). For McClelland, the historian begins with an action committed by an individual, and seeks to uncover the cause(s). While this will involve consideration of external factors, it also requires hypotheses concerning humans' internal dispositions (McClelland, 1975, pp. 67-68). Similarly, Collingwood believed that while natural events may be explained from the outside, historical events have an inside or thought-side, thus their explanation requires that the thoughts of the actor be discovered (Dray, 1964, p. 11). To this end, Collingwood espoused the doctrine of 're-enactment', wherein the historian tries to 'get inside the head' of the historical character in order to assess the opportunities and challenges surrounding them at the time of the action, thus leading to an understanding of the actor's behaviour. For Collingwood, whereas a scientist aiming to explain a natural event attempts to demonstrate its inevitability, the historian exploring human action instead tries to reveal its point or rationale (Dray, 1964, p. 12). Various criticisms

have been directed at this approach though. As Evans put it: *"Getting inside the head of someone who buried treasure in a grave in the fourth century, or made a newsreel in the twentieth, is far from easy"* (Evans, 2000, p. 92). In other words, the lack of relevant artefacts and documents renders re-enactment impossible in many cases. Another criticism concerns the assumption of 'rational behaviour' on the part of the actor. For Dray, humans commit not only conscious, rational acts, but also sub-conscious, irrational ones, or even rational acts but towards foolish ends (Dray, 1964, pp. 12-13). A third criticism comes from the positivist tradition, arguing that the doctrine of re-enactment is merely a methodological tool or 'heuristic device' for deriving psychological hypotheses (Hempel, 1942, p. 44). Those hypotheses are in turn dependent on universal laws of the form: *"a rational agent, when in a situation of kind C, will invariably (or with high probability) do X"* (Dray, 1964, p. 14). Thus, while Collingwood asserts that the explanation of human action is fundamentally different from the scientist's explanation of natural events, Hempel wishes to show that the former, while employing the tool of 'empathetic understanding', nevertheless involves recourse to universal laws if it is indeed to explain anything.

Whether supporting Collingwood's account of human action informed by an empathetic approach, or Hempel's call for an account based on psychological laws, it is clear that explaining human action in history is problematic. For the former approach, this is due to the subjective nature of one historian in a different place and time attempting to recreate in their mind the conditions and thought processes of an historical character. For the latter approach, the problem is rather due to the difficulty in identifying suitably robust psychological 'laws' to account for different types of human behaviour. As Evans explains, in either case, a lack of relevant information in the form of documents and

artefacts leaves most human actions – let alone their causes – all but inaccessible to the historian (Evans, 2000, p. 92).

Still, both approaches share one important thing in common: a distinction is drawn between external conditions and internal response mechanisms. That those mechanisms are described by some as being characterised by freedom of choice, and by others in a more deterministic manner, does not preclude a role for the psychological and sociological disciplines in accounting for human actions. In the next section, the contribution of these disciplines in accounting for consumer behaviour will be discussed, but first a summary is provided of the key lessons to be drawn from this review of the epistemology of historical explanations.

4.3.4 Lessons for qualitative scenario narratives

This review of thinking within the historical discipline has attempted to elucidate a range of views on a number of topics of interest to futures thinking. Firstly, the notion of history-as-science throughout the ages has been addressed. It seems clear that historians' views on this have been significantly influenced by developments in the philosophy of science. From a relatively strong view of the objectivity and scientific nature of their discipline in the late nineteenth century, historians experienced a crisis of confidence in the wake of the First World War when proponents on different sides of that conflict produced works heavily biased in their favour. The resurgence of history-as-science coincided in the 1950s with the emergence of Popper's ideas on falsification in science. In history this led to the emergence of more statistical approaches to the reading of historical data. Meanwhile though, it was clear that a purely statistical approach was of limited use in the historical discipline. History consists also of

individual people and events which would always resist homogenisation into general trends.

That process of homogenisation, problematic enough at times for the sciences, can prove intractable for historians given the complexity of their subject matter. Thus, the strong generalisation of causes and events into universal laws as in the sciences cannot be duplicated in history. Instead a more localised approach to describing groups of events must suffice, in the form of contextual generalisations aimed at drawing out patterns within a particular time and place. The notion that such contextual generalisations cannot admit of predictive power, nor even claim to be exhaustively applicable within the time and place of interest, may invite criticism of their contribution to knowledge. When history is regarded as an idiographic discipline however, concerned with describing particular events for their own sake, such modest generalisations may be seen as useful sense-making devices, rather than scientific hypotheses. But history-as-craft nevertheless requires that the documents and artefacts that represent the starting point of enquiry be methodically investigated, following sound scientific procedures, before these can be counted as evidence. In this way, as Trevelyan argued, history begins with scientific research, and only then proceeds to speculative interpretation and literary presentation (Evans, 2000, p. 25).

In the end, history might best be viewed – as in the eyes of Windelband, Megill and Evans – as a form of *Wissenschaft*, *"an organised body of knowledge acquired through research carried out according to generally agreed methods, presented in published reports, and subject to peer review"* (Evans, 2000, p. 73). If the desire for a more scientific view of the discipline has preoccupied many historians over the past century

or so, this might be understood as a consequence of the logical positivist inspired elevation of the nomothetic over the idiographic disciplines, and the appropriation of the term 'science' for the nomothetic disciplines only. At the other extreme, for those commentators who wish to take a postmodernist approach to understanding history, Benson and Stangroom remind us that:

> *"history is not the same thing as wishful-history. The word 'history' itself derives from the Greek 'historein' which means both 'research' and 'enquiry'... History is highly interpretive, to be sure, but it is always, when done properly, grounded in evidence. The questions are empirical ones, and the interpretation is of evidence, not of daydreams or fantasies."* (Benson & Stangroom, 2006, pp. 122-123)

In turning attention back to the future, it might be said that futures studies are similarly a kind of 'craft', rather than a science. Indeed, according to Heijden:

> *"Scenario planning is a practitioner's art. Its origins are in the real world of management, it is therefore more a craft than a science. Over the years a number of general principles have emerged but most of the rules of implementation evolve from day-to-day practice."* (Heijden, 1996, p. 133)

A problem remains though, even for this soft defence of futures-thinking-as-craft. Whereas history begins with the scientific analysis of documents and artefacts before proceeding to the interpretive and literary stages, it is very often the *outcomes* of these

speculative stages that futures thinking has as its own starting point. In other words, the 'documents and artefacts' employed in futures thinking include the very generalisations, trends and causal explanations that historians would consider to be purely speculative. In other cases though, the trends in question are claimed by their proponents to have a more reliable, scientific quality to them, including in the case of quantitative trends identified in historical economic data.

Thus, it is necessary to conduct a discussion of the epistemological issues in economics, as these relate to the modelling of consumer behaviour.

4.4 Epistemology in economics and consumer behaviour

In a discussion of epistemology in economics, an important distinction to begin with is that of monism vs pluralism in economic enquiry. Before this distinction can be drawn out, some clarification of terms is required, given that monism and pluralism - and indeed methodology - are used in different ways in the literature. It should be obvious enough that monism and pluralism refer to 'one' and 'many' respectively, but these are applied at various levels of the discussion, and so for clarity, in this chapter: 'epistemological monism' refers to the view that there ought to be unity across the sciences in terms of what qualifies as knowledge, while 'epistemological pluralism' implies that different standards may be deemed appropriate for different scientific disciplines; 'methodological monism' here is the view that, within economics, there is one school of thought best equipt to address questions of an economic nature, while 'methodological pluralism' allows that different economic schools may have complementary insights to offer according to their different strengths (Blaug, 1992, p. 42, Dow, 2008).

Proponents of the neoclassical school might assert its dominance over heterodox schools in the form of methodological monism, although in principle there is no reason why a neoclassicist should not consider other schools of thought to be more appropriate in addressing some aspects of economics. Proponents of other schools, however marginalised, might still adopt a methodological monist position, insisting that their school is in fact the most appropriate lens through which to examine economic issues, while others may adopt a pluralist approach. Whether any of these proponents would argue that economic theories in general should be judged by the same standards as the physical sciences, adopting epistemological monism, will depend very much on the methods of enquiry within their particular school.

This is intimately linked to the question of whether economics is more a 'nomothetic' discipline, aimed at deriving general laws, or an 'idiographic' discipline focused instead on describing individual actions and events. It seems clear that the neoclassical school which dominates modern economics is best characterised as seeking general laws, or at the very least law-like statements applicable across time and space, and does not limit itself to descriptions of individual phenomena.

To give a sense of how modern economics came to be shaped this way, a brief selected history of economic enquiry is provided below.

4.4.1 Theory in the history of economics

Whatever their contributions to economic thought, many of the early economists failed to address issues of methodology directly (Blaug, 1992, p. 51). Thus, the works of

Adam Smith, David Ricardo and Thomas Malthus offer no explicit treatment of their philosophical approach to economic theorising. Instead, Blaug points to other figures including Nassau William Senior and John Stuart Mill as the classical economists who did the most to develop the methodology of the young discipline (Blaug, 1992, pp. 51-52).

Early economic methodology followed a process of deductive reasoning: a theory consisted of certain premises, structured according to the rules of logic, which led to certain implications. But the classical economists were wary of the notion that the implications of economic theory ought to provide predictive power. Rather, the ability of a theory to predict was seen as an indication of its applicability in a given context, not of its validity in general. Consequently, where the implications of a theory did not match real world experience, this was due to 'disturbing causes' which, rather than invalidating the theory, merely indicated that the theory was not applicable in that particular instance (Blaug, 1992, p. 51). The validity of a theory was instead determined by the appropriateness of the premises, the assumptions about economic behaviour upon which the theory was built, and so it was here that the early methodologists focused their efforts.

The premises of economic theory were said to consist of *a priori* facts, know to be true independent of experience. For Senior, these premises are *"the result of observation, or consciousness, and scarcely requiring proof, or even formal statement, which almost every man, as soon as he hears them, admits as familiar to his thoughts"* (Senior, 1836, p. 129). Chief among these *a priori* facts was the principle of rationality, or utility-maximisation, i.e. the observation, in Senior's words, that: *"every person desires to*

maximise wealth with as little sacrifice as possible" (Senior, 1836, p. 129).

In his own work elaborating on the concept of rationality, Mill was keen to emphasise that this concept was only an abstraction, which perhaps explains why Mill and his contemporaries were less concerned with prediction: if true premises are required to ensure true conclusions, then untrue premises (including abstractions such as utility-maximisation) necessarily produce wrong conclusions (Blaug, 1992, pp. 55-56).

The methodological approach espoused by Senior, Mill and their contemporaries was endorsed as late as 1932 by Lionel Robbins. For Robbins, there are *a priori* economic truths, general laws, that form the basis of economic theory, and though it may be necessary to supplement these general laws with details about the context in which we wish to apply them, the laws themselves are never reducible to contextual details (Robbins, 1932, p. 80).

This view of economic laws as *a priori* truths, or in Robbins' words *"the stuff of our everyday experience"* (Robbins, 1932, p. 80), came under increasing pressure coinciding with the emergence of logical positivism in the sciences generally. In 1947, Paul Samuelson, stated one of the central aims of economics as being to derive *"meaningful theorems"* by which he meant *"a hypothesis about empirical data which could conceivably be refuted if only under ideal conditions"* (Samuelson, 1947, p. 4). And so, despite the lack of any explicit reference to Popper, Samuelson set out to apply falsificationism to economic theory.

But no sooner had Samuelson expressed this intention than Milton Friedman, in his

1953 essay on economic methodology, dismissed the very idea that economic theorists should proceed by testing assumptions (Friedman, 1953). Friedman argued that the validity of a theory does not rest on the conformity of its assumptions with the facts, indeed: *"to be important... a hypothesis must be descriptively false in its assumptions"* (Friedman, 1953, p. 14). Instead, he argued, the validity of a theory depends solely on whether it delivers accurate predictions, an approach known as *instrumentalism*. Thus, in Friedman, we have a methodological attitude to the validation of economic theories that is diametrically opposed to the early classical economists such as Mill.

Friedman's essay has been criticised for lacking a proper treatment of the different kinds of assumptions that may be used in economic theories, i.e. assumptions about: motivations, behaviour, functional relationships, boundary conditions etc (Blaug, 1992, p. 94). Blaug provides further criticism of Friedman's approach, suggesting that without *"an underlying structure of assumptions"*, there is nothing that can be adjusted and improved if the theory initially fails in its predictions: *"It is for this reason that scientists usually do worry when the assumptions of their theories are blatantly unrealistic"* (Blaug, 1992, p. 99).

According to Blaug (1992, p. 110), despite the array of methodological criticisms it encountered, Friedman's essay nevertheless persuaded a generation of economists that theories were ultimately to be judged according to the accuracy of their predictions and that the alternative approach focussing on testing of assumptions was *"fundamentally wrong"* (Friedman, 1953, p. 14). Summarising, Blaug says:

> *"The prevailing methodological mood is not only highly protective of*

received economic theory, it is also ultrapermissive within the limits of the "rules of the game": almost any model will do provided it is rigorously formulated, elegantly constructed, and promising of potential relevance of real-world situations... Modern economists frequently preach falsificationism... but they rarely practice it" (Blaug, 1992, p. 111).

4.4.2 Rational choice

One of the core assumptions of mainstream economics in relation to consumer behaviour that might be considered 'unrealistic' is that of utility-maximisation, or rational choice, outlined above. According to rational choice theory, human behaviour can be characterised as the result of self-interested individuals making calculated decisions on the basis of their preferences. In any decision making process, the individual assesses the expected benefits and costs of the various options, and chooses the option which will maximise their gains while minimising their losses. The theory of consumer preferences draws on the assumptions of rational choice to explain how a consumer with particular tastes and preferences, faced with a given level of income and a particular range of goods (at particular prices), will choose from those goods in such a way as to maximise their expected utility (Jackson, 2005, p. 30).

Jackson (2005) makes some observations about rational choice theory as it relates to consumer preferences. Firstly, in the world of rational decision making, information (e.g. on available goods and their prices) is key to consumer behaviour. Rational choices are said to be possible only where perfect information is available on market conditions. Secondly, consumer tastes and preferences are exogenous to the model.

There is no exploration of the forces, internal or external, underlying them.

It should be self-evident that these problems impose serious limitations on the 'realism' of rational choice theory. Perfect information would seem to be a rare attribute of real world decision making processes, while satisfying (and verifying) this condition for the purposes of empirical work would be problematic to say the least. Many leading economists now emphasise the centrality of *information asymmetry* in making sense of economic outcomes (Royal Swedish Academy of Sciences, Nobel Foundation, 2001). That consumer tastes and preferences are treated as exogenous to the model also limits opportunities for those seeking to intervene and influence consumer behaviour. Without any exploration of how tastes and preferences are formed and how they may be re-formed, the rational choice model would seem to offer only two points of intervention: through the provision of information (where that information has a bearing on the expected benefits and costs of particular choices) and by changing those benefits and costs directly, e.g. through taxes or subsidies (Jackson, 2005, p. 31).

4.4.3 Core criticisms of rational choice

Jackson (2005) characterises criticisms of rational choice theory as tending to focus on three main assumptions of the model: rationality, individualism, and self-interest. Each set of criticisms will be explored here in turn.

For Simon (1957), in real life situations, obtaining information for decision making not only imposes a time cost but is often hampered by uncertainties regarding future outcomes. For this reason, he argued for a model of 'bounded rationality' in which, rather than reviewing all information to obtain the optimal outcome, individuals instead

make do with a satisfactory outcome that meets a minimum level of utility (Jackson, 2005, pp. 35-36, Simon, 1957). The bounded rationality model points to the use of heuristics for decision making, which needn't contradict rational choice *per se*, especially if such heuristics are viewed as devices for saving time, or in economic terms, reducing transaction costs. However, unconscious or habitual behaviour would seem to contradict rational choice in cases where it acts as a substantial impediment to (a consciously preferred) behaviour change.

Further criticisms along these lines point to the significant role played by emotions in decision making. Again, allowing for an affective component in decision making needn't contradict rational choice if the satisfaction of emotional needs were treated as simply another aspect of utility. Things get more complicated though, when cognitive processes are seen as being fundamentally driven and shaped by emotions, which are themselves triggered by physiological factors. In this view, *"reason itself [is] a construct of our emotional responses to situations"* (Jackson, 2005, p. 37). Not all criticisms of rational choice theory treat emotion in this way. Nevertheless, rational choice theory lacks any explicit treatment of its own with regards to affective aspects of behaviour.

The next set of criticisms Jackson describes are those focused on the assumption that the individual is the appropriate unit of analysis in the study of behaviour. This 'methodological individualism', epitomised in rational choice theory, is to be found more widely embedded in the Western society and economy (Jackson, 2005, p. 38). Seen through this lense, social behaviour is understood as an 'emergent property' of the many behaviours performed at the individual level. Early criticisms of individualism drew

upon the notion of the self as partly socially constructed:

> *"At the very least, according to social psychology, the relationship between self and other must be regarded as dualistic. Though the concept of an individual 'self' capable of engaging with others and thereby influencing the nature and structure of social conversations is at one level coherent, it depends for its existence and its development on social interaction, on the social conversations that it also plays a part in perpetuating."* (Jackson, 2005, p. 38)

Other critics point to the organisational or collective manner in which decision making is often carried out in practice. In addition to the overt negotiations, compromises and settlements that are often dictated by procedural constraints, organisational psychology indicates that individuals often adopt 'social roles' that relate strongly to the group setting. Nor are individuals alone in adopting social roles. The behaviour of the group itself can often be determined by its identity in the wider social setting (Jackson, 2005, p. 38, Tajfel, 1982).

Another criticism of individualism is a more general attempt within sociology to resist a reductionist approach to the understanding of social structures. For sociologists, there are simply too many factors relating to social structures that fail to correspond to the self-interest of individuals. This has led to the development of alternative accounts of social action wherein the structures themselves, rather than the individual, are treated as the main unit of analysis. Far from resolving the situation though, the sociological approach has been accused by some of going too far in its response to individualism,

leading to an ongoing debate in the literature. Nevertheless, Jackson (2005, p. 39) concludes that there is a sufficiently strong case to be made against rational choice theory in terms of its persistent 'undersocialisation' of human behaviour.

The third and final strand of criticism relates to the treatment of the individual as purely self-interested. One aspect of this criticism echoes the claim of sociologists described above: that individualism fails to account for the influence of social structures. Instead, these critics would argue, our sense of 'self' emerges within these structures and we are effectively bound by them; or else, as individuals with agency, we nevertheless recognise that the good of society as a whole cannot be met through having all its members act out of self-interest. In the former case, individuals lack the power to act independently of social structures; in the latter case, we consciously sacrifice our self-interest for the good of society.

Rational choice theorists may seek to account for altruistic behaviour by widening their notion of self-interest, i.e. where individuals act to secure the best interests of the family/tribe/species as a whole. Alternatively, seemingly altruistic behaviour may be put down to a simple 'feel good' factor, or the expectation that such behaviour will be reciprocated. But critics insist this is a move too far from the individual self-interest implied by the theory. Instead of developing the theory in a way that may provide scope for further investigation, these responses simply redefine self-interest so broadly that, in the end, the theory lacks all explanatory power.

Criticisms of rational choice theory come not only from other academic disciplines, such as psychology or sociology, but also from alternative schools of thought within

economics itself. Thus, while rational choice may be considered a hallmark of mainstream (i.e. neoclassical) economics, the theory receives substantial criticism from more heterodox economics schools, such as institutional, behavioural and ecological economics (Hodgson, 2000, Wilkinson, 2008, Faber *et al*., 2002). A thorough treatment of these heterodox schools is beyond the scope of this research. Rather, these schools are highlighted here to make clear that the criticism of rational choice is not a criticism of economics *per se*.

4.4.4 Rationality revisited

To assess the prospect of reconciliation between proponents and critics of rational choice, or to be able to proceed with meaningful enquiry into consumer behaviour regardless, the historical development of the concept must be revisited.

Senior was quoted earlier, outlining the core principle of rationality: *"every person desires to maximise wealth with as little sacrifice as possible"* (Senior, 1836, p. 129). Mill subsequently elaborated on the concept, insisting that this supposition should be treated as a mere abstraction, but one that was necessary for the science of political economy: *"Not that any political economist was ever so absurd as to suppose that mankind are really thus constituted, but... this is the mode in which science must necessarily proceed"* (Mill quoted in Blaug 1992, p.55).

Furthermore, Mill was adamant that there are many aspects of human conduct where *"wealth is not even the principle object"* and to which economics does not apply (Mill quoted in Blaug, 1992, p. 55). Instead, Mill argues that economics applies only to those areas of human conduct where the accumulation of wealth is the main objective, and

must proceed by treating this main objective as if it were the sole objective, in order to arrive at an *approximation* of reality. Crucially though, that approximation must be adjusted to take account of non-economic impulses. Mill delivers a clear statement of the necessity of such accommodation:

> *"So far as it is know, or may be presumed, that the conduct of mankind in the pursuit of wealth is under the collateral influence of any other of the properties of our nature that the desire of obtaining the greatest quantity of wealth with the least labour and self-denial, the conclusions of Political Economy will so far fail of being applicable to the explanation of prediction of real events, until these are modified by a correct allowance for the degree of influence exercised by the other cause"* (Mill quoted in Blaug, 1992, pp. 55-56)

Despite Mill's clarity in describing rational behaviour as an abstraction and his call for corrections to be made for other effects, the concept of Homo economicus was born in response to his work, and the view that economic man could be used directly as a basis of economic theory would gradually take hold (Blaug, 1992, p. 74).

Although rational choice has come to dominate modern economics as an approximation of actual human behaviour, as opposed to a mere abstraction of certain aspects of it, Mill's writing makes it clear that the consideration of non-economic factors is embedded in the heritage, at least, of modern economic theory. Thus, any attempt to incorporate non-economic factors into models of consumer behaviour should not be seen as an attack on the discipline of economics, but rather as an attempt to provide the kind of

correction advocated by one of the fathers of the discipline. Of course, if it can be shown that the principle of rationality can fully account for consumer behaviour, then there would be no need for such corrections, and the instrumentalism of Friedman - which disregards the 'realism' of assumptions - may be seen as a sufficient methodological approach. Where the principle of rationality fails to account fully for consumer behaviour however, greater consideration for the *"underlying structure of assumptions"* will be necessary if adjustments are to be made in an informed and systematic way (Blaug, 1992, p. 99).

4.4.5 Accounting for non-economic factors

In the context of the current research, this problem of adjustment and correction around the core principle of rationality can be articulated in the following way: to what extent can economic factors account for expenditure patterns of UK households, and to what extent do non-economic factors play a role? The quantitative component of this research employs a model that has attempted to address this very question in an analysis of the historical data (Chitnis & Hunt, 2009, 2010). ELESA (Econometric Lifestyle Environmental Scenario Analysis) employs a number of econometrically estimated equations across 16 categories of goods and services to determine the impact of changes in income, price and exogenous non-economic factors (ExNEF) on changes in expenditure. The relative importance of these three factors differs between categories, however the equations estimate that for some categories, e.g. 'recreation and culture', or 'communications', the economic factors of income and price can explain only a fraction of the observed changes in expenditure, with the majority of the change attributed to non-economic factors. In other categories, the relative importance of different factors was more evenly mixed, but importantly, non-economic factors made some contribution

in driving changes in expenditure in all categories (Chitnis & Hunt, 2010).

More will be said in Chapter 5 about how this model operates and how it has been used to derive illustrative figures for UK household expenditure. Clearly though, for UK household expenditure, the principle of rationality alone is not sufficient to fully explain the observed data. Thus, even though an improved economic theory is beyond the scope of this research, it is clear that any such theory will require consideration of non-economic factors as explored here.

4.4.6 Lessons for Quantification

The earlier review of theory in the history of economics suggests a move away from the early economists' focus on assumptions alone, towards an exclusive focus on predictions in the latter half of the twentieth-century. In that context, the importance of the 'realism' of assumptions has been downplayed. Instead, instrumentalists regarded it as sufficient, even desirable, to rely on overly simplistic assumptions and to focus instead on testing the predictions of theories against empirical data. However, this lack of an underlying structure of assumptions complicates the process of refining and improving theories in light of predictions that fail. Thus, in the case of consumer behaviour, where the principle of rationality is employed as one such 'unrealistic' assumption, an instrumentalist approach leaves the theorist stranded when the observed data cannot be explained in terms of rational choice alone.

In this research, a model is employed that highlights the role of non-economic factors in driving changes in UK household expenditure. Although no alternative economic theory is proposed here, a number of criticisms of rational choice theory have been

explored above, indicating a possible route forward in more accurately accounting for consumer behaviour. Importantly, it is argued that any attempt to improve upon the principle of rational behaviour should not be seen as an attack on the discipline of economics. Rather, it should be treated as a return to the requirements of John Stuart Mill, one of the originators of the principle of rationality and of the discipline of economics itself, who made an early case for the need to adjust and correct for non-economic factors.

In the next chapter, the methodology adopted in this research is explored in detail.

5. Methodology

As discussed in Chapter 3, the literature on scenario planning reveals a multitude of methodologies under the broad heading of the intuitive logics approach. Bradfield *et al.* explain that each variation identifies *"a number of discrete steps, varying from five to 15 or more, depending on what features of scenarios are highlighted or ignored."* (Bradfield *et al.*, 2005).

Given the objective of developing descriptive scenarios, it was decided that the key stages and outcomes of this research should be reviewed by a panel of experts, to ensure that those outcomes avoid being skewed by the subjective values of a sole scenario developer. Throughout the research, this panel would be called upon to bring a variety of perspectives to bear on any key decisions, ensuring that those decisions were subject to close scrutiny and conscious reflection, and that outcomes were consistent with the data gathered. The scenario panel was therefore appointed prior to conducting the initial interviews, and consisted of this author and four members of RESOLVE: Professor Lester Hunt, Professor Tim Jackson, Dr Yacob Mulugetta and Dr Michael Peters.

As a first step towards developing a methodology for this study, a brief outline of proposed stages was developed. This outline was then sent to two individuals with different scenario-related expertise who had agreed to provide critical feedback. The first of these was Ron Bradfield at Strathclyde Business School. Bradfield is a leading practitioner in the scenario planning field, the author of several journal papers on the history and successful uses of the scenario technique, and coauthor - with Kees van der

Heidjen and others - of 'The Sixth Sense: accelerating organizational learning with scenarios' (Heijden *et al.*, 2002). The second expert was Nick Hughes at King's College London. Hughes also has experience as a scenario practitioner, but perhaps more importantly for present purposes he conducted the critique of low carbon scenarios discussed in Chapter 3.

5.1 Feedback on proposed methodology

The original email sent to these experts can be found in *Appendix I. Proposed Methodology.* In response to this email, Bradfield was generally supportive of the broad approach outlined. He suggested that in addition to consulting 'experts' it may be worth consulting groups of young people or students to ensure a more varied set of contributions. Bradfield also highlighted the work of Philip Tetlock, whose research has questioned the role that experts can usefully play in forecasting work. Tetlock found that although experts tend to be more confident in their predictions than lay people, they are generally no more accurate, and in any case they are less accurate than simple computer model extrapolations. Bradfield also emphasised that scenarios are not a science, rather they are an art and a craft and as such the particular approach or 'methodology' that should be followed will depend on particular aspects of the research at hand. *"There are it has been said, as many processes are there are practitioners"* (personal correspondence, Bradfield, 2009).

Hughes offered similar encouragement and delved a bit more into the methodology. He commented that the various categories of external factors identified (social, technological etc) are of course dynamically integrated to one another, and suggested

thinking about how to reintegrate these having previously delineated them for the interview stage. Hughes's most substantial point focused on the extensive use of external experts and the multiple rounds of assessment involving RESOLVE members and a scenario panel. Here he plays devil's advocate:

"In terms of how you are getting your data, the raw materials from which you are going to build scenarios- you are getting it from a mix of people. From 'experts' in particular areas (who as you say won't be experts in other areas). Some of these may have a relatively 'neutral' view of their area, some may have preference for how things should evolve. Then you are going to put the responses in front of a panel of your colleagues who you hope are going to be reasonably well informed across the board but able to remain impartial. and you are going to use them to identify some key variables. then you are going to use a smaller group to develop some 'pathways' and then flesh out the narratives yourself.

"I suppose my general question is whether you need all of these processes. what added value are you gaining from getting all these different peoples' inputs- are they finally going to boil down to a few key trends or variables? how different would it have been if you had just thought up the variables yourself, intuitively (apart from the sense of having 'validated' variables)?

"I think the process of interviews and consultation are most obviously relevant for company-based scenarios. here you are asking a bunch of people who all have the shared interest of working for the same company, how it should evolve and what the key threats are. the process of making

> *scenarios about broad societal changes is more complicated. you can't talk to the whole of society. even if you select some experts and ask them so speak around broad areas like 'consumption' you risk being overwhelmed with data. you will end up hoovering these up into a few separate bags to give you broad themes- but as i provocatively suggested these might not be much more enlightening than if you had just thought up the themes yourself."* (personal correspondence, Hughes, 2009)

One point raised here by Hughes relates to an ongoing concern in this study: the predominance of organisation-based scenarios in the literature, and the subsequent difficulty in identifying a suitable methodology for developing scenarios in any context other than this. While the approach set out above would certainly ensure useful input was gathered from experts, Hughes was keen to suggest that the present study shouldn't necessarily follow the steps outlined in the organisationally focused scenario literature, if another process would be more suitable here. Through subsequent correspondence, Hughes was keen to highlight that he wasn't necessarily advocating scrapping the approach outlined above, but rather was encouraging conscious reflection on whether this approach was being adopted for the right reasons.

These comments from Bradfield and Hughes provided a useful stimulus for subsequent reflection on the proposed methodology, and led to a substantial rethink on how to ensure the most effective use of the time and resources available.

5.2 Revised methodology

In line with both Bradfield and Hughes' comments about the role of experts, it was important to call into question the value of conducting 20 expert interviews simply to draw out the key trends and issues of interest. This exercise would certainly have helped in building credibility and legitimacy for the scenarios, thus some level of external consultation would need to be retained. However, it was decided that the initial scanning exercise could just as effectively be conducted with members of RESOLVE, who are themselves experts in various fields. This would involve a much less onerous round of interviews, given the ease of access to interviewees, and the basic preparations already made on the interview protocol would remain valid.

This initial round of internal interviews would be followed by analysis of the key themes, drivers and uncertainties, which would be summarised into a draft 'scenario framework' report for review by the scenario panel.

Following agreement among the scenario panel on a provisional scenario framework, this framework would then provide the basis for a series of external interviews, in which a range of expert would be invited to critique the provisional framework and offer their thoughts on the key factors of interest to the study.

After analysing the data from the external interviews, a series of 'narrative outlines' would be developed, synthesising the key contributions of the external and internal interviewees into a set of cohesive and plausible list of developments. These outlines would subsequently be revised and expanded into narrative form.

Finally, the econometric model developed by Chitnis & Hunt (2009) would be used to produce illustrative forecasts of expenditure and emissions for each scenario.

This revised methodology reverses the order in which internal and external experts would be engaged in this work. With this new approach, the key themes and even a provisional framework would all be prepared prior to consulting externally. This would ensure the most effective use of the limited time available with experts. It might be remarked that the prior identification of two key trends by a scenario panel internal to the research group seems premature given the subsequent opportunity for external experts to contribute more of their own. An alternative approach would be to conduct the internal and external interviews in the same phase, before clustering these into one collection of insights for the scenario panel to review and select from. The approach taken here is justified on three grounds:

- The research group are recognised experts on issues around lifestyle and environmental behaviour. Therefore, it seems reasonable to assume that those individuals can provide important insight into the issues and trends of interest to the study.
- The scenarios will be built in a way that requires close collaboration across the research strands in the group, and will be published under the auspices of the group as a whole. Therefore, it is imperative that the building of the scenarios follows a direction which is appropriate for the exploration of those issues felt to be most significant by the group, thus maintaining support internally.
- The framing of the scenario spaces prior to consultation with external experts allows a more focused approach to be taken at this stage, both in terms of the

identification of relevant experts as well as in the preparation and conduct of the interviews in order for these to offer the greatest insight possible.

Nevertheless, in order to ensure flexibility within the methodology and to take full advantage of the expertise available, the working framework would be subject to the scrutiny of these experts during the initial part of each interview. In this way, feedback on the suitability and usefulness of the working framework would be received in an ongoing fashion. Should it become apparent that there was a consensus among the experts for a modification of the framework, this could be discussed during a meeting of the scenario panel. Either way, as the interviews progress, the scenario framework would become increasingly solidified.

The suggestion by Bradfield to conduct workshops with a variety of groups was deferred to future work. While engaging with stakeholders is paramount if the scenarios are to have an impact on decision making, this is perhaps most applicable in the dissemination phase. Since the current study aims to *build* the relevant scenarios only, a limited round of external engagement at this stage seems sufficient, while any subsequent engagement workshops may still be arrange by the research group to ensure impact.

In the following sections of this chapter, each stage of the methodology is discussed in more detail.

5.3 Environmental scanning - Internal Interviews

The initial phase of the scenario building process involved semi-structured interviews with members of RESOLVE. The interview protocol is provided in *Appendix II*. The purpose of this phase was to gather together insights from the different disciplines within the research group and begin to identify the broad issues and trends considered to be important for the future carbon intensity of lifestyles. Interviewees were invited to reflect on the social, technological, economic, political, psychological and environmental factors (STEPPE) that they believe will drive lifestyle change. They were encouraged to discuss these in terms of the four categories of consumption discussed previously: around the home, the food we eat, getting around, and getting away.

Describing the interview process, Heijden explains:

> *"Interviews are as much as possible of an open-ended nature. This means that the interviewer does not arrive with a ready set of specific questions concerning the business. Instead questions are general, and intended to trigger a free-flowing conversation, in which the interviewee sets the agenda."* (Heijden, 1996, p. 145)

This open-ended approach ensures that the interviewee is able to bring to the fore those issues which they believe to be pertinent to the research, rather than the interviewer deciding in advance on a pre-selected range of issues to be discussed. The difficulty comes in preparing an interview protocol that encourages the interviewee to focus on

lifestyles and the relevant external factors, whilst leaving the discussion sufficiently open to ensure the issues solicited have not been contaminated by the interviewer's own agenda.

The interview usually begins by allowing the interviewee to explain their background and perspective on the area of interest. This helps to settle the interviewee and get the discussion flowing before the main part of the interview begins (Heijden, 1996, pp. 145-6). A number of possible trigger questions are then suggested by Heijden, intended to ensure the interview flows in the manner described above. The first set of questions are intended to uncover the main uncertainties in relation to the business environment under consideration, in this case the carbon intensity of UK lifestyles. To begin, the interviewee is asked to imagine that they are able to present three questions to a clairvoyant (Heijden, 1996, p. 146). The interviewee is invited to elaborate on how they would use these three questions, and to discuss how they would prioritise the various issues they might wish to explore, giving due consideration for the uncertainty and impact of each.

The light-hearted approach of this initial question eases the atmosphere of the interview and helps the interviewee become comfortable in thinking about the future (Heijden, 1996, p. 146). When the interview begins to slow, the next question is raised. This time the interviewee is asked to assume the role of the clairvoyant, providing the answers to the three questions. Specifically, the interviewee is asked to provide a vision of the future which turns out favourably. Then, they are asked to consider all three questions again but this time within a future which is undesirable. Heijden explains:

> *"Earlier (page 109) I argued strongly that the idea of 'good' and 'bad' futures in the scenario design stage lead to poor quality scenarios. In most circumstances the scenario planner does best to stay away from good and bad worlds, instead focusing on what is plausible and internally consistent. However, in the elicitation interview the discussion of good and bad worlds tends to be powerful in triggering ideas of what could be important factors to look at, leading to the discovery of underlying driving forces."* (Heijden, 1996, p. 147)

The development of these issues into actual scenarios would be done at a later stage, thus the subjective visions collected in this interviewing phase are used merely as a tool for eliciting the issues of interest.

Taking inspiration from some of these ideas, the interview protocol in *Appendix II* was then prepared. The protocol includes an introduction, in which the interviewee was reminded of the context of the study and nature of the scenario process. A brief overview was then provided of the earlier work in characterising lifestyles, and the four consumption categories were explained to the interviewee, along with the various categories of external factors. A 'crib sheet' was then provided to the interviewee, consisting of the diagram in Figure 2.2, portrayed in Chapter 2, with the four consumption categories and the external factors, along with some examples of what might fall under each category. The interviewee was encouraged to use this as a prompt if they required inspiration, but also cautioned that this was purely an illustrative

diagram and that they shouldn't feel bound by the categorisation provided therein.

After this introduction, the so-called 'oracle question' was presented, albeit in slightly modified form. Interviewees were then given time to reflect and respond, often seeking clarification of the categories etc. Only when the answers seemed to slow did the interview proceed to the next question, in which the interviewee was invited to express their vision of a desirable world. The interviewee was reminded of some of the key issues they had previously drawn out, and invited to describe how those might unfold in a desirable world. Naturally, this was followed by the question regarding an undesirable outcome.

Having explored these desirable and undesirable worlds, the interviewee was then invited to consider what developments within the external (STEPPE) factors might lead towards the desirable and away from the undesirable world. Finally, they were asked to reflect on what challenges and opportunities might lie ahead on these pathways. Specifically, the interviewee was asked to consider the challenges and opportunities from the perspective of different actors, including individuals, firms, government and NGOs.

5.4 Identification of key uncertainties

Having prepared the interview protocol, a series of eight internal experts were approached and invited to participate. Seven of these were selected from across the different strands within RESOLVE, to gather expert views on social, psychological,

economic and political factors. With no 'technological' research strand within RESOLVE as such, one further expert was recruited from the wider Centre for Environmental Strategy at the University of Surrey. Those experts and their main academic field (in alphabetical order) were: Kate Burningham, Sociology; Mona Chitnis, Economics; Angela Druckman, Economic Modelling; Shane Fudge, Politics and Governance; Birgitta Gatersleben, Psychology; Lester Hunt, Economics; Matt Leach, Environmental Technology; Michael Peters, Politics and Governance. These eight interviews were then conducted over a four week period, with the interviews being audio recorded and later transcribed.

Heijden suggests that a typical interview *"may produce between 40 and 60 important insights"* (Heijden, 1996, p. 151). These insights must then be brought out of the individual transcripts and clustered together. The software package NVivo is a qualitative analysis tool that allows passages of text or audio to be coded, enabling clustering of common themes. Once the transcribed interviews had been loaded into NVivo, each one was analysed in turn. Coding tags were initially developed for the four consumption clusters, the various external factors, and key concepts that had been introduced during the interviews such as 'desirable', 'undesirable', 'challenges', 'opportunities' etc. In this way, any given passage might be coded multiple times to capture e.g. a 'social' development leading to a 'desirable' outcome in relation to the 'food we eat'.

During the encoding process, new and more specific themes would become apparent. New codes were accordingly added in a hierachical fashion, so that 'technological' became composed of: 'electricity grid', 'heating', 'energy efficiency and conservation',

'decentralisation' etc, until eventually over 50 tags were used in the analysis.

A number of issues were identified as 'key uncertainties' by the interviewees. These issues were grouped together, in terms of 'scope', i.e. global, national or household level, along with possible outcomes for each, to produce the following candidate uncertainties:

- Global Factors
  - growth (strong/trend/weak/nil/negative)
  - geopolitical stability (increased/same/decreased)
  - international emissions regime (strong/moderate/weak overall target, equitable/inequitable share of responsibilities, effective/ineffective operation)
  - world markets and prices (scarce/abundant energy and mineral resources, high/trend/low growth in demand)
  - global equity (greater/similar/less disparity between nations)
  - technological innovation (rapid/trend/slow rate of innovation)
- National Factors
  - growth (high/trend/low/nil/negative)
  - income distribution (greater/similar/less disparity between households)
  - energy security (increased/similar/decreased security of supply, increased/similar/decreased energy dependence)
  - national emissions targets and how these are attempted (strong/moderate/weak overall UK target, nature of regulation and policy/financial mechanisms, strong/weak public and private investment)
  - electricity grid (centralised/decentralised, increase/stable/reduced demand, extensive/limited decarbonisation)
- Household/Lifestyle Factors
  - Household Income (high/middle/low income)
  - Values/Attitudes (more/less pro-environmental values)
  - Behaviour/Social Norms (more/less pro-environmental behaviour)
  - Socio-demographics (urban/suburban/rural household etc)

While it would be possible to rank these issues according to the number of passages in which these are discussed, or the word count of those passages, such quantitative analysis would provide little insight into the stated *significance* of the issue for the interviewees. Thus, the process of identifying appropriate uncertainties from this list necessarily proceeded in a qualitative fashion.

A scenario panel meeting was arranged, where the members were provided with the complete list of candidate uncertainties above. At the same time, a presentation of possible combinations of these uncertainties was delivered, highlighting the possible broad scenarios that might result from different pairings on a 2x2 matrix. The criteria for the selection of uncertainties were threefold: they should each be expected to have a significant impact on the carbon intensity of lifestyles; they should each present a significant degree of uncertainty; together, the two uncertainties should provide a suitable scenario framework in terms of policy relevance.

5.4.1 Inputs and outcomes

Before proceeding with an assessment of the candidate uncertainties, a brief discussion of the nature of the variables in this scenario study is required. The various global, national and household factors identified earlier might be considered in any set of scenarios developed. In some cases, these factors will need to be treated as 'inputs' to the scenarios, i.e. factors that will drive change. In other cases, they will be more appropriately considered as 'outcomes', i.e. changes driven by the conditions of the scenario. In reality, these key factors would operate as both inputs and outcomes, as part of a dynamic interplay or co-evolution. Nevertheless, as with any modeling

process, abstractions must be made if the investigation and communication of the system is to be made possible.

Some of the factors may be consistent across all four scenarios, if for example UK emissions targets had been applied as an exogenous constraint. Others may vary according to one of the uncertainty axes, but not the other. Finally, some of the factors may differ in each of the four scenarios.

In essence what needs to take place is the selection of four scenarios from a vast series of possible configurations. Assuming, for simplicity's sake, that each of the key factors has only two possible values, a set of 14 key factors therefore presents a total of 2^{14} or 16,384 possible configurations. In fact, many of the key factors identified during the environmental scanning phase contain a myriad of further uncertainties within them. Thus, UK electricity production for example, contains within it uncertainties around (de)centralisation, demand, and carbon intensity. So too for behaviour change/social norms, values/attitudes and so on. The point here is that the number of variables and possible outcomes quickly makes the range of possible configurations effectively infinite. Clearly the approach towards selecting four of those cannot proceed by assessing all possibilities. Instead, an intuitive process must take place.

The following passages provide a summary of the case for selecting various uncertainties for use in this scenario study.

5.4.2 UK and international emissions reduction targets

UK emissions targets are now enshrined in legislation, following the Climate Change Act 2008. Key provisions of the Act include GHG emission reduction targets of at least 80% by 2050. For the RESOLVE scenarios, suitable interim targets could be identified for 2030. The achievement of the UK target could be taken as one of the key uncertainties. Alternatively, the UK targets could be taken as an exogenous constraint on all four scenarios, although this approach has been criticised above. It should be noted that the 80% emissions reduction by 2050 is intended to be achieved through a combination of action in the UK and abroad. The Act requires that *"the Secretary of State must have regard to the need for UK domestic action on climate change"* (DEFRA, 2008, p. 9). However, the achievement of the target clearly assumes a role for international emissions trading. No figures are given in the legislation with regards to the proportion of reductions to be undertaken in the UK or abroad, instead responsibility for assessing the appropriate extent of emissions trading is placed in the hands of the Committee on Climate Change, an independent advisory body set up as part of the Act. Thus, even assuming the UK targets were met, different outcomes could still be explored from a consumption perspective as adopted in this study. Indeed, without the sufficiently robust operation of any international regime, the continued offshoring of emissions could become the chief means by which the UK targets are met.

In this way, the international emissions regime could be taken as one of the key uncertainties. Three factors seem relevant here: the extent of the targets in absolute terms, the equitable sharing out of responsibilities, and the robustness of the operation of the regime. With no firm agreement resulting from the Copenhagen negotiation, all three factors would seem to contribute to the overall uncertainty at present. Even if an

international agreement was achieved in the short term that had a clear absolute target and distribution of responsibilities, arguably the effectiveness of its operation would remain an ongoing uncertainty. This encompasses several issues of concern including: the ability to accurately monitor emissions in different member states, the operation of different mechanisms including 'Reducing Emissions from Deforestation and Forest Degradation in Developing Countries' (REDD), the transparency of emissions trading and offsetting schemes. Thus, a combination of these concerns might be captured in the uncertainty: 'effective international action on emissions' vs 'ineffective international action on emissions'.

Of particular concern here is that 'action abroad' may not represent a substantial reduction in current emissions, whether that is due to trading within a legitimate (but insufficiently strong) emissions framework or due to the ineffective operation of that framework. As a result, it is possible to envisage a future in which the UK can claim to have achieved an 80% emissions reduction, while from a consumption perspective the carbon intensity of UK lifestyles has fallen far short of this. In assessing the potential carbon intensity of UK lifestyles through to 2030 then, the first combination of uncertainties to be recommended to the scenario panel was the 'effectiveness of the international emissions regime' against 'domestic action'.

The candidate uncertainties below were also presented to the scenario panel for consideration.

5.4.3 Growth

A key uncertainty is the extent and nature of economic growth over the 20 year period. A distinction between global and UK growth is also important here. The rate of UK growth and thus incomes will have a powerful influence on both the level of consumption of UK households, and the nature of goods and services produced in this country. Meanwhile the rate of global growth might have an impact on the carbon intensity of imported goods and services, and on the demand for those goods and services on the world market, subsequently affecting prices to UK consumers. Taking 'Growth' as an axis therefore presents four possible configurations (allowing for high/low growth at the global/UK level). Arguments may be put forward as to the (im)plausibility of those combinations, which might help to identify the two most appropriate opposing outcomes. Of course, determining what constitutes 'high' and 'low' remains a matter of further uncertainty.

5.4.4 Electricity Production

A decarbonised electricity supply has the potential to reduce the carbon intensity of lifestyles without necessarily requiring significant lifestyle change. However, there are various characteristics of the electricity supply that make its selection as an axis less than straightforward. Decarbonisation is clearly a central issue, but is this in relative or absolute terms? That is, what if electricity demand is driven upwards by a transition to electric cars and/or electric heating? Also, the currently centralised nature of the grid might change substantially over time. So, three distinct characteristics – carbon intensity, demand, (de)centralisation – would again lead to eight possible configurations. Resolving these for use as one composite axis would be problematic.

5.4.5 Equity

A recurring theme across the internal RESOLVE interviews was the question of 'equity'. This was discussed variously in terms of global equity, national equity, social justice, income distribution etc. It seems straightforward enough to determine what the opposing outcomes might be: global equity could be seen as more vs less even distribution of global GDP, while national equity could be seen as more vs less even distribution of UK GDP. Global equity will be driven by global growth (relative to OECD growth), therefore global growth might be preferable to global equity as an axis. Domestically though, the growth of the UK economy could still result in a more or less even income distribution, thus national equity might offer some scope for exploring the changing nature of household carbon intensity in a UK with more or less even income distribution.

Another way to bring in the equity issue would be in terms of the regulatory approach taken towards meeting the UK emissions target. The mechanisms may operate on a per capita basis, or else per unit of carbon/GDP. This distinction may be crucial in driving national equity in one direction or another, and thus might be considered a more suitable uncertainty.

5.4.6 Governance

The shape of UK governance might also be considered. Specifically whether the responsibilities for carbon mitigation are distributed more centrally or regionally. This

uncertainty might present an opportunity to include associated uncertainties like the nature/success of community responses, and the currently centralised nature of the electricity grid.

5.4.7 Lifestyle Change

It could be argued that using 'lifestyle change' as an axis offers the opportunity of exploring the consequences of a shift in societal values. Ideally, since (potential) lifestyle change is what the scenarios are intended to explore and portray, it may be preferable to seek to portray the *drivers* of such change, in order to avoid 'lifestyle change' simply happening or not happening, as an exogenous constraint.

5.5 Provisional Scenario Framework

In order to develop an appropriate provisional framework, a series of possible combinations of uncertainties were assembled, including a short summary of the outline scenarios that might result from these. Thus, from the longlist of candidate uncertainties identified earlier, a shortlist of possible frameworks were developed and presented to the scenario panel for consideration. Of these possible frameworks, a recommendation was made to the panel for a provisional scenario framework consisting of the 'international emissions regime' as one axis and 'domestic action' as the other. This combination would allow the differences between the production and consumption perspectives to be explored, in particular the possible role of imported goods and services in driving consumption emissions even as production emissions are in decline. This framework was approved by the panel and prepared for the next stage.

Further reflection on the particular outcomes of the 'domestic action' uncertainty led to a slight modification in how this was articulated. Rather than 'domestic action' *per se*, the axis was described in terms of the timing of any domestic action. On the one side, an 'early transition' would involve a strengthening of UK (and European) policy for a low carbon economy, while a 'late transition' would reflect a response to the global recession that saw funding cuts for existing low carbon initiatives, and a focus on business-as-usual growth[3]. This formulation would then enable the exploration of a key issue discussed in the internal interviews: energy and resource depletion.

As discussed in Chapter 2, in a 2009 report on global oil depletion the UK Energy Research Centre (UKERC) conclude that a peak in global oil production is highly likely to occur within the time horizon of the present study, 2030 (UKERC, 2009a). The report further concluded that there was even a significant risk of the peak occuring by 2020. Given the potential impact of oil depletion on (the carbon intensity of) lifestyles, and the timeline for depletion suggested in the UKERC report, it was essential that the scenarios addressed this issue directly. The positing of different configurations of domestic and international action on emissions in this study sets the scene for a variety of responses to the risk of oil depletion. It was decided that, along with other basic commodities, a significant increase in oil prices would be represented in the scenarios, over the period 2015-2020. The different conditions in each scenario would then determine the response during that phase, and the possible consequences for the following period

3 At this point, it was still being contemplated whether the early and late transitions might represent distinct responses to the economic recession and thus involve a dramatic departure in terms of assumptions around growth, employment etc with a possible double dip recession being implied if the response to the crisis was poor. In the end, it was concluded that to conflate the 'late' and 'early' low carbon transition with 'good' and 'bad' responses to the economic crisis would be to conflate quite seperate political and economic factors in what might be seen as a deeply partisan approach. Thus, although remnants of the 'recession response' issue came through in the discussions that took place with external experts, the uncertainty was eventually resolved purely in terms of the timing of the transition, as will become clear in the scenarios themselves.

2020-2030.

5.6 External expert interviews

Having identified the general issues and trends of interest to the research group and selected two key uncertainties from those, a series of interviews were then arranged with external experts. To select appropriate individuals, a longlist of potential experts was drawn up in consultation with members of RESOLVE. A spreadsheet matrix was created in order to mark out the external factors, consumption categories and sectors of the economy that each potential expert could be said to represent. From this longlist, a shortlist of individuals was then created, with the experts being selected in such a way as to cover as much ground as possible in an initial round of interviews. Although a provision was made to conduct a further round of interviews if deemed necessary, it became clear during the first round that diminishing returns had set in, such that the latter interviews tended to reaffirm the significance of key factors already identified. The experts were sought from a variety of sectors, including academia, government, business and industry, and included:

- Chris Foster, an environmental consultant for EuGeos Limited and visiting research fellow at Manchester Business School. Mr Foster's research and consultancy has included projects focusing on the sustainability of food production and consumption.
- David Kempton, a non-executive director of Impax Funds Ireland plc, "an environmentally focused fund management company for institutional and private investors". Mr Kempton is also Chairman of EGS Energy, engineered geothermal systems, and an occasional columnist for 'citywire', a financial news and investment magazine.
- Francesco Sindico, Lecturer and Deputy Director of the Environmental

Regulatory Research Group at the University of Surrey. Mr Sindico's research interests include international environmental law, emissions trading and carbon leakage.

- Nicholas Howarth, School of Geography and the Environment at University of Oxford. Mr Howarth is co-author of "Carbon Markets: an International Business Guide".
- Nick Eyre, Jackson Senior Research Fellow at the Environmental Change Institute, University of Oxford. Dr Eyre is the leader of the Lower Carbon Futures group and co-director of the UK Energy Research Centre.
- Ruairi O'Connell, Advisor to the Special Representative for Climate Change, Foreign and Commonwealth Office.
- Nick Robins, Head of Climate Change Centre of Excellence, HSBC, and co-editor of "Sustainable Investing: The Art of Long Term Performance".

Prior to each interview, a short primer entitled 'Introduction to the RESOLVE scenario framework' was sent to the interviewee providing context to the study (Appendix III). This included a summary of the distinction between production and consumption perspective accounting of emissions, and the implications in terms of historical trends for the UK. The two uncertainties were explained, followed by a diagram representing the 2x2 matrix:

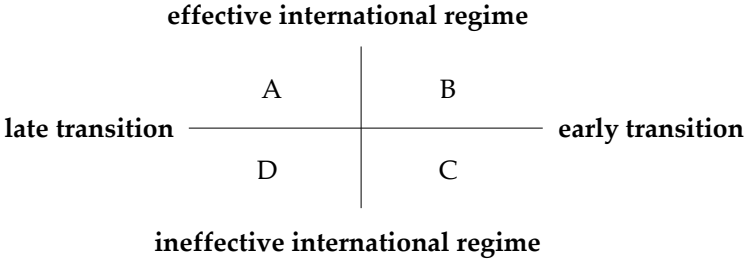


Figure 5.1: Provisional scenario framework

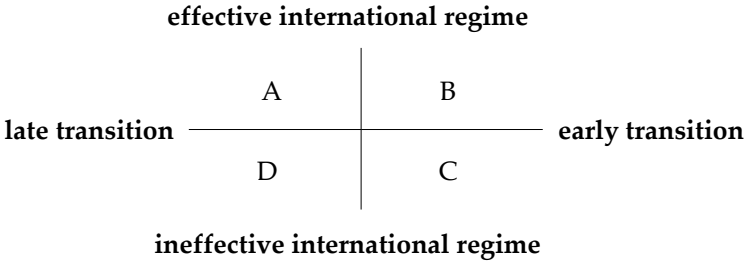
Finally a list of key questions to be considered during the interview were provided. Having mailed out this primer in advance, each interview began with a general summary of the work of RESOLVE and the goal of the scenario study, followed by a quick review of the primer, including the scenario framework and the choice of uncertainties. The interviewees were then invited to respond to the general framing of the scenarios as critically as they felt necessary.

Following any discussion around the scenario framework itself, the implications of each scenario arising from the framework were then drawn out. The resulting transcripts proved invaluable in refining the framework. For example, Scenario A, in which there is a late transition domestically, alongside a strong international regime, was seen as problematic by some of the interviewees. In response to this, a more nuanced outline emerged from the interview process, in which a business as usual approach, both domestically and internationally, was pursued through to 2020, until the pressures of resource scarcity led to a crisis and a collective turning point in terms of environmental legislation, with the following ten year period involving rapid decarbonisation. Similarly, Scenario C, in which there is an early transition domestically but no action internationally, drew attention to the inseperable nature of UK and EU policy on emissions, such that 'domestic' here could only work if it described the direction of the EU as a whole. This neatly gave rise to the possibility (subsequently adopted) that Scenario C could involve trade disputes between EU and key trade partners. Scenarios B and D were seen as less problematic, and attracted less criticism in terms of their inherent plausibility.

The key issues raised in the expert interviews were once again clustered together. The clustering process grouped these issues in relation to the key actors responsible, such that a series of possible global or international developments were grouped under the headings "EU", "US", "China", while further potential developments at the UK level related to "Government", "Media", "Activists/Society", "Firms". The document containing these clustered insights is provided in Appendix IV. At this stage, an outline narrative began to be formed for each scenario, by working through the insights and reflecting on whether that particular development was consistent with the broad conditions implied by the scenario or not. In this way, a series of *potential* developments as part of a generic template were transformed into a series of *actual* developments (or non-developments) in four seperate documents.

5.7 Draft scenarios

At this stage, a series of outlines were then produced to briefly summarise the essence of each scenario. The outlines consisted of a paragraph describing the development of macro- and micro-level factors over the 20 year period. Revisiting the scenario framework:



The outlines for each of the four scenarios are listed below:

- **A: Better late than never** - Little significant change in efforts to tackle emissions up to 2020, when increasing calls for climate action combine with rising fuel and commodity prices to bring things to a crisis point. Out of the crisis, international leaders build consensus on a comprehensive programme of emissions cuts. Although there is little improvement in the carbon intensity of UK lifestyles before the crisis, the securing of a global deal instills a sense of common purpose that encourages proactive behavioural change.

- **B: All together, now -** Voluntary climate action by different countries, including through green job programmes to aid economic recovery, helps to lay the groundwork for a comprehensive and equitable global deal in 2015. The cooperative approach observed at the international level is reflected in the behavioural change undertaken at the household level.

- **C: Trading woes** - Unilateral climate action by the EU is intended to draw further commitments from other parties, but with no such action forthcoming by 2015, the EU threatens the use of trade measures. After a period of heightened political tensions and economic slowdown, a compromise is reached. The result is a series of bilateral emissions targets that remain insufficient to avoid dangerous climate change. The UK public are cautiously optimistic at first, but without commensurate international action, enthusiasm for pro-environmental behavioural change is weakened.

- **D: Over the edge** - With little effort on emissions reduction, the global economy is exposed to increasing fuel prices towards 2020. With intensified social

pressure to reduce fuel prices, and unable to work cooperatively on establishing an equitable emissions regime, countries instead pursue divergent, often conflicting energy security policies. The persistence of fossil fuel extraction as part of those policies extinguishes any hope of a low carbon transition, and leads to international conflict.

The bullet point scenario outlines were then refined and developed into a more narrative form, and a formatting protocol was devised, including representation of the time period under discussion, colour coding and icon labelling of each paragraph of text according to whether the passage related to global, national or household level developments, where the latter related to the four consumption categories identified previously: in the home, the food we eat, getting around and getting away. A draft narrative for each scenario was then used as the basis of the quantitative work, described next, with the narratives being further refined alongside the quantification.

5.8 Quantification

The four household consumption categories described above help to give shape to the narratives. Nevertheless, in producing what are intended to be seen as complementary, illustrative quantitative figures, it was essential to adopt the formal classification system used in the economic model, ELESA, employed in this research (Chitnis & Hunt, 2009). That classification system is the UN Classification of Individual Consumption According to Purpose (COICOP).

The COICOP classification system consists of 12 top level categories of goods and services, each of which can be disaggregated further into sub-categories as appropriate. In the ELESA model, most of the top level categories have been adopted, while others, such as 'Housing, water, electricity, gas and other fuels' have been disaggregated to better understand the trends occuring in each sub-category. The final categorisation used within the model is as follows:

- Food and non-alcoholic beverages
- Alcoholic beverages, tobacco and narcotics
- Clothing and footwear
- Electricity
- Gas
- Other fuels
- Other housing (includes: actual and imputed rentals for housing, maintenance and repair of the dwelling, water supply and miscellaneous services relating to the dwelling)
- Furnishings, household equipment and routine household maintenance
- Health
- Personal vehicle fuels and lubricants
- Other transport (includes purchase of vehicles, operation of personal transport equipment and transport services, i.e. rail, road, air and sea)
- Communication
- Recreation and culture
- Education
- Restaurants and hotels
- Miscellaneous goods and services

While the ELESA model has been described previously (Chitnis & Hunt, 2010),(Chitnis & Hunt, in press) a short summary is necessary in order to explain how the model has been used in the current scenario work.

ELESA is a structural time-series model, using historical data over a 45 year period for each of the 16 categories listed above. Quarterly data for price and expenditure in each category, and for income, is taken from the Office for National Statistics database. Econometric analysis is then used to determine the effect of price changes and income changes on changes in expenditure. Having established the role of income changes and price changes, the model attempts to attribute remaining expenditure change to 'exogenous non-economic factors' (until only a small random error remains). Figure 5.2 depicts the structure of the ELESA model for a given category.

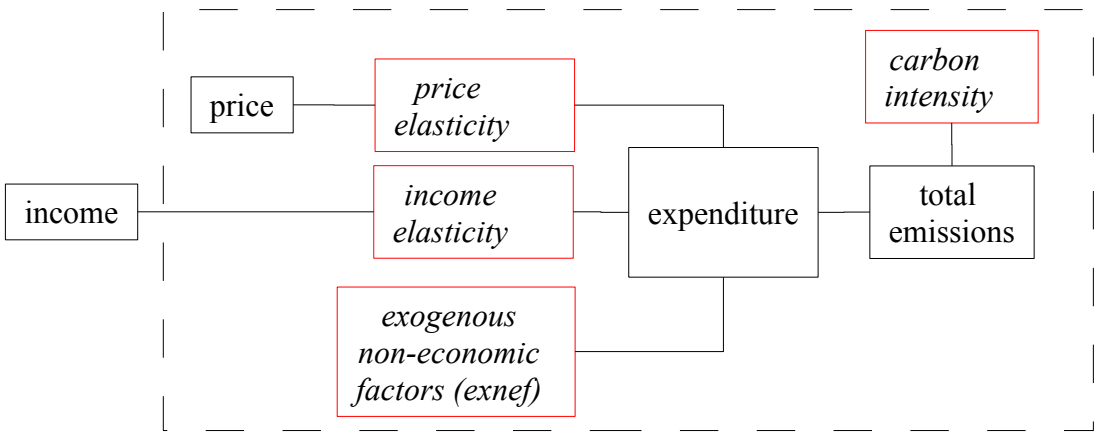


Figure 5.2: overview of key components of ELESA[4]

4 Plain text indicates where historical data has been used, while text in italics represents values derived from this data using the model. The dashed line indicates a single category, with category specific values embedded inside, while income is consistent across all categories.

With these historical relationships established, a procedure was then possible whereby assumptions for incomes and prices could be projected out to some point in the future, with the price and income elasticities (along with the historical ex-nef trend) used to determine the impact on expenditure. For example, a sharp increase in prices for a category sensitive to price changes might be expected to show a significant reduction in expenditure (other things being equal).

Incorporating carbon modelling data, it was also possible to establish annual carbon emissions attributable to each category over the period 1992-2005 (Chitnis *et al.*, 2009, Chitnis & Hunt, 2009). Combined with expenditure data, it was then possible to determine the carbon *intensity* of each category over those years (as $MtCO_2e$/£m). Knowing the level of carbon intensity at 2005, and the trend in carbon intensity over the period, it was then possible to extrapolate future emissions for each category, given expenditure.

In this research, the ELESA model is used to provide illustrative quantification to the scenarios. The variables for which assumptions must be made are 'income' (applies across all categories), and 'price', 'exnef' and 'carbon intensity' for each category. Rather than forecasting on the basis of historical trends, the assumptions are derived from the storyline of that particular scenario. To be clear, the historical trends are used as a starting point in all four scenarios, from which they deviate as the narratives unfold.

5.9 Chapter Summary

At the outset of this research, a proposed methodology was prepared, and feedback sought from experts in the field of scenario planning. In response to that feedback, the methodology was revised before being carried out. The qualitative scenario narratives were developed over a series of stages, beginning with in-depth interviews with internal experts. The key uncertainties derived from this interview data were collated and presented to the scenario panel, an internal board appointed to provide guidance and oversight at key stages of the process. Two key uncertainties were then used to form a provisional scenario framework, which was tested with a series of external experts during a further round of in-depth interviews. The insights gathered from these experts, including further uncertainties and possible developments, were then compiled into a scenario narrative template. This template was used to inform the draft narratives for each scenario, before these drafts were expanded and revised into more fully formed storylines. For the quantification of the scenarios, an econometric model was employed whereby assumptions for key variables were derived from each of the scenario narratives.

In the next chapter, the complete scenario narratives resulting from this process are provided, preceeded by a short introduction on how the read the narratives, and followed by a summary of the illustrative quantification and a discussion of some of the key implications of the scenarios.

6. Scenarios

6.1 Introduction to the Scenarios

In the next four sections of this chapter, the scenario narratives are provided including a summary of the quantification for each one. A more detailed breakdown of the quantification process is provided in Appendices V-VIII. A description of the formatting used to present the narratives and the quantification is provided below.

Reading the Qualitative Narratives

The scenarios follow a consistent format to enable cross-comparison. In each case, the narratives have been broken down into three time periods, describing events unfolding from 2010-2015, 2015-2020, 2020-2030. A timeline feature identifies the relevant scenario and time period under discussion:

Key developments among the various factors of interest are then discussed:

Global factors. These include social, political and economic developments at the international level, e.g. an international emissions regime, trade relations, or particular climate action taken by the US, EU and China.

UK Factors. These include social, political and economic developments at the national level, such as environmental policy measures, financial incentives, social pressures and media coverage.

In each time period, global factors are generally grouped together in a series, followed by UK factors. Since some factors relate to general trends, while others relate to particular events, in some cases it is necessary to intersperse global and UK factors to give a sense of sequence. Thus, although specific dates have been purposely avoided, a general chronology can be assumed from the order in which factors are described.

Next, a set of four icons are used to indicate outcomes in terms of household consumption, according to the categories described in Chapter 2:

At Home. Describes consumption activities around the home, including use of energy for heating and appliances. As with all the consumption categories, outcomes described here include behavioural changes resulting from price signals as well as those influenced by non-economic factors.

The Food We Eat. Relates outcomes in terms of dietary changes, food waste etc. As with the other categories, the carbon intensity of household consumption can be impacted by supply/production processes as well as behavioural change. Any changes in carbon intensity due to production changes are therefore also treated as outcomes.

Getting Around. Includes day-to-day transport use for commuting, visiting, leisure practices and so on. The category covers private car use as well as public transport, walking and cycling.

Getting Away. Relates exclusively to aviation for tourism. Whereas the other three are composite categories comprising a series of activities, the identification of aviation by members of the public as one of their four key consumption categories hints at the significance of this activity in two ways: the central importance of foreign travel as an aspiration in peoples lives, but also as an acknowledgement by consumers of the environmental impact of this activity.

Quantification

At the end of each scenario narrative, two charts are provided summarising total UK household expenditure and emissions over the full 20 year period of the scenario. For a more thorough examination of the illustrative figures, a detailed breakdown of the assumptions used in each variable, for each category, across each time period is provided in Appendices V-VIII.

An example of the expenditure data for one time period is shown in Table 6.1:

Household disposable income: 1.7% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2015 Expenditure (m£)
Electricity	*3.00*	0.43	-0.82	*0.41*	0.10	9200
Gas	*2.00*	-	-1.07	*1.48*	0.37	9697
Vehicle fuels and lubricants	*0.63*	0.13	-0.14	*2.51*	2.51	28495
Other fuels	*3.50*	0.46	-0.09	*-4.87*	-4.46	832
Other transport	*0.13*	0.84	-0.15	*2.25*	2.94	111382
Food and non-alcoholic drinks	*-0.50*	0.30	0.21	*0.25*	0.74	71075
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	26052
...	...	...	...	...	...	...

Table 6.1: Example scenario expenditure data

First, the average annual change in household disposable income over the period is provided. Then, in the main table, the columns are arranged as follows:

1. The name of the category of goods and services;
2. the average annual change in prices;
3. the average annual change in expenditure:
    1. due to income effect;
    2. due to price effect;
    3. due to exogenous non-economic factors;
    4. in total (sum of all three);
4. total UK household expenditure for the category in the year falling at the end of the time period.

The expenditure table is followed by a series of notes explaining how key assumptions were derived from the scenario narrative.

Next, the emissions data are summarised for that time period, as in Table 6.2:

		in 2015		
	carbon intensity	Carbon Intensity	Expenditure	Emissions
	change (% p.a.)	(tCO_2e/m£)	(m£)	($mtCO_2e$)
Electricity	*0.00*	7.79	9200	72
Gas	*0.00*	10.43	9697	101
Vehicle fuels and lubricants	*0.58*	3.11	28495	89
Other fuels	*-2.74*	7.05	832	6
Other transport	*1.03*	1.46	111382	163
Food and non-alcoholic drinks	*-1.92*	1.12	71075	79
Alcohol and tobacco	*2.72*	0.33	26052	9
...	...	...	...	...

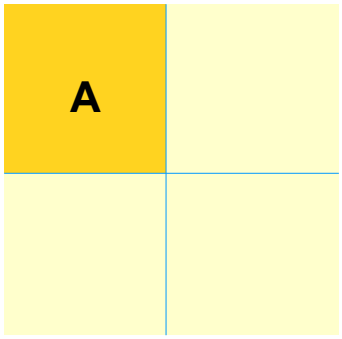
Table 6.2: Example scenario emissions data

The columns are arranged as follows:

1. The name of the category of goods and services;
2. the average annual change in carbon intensity (%);
3. then, for the year falling at the end of the time period:
    1. the level of carbon intensity (in tCO_2e/m£):
    2. total UK household expenditure for the category (in m£, reproduced from the expenditure table);
    3. total emissions resulting from UK household expenditure for that category (in $mtCO_2e$).

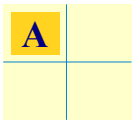
As with expenditure, notes are provided beneath the emissions data table to indicate the reasoning behind key assumptions. The expenditure and emissions changes over each time period are then summarised in chart format.

6.2 Scenario A



Better late than never

Little significant change in efforts to tackle emissions up to 2020, when increasing calls for climate action combine with rising fuel and commodity prices to bring things to a crisis point. Out of the crisis, international leaders build consensus on a comprehensive programme of emissions cuts. Although there is little improvement in the carbon intensity of UK lifestyles before the crisis, the securing of a global deal instills a sense of common purpose that encourages proactive behavioural change.



The lack of a decisive outcome from the Copenhagen summit leads to a general slowing down of efforts to achieve a substantive international agreement on climate change.

Concerns turn towards the economy and the precarious recovery from the global recession of 2008.

As a result of the global slump in demand, commodity prices including fossil fuels remain below the historically high levels seen leading up to the recession. Consequently, there are few substantial incentives to encourage greater energy or resource efficiency, either by producers of goods and services or by households directly.

In developed countries, mainstream media coverage continues to represent climate science as something contested, and the solutions expensive, ensuring the marginalisation of climate activists and campaigns. In those countries worst affected by extreme weather events, there are continued (and increasing) calls for developed countries to act on climate change.

At home, the government renege on some of the environmental policies of their predecessors, while attempting to establish a green agenda of their own. On balance though, environmental policies become another victim of the programme of cuts in public spending.

For most UK households, employment remains the primary concern during a period of slow recovery.

The negative portrayal of climate science in parts of the UK mainstream media intensifies, with increasing attacks on leading climate scientists and institutes detracting from the science itself.

Meanwhile, other parts of the UK media continue to report on climate change in accordance with the mainstream scientific community. For these outlets, the extreme climate variability of recent years acts as a stark warning of the need for radical change.

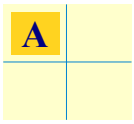
Whilst the environmental movement grows in number and improves its outreach capacity, a largely ambivalent public refuse to commit to serious behavioural changes or support political action.

A lack of government incentives and subsidies combined with short term financial worries keep capital expenditure on home insulation and micro-generation at a low level. Although consumers report energy efficiency as being an important consideration when purchasing new appliances, actual purchasing behaviour points to the prevalence of cheap, low energy efficiency products.

The absence of economic or behavioural incentives means there is no meaningful change in food consumption patterns.

Financial contraints prevent significant uptake of new, more efficient vehicles. Meanwhile, lack of incentives means no significant reduction in vehicle use, e.g through shorter trips or car sharing.

The absence of effective policy measures to tackle the environmental cost of aviation leads to an increase in flights, with demand recovering sharply from a drop during the economic crisis of 2008.



From 2015, rising global demand leads to significant increases in prices of commodities and fuels. Through to 2020, this sustained price pressure leads to slower growth in the global economy.

Concerns about unrelenting fuel prices crystallise into two distinct factions: those calling for short term action (lowering fuel taxes), and those attaching themselves to a growing and increasingly coordinated environmental lobby, calling for a rapid transition away from dependence on fossil fuels.

These social movements are mirrored politically, with world governments and their opposition parties grappling with these competing interests.

By 2020 the issue remains unresolved, but the impact on the global economy combined with increasing social unrest means that action becomes inevitable. International talks are scheduled, sparking the largest, most coordinated environmental campaign to date.

In the UK, as elsewhere, increasing fuel prices put pressure on household expenditure. Unable to make an immediate transition away from fossil fuels in the absence of appropriate government support, households are forced to curtail expenditure on other goods and services.

The slowing of the economy towards 2020, and the associated impact on incomes, leads to increasing dissatisfaction with government and a political crisis.

The motoring lobby campaigns vigorously for reduced taxes on vehicle fuels, elements of the energy sector campaign for a relaxation of environmental targets. Meanwhile other players in the transport and energy sectors call for subsidies to support investment in public transport and low carbon energy sources respectively. These competing industry forces form alliances with social movements in an ideological conflict that reflects the global crisis as a whole.

Although modest steps are taken towards emissions reductions, and the economic slowdown inevitably results in less economic activity, it also has a significant impact in delaying low carbon investment in the private sector. There is a gradual realisation that emissions reduction targets for 2020 will not be achieved.

Going into international negotiations in 2020, the UK government comes under immense pressure from both sides of the debate, as opposition parties wait to take full advantage of any public dissatisfaction arising from the talks.

While some basic energy efficiency measures are adopted, lack of robust policy measures and capital funding for retrofit leaves most households exposed to higher fuel prices. Those increases in fuel prices mean that electricity and gas bills take up an ever larger share of household expenditure through this period.

Food prices are similarly affected by global demand (and by higher fuel costs). Unlike electricity and gas though, households are able to adapt by shifting expenditure from high-end, quality food to more affordable value products.

Regardless of a shift in quality, the broad footprint of food purchasing hardly changes, with no transformation of attitudes with respect to meat consumption or local sourcing, and little progress on the reduction of food waste.

A significant rise in vehicle fuel prices means an increasing proportion of households' disposable income is spent on petrol/diesel. Despite continued price pressures, only a gradual shift in transport behaviour is observed over the period, with some households beginning to cycle, car share etc. as they increasingly identify with the sustainability movement.

Increasing fuel costs feed through to flight ticket prices. Still, in the absence of any policy measures or significant behaviour change, growth in household disposable income means that increased costs can only slow the growth in aviation, rather than stop it.

The international summit of 2020 comes at a time of crisis in the global market, with unprecedented demand for fuels and commodities.

In developed countries, there are concerns about the impact of high prices on economic growth, and the viability of a business as usual approach for the long term.

In developing countries the impact has been more severely felt, with lack of sufficient food and fuel supplies leading directly to conflict and humanitarian disaster.

In response to the crisis, leaders at the summit manage to agree on a programme of measures including a global emissions trajectory peaking by 2030 and falling substantially by 2050. Developed countries commit to stringent domestic cuts and an assurance of support for developing nations via low carbon technology transfer and preferential trade agreements with countries implementing decarbonisation programmes.

In accordance with its international commitments, Europe and the UK pass climate and energy legislation aimed at substantial cuts by 2050, with a programme of short term measures towards interim 2030 targets.

In the UK, government rapidly enacts legislation drafted in anticipation of a successful international deal. Funding is made available for a suite of decarbonisation programmes, while financial support mechanisms are established – for households and industry – to encourage take up of low carbon technologies.

The success of the sustainable development movement inevitably signals the defeat of the motoring lobby in its demands for vehicle fuel subsidies. Instead, government signals a long term commitment to the diversification of the private vehicle fleet, with strict targets for manufacturers on electric, hybrid and flexifuels vehicles.

A commitment to low carbon public transport, including substantial seed funding, raises the prospect of a long term resurgence, attracting further private sector investment. Nevertheless, the nature of the industry means that change is slow to materialise in the short term.

A series of measures are aimed at reducing gas consumption. A nationwide domestic retrofit programme initially focuses on the most vulnerable households: older people and low income families in the most inefficient buildings. The programme includes insulation, solar water heating and micro-renewables where appropriate, at no cost to those households.

After the first few years, the programme scales up sufficiently to be rolled out beyond those priority groups, with financial mechanisms in place to ensure capital costs are paid through savings in bills, rather than upfront investment.

Community level micro-generation schemes, including wind, small-scale hydro and biomass with district heating, contribute to the decarbonisation of electricity while bringing further reductions in gas use. These schemes are co-funded by central and local government, private operating companies, and local residents who benefit from price guarantees.

In a collective push to reduce food waste, government, food retailers and NGOs work together to raise awareness and provide information and tools for better food planning and storage, with reasonable success over the period.

Growing awareness of the impact of food production leads to a slight reduction in meat and dairy consumption, and a drive on the part of producers to reduce that industry's environmental impact.

Introduction of mandatory carbon labelling for food leads to further consumer behaviour change.

There is a general expectation that vehicle fuel prices are likely to be driven higher over the period, leading to significant shifts in behaviour.

Purchase of fuel efficient vehicles gathers apace, while government commits to more rapid deployment of electric vehicle charging infrastructure, sparking substantial growth in electric vehicle sales and signalling the beginning of a gradual shift away from liquid fossil fuels.

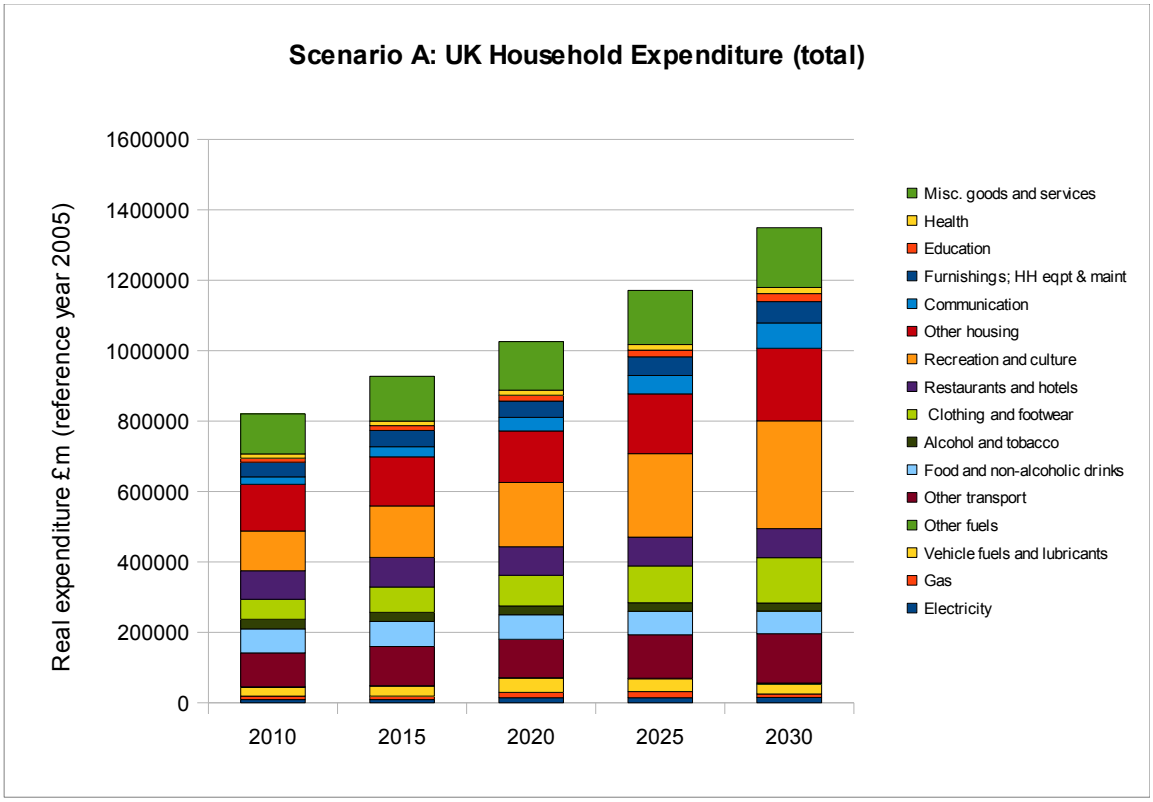
Equally significant is the reduction in single person car journeys, including through increased car-sharing, aided by innovations in communication technologies that allow more effective coordination between networks of friends and colleagues.

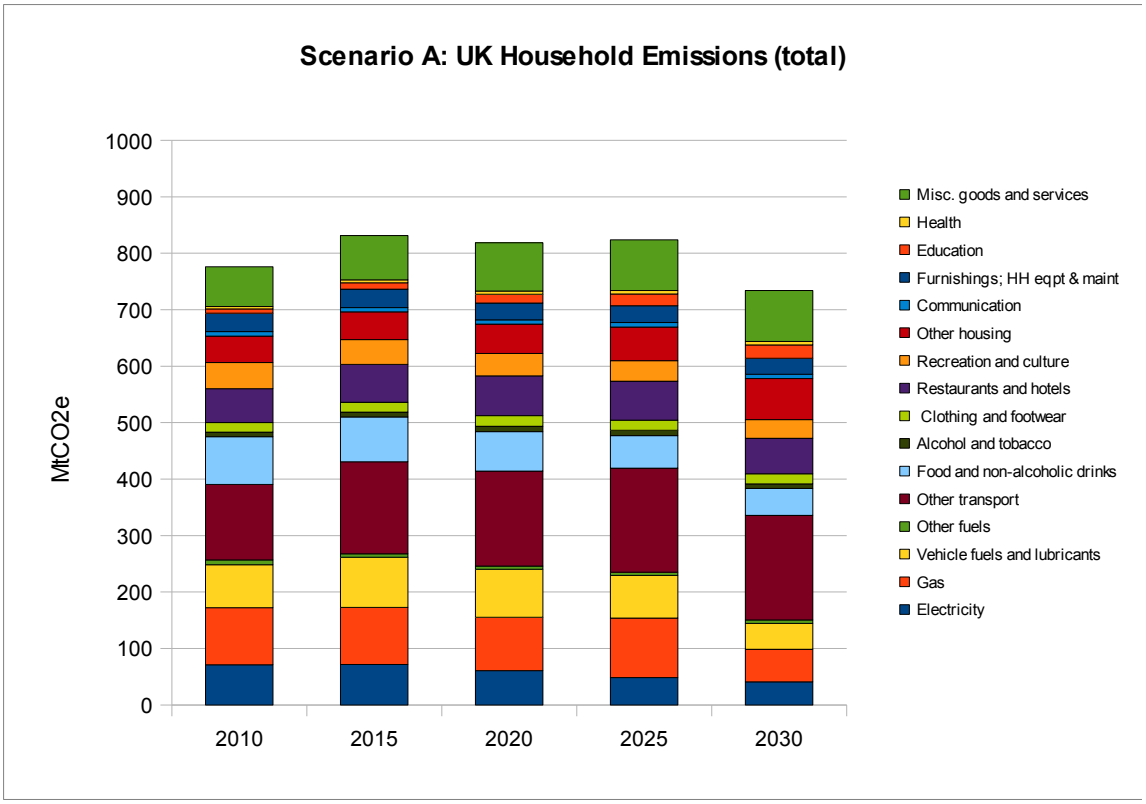
Public transport use begins to increase. The gradual shift away from cars and onto trains and buses, results in a less carbon intensive transport sector overall, although aviation continues to play an ever greater part.

With rising aviation fuel costs leading to higher ticket prices, some families opt for 'staycations'. Nevertheless, increasing disposable incomes ensure that many people remain ready and willing to pay higher prices to ensure regular foreign holidays, meaning growth in aviation is only curbed so far, and is somewhat offset by increased road/rail/bus travel.

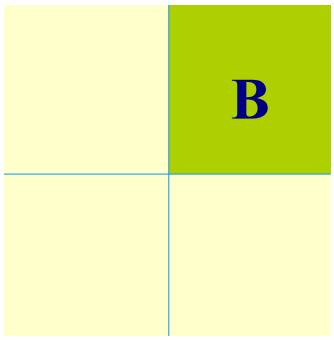
Illustrative Quantification

(for full breakdown see Appendix V)





6.3 Scenario B



All together, now

Voluntary climate action by different countries, including through green job programmes to aid economic recovery, helps to lay the groundwork for a comprehensive and equitable global deal in 2015. The cooperative approach observed at the international level is reflected in the behavioural change undertaken at the household level.

The perceived failure of the Copenhagen summit leads to a period of soul searching among activists, policy makers and climate scientists, and while the UNFCCC process continues, with regular meetings and summits, there is no great hope of this process delivering any substantial deal in the short term.

A slow recovery from the economic crisis of 2008 ensures that jobs remain the central concern for developed countries.

Sustainability advocates pursue a localised, participatory approach to developing positive visions of a low carbon future. Gradually, these groups build support for a green recovery campaign, outlining how a green job creation programme can result in a 'triple win' for economic, environmental and social concerns.

While mainstream media remains a complex terrain in terms of climate science reporting, effective public communication by a 'transition alliance' manages to engineer a shift in column inches towards an emerging positive outlook, particularly around a green economic recovery.

Meanwhile, the EU improves its emissions reduction target to 30% on 1990 levels by 2020.

In the US, despite lack of progress in establishing climate legislation, action begins at the sub-national level with some states establishing programmes for green jobs, emissions trading, and sector-by-sector industrial efficiency targets.

Continuing along a high growth trajectory, China announces a series of ambitious industrial carbon intensity targets.

In the UK, amid the public spending cuts announced in 2010, there is concern that a number of environmental initiatives may be dropped.

As part of a global alliance, activist groups in the UK renew strategies for public engagement, with a focus on green jobs for a sustainable recovery. Allied with trade unions and social justice campaigners, environmental groups attract considerable support for their green jobs agenda.

The UK media seek to capitalise on public anxieties around the recovery, with many spearheading their own campaigns for green jobs, giving a platform to those concerned about the possible impact of proposed spending cuts.

Coordinated protests and strike action puts significant pressure on the government to abandon spending cuts, including on green initiatives.

Citing a desire to lead on emissions reductions within Europe, the UK government responds to improved EU-wide targets with an ambitious emissions reduction target of 42% by 2020, on 1990 levels. In light of the revised target, the government announces a reorientation of public spending priorities, with some ringfenced spending for emissions reduction initiatives, and measures to boost green jobs.

Government launches the green bank to coordinate low carbon investment. Although funds are initially low due to the slow recovery, priority is given to job training programmes for retrofitting, and investment for wind turbine manufacture.

A national retrofit schedule is published, in preparation for a roll out across the most vulnerable households. Measures are also put in place to galvanise neighbouring private households to act collectively in adopting retrofit measures, with a pool of money made available for a range of insulation options to reduce energy demand, and installation of renewables for electricity and heat generation.

Changes to the tax structure around private transport are announced, intended to incentivise more fuel efficient vehicles.

The emergence of a more positive vision of transition leads to more favourable public attitudes on climate action. Still, a gap remains between commitment and action as many households remain unclear as to the most effective action to take.

Having succeeded in persuading their own decision makers to lead on the strengthening of binding targets, UK environmental groups are joined by the general public in calling for government to insist this example is followed internationally.

Exploiting the low hanging fruit of energy efficiency and conservation ensures the EU is on track with voluntary emissions reductions towards the end of this period.

In the US, progress by 'early adopter' states leads to wider adoption of industry targets and sub-national emissions schemes, with steps taken towards a link up with the EU, putting pressure on the US government for implementation at the national level.

In China, industry presses ahead with efficiency measures, in line with sectoral targets.

A global alliance of sustainability advocates gains momentum, citing various early successes in the EU, parts of the US, and in China as evidence of the viability of low carbon development. The alliance calls for global leaders to commit to further action in the form of an international legally binding agreement.

Ahead of a global summit in 2015, two possible outcomes begin to emerge. With the EU, US and China pursuing their own unique strategies for low carbon development, the cementing of these commitments under a unified emissions regime seems credible. Nevertheless, there are fears that without such a binding regime, these distinct approaches may come to be seen as competitive rather than complementary, with the threat of trade measures being used to protect key industries in each region.

Although slowly at first, household energy management shows some improvement over the period, reducing demand for electricity and gas. This is aided in part by publicity around the national roll out of smart meters and energy display devices, although coverage over this period remains low.

Financial incentives for private households to adopt retrofit and micro-generation leads to increased adoption of such technologies, although the initial funds are limited. A government scheme to retrofit the most vulnerable households begins to unfold in parallel. However, starting from such a small base, the initial success of these schemes is more symbolic than substantive.

As part of an improved EU target, increased energy efficiency requirements for electrical appliances leads to higher expenditure on these items, but in the short term there is no significant reduction in household electricity consumption resulting from these measures.

As part of a positive vision for a sustainable transition, environmental groups promote low carbon cuisine, with celebrity and retail endorsement, beginning a shift in attitudes on food, but little immediate reduction in the carbon intensity of food production.

Increasingly, households attempt to grow some of their own food, with results initially failing to match enthusiasm. Nevertheless, local support networks ensure persistence and the development of knowledge and skills.

Households become increasingly engaged in the need to reduce food waste and some progress is made in this regard.

Overall expenditure on new vehicles remains constrained by the slow recovery at first, although changes to pricing mean that fuel efficient models become relatively more popular. Demand for electric vehicles outstrips their modest supply, with hybrid vehicles securing a greater share of the market over this period.

The shift in environmental attitudes leads to a modest change in travel behaviour, with a slight increase in walking and cycling for short journeys and informal car sharing.

After a dip during the recession, aviation begins to grow again with foreign holiday travel proving a particularly difficult area in terms of pro-environmental behaviour change. Although aviation is brought into the EU Emissions Trading Scheme from 2012, the generous provision of permits allows the industry to continue largely as before.

Ahead of the 2015 summit, a global sustainability alliance campaigns for a positive, ambitious and equitable outcome. The movement capitalises on the international participation in visioning projects to demonstrate the widespread grassroots support for a low carbon future. The co-option of leading thinkers, business leaders and decision-makers reinforces the case for a successful outcome, putting further pressure on negotiators to deliver.

The successful performance by early adopters, concern about the high costs of a carbon intensive pathway and the implications of failure in terms of trade relations, all contribute to a successful summit outcome. Developed countries establish a series of ambitious emissions reduction targets for 2030, 2040 and 2050.

A revitalised UNFCCC takes on a monitoring and evaluation role in relation to carbon trading schemes and emissions reporting, with developing nations committing to deeper transparency in addition to further efficiency targets. Technology transfer agreements offer significant opportunities to the least developed countries.

Despite efficiency gains, rising global demand leads to higher prices of commodities and fuels, amid expectations that this trend will be sustained.

In the UK, the signing of an international agreement reinforces business certainty, most immediately noticeable through a surge of interest by large investors, including pension funds, unlocking much needed funding for a series of large-scale infrastructural investments through the green bank.

Despite teething problems, the retrofit of vulnerable households begins to deliver steady results, expanding coverage steadily through this period. The financing scheme for retrofit of private households proves extremely popular, but progress is limited by budgetary constraints, with the scheme being oversubscribe each year.

Decarbonisation of electricity generation continues at a reasonable pace, but a serious step change is required to meet expected future demand as a result of electrification of transport and heat.

Additional funding for the green bank is announced, with support for smart grid, high speed rail and electric vehicle charging technologies. The institution also launches a series of products aimed at attracting capital from individuals and community groups. These products prove popular, attracting funds away from high street banks, and prompting those institutions to offer similar product ranges of their own. An active customer base increasingly influences project funding, leading to a diversification of low carbon investments.

Small and medium enterprises are some of the beneficiaries of that diversification, as a revival of local agriculture and manufacturing is promoted against a backdrop of anticipated higher costs for overseas goods.

The deployment of smart meters and energy display devices continues, with the aim of covering every household by 2020. The devices contribute to a small reduction in demand although advocates suggest that advanced features such as tarriffs allowing remote control of appliances are essential to deliver further savings and to assist in load balancing.

Demand for private retrofit grows substantially over this period, with financial support remaining oversubscribed despite increases in funding. A national roll out of retrofit solutions across vulnerable households remains on track, contributing to reductions in fuel consumption and fuel poverty.

Improvements in energy efficiency requirements for electrical appliances continue to have a small impact on electricity consumption, although efficiency gains are somewhat offset due to an increase in the average size of televisions, fridges etc.

Initiatives aimed at promoting a low carbon diet lead to increased awareness of the environmental impact of food production, and significant attitudinal change towards low impact food. Still, the diversity of ethical considerations means that 'low carbon' isn't always the primary target of voluntary changes in food purchasing. Meanwhile, the improved EU emissions target has led to stronger measures to reduce GHGs arising from food production, reflected in the increased price of carbon intensive food products. Arguably, these price signals are proving more effective in shifting food purchasing towards lower carbon items, and the international emissions regime is widely expected to have a further impact in this regard.

The persistence of households attempting to grow their own food begins to pay off, with a steady build up of knowledge and skills leading to more successful yields each year, encouraging further participation. Support networks blossom, with some crystallising into small-scale community farming ventures.

Efforts to tackle food waste prove popular at a time when food prices are rising.

With increased financial backing for charging infrastructure, and with manufacturers having gradually scaled up production, sales of plug-in hybrid and all electric vehicles climb rapidly. Unable to match the fuel economy of EV/hybrid models, and with pricing trends changing irrevokably against them, sales of traditional internal combustion engine vehicles begin to give ground. Nevertheless, these traditional vehicles still account for the majority of new car sales in 2020, and continue to dominate the existing vehicle fleet.

Despite the persistence of private car ownership, a significant rise in vehicle fuel prices leads to a reduction in passenger miles. These prices pressures are added to by changing attitudes towards transport, with a shift towards walking/cycling for short journeys, increased public transport use, and the innovative use of communication technologies in support of car share and car pool networks.

As part of the international agreement established in 2015, strict emissions targets are to be applied across the aviation industry from 2020, with a carbon trading mechanism that will increase costs but allow growth for the foreseeable future.

Already, increasing fuel prices have slowed the growth in aviation, but with increasing disposable incomes and foreign travel remaining an important aspiration for many households, it seems unlikely that behaviour change alone will be sufficient to reduce consumption.

Following a sustained period of increased global demand, there are significant pressures on global prices of fuels and commodities. This pressure has been alleviated somewhat by global developments on energy efficiency, preventing a full-scale crisis. Nevertheless, ongoing improvements in energy and resource efficiency are called for to reduce further impacts, particularly on the world's poorest nations.

The scarcity of fossil fuels and the incremental impacts of carbon pricing provide further stimulus for developed countries in their efforts to decarbonise. The burst of activity around low carbon development brings price pressures of its own, although these begin to stabilise over the course of the period.

With increasing pressure to reduce emissions from transportation, countries are required to balance the drive towards specialisation with the need for more localised production. As a result, economies become increasingly diversified.

The UK economy enters the 2020s with domestic emissions on a strong downward trajectory. The resurgence of the agriculture and manufacturing sectors, whilst contributing to that reduction in emissions in many ways, also brings some emissions back 'onshore' by displacing production of goods imported from overseas. Whilst positive from a global emissions perspective, this trend puts an increased emphasis on the need for more strategic economic development if these industries are to develop amid increasingly stringent emissions targets.

By 2020, involvement by mainstream society in the articulation of a sustainable future has ensured that low carbon development is no longer seen as a constraint, but rather as something positive and constructive. Although the visions themselves remain diverse, an underlying commitment to the basic principles of participation and fairness ensure that the transition is viewed positively and carried forward proactively by the majority of individuals and communities.

Through this period, the drive for carbon reductions brings further diversification of the economy. The resurgence of domestic production in agriculture and manufacturing coincides with increased efforts by all sectors of the economy to identify energy savings through improved industrial ecology, maximising the reuse of energy and resources, whilst minimising waste. This leads to innovative regional partnerships, with waste agricultural products increasingly used for biomass energy production, and the heat from those processes reused in district heating networks for local homes, hospitals and schools.

Through this period, the electrification of the UK energy system becomes the primary mechanism by which further domestic emissions reductions are to be achieved. After years of technological development, attitudinal change, and investment in infrastructure, the groundwork has been laid for a decade of mass electrification of the transport sector. Significantly increased demand is also anticipated from the electrification of residential heat.

With the roll out of smart meter technology essentially complete, householders are better able to assess and understand the impact of particular energy related activities. Energy companies begin to roll out advanced metering contracts, with households offered incentives to allow appliances including fridges, freezers, hot water tanks and storage heaters to operate partly in response the needs of the grid. Towards the end of this period, such contracts are making a valuable contribution to load balancing.

The retrofit programme for vulnerable households begins to scale down, with the majority of intended recipients having been targetted by 2030. Retrofit work continues apace in the private sphere, as households seek to reduce their own vulnerability to sustained high energy prices through improved insulation and microgeneration.

Such retrofit solutions increasingly include community-wide schemes, allowing some deployment of biomass power stations and district heating systems.

Earlier regulatory measures to improve the energy efficiency of household appliances have ensured that all new electrical appliances now meet stringent efficiency standards, although energy savings are partly offset by the emergence of ever more electrical and electronic gadgets in the home.

By 2020, changing attitudes towards food production and consumption have had a noticeable impact on the carbon intensity of food purchases.

The 'grow your own' culture continues to develop, with local networks and cooperatives for knowledge (and produce) exchange, and expanded allotment schemes for households without private gardens, including 'city farms' run by urban households. These schemes are successful not just in reducing food expenditure directly, but in influencing people's attitudes towards the food that they do buy, with stronger support for local and organic produce.

This adoption of more pro-environmental attitudes to food purchasing is reinforced by continuing price increases for carbon intensive products, including meat and air-freighted foods, ensuring that low carbon food consumption is widely established as a way of life, rather than just a trend.

By 2020, the charging infrastructure for plug-in hybrid/electric vehicles has reached a critical level of deployment, ensuring that these are increasingly seen as the technologies of choice for new car purchases. Although petrol/diesel engines continue to play a role, this is increasingly as a range extending device in plug-in hybrid vehicles. By the end of the decade, the purchase of new internal combustion engine vehicles is negligable, and their share of the overall vehicle fleet has fallen significantly.

Through the 2020s, investment in public transport ensures further electrification of the rail network, while the introduction of new high speed rail lines leads to increased passenger miles by train. Crucially, efforts are made to integrate all aspects of the public transport infrastructure, and to streamline payments and journey planning, encouraging further adoption of public transport among commuters.

Improvements in information and communication technologies continue to impact on working arrangements, with more employers allowing and even encouraging employees to work from home where appropriate.

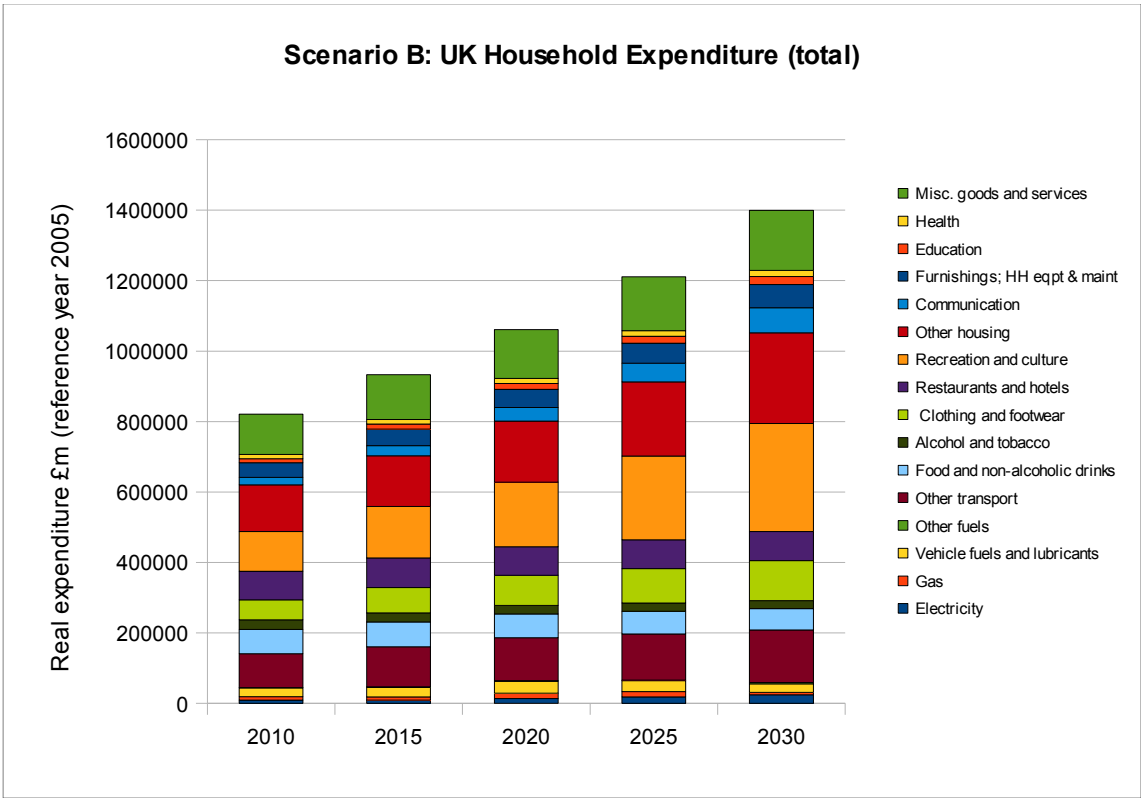
With the implementation of strict emissions targets for the aviation industry, costs increase considerably through this period. With improved public transport infrastructure in the UK, domestic flights begin to fall, and with high speed rail links to many parts of Europe, growth in short-haul european flights is halted.

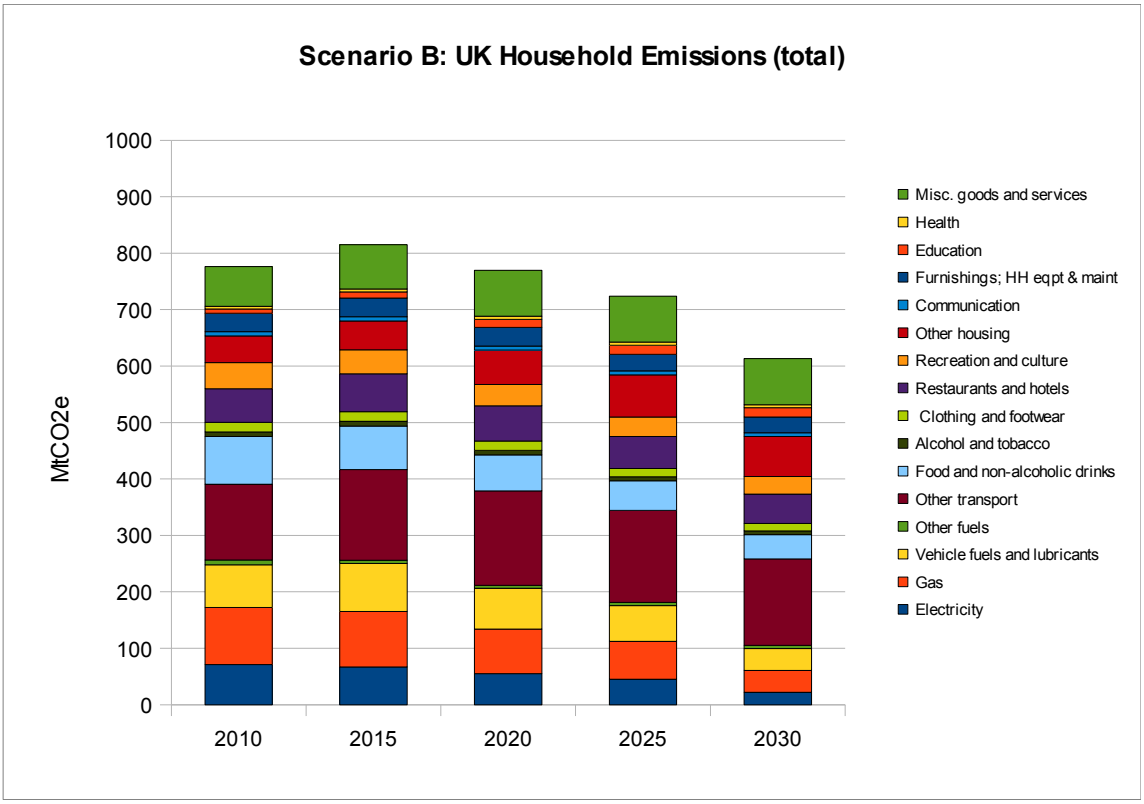
International long-haul flights prove more difficult to curb, although with higher prices and changing attitudes on the part of holidaymakers - increasingly prepared to look for holiday destinations closer to home – growth begins to slow.

In addition to behavioural change resulting from price signals and more pro-environmental attitudes, logistical and technological developments ensure a leveling off of aviation emissions attributable to UK households by 2030.

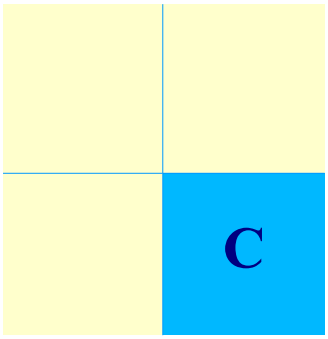
Illustrative Quantification

(for full breakdown see Appendix VI)





6.4 Scenario C



Trading woes

Unilateral climate action by the EU is intended to draw further commitments from other parties, but with no such action forthcoming by 2015, the EU threatens the use of trade measures. After a period of heightened political tensions and economic slowdown, a compromise is reached. The result is a series of bilateral emissions targets that remain insufficient to avoid dangerous climate change. The UK public are cautiously optimistic at first, but without commensurate international action, enthusiasm for pro-environmental behavioural change is weakened.

In the aftermath of Copenhagen, enduring divisions between the various parties in the negotiations overshadow the efforts of sustainability advocates to rebuild a sense of momentum towards action on climate change. Instead, campaigners in the EU and US focus on green jobs programmes as a route to recovery.

The shifting political landscape in the US ensures that commitment to low carbon development remains weak, with rhetorical demands for commensurate action from China, and energy security the predominant policy objective. With the increasingly distant prospect of federal climate legislation, some individual states set out their own policies on low carbon development, including regional emissions trading schemes, green jobs programmes and industrial efficiency targets. However, these initiatives come under concerted attack from carbon-intensive industries and conservative political groups.

Continuing to insist that developed countries must lead on climate action, China refuses to commit to binding targets, but pledges that it will adhere to existing, voluntary measures on energy efficiency.

In the EU, campaigners are cautiously optimistic as leaders agree to an improved emissions reduction target of 30% on 1990 levels by 2020 in an apparent effort to encourage action from the US and China.

With hopes fading for an international agreement in the short term, UK sustainability advocates focus on securing domestic action in line with the improved EU emissions targets, including a green jobs programme to lead an economic recovery.

Afraid that such action is threatened by proposed austerity measures, the environmental lobby join trade union activists in offering fierce resistance to public spending cuts.

In the absence of any significant climate action outside of the EU, the UK media is divided over the issue, with some commentators joining the call to reign in spending cuts in support of green growth while others insist further unilateral action would be futile, and would only cede bargaining power.

Pressured by the improved target at the EU-level and increasing calls for action at home, the UK government announces an improved emissions reduction target of 42% by 2020, on 1990 levels, but signals that an increased proportion of reductions may be met through carbon trading and offsetting measures until an international agreement is reached.

Alongside the revised emissions target, the government announces it is ringfencing funding for emissions reduction initiatives and providing measures to boost green jobs.

A green bank is also established, amid concerns that it will simply streamline existing investment commitments. Although government announces some fresh funding, fears remain that - with the increased role for carbon trading and offsetting - the green bank will be used to fund projects that fail to provide 'additionality' of carbon savings.

In a bid to counter such criticism, a range of domestic programmes are some of the first to be given support through the green bank, including support for wind turbine manufacture and other renewables research and development.

Sensing that the public remain divided on the merits of unilateral climate action, government stops short of adopting policy measures that risk being seen as restrictive of lifestyles. Instead, policy is focused on the 'cost saving' arguments for action, through retrofit schemes funded by the private sector, and costs recouped from savings on household bills.

Towards the end of this period, the lack of international cooperation leave the public unwilling to adopt measures that are seen as self-sacrificial, but investment focused on green growth and opportunities to adopt more eco-friendly purchasing behaviour are broadly welcomed.

Through a combination of energy efficiency and conservation measures, investment in renewable capacity and extensive carbon trading and offsetting, the EU remains nominally on track with emissions targets by the end of this period. Environmental groups are scathing of the role of carbon offsetting, arguing that real emissions reductions fall far short of the levels required.

In the US, efforts by individual states to establish their own industry efficiency standards and emissions targets have been hampered by intensive lobbying and legal action.

In China, growth remains the priority, with no strengthening of emissions targets beyond existing efficiency goals.

In what feels like the last roll of the dice ahead of an international summit in 2015, global sustainability campaigners warn of serious economic consequences resulting from failure to secure a deal.

Unilateral action by the EU has failed to prompt a commensurate response from either the US or China. Bowing to intensified lobbying by energy and other heavy industries who face tough carbon constraints, the EU warns other parties that trade measures are being considered in order to protect those industries against cheap, carbon-intensive imports.

A national roll out of smart meters and energy display devices begins in this period, although coverage remains too low to deliver significant savings through behavioural change. Ambivalence at the household level towards voluntary actions on climate change prevents any significant attitudinal or behavioural change around household energy use.

There is an increase in the uptake of retrofit and micro-generation technologies by private households over the period, although a relatively low starting point means there is only a small impact on demand for gas and electricity.

In line with an improved emissions target, the EU establishes plans for increasingly stringent efficiency standards for electrical goods over the forthcoming decade.

Environmental groups seek to influence dietary habits through the promotion of a low carbon diet, gaining some support from celebrity chefs and supermarket chains, but with limited uptake from hesitant consumers.

Efforts to encourage home growing of basic food staples are also met with brief enthusiasm but limited success. Meanwhile, food waste is reduced to some extent.

Although initially constrained by the slow recovery, sales of new vehicles begin to pick up again with more fuel efficient models enjoy an increasing share of the market. Demand for electric and hybrid vehicles also send positive signals to manufacturers regarding the promise of future sales.

Lingering scepticism around the merits of voluntary behavioural change prevent any significant shift in environmental attitudes towards transport use.

After falling during the recession, aviation bounces back with strong growth. Even with aviation brought into the EU Emissions Trading Scheme in 2012, the move has little impact on prices due to the abundance of permits allocated to the industry.

The 2015 summit descends into crisis, with seemingly intractable divisions between negotiating parties. Despite desperate efforts from a broad alliance of activists to push for an agreement, the summit fails to reach a conclusive outcome, putting the entire UNFCCC process in doubt.

The EU sets a timetable for the imposition of trade barriers to protect carbon intensive industries and prevent them from relocating to other regions, sparking immediate retaliation from the US and China through the World Trade Organisation.

The period is marked by a slowdown in economic activity as trade disputes multiply between key countries and trading blocs.

In the US, efforts to boost energy security focus on the development of North American fossil fuel supplies.

In China, increased priority is given to developing the domestic market.

Increased demand from developing nations puts upward pressure on prices, just as world markets are marred by trade disputes, leading to significantly increased prices for commodities and fuels.

In the UK, as elsewhere in the EU, business certainty is rocked by developments in international trade. Industry opinion is divided on the merits of trade action. Those that largely serve the European market argue trade barriers are necessary if their businesses are to be protected from competition from cheaper, more carbon intensive imports. Others, particularly exporting industries, raise concerns that their goods will be less able to compete on the international market if strict emissions standards are driven through domestically without commensurate action abroad.

Uncertainty around the international situation saps investor enthusiasm for industrial decarbonisation projects, although many other investment opportunities remain attractive such as renewable energy installations, with domestic government commitments unaffected by international concerns.

Funding for the green bank remains at a low level, with government nervous about redirecting further funds to low carbon development at a time when the economy is experiencing a slow down as a direct result of trade action resulting from lack of climate action abroad.

In the light of funding and political constraints, plans to roll out a nationwide retrofit of vulnerable households are shelved.

Ongoing investment in electricity decarbonisation continues to deliver carbon reductions, even as demand is rising. But if plans for the electrification of transport and heat are to proceed, far greater capacity is required than the current investment climate is delivering.

With uncertainty around how international trade disputes will be resolved, there is some reorientation of the economy around local production of goods and services. Although resulting in overall emissions savings, from reduced transportation and more efficient production processes, this relocalisation also brings those emissions back within the jurisdiction of the UK, putting further stress on self-imposed emissions targets.

Although the trade disputes have encouraged some increase in domestic production, consumers are increasingly resentful of the increased costs arising from these disputes, with consumer groups drawing attention to the impact of increased prices on the poorest in society, and calling for a rethink on the pursuit of unilateral action.

Isolated climate action in the EU has resulted in significant emissions cuts, but the use of carbon offsetting schemes to make up the gap between actual cuts and legally-binding targets has drawn sharp criticism from other countries and from critics within the EU.

International trade disputes and rising commodity and fuel prices have taken their toll on the global economy, leading to calls for international compromise on trade and emissions cuts.

The roll out of smart meters and energy display devices continues over this period, leading to widespread coverage by 2020. The devices encourage some reduction in electricity demand due to cost concerns, but with continuing reservations towards pro-environmental behaviour, significant householder engagement around energy reduction has failed to materialise.

Retrofit of private households proves increasingly popular, with demand increasing as fuel costs soar. However, plans for a publicly funded retrofit programme across vulnerable households are put on hold over this period.

Attempts at improved standards for the energy efficiency of household appliances are stalled amid trade disputes. With increasing demands in terms of the size and performance of appliances such as televisions, consoles, fridges etc, electricity use for these appliances increases.

Although the trade situation has encouraged some increase in demand for domestic food produce, this shift has taken place amid resentment rather than enthusiasm, with many consumers feeling they are being penalised by increased costs when trade measures have failed to elicit legally binding commitments from other countries. Adoption of a lower carbon diet is therefore a by-product of higher prices, rather than enduring attitudinal change.

Another by-product of increasing prices is the reduction in food waste, as households become increasingly conscious of the need for better food purchasing, planning and storage to reduce overall costs.

The research and development of electric vehicles and the necessary charging infrastructure have been a priority of EU governments, providing some investor confidence during a time of uncertainty around low carbon investments. However, with less enthusiasm for such technologies outside of Europe, and trade barriers affecting the import of key materials and components, technological development has been slower than hoped. Sales of electric vehicles have increased, although with persistently high purchasing costs the mass electrification of transport seems a more distant prospect. Plug-in hybrid vehicles have taken a larger share of the market, while the traditional internal combustion engine seems set to dominate the market for the foreseeable future, with steadily improving fuel efficiencies in response to concerns over fuel prices.

Increasing fuel prices encourage private car owners to economise to an extent, although there is little appetite for a significant shift to public transport or walking/cycling.

Although flights within the EU are subject to the Emissions Trading Scheme, the industry continues to benefit from a generous allowance of permits. Attempts to apply charges for international flights become yet another area of dispute through the WTO.

Increased fuel prices have had some impact on the growth of the industry, but enthusiasm for foreign travel is otherwise unabated.

With little progress on emissions reductions from other parties, the appetite within Europe for further unilateral action on climate change is severely diminished.

Meanwhile, there is an increasing acceptance within the US that action on climate change is both necessary and inevitable, and a softening of the Chinese stance on a legally-binding emissions cap. In an orchestrated stand down from the deadlocked trade disputes, the EU begins to scale back its use of trade measures, in return for bilateral agreements on emissions reductions from trade partners.

After years of trade disputes and the threat of increasing protectionism, the result is a compromise which - through some energy efficiency savings – stabilises commodity and fuel prices on world markets in the short term. Nevertheless, critics insist the bilateral agreements fall far short of the drastic cuts in emissions necessary to tackle climate change.

While European countries continue to pursue domestic decarbonisation programmes, the dismantling of trade barriers means consumption of carbon intensive imports continues to grow.

In the UK, the dismantling of trade barriers leads to a resurgence in economic growth in the short term, and a drop in prices of goods and services from overseas.

Though domestic emissions continue to fall as a result of ongoing decarbonisation programmes, a flood of cheap carbon intensive imports causes emissions from consumption to rise rapidly before beginning to stabilise, as producer countries begin their own decarbonisation programmes.

Through the 2020s, environmental groups push hard to raise awareness of the impact of embedded emissions. For some, the disparity between domestic and foreign carbon intensity is a reason to 'buy British', but recent experience with trade measures and the resulting price impact leads most consumers to believe that the solution is further decarbonisation of those overseas economies, rather than the relocalisation of their own. Concessions on emissions from the US and China, however limited, simply reinforce this view.

Good progress is made with electrification of transport and heat over the decade, but delayed investment during the previous period and subdued public support mean that the energy system remains significantly dependant on fossil fuel inputs by 2030.

With coverage of smart meters essentially complete, households are better able to monitor and minimise energy use as a cost saving measure. By the end of the period, more advanced metering contracts become available, enabling cheaper per unit electricity in exchange for flexible operation of appliances including fridges, freezers, hot water tanks and storage heaters.

With high prices having contributed to a significant increase in fuel poverty, a nationwide programme of retrofit for the most vulnerable households is finally given the go ahead. Despite a delayed start, increased capacity in the industry means this work can proceed rapidly, contributing to significant reductions in gas use by 2030. Retrofit of private households continues apace.

The immediate drop in food prices after trade barriers are removed leads to a significant increase in imported, particularly air-freighted food products. The prospect of emissions reductions from producer nations, however limited, ensures a low level of consumer engagement around the carbon intensity of food purchasing.

The return of lower food prices also means a slight relapse in levels of food waste.

Further investment in infrastructure and technological development through this period makes electric and plug-in hybrid vehicles increasingly financially viable. By the end of

the period, these account for the majority of new vehicle sales, although internal combustion engines continue to dominate the existing vehicle fleet.

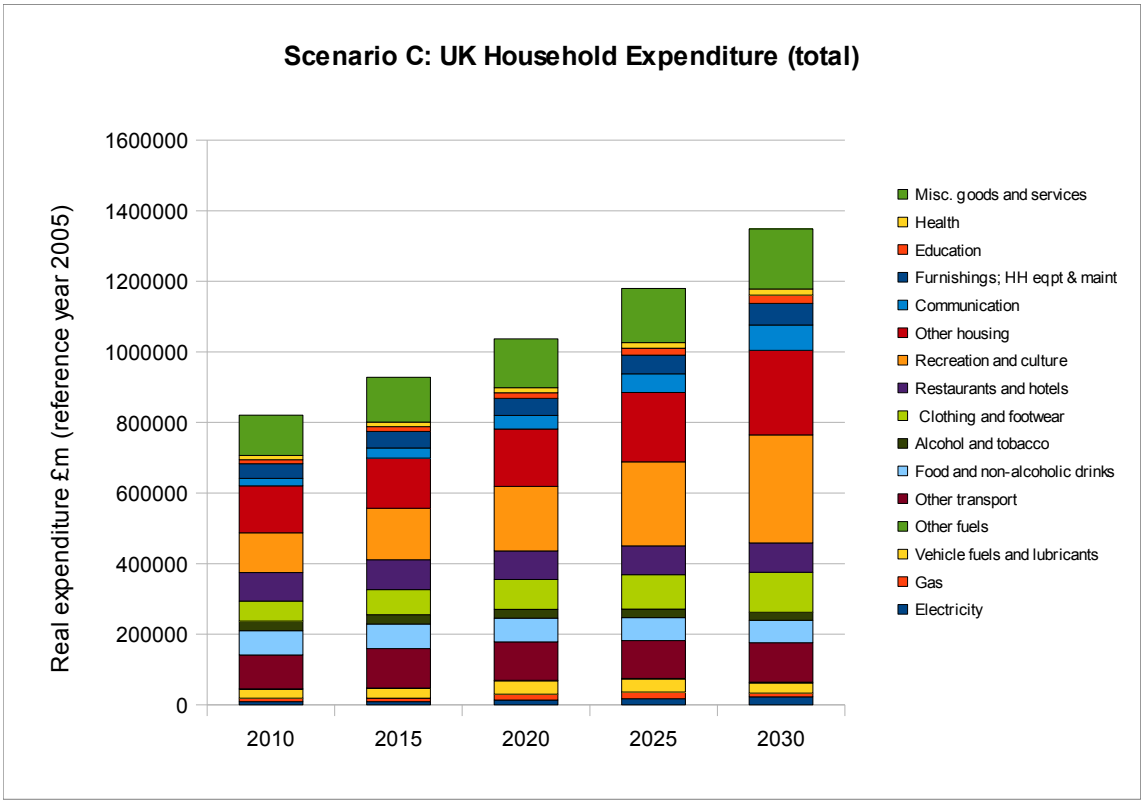
As well as a preference for fuel efficiency in the purchase of new vehicles, increasing vehicle fuel costs lead to a reduction in single person car journeys, with colleagues, neighbours and friends finding ways to combine journeys where convenient, aided by advances in information and communications technology.

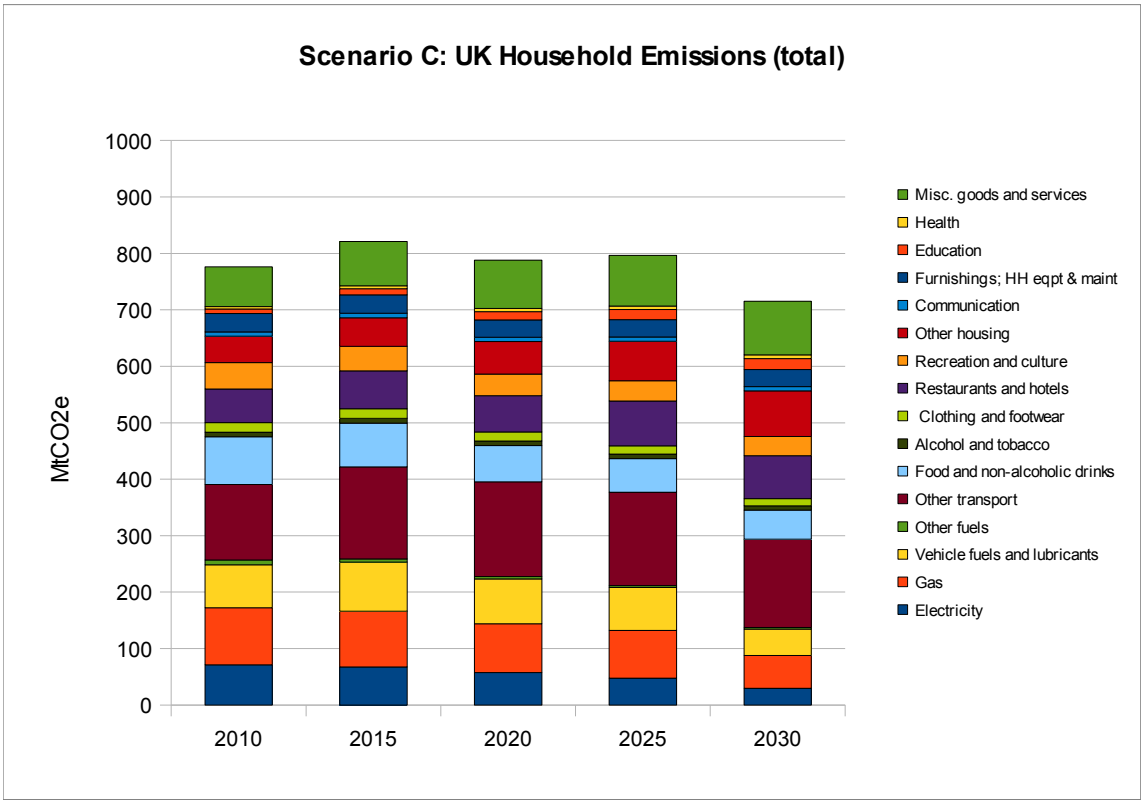
Increasing vehicle fuel costs also lead to an increase in public transport use, with electrification of the rail network leading to further emissions reductions.

With aviation now receiving fewer allowances under the EU ETS, costs begin to increase over the period. Concessions on tackling international aviation mean that long-haul flights gradually become subject to carbon pricing, but the appetite for foreign travel ensures continued growth in aviation emissions attributable to UK households.

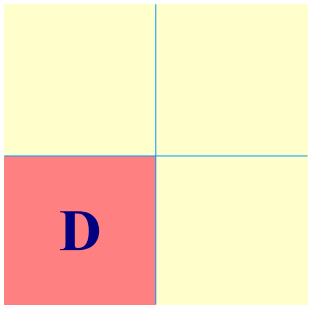
Illustrative Quantification

(for full breakdown see Appendix VII)





6.5 Scenario D



Over the edge

With little effort on emissions reduction, the global economy is exposed to increasing fuel prices towards 2020. With intensified social pressure to reduce fuel prices, and unable to work cooperatively on establishing an equitable emissions regime, countries instead pursue divergent, often conflicting energy security policies. The persistence of fossil fuel extraction as part of those policies extinguishes any hope of a low carbon transition, and leads to international conflict.

D

2010 2015 2020 2030

The failure of Copenhagen leads to a loss of faith in the UNFCCC process and the effective abandonment of any serious attempts to secure an international emissions regime.

Short term action is taken around the world to stimulate the global economy.

Commodity and fuel prices remain below pre-recession levels for some years, offering little incentive for energy or resource efficiency.

Media portrayal of climate science and activists is increasingly scathing, with the individuals involved being accused of pushing a political agenda that risks undermining the recovery. Extreme weather events are attributed to natural variability and in many cases to poor development strategies, including deforestation.

Prioritising deficit reduction, the UK government renege on a number of key environmental policies, focusing political capital on pushing through cuts in public spending.

Amid the austerity measures, employment remains the primary concern for the majority of households.

Climate scepticism among the public is fed by further negative portrayals of climate science in the popular UK media, even as limited corners of the progressive UK media report on climate change in accordance with the mainstream scientific findings.

The environmental movement fails to attract significant support over the period with enduring scepticism on the part of the public preventing any significant behavioural change or political action.

A lack of funding mechanisms prevents any significant expenditure on home insulation, let alone micro-generation.

With food prices remaining relatively stable, and in the absence of any other behavioural incentives, food consumption patterns show little change over this period.

The slow recovery limits new vehicle sales at first, and when sales do begin to pick up there is no significant 'above trend' shift to more fuel efficient models. Lack of any behavioural incentives over this period means no significant reduction in vehicle use, e.g through a shift to public transport use or car sharing.

As the economy recovers, and in the absence of any policy measures to mitigate against aviation growth, the industry sees record passenger numbers.

D

2010 **2015** **2020** 2030

From 2015, rising global demand leads to significant increases in prices of commodities and fuels.

The global environmental lobby calls for a transition away from fossil fuels, but these calls are drowned out by lobbyists in different countries insisting on further investment in fossil fuel resources for energy security.

In the US, this leads to rapidly increased investment in non-conventional oil and gas and further deep sea exploration. In Europe, there are calls for closer cooperation with Russia to secure long term gas supplies, and investment in deep sea oil and gas resources in the Arctic and North sea.

By 2020, significantly increased investment helps to stunt the increase in fuel prices but with little action on developing alternative energy solutions, countries remain locked in to carbon intensive development for the foreseeable future.

In the UK, increasing fuel prices lead to some reduced consumption but social pressures on government to act eventually lead to some reduction in fuel taxes. Towards the end of this period, significant investment in oil and gas exploration reduce these price pressures, removing any real incentive for households to adopt significant energy conservation measures.

Meanwhile, some decarbonisation of the electricity supply has taken place, through increased investments in renewables and further switch from coal to gas. However, the absence of sufficient direct support in the form of subsidies, and the lack of any real prospect of a global emissions regime lead to a slow down in investment in renewable capacity.

Despite temporary price increases during the early part of this period, the slowing of this trend offers little incentive to households to invest in retrofit measures. Insufficient support for micro-generation also prevents any significant adoption of these technologies.

Food prices are affected by increased global demand and higher fuel prices. Consumers respond by shifting to more affordable food products with little impact in terms of reducing carbon emissions.

In addition to purchasing cheaper food products, some action is taken to reduce food waste in response to high costs.

A significant rise in vehicle fuel prices is then alleviated through reduced fuel tax, removing pressure on households to shift from private car use, or towards more efficient vehicles. Although the research and development of electric and hybrid vehicles continues, insufficient funding ensures these remain expensive and very much on the periphery.

With environmental attitudes undergoing little change over this period, and vehicle fuel prices brought under control, there is little appetite for a shift to public transport use, or walking/cycling as an alternative.

Aviation fuel costs rise over this period, then stabilise. Meanwhile, increasing household disposable income means that even in the face of increased costs, this important aspiration is increasingly fulfilled.

In Europe and the US, measures to bring additional fossil fuel supplies onstream have helped to alleviate price pressures in the short term. While gas supplies remain sufficient to meet demand over this period, oil supplies plateau through to 2025.

In the first half of this period, in developing countries, increased prices for food, fuel and basic commodities leads to social unrest and humanitarian crises. In developed countries, despite measures to increase domestic oil production, limited global supply leads again to steadily increasing prices.

The global market for oil becomes increasingly redundant as powerful consumer nations pursue direct bilateral supply agreements with producers.

In the UK, some increased renewable capacity contributes to the electricity supply, but apparent lack of public support for a wholescale decarbonisation programme have seen increased gas supplies used to replaced retiring coal and nuclear power stations.

With domestic oil supplies grossly inadequate to meet demand, and global market mechanisms under threat, the UK looks vulnerable to oil shocks. With increasing prices once more towards the middle of this period, pressure mounts on government for further tax reductions.

While environmental campaigners continue to call for desperate measures to shift away from fossil fuels, the movement becomes increasingly marginalised from the crisis politics that defines the period. Rising membership of environmental NGOs among young people offers hope, but can do little to divert the UK from its current path in the short term.

Towards the end of this period, it is established that global oil production peaked in 2025. The associated price shocks lead to economic crisis. Major oil consumers, including the US, Europe and China compete for access to remaining oil resources, particularly in the Middle East, leading to military skirmishes and conflict by proxy.

Meanwhile, efforts to increase production of unconventional oil supplies receive substantial investment, enjoying a level of commitment that sustainability advocates could only have dreamed of with regard to their own cause.

Competition over oil leaves many developing countries unable to secure the feedstocks for agricultural production, leading to widespread humanitarian disaster.

Transportation costs also affect global trade, with air freight becoming increasingly untenable.

In the UK, an oil price shock pushes the economy into recession towards the end of the period.

Despite right wing calls for intervention abroad, the UK's reduced standing in the world leaves little scope for competing with the US and China for oil resources. Instead, emergency measures are introduced to ration fuel for agricultural use first, public transport second, and private car use last.

Significant steps to secure long term gas supplies has removed any immediate pressure on households to adopt retrofit measures to reduce gas consumption, although prices rise again towards the end of this period, tracking high oil prices.

Household electricity demand continues to increase over the period, but insufficient investment in renewables and continued reliance on gas means reduction in emissions proceeds slowly.

In the early half of this period food consumption is impacted by increasing prices, but this is partially offset by increasing incomes and continued adaptation through purchase of cheaper food products. As the period progresses, a crisis in global food production leads to shortages of imported foods. As a result, households are forced to adopt dietary changes that imply some reduction in carbon intensity.

Food waste is significantly reduced over this period, as pressures mount on households for better management of household budgets.

Despite a stabilisation of prices for vehicle fuels by the beginning of this period, global developments lead to further price shocks, partly offset by government action to reduce fuel taxes. By the end of the period though, private car use has been significantly curtailed.

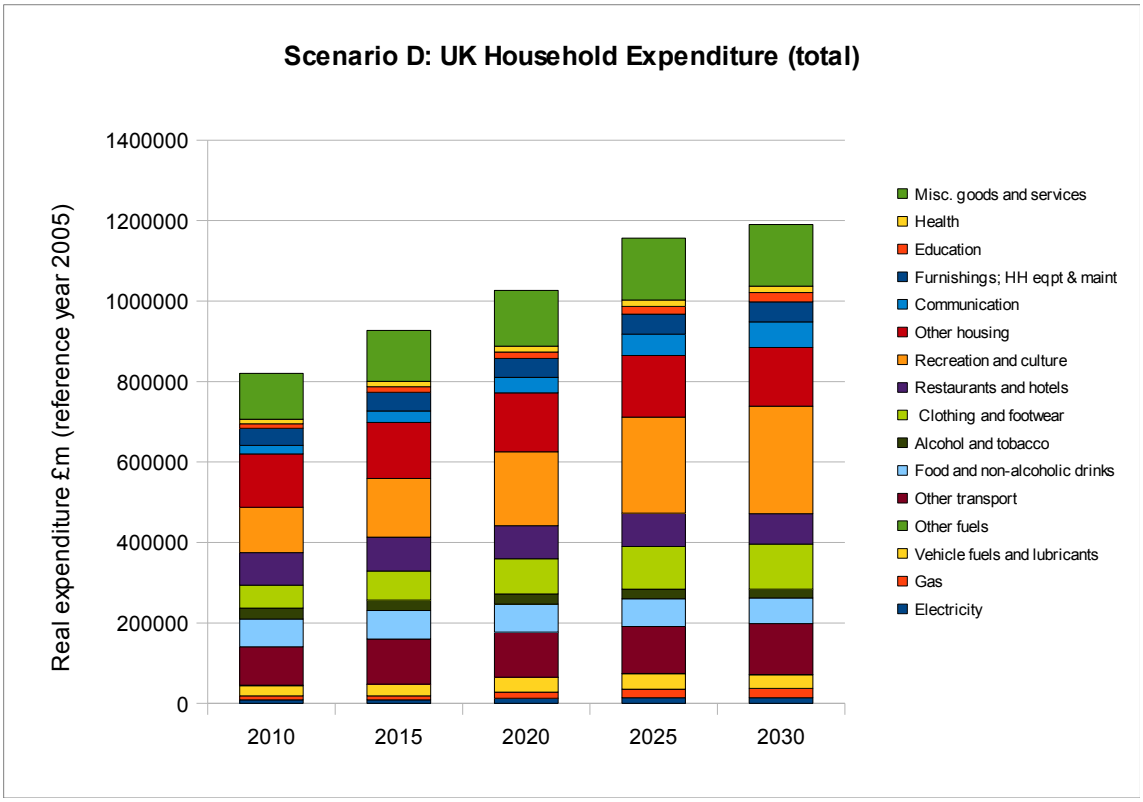
Where private cars are used, measures are in place to effectively oblige drivers to carry passengers. Fuel inefficient vehicles are subject to increasing vilification. More efficient vehicles take up a far larger share of new vehicle sales, although sales drop away to due to the recession. Electric and hybrid cars see a surge in popularity, but from such a small base that they make up only a small share of the market by 2030.

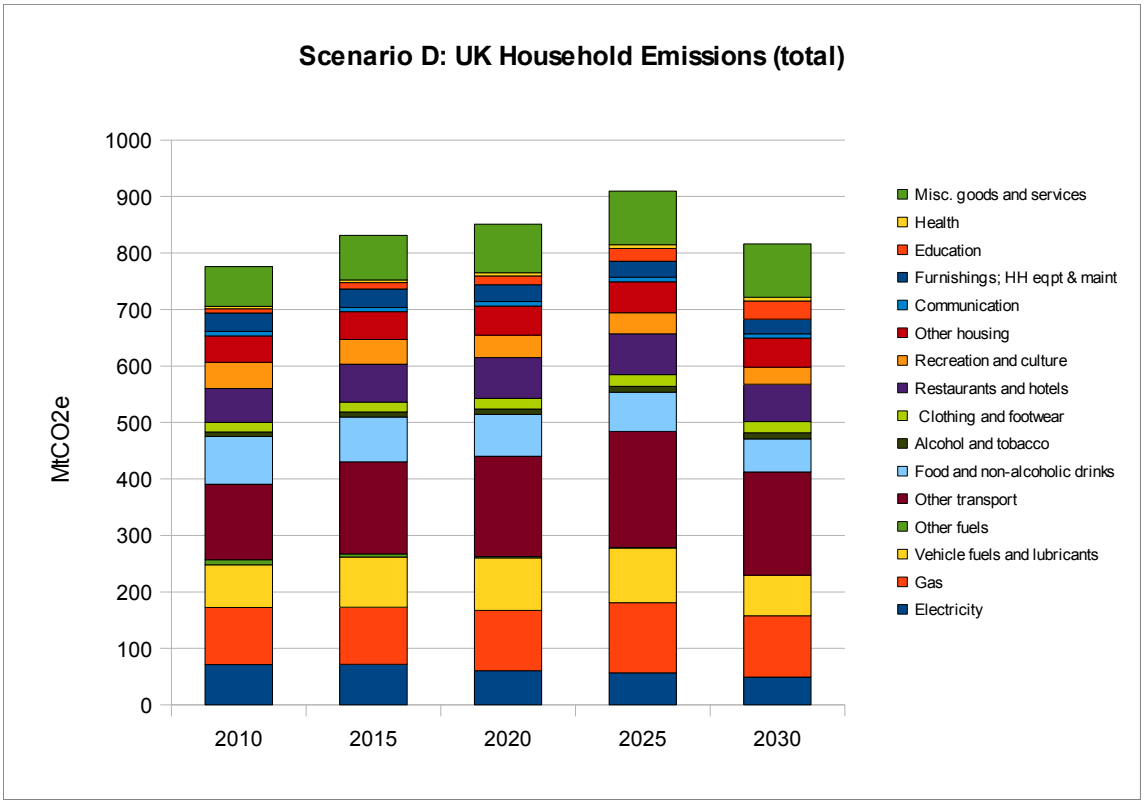
Public transport use sees a surge over the second half of this period.

Gradually increasing prices in the early half of this period give way to wholescale shocks, with many airlines falling victim to economic conditions. In the UK, a combination of the high cost of aviation fuels and an economic recession leads to a collapse in demand towards the end of the period.

Illustrative Quantification

(for full breakdown see Appendix VIII)





6.6 Scenarios Summary

In this section, the emissions figures for each scenario are brought together to enable cross-comparison, before some general reflections are offered in relation to key factors.

6.6.1 Emissions comparison

In the preceeding sections, each of the four scenario narratives were accompanied by two graphs summarising total expenditure and emissions (across all categories of goods and services) associated with UK household consumption from 2010-2030. More specific details about the assumptions used for each variable in each category and across each time period are available in Appendices V-VIII, along with a series of notes explaining the reasoning behind those assumptions.

A comparison of the total *expenditure* charts reveals a relatively consistent set of pathways across the four scenarios, with the exception of 'Scenario D: Over the edge', in which economic turbulence from 2025 onwards results in stagnating household incomes and expenditure. More pronounced is the difference in *emissions* trajectories between the four scenarios, compared in Figure 6.1.

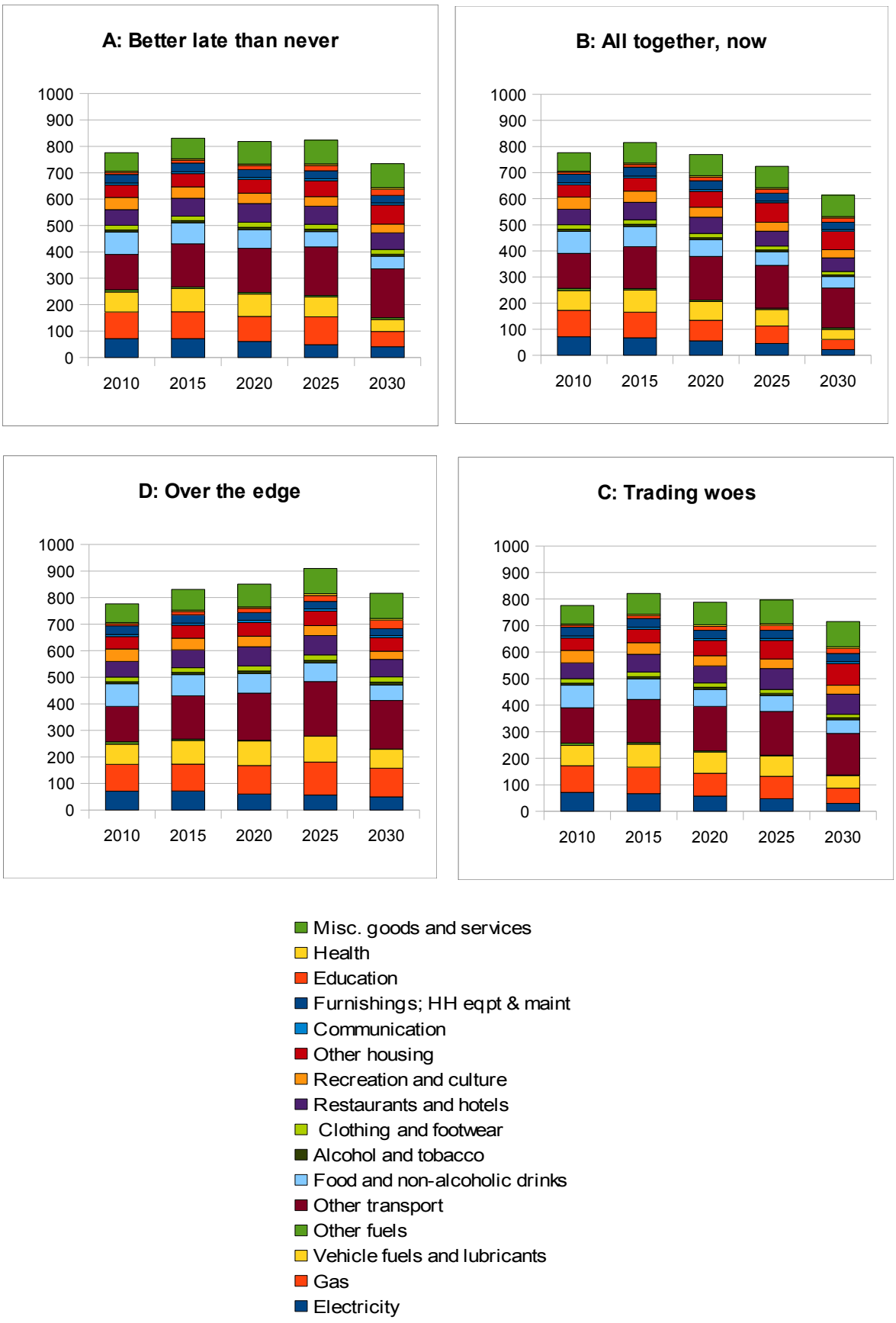


Figure 6.1: Emissions trajectories across the four scenarios (in $MtCO_2e$)

Looking at these four emissions trajectories, a number of observations can be made with regards to the general direction of each. In 'B: All together, now', emissions continue to increase in the first five years, but decline steadily thereafter, to end at the lowest level of all the four scenarios. 'D: Over the edge' demonstrates a steady increase in emissions through to 2025, before events (described in the narrative) lead to a severe economic contraction resulting in significant emissions reduction. Nevertheless, the fossil fuel intensive nature of economic development over the course of this scenario means that even those reduced emissions remain at the highest level of all four scenarios.

In 'A: Better late than never', the lack of proactive change in response to rising prices of fossil fuels slows the economy towards 2020, before a strong global commitment to decarbonisation leads eventually to a decline in emissions. In 'C: Trading woes', there is a proactive attempt at decarbonisation across Europe in the first half of the scenario, but trade conflicts with China and the US have their own dampening effect on the economy, and the resulting compromise adversely affects the rate of emissions reductions. Thus, for Scenarios A and C, despite the distinct economic development pathways described in the narratives, the net result is a close proximity in the 2030 emissions levels between the two.

An important comparison should also be made between 'Scenario A: Better late than never' and 'Scenario D: Over the edge', where developments in the first five years are remarkably similar, but where, in response to the fossil fuel and commodity price pressures from 2015-2020, there is a divergence in reactions seen at the social level, which drive responses at the political level, i.e. the (un)successful establishment of an emissions regime. These scenarios highlight the significance of social action as a

driving force in any transition.

Ultimately, it is a matter of opinion as to whether these trajectories ought to be seen as 'conventional' or 'alternative' in terms of their level of deviation as discussed in Section 3.4.3. In this research, the process of establishing appropriate assumptions for use in the model has proceeded by using the historical trends identified in the data as a starting point for all four scenarios. Then, according to developments in the storylines, those assumptions gradually deviate from this trend. The key point to note here is the 'gradual' nature of that deviation. That is, where expenditure in a given category of goods and services has been found to have a strong positive contribution from exogenous non-economic factors in the past, in this research the decision has been made not to suddenly 'flip' this contribution on its head but rather to phase in any changes over time. Similarly, where one scenario exhibits a change in certain prices due to economic policy interventions, it is assumed that these would also be phased in gradually. In that sense, the rate of change applied to the quantitative trends used in the scenarios is subject to inertia.

Imported emissions and the relevance of the consumption perspective

One of the key concerns raised in this research is the growing gap between emissions measured from a production versus consumption perspective. The decarbonisation of the UK economy over the last 20 years has been due in large part to the 'dash for gas' and the offshoring of heavy industry. Households have meanwhile continued to purchase more goods and services, now increasingly produced abroad. The implications of any further shift in production and consumption patterns are explored in the qualitative scenarios, although these are hard to quantify in the model used to

produce illustrative emissions figures, as no explicit distinction is made between emissions from imported vs domestically produced goods and services. Nevertheless, the issue can be investigated further by conducting a thought experiment pitting strong domestic decarbonisation in the UK against inaction 'abroad'. As documented earlier, when tested with experts it became clear that this simple formulation was implausible, and that the UK could only feasibly act in concert with the rest of the EU, however the initial thought experiment and associated calculations provided a useful foundation for exploring the growing emissions gap. In those calculations, emissions over the period 1992-2004 were seperated into those associated with direct energy use (electricity, gas, vehicle fuels and other fuels) and those 'embedded' in goods and services. Embedded emissions were then further divided into 'UK' and 'imported' emissions (Druckman & Jackson, 2010). These three categories, 'direct', 'UK embedded' and 'imported embedded' emissions could then be assessed in terms of their levels, growth and share of the total over that period. Conducting a simple extrapolation, it was then possible to suggest where this would lead by 2030, assuming those historical growth trends continued. Table 6.3 summarises the results.

Emissions in $MtCO_2e$ (share of total)	**1992**	**2004**	**2030** *projected*	**annual growth**
Direct	244 (41%)	235 (35%)	217 (20%)	-0.30%
UK Embedded	234 (39%)	260 (38%)	330 (30%)	0.92%
Imported Embedded	118 (20%)	181 (27%)	563 (50%)	4.47%

Table 6.3: Extrapolated trends in household consumption emissions

The results from this simple analysis imply that even *without* a domestic decarbonisation programme, emissions attributable to the UK (direct and UK embedded emissions) would fall as a share of total UK household emissions from 73% to 50%. It

may be argued that only so much of UK goods and services could really be 'economically' offshored, and that accordingly a slowing of the growth for imported emissions should take place over time. Nevertheless, it can be countered that if a domestic decarbonisation programme *were* to be introduced, direct emissions (and UK embedded) could fall dramatically. Thus, although the result would be lower absolute emissions, the proportion of the remaining emissions falling within the jurisdiction of the UK and therefore amenable to UK policy intervention, would be lower.

These illustrative calculations emphasise the significance of the axes chosen in this study. The continued uncertainties around how these might play out have implications for policymakers as well as for households and individuals themselves, in understanding the global implications of domestic and household behaviour. If things turn out one way, it may be that consumption emissions fall into line with production emissions, obviating the need for a redundant 'shadow' accounting method. Alternately, as the calculations and scenarios suggest, the gap between consumption and production emissions may widen further still, perhaps reinforcing the need for a complementary if not competing approach to the official accounting mechanism.

6.6.2 Reflections on scenario inputs and outcomes

In the development of any set of scenarios, it seems inevitable that the key themes, uncertainties, drivers and outcomes of interest will - to a significant extent - be a product of their time and place. The wider social and cultural setting of the work and of the facilitator(s), experts and participants will necessarily influence the process, and the emergence in the recent past of particular threats and opportunities in the public

discourse will influence the perceived significance of different variables. There is therefore an inescapable subjectivity about the framing of the 'problem' space and the articulation of 'solutions' to that problem.

It is also inevitable that significant events will come to pass *during* the course of constructing the scenarios, challenging and/or vindicating the selection of particular variables and values in different ways. The present study has certainly witnessed important developments, both stresses and shocks, that might impact on the perceived significance of different variables included in the scenarios, and the direction in which those were assumed to unfold in the given circumstances of each narrative. Although there have been many developments over that time, it is perhaps worth reflecting on those that relate most strongly to the two key uncertainties and to the challenge of high oil and food prices, starting with the latter.

Food and fuel prices

In Chapter 5, it was explained that a period of rising costs of fuels and basic commodities would be introduced to each scenario, from 2015-2020. The particular conditions of each narrative would then determine the social, political and economic implications over the subsequent period. The decision to include such a development was motivated by the publication of the UKERC report on global oil depletion, with its conclusion that there was a significant risk of a peak in conventional oil production before 2020 (UKERC, 2009a).

Oil prices had reach a record high of $147/barrel in 2008, with a knock on effect on food and other commodity prices. However, the financial crisis that followed (and the

subsequent drop in global demand for oil and commodities), coupled with the apparent slow recovery, were taken as a reason for assuming that any future oil price rises would be some time in coming. In fact, over the course of the development of these scenarios, oil prices have recovered from a low of around $35/barrel in 2009 to over $115 in March 2011. At the same time, global food prices have reached historic highs (Brown, 2011).

A comprehensive analysis of the causes and effects of these price changes is beyond the scope of this discussion, but at the time of writing it is clear that there are pressures on both supply and demand, including: unrest in the MENA (Middle East and North Africa) oil producing countries; growing demand from emerging markets; increased domestic consumption within oil producing nations, increased costs associated with extraction of non-conventional oil (not forgetting the cost of disaster response as in the case of the BP Deepwater Horizon accident).

An analysis of factors behind the recent record food prices is also beyond the scope of this study, but once again these clearly include a mixture of demand and supply side pressures, such as: the changing diet of the burgeoning middle class in developing countries and the impact of numerous extreme weather events on food crops in 2010.

Important to note here is the dynamic interplay between these different factors, with higher oil and gas prices leading to higher costs of energy and resource inputs for agriculture, and higher food prices (among other things) contributing to the unrest in MENA countries and the subsequent impact on oil production.

It was suggested in the scenario narratives that developments in energy and environmental policy, as well as social outlook, would determine how well-equiped the world would be to deal with these crises through 2015-2020. With price pressures reappearing so soon, however, the exact role of social and political factors in responding to these remains in the balance. Much depends on whether these price levels stabilise, fall away, or even intensify in light of further developments. Clearly, the global (and UK) economy can only withstand so much, but exactly what level oil prices would need to reach and for how long, to bring about a recession, remains a point of ongoing debate. At the same time, the higher fuel prices might be the catalyst for a rapid shift in social and political attitudes towards a low carbon transition. In developing countries of course, the impact of high food prices is felt all the more severely, and the spectre of humanitarian crises abroad - as articulated in some of the scenarios - could well play a part in motivating abrupt social responses in the UK, sooner than imagined.

Europe

One of the key uncertainties used to frame this scenario study was the question of whether or not the UK (as part of the EU) would voluntarily adopt more ambitious targets at the outset of this decade, and partake in an 'early transition' to a low carbon economy.

The initial impact of the 2008 financial crisis and the perceived significance of various economic factors were clearly formative to this study. However, the crisis was far from over, nor were the full consequences yet clear, while the scenario study was being conducted. As such, a variety of economic factors related to that crisis remain deeply uncertain, affecting the prospects for a low carbon transition. In Europe, concerns over

levels of sovereign debt, the so called Eurozone crisis, culminated in May 2010 with a bailout package for Greece, and fears that the crisis might spread to other peripheral Eurozone countries. In November 2010, Ireland became the second country to receive a financial package from the EU/IMF. The downgrading of some European countries by credit ratings agency continues to have an impact on market confidence (BBC, 2011). Depending on one's political and economic outlook, concerns over levels of sovereign debt are either alleviated or compounded by austerity measures at the national level. For some, the measures are necessary to drive down deficits as quickly as possible and restore confidence, while for others the measures risk exacerbating economic woes by adding to unemployment and heightening the chances of a double dip recession.

It is impossible to know how the uncertainties around the broad economic fortunes of European countries will play out, but it should be clear that the outcomes will be crucial in determining approaches to - and levels of - investment for a low carbon economy. If anything then, the increased stakes around European countries' finances and the associated impact on energy and environmental policy have come into even sharper relief since the outset of the study.

Aside from the issue of finance, there remains the question of whether or not EU decision-makers adopt the stronger target of a 30% reduction on 1990 levels by 2020. The UK climate change secretary, Chris Huhne, has argued: *"moving to 30% would give our businesses a head-start in new green industries and get us off the oil hook quicker, insulating us from oil price spikes"* (Harvey, 2011b). Meanwhile, opponents of such a move have argued that a unilateral adoption of stronger targets would simply lead to further offshoring of industry. In the most recent analysis at the time of writing, the

recently announced low carbon 'roadmap' for the EU appears to suggest a compromise of 25%, although this target would require to be ratified (Public Service, 2011).

International emissions regime

Ahead of the Copenhagen summit in December 2009, there was a sense of anticipation over the possibility of a comprehensive global deal, as evidence by the responses gathered during the internal interviews in this study. Unfortunately, by early 2010, this anticipation had been replaced by a deep sense of pessimism, even cynicism, made clear by the responses from the external interviews conducted during that period. This pessimism inevitably informed the development of the scenarios, ensuring that even in the most 'optimistic' or 'green' scenario (B) the emergence of a comprehensive global deal on emissions would have to wait until 2015. The subsequent summit in Cancun in December 2010 was widely expected to achieve not very much at all, and indeed, despite talk of consensus, no further legally binding commitments were adopted over existing measures by member states. In fact, given the expectation in some quarters that the entire UNFCCC process was now defunct, even the achievement of a political agreement (to agree further measures in the future) was hailed a success (WWF, 2010). The speed of change in outlook that has taken place from pre-Copenhagen to post-Cancun - anticipation, disappointment, disillusionment, renewed hope - is a reminder of both the significance and uncertainty that continues to surround the establishment of an international emissions regime.

6.7 Summary

In this chapter, a short guide to reading the scenarios has been provided, followed by the four scenario narratives themselves. A comparison was then made between the

emissions trajectories for each scenario, and with regards to imported emissions a brief calculation was performed to highlight the importance of adopting a consumption perspective as a complement to the traditional production perspective. Finally, some of the key factors explored in the scenarios were discussed as they relate to recent developments, including around food and fuel prices, European policy on climate change and the prospects of an international emissions regime.

7. Conclusions

A summary of key issues arising out of the scenario narratives themselves was provided in Chapter 6. In this chapter, some of the more general conclusions arising from the overall research process are highlighted, including lessons for qualitative narrative development and dissemination, ideas for a revised model and reflections on the epistemological enquiry discussed in Chapter 4.

7.1 Scenario planning and beyond

Chapter 5 described personal correspondence between this author and Ron Bradfield of Strathclyde Business School in which Bradfield argued that: *"developing scenarios is not science, it is art and craft and as such, the process must be flexible"* (Bradfield, personal correspondence, 2009). Accordingly, in that chapter, differences were highlighted between an early proposed methodology and the steps that were actually carried out. In many scenario building exercises, participatory approaches are central to the development of the narratives. However, one of the key challenges in this research was the need to maintain ownership over the process, in order for the outcomes to qualify as a personal contribution in the form of a PhD. For this reason, participation was limited to data collection through expert interviews. It was also made clear in Chapter 3 that this research was focused strictly on the task of 'scenario building', and that any 'scenario planning' activities would be performed subsequent to the main body of research and completion of this thesis. Having developed the scenarios then, it is worth considering how these might be disseminated successfully in order to ensure maximum impact.

7.1.1 Scenario dissemination

An important next step, and a priority of the research group, is to now prepare and publish a high-quality output around the scenarios, for public dissemination. In addition to the scenario narratives themselves, this 'glossy' publication might include a series of short responses from members of the research group, and/or a selection of external stakeholders. These responses would include a reflection on the implications (for their discipline or sector) of each scenario, and might involve challenging some of the assumptions made.

Following publication of this 'glossy' report, it is anticipated that one or more stakeholder workshops would be organised, including academics, policy makers and business leaders, but also potentially civil society groups. By drawing out responses from stakeholders to specific characteristics of the different scenarios, it would be possible to identify perceived points of conflict or opportunity for specific groups on certain issues. Responses from one stakeholder group could be fed into the discussion of the scenarios presented to the next group. Ideally this process would be conducted in such a way that the groups were able to interact in a truly dynamic way, simultaneously debating and responding to the developments of the scenarios.

A final activity being discussed as part of the dissemination process, possibly constituting part of the 'glossy' publication, is the development of a series of fictional accounts of individuals and households in each scenario. This was inspired by the use

of 'Personas' in the field of Human-Computer Interaction (HCI) Design, a technique developed to help software engineers better appreciate the needs of end users by representing the motivations, skills, (dis)abilities etc of a fictional character in the form of a short biography. Typically, the personas are built through a series of interviews with real users. The personas are then presented to the software engineers to encourage them to reflect on how their design decisions might impact on these users. One outcome of any stakeholder workshops with civil society groups might be a collection of ideas around how individuals and households might respond to and shape the circumstances of each scenario, which may then be brought together into discrete stories representing different households according to the age and number of occupants, rural/urban setting, socio-economic status etc. These 'personas' might be portrayed as progressing in time through each scenario, with relevant actions, decisions and conflicts accounted for. Alternately, the personas might take the form of a reflection, in 2030, on the past 20 years.

The intention behind the inclusion of personas would be very much in keeping with the motivation for using the technique in HCI, namely to better represent individuals and the lifestyle choices they might make, for the benefit of decision and policy makers.

7.1.2 Ideas for a revised model

From the outset, the quantitative work performed within this study has been described as illustrative, with the intention that these should be read as secondary to the scenario narratives themselves. Inevitably, for those who prefer to deal with numbers, the quantitative side of the scenarios may come to dominate, thus it remains an important

aspect of any future dissemination activities to ensure an appropriate representation of the model, its strengths and weaknesses, and its application in this study. Importantly though, the application of the model in these scenarios has proved invaluable in assessing exactly what those strengths and weakness are, and how things might have been done differently with the benefit of hindsight. Thus, several constructive ideas have emerged from the application of the model in the present work that might form part of any follow-up work devising a second version of the model. At the very least, these might prove insightful for other researchers developing different but related models.

Classification of goods and services

The disaggregation of COICOP categories, as outlined in Chapter 5, has proved limiting in certain specific areas. Importantly, electricity, gas and other fuels were disaggregated from the top level 'housing' category, ensuring that trends within these emissions intensive sub-categories could be uncovered. Furthermore, 'vehicle fuels and lubricants' was taken outside of 'transport' for explicit analysis. However, the current study has made it clear where further disaggregation might prove useful in better understanding key trends, e.g. by extracting aviation from 'other transport'.

The following list offers a proposed disaggregation that might be applied in any revision of the model:

01 - Food and non-alcoholic beverages[5]

02 - Alcoholic beverages, tobacco and narcotics

5 bold formatting indicates a useful category. In some cases new composite categories have been proposed, with a suggested heading for the category indicated in single quotes, followed by a list of component categories from the official COICOP classification system.

03 - Clothing and footwear

(04 - Housing, water, electricity, gas and other fuels) disaggregated into:

'Rentals for housing' composed of:

04.1 - Actual rentals for housing

04.2 - Imputed rentals for housing

'Household maintenance, repairs and services' composed of:

04.3 - Maintenance and repair of the dwelling

04.4 - Water supply and miscellaneous services relating to the dwelling

04.5.1 Electricity

04.5.2 Gas

Other fuels composed of:

04.5.3 - Liquid fuels

04.5.4 - Solid fuels

04.5.5 - Heat energy

(05 - Furnishings, household equipment and routine household maintenance)

'Furnishings and routine household maintenance' composed of:

05.1 - Furniture and furnishings, carpets and other floor coverings

05.2 - Household textiles

05.4 - Glassware, tableware and household utensils

05.5 - Tools and equipment for house and garden

05.6 - Goods and services for routine household maintenance

05.3 - Household appliances[6]

06 - Health

(07 - Transport)

'Purchase and maintenance of personal vehicles' composed of:

07.1 - Purchase of vehicles

07.2.1 - Spare parts and accessories for personal transport equipment

07.2.3 - Maintenance and repair of personal transport equipment

07.2.4 - Other services in respect of personal transport equipment

07.2.2 - Fuels and lubricants for personal transport equipment

(07.3 - Transport services)

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6 Further categories covering different types of electrical appliances can be found in recreation and culture, communications, and miscellaneous, thus there is an opportunity to consolidate these under a composite 'appliances' category

'Rail, road, sea passenger transport' composed of:

07.3.1 - Passenger transport by railway

07.3.2 - Passenger transport by road

07.3.4 - Passenger transport by sea and inland waterway

07.3.5 - Combined passenger transport

07.3.6 - Other purchased transport services

07.3.3 - Passenger transport by air

08 - Communication

09 - Recreation and culture

- 09.1 - Audio-visual, photographic and information processing equipment
- 09.2 - Other major durables for recreation and culture
- 09.3 - Other recreational items and equipment, gardens and pets
- 09.4 - Recreational and cultural services
- 09.5 - Newspapers, books and stationery

09.6 - Package holidays (taken out of recreation and culture for possible combination with passenger transport by air)

10 - Education

11 - Restaurants and hotels

12 - Miscellaneous goods and services:

- 12.1 - Personal care
- 12.2 - Prostitution
- 12.3 - Personal effects n.e.c.
- 12.4 - Social protection
- 12.7 - Other services n.e.c.

'Insurance and Financial Services', composed of:

- 12.5 - Insurance
- 12.6 - Financial services n.e.c.

Automating reallocation of expenditure

As part of the modelling process, assumptions were applied that led to increased or decreased expenditure in particular categories. Inevitably, for households that avoid

expenditure in one area, e.g. on gas as a result of improved insulation, the money saved will be reallocated either as expenditure elsewhere or as savings. Unfortunately, no mechanism exists within the model at present to automate this process, meaning that - as assumptions are applied to specific categories - gaps emerge between household income and total expenditure. One approach might be for future expenditure in a particular category to be modified not only by the fixed *income elasticity*, but also by a dynamic variable that operates on 'remaining' or 'available' income, taking into account expenditure as currently estimated for the other categories. More simply perhaps, any income saved in one category could be reallocated to other categories in a way that is proportional to the income elasticity, i.e. more of the avoided expenditure would be allocated to categories that demonstrate a strong historical relationship between increases in income and increases in expenditure.

Translating production assumptions into consumption emissions

Given the preeminance of the production perspective, it is unsurprising that the majority of work to date around modelling of emissions has adopted this approach. Accordingly, when policy documents appear indicating future emissions targets, a range of models can be adopted in order to assess how these targets might be distributed across different sectors of the national economy.

This research has argued the need for a consumption perspective and employed an econometric model designed for that purpose. An important next step would be to think about how the frequently published sectoral targets and pathways can be translated in a way that demonstrates the impact on UK household emissions from a consumption perspective. Clearly it would be necessary to identify, for each category of goods and

services, the breakdown of expenditure and emissions between the UK and other regions. At a very basic level, it would then be clearer where the sectoral targets indicated for the UK economy might be expected to impact on different consumption categories. Similarly, if those other regions were themselves disaggregated into e.g. EU and rest of the world, then targets and pathways developed for the European economy could be similarly followed through.

7.2 Epistemological conclusions

At the outset of this study an epistemological question was raised, asking what contribution might be made to the knowledge space by a set of scenarios around the carbon intensity of UK household consumption. Chapter 4 described an enquiry into how historians explain or make sense of past events. This was intended as a guide for futures thinking: If scenario planning involves the positing of a causal narrative across possible future events, then starting from more solid ground what lessons can be drawn from the process historians go through in developing a causal narrative across events that have already unfolded. As was shown in that chapter, even when historians take events that have already unfolded, trying to identify conclusively the set of causes that gave rise to those specific events is deeply problematic. The attempt to derive general laws that might indicate where such events can be predicted in the future was passed off as folly, mere speculation. Historians do not attempt to derive general laws in a scientific sense, but rather 'contextual generalisations' that may provide a helpful heuristic guide to understanding events within a limited time and place.

Despite this speculative aspect of historical analysis, the process at least *begins* with more or less scientific procedures (e.g. in assessing archaeological artefacts). In futures

thinking though, the building blocks are often those very generalisations and trends drawn from history. Thus, the epistemological contribution of scenarios can hardly be judged along scientific lines.

Benson and Stangroom argued that: *"history is highly interpretive, to be sure, but... ...the interpretation is of evidence, not of daydreams or fantasies"* (Benson & Stangroom, 2006, pp. 122-123). Interpretation can be more or less robust. Even once we accept that futures thinking is necessarily speculative then, there is still a role for ensuring that such speculation is based on the most robust interpretation of the data available.

As Kaplan explained, whereas the historian may be content with an explanation covering specific events: 'what is true of these cases', the scientist aims to discover what must be true in all cases (Kaplan, 1964, p. 123). Instead of settling for contextual generalisations then, it would be worth examining the social sciences to see just how much progress has been made in establishing 'general laws' for use in predictive work. In such an examination, a more complete review of the epistemologies of different disciplines, assessing strengths as well as weaknesses, might provide a grounding for a more informed synthesis of 'general trends' drawn from different bodies of work. Unfortunately, a meaningful review of the epistemology of psychology, sociology, political science etc remains beyond the scope of this work, but as this study employed an econometric model that derived trends from historical data, a discussion of epistemology in economics was provided.

It was argued that since the establishment of the discipline, economists have moved

from employing the method of inductivism, briefly through deductivism, before settling on an instrumentalist approach as articulated by Milton Friedman in 1953, who argued that the 'realism' of assumptions used in economic theory should be disregarded, and that economists should be concerned only with the accuracy of a theory's predictions (Friedman, 1953). This view has been heavily criticised by philosophers of economics, who insist that the examination of the realism of assumptions is essential to ensure the progression of the discipline. As suggested in Chapter 4, if simple 'unrealistic' assumptions were sufficient to fully explain consumer behaviour, then perhaps this instrumentalist approach would be defensible. Instead, an analysis of the historical data (which was the basis for the quantification in this research) highlighted the important role played by non-economic factors across all categories of goods and services consumed by UK households, in some categories far outweighing the role of economic factors. Thus, if a more accurate explanation (and/or prediction) of consumer behaviour is to be developed, this will require moving beyond instrumentalism towards a more systematic examination of the underlying assumptions employed in economic theory. Such an examination lies beyond the scope of this research. However, the scenario narratives have provided a 'sandpit' for the exploration of key economic *and* non-economic factors that might influence UK consumer behaviour over the next 20 years.

7.3 Concluding remarks

In the Introduction, three research questions were articulated. One of these, described as a prelimenary question, sought a definition of lifestyles for use in this research. Chapter 2 explored this question, concluding that - in relation to sustainability - the key to understanding lifestyles was consumption. Thus, four categories of consumption were adopted as a working framework in this research, with a variety of external factors

placed around these as drivers of consumption.

An epistemological question was also identified, asking what contribution can be made to the knowledge space by a set of scenarios exploring the carbon intensity of lifestyles. In Chapter 4 this question was addressed from two angles. Firstly, the epistemological contribution of qualitative narratives was explored through an examination of history, including how historians have viewed their discipline through the ages. A discussion of causality and of general laws was provided, wherein it was concluded that rather than being a 'nomothetic' discipline concerned with deriving general laws, history can be better understood as an 'idiographic' discipline focused on describing particular instances and events. Where generalisations do occur, these are 'contextual' generalisations and are not intended to be applied outside the time and place under investigation. Lessons were drawn from this discussion in relation to futures thinking, where it was suggested that the term *Wissenschaft* might be employed, as in history, to describe *"an organised body of knowledge acquired through research carried out according to generally agreed methods, presented in published reports, and subject to peer review"* (Evans, 2000, p. 73). In addition, an examination of epistemological issues in economics were highlighted, indicating the progression (or regression) of approaches to validating economic theory, from inductivism, through deductivism and eventually on to instrumentalism where predictions alone are all that matter. In this way, the principle of rationality - originally intended as a 'mere abstraction' requiring subsequent accommodation of non-economic factors if human behaviour were to be explained - was able to become enshrined in modern economics as a core assumption, however 'unrealistic'. Criticisms of this assumption were discussed, along with a summary of the model employed in this research, in which non-economic factors were

shown to play an important role in consumer behaviour. Thus, if consumption is to be more fully understood, and sustainable consumption in particular encouraged, then the accommodation of non-economic factors into the underlying framework of assumptions represents an essential step in the progression of the theory of consumer behaviour.

Finally, the central research question asked how the carbon intensity of UK lifestyles might be affected by various external factors over the next 20 years. In conducting a scenario building exercise that resulted in four qualitative narratives with accompanying quantification, this research has illustrated a series of pathways that attempt to address this question. Those narratives were also quantified using a structural time series model based on historical trends in the data.

In arriving at appropriate assumptions for the different variables in each scenario, a decision was made to introduce any changes to the trends gradually over time. The comparison of emissions trajectories in Section 6.6 highlights the effect of this: rather than incorporating abrupt changes in voluntary behaviour change and economic incentives, these processes of social and economic change are instead characterised by a sense of inertia. Clearly, a decision could have been taken to dispense with such caution and to develop a more radical set of alternative trajectories by allowing historical trends to be flipped at a specific point in time. However, that approach would itself require considerable justification, ideally with reference to historical data showing abrupt but persistent changes in the relevant trends. Such data may well exist outside the purview of the present research (e.g. data from an earlier period, from an alternative country, or from more narrowly disaggregated categories of goods and services than are explored here), however the approach taken here has been to acknowledge those trends identified

in the historical data that *was* used to inform this research, and to adopt those trends as a starting point, requiring gradual and persistent pressure in a particular direction before any changes could really be seen to affect expenditure and emission outcomes.

As highlighted in section 6.6, there are several key issues arising out of the scenarios that may be relevant to policy and decision-makers in the UK and elsewhere. One of the key themes explored has been the role of trade and - in 'Scenario C: Trading woes' - even the use of trade measures, in affecting UK consumption emissions. Clearly, any further decarbonisation of the UK economy, if it were to come at a cost to UK producers and manufacturers, would risk exacerbating the offshoring of heavy industry unless this decarbonisation takes place within an effective international emissions regime or is subject to the use of tarriffs on more carbon intensive imports. Exactly what impact these measures might have on the UK economy and consumption emissions would require further review, including through a more disaggregated multi-regional model of embedded emissions flows. Nevertheless, as a signpost of possible political trouble ahead, these scenarios have highlighted this threat.

Another surprise, as discussed in Section 6.6.2, has been the speed with which the prices of fossil fuels, food and basic commodities have recovered since the crash of 2008, even in the midst of a lacklustre economic recovery in the developed world. Greater attention is now being paid to suggestions in recent data from the International Energy Agency that conventional oil production may in fact have peaked already (Inman, 2010). In light of these developments, the decision to adopt a 'peaking' period for conventional oil production of around 2015-2020 might now be considered conservative, nevertheless the approach is defended here as having made use of the

conclusions from the most authoritative report to date on the subject. It is for the reader to reflect on how economic and energy policy, not to mention social unrest and other developments in the UK and elsewhere, might be affected if the threat of energy and resource depletion is found to be more imminent than has been supposed here. In that case, it must also be for the reader to consider how the storylines explored in these scenarios might nevertheless inform strategic responses on the part of different interest groups.

No set of scenarios can ever be said to provide conclusive explanations in a scientific sense. Importantly though, the epistemological enquiry carried out here has given context to the scenarios by clarifying the nature of the knowledge contribution they can be said to offer, namely that of informed narratives that play a 'propaedeutic' or learning role aimed at challenging people's assumptions and mental models, and assisting in making sense of the uncertainties of the present.

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Appendix I. Proposed Methodology

Email message sent to experts detailing the first iteration of a proposed methodology:

> My intention is to interview approximately 20 experts in a variety of fields. My model of lifestyles focuses around consumption, as this is of course the key determinant of carbon emissions. The three main consumption clusters are Food/Nutrition, Transport, and Housing. Also I have identified six external factors that shape the development of our lifestyles: Social, Technological, Economic, Political, Psychological and Environmental. Basically, I wish to identify experts that can speak for each of these clusters/factors. Of course an expert on 'Food' say, may well be more than just that, if they have an economics background or have had a role in advising on policy. But as a general rule, I want to secure a representative sample from across these key areas. Additionally, I wish to ensure that these 20 or so experts come from across the range of sectors, public/private/third. My final consideration here is to ensure I don't simly recuirt 'green' experts, i.e. those who will speak normatively towards a sustainable future. I wish these scenarios to be descriptive and as such I think it is important to have a balance of views.
>
> This selection of experts is not a major hurdle in itself, indeed I have prepared a shortlist of candidates. What I am struggling with though is how best to conduct the interviews. For example, largely inspired by [...] Kees van der Heidjen et al, there is the open ended approach of inviting interviewees to imagine themselves dealing with a clairvoyant, asking questions about the things of interest to them etc etc. This seems a particularly useful mechanism for putting the participant at ease, and allowing them to think in an unconventional manner. On the other hand I want to ensure I collect ideas across the full range of clusters/factors identified above. So, with that in mind, I have colleagues encouraging me to use semi-structured

interviews, and such an approach might be one way to incorporate each of the clusters/factors, ensuring I get a good range of feedback from each interviewee on these topics. I have been questioning the wisdom of this approach however. Specifically, if I call in an expert on 'technology', perhaps I should confine my questioning to that area, rather than also eliciting their views on social and environmental matters for example. Otherwise, as far as social and environmental matters are concerned, I'm essentially just interviewing a lay person.

So, the range of options for this interviewing process are vast and I want to get it right. If you have any thoughts on this from your experience as a practitioner, I would love to hear them.

These interviews will then be transcribed using NVivo, whereupon I can tag relevant contributions and begin to analyse common themes from across the interviews. The result will be a set of key themes, or clusters of insights, that I shall take forward into the next phase.

My intention beyond this stage is to hold a scenario agenda workshop with the (approximately) 20 members of our research group. They would be presented with the clusters of insights extracted from the interview data and invited to discuss and debate the relevance and significance of each. Over the course of a day or two, the intention would be for the team to agree on the key themes to be researched further - the scenario inputs - and on the two key uncertainties that should frame the scenario development.

After this a period of desk research on the identified themes would be undertaken by myself. This would then develop into a series of discussion meetings with a scenario panel comprising a small selection of the experts in our research group. At these meetings we would begin to discuss the pathways for each of the inputs under each of the scenarios. At this stage I will also take advantage of the work of one of my colleagues on an econometric model of consumption trends in the UK to offer illustrative forecasts of where our consumption and consequently out carbon emissions might be

headed under each scenario. From here it would only remain to develop the actual narratives based on the agreed input pathways and forecasts.

Appendix II. Interview protocol

The following script was prepared for use in the interviewing of experts as part of the environmental scanning process:

Thanks again for putting time aside to talk with me, much appreciated. For your information, let me just point out that this recording will be transcribed for use in my data collection. I thought it might be useful if I begin by reminding you of the context of my research to help ease us in to the discussion.

I'm developing scenarios to portray the carbon-intensity of UK lifestyles through to 2030. So my work actually draws on all of the RESOLVE research themes – the modelling, the psychological, sociological and policy and governance, and brings these insights together to help inform those scenarios. I'll soon begin conducting interviews with a series of external experts from government, industry, academia, and I'll be asking them to give me their views on the future of various key factors likely to impact on lifestyles.

Now obviously I'll be inviting them to tell me what they think those key factors are, but in order to prepare a framework for those interviews I want to do some initial scanning for factors within the RESOLVE team, for three reasons really:

1) It will help me identify the right experts. Obviously if I get a clear signal from RESOLVE colleagues that a particular set of factors should be explored, it sets me on the trail of the right people to inform me on those topics.
2) It helps me build a framework or protocol for the interviews so that, if the conversation isn't flowing so naturally, I can suggest some topics for discussion.
3) But also, it's because I want these scenarios to capture the essence of our research concerns within RESOLVE, and so, by conducting these initial internal discussions, I'm able to get a broad idea of ways in which I might begin to frame the scenarios to reflect the work of the group and ensure that I'm developing scenarios that are going to engage the rest of the team and ensure their contribution.

WHAT ARE LIFESTYLES

So what is it I'm trying to portray exactly, what do I mean by lifestyle?

Well, we've had discussions on this before if you remember, where different people across the research strands in RESOLVE offered their views on what they mean when they say 'lifestyle'. For the purposes of this work, what it boiled down to was that - in order to discuss the carbon-intensity of a lifestyle - we need to focus on consumption. So I've developed a working model that focuses on the key areas of consumption. So let me talk you through this briefly.

At the centre we have these four 'consumption clusters', these are collections of activities and behaviours grouped together thematically, so we have 'at home' including heating and applicances and so on, 'what we eat' which is self-explanatory, 'getting around' in other words day-to-day travel for commuting, visits, leisure, and 'getting away' or holiday travel. I've also listed a sample of the kinds of things that might contribute to the carbon-intensity of those sets of activities, but I'm sure you can think of others.

So that's how I have characterised lifestyles, but of course we then have all sorts of external factors that impact upon our lives and our decisions, and the choices available to us, so these also form part of the model. There are: 'Social' factors such as fashion, religion and belief; 'Technological' factors like innovation or research and development;
'Economic' so productivity, growth, incomes; 'Political' factors like the model of growth pursued, international agreements; 'Psychological' factors like our needs, attitudes and desires; and finally 'Environmental' factors, so we're talking here about direct impacts of climate change, resource scarcity etc.

Now I want to stress that this is a working model, the categories are of course arbitrary, I've chosen to bundle together certain consumption activities in a way that is convenient for me given the purposes of this study, to build a set of narratives about how our lifestyles might change over time, so if you feel at any stage that you want to discuss ideas that don't necessarily follow this model,

that's fine, just think of this as a guide or a prompt to help you conceptualise your ideas, rather than a strict framework.

So before we begin, I wonder if you might want to just summarise your work within RESOLVE and that might lead us in to some of the areas I want to explore .....

Excellent, thank you.

KEY ISSUES

Well, let's begin to explore this idea of future lifestyles then. What I'd like us to do to begin with is for you to imagine that you can see the future! I want you to transport yourself forward to 2030 and imagine that you only have a few minutes to speak to someone in the future and you want to gather as much knowledge about lifestyles as possible, where would you start? What would be the key issues in each of these categories that you would most want to know the outcome of?

At home.....
What we eat.....
Getting around.....
Getting away.....
Social.....
Technological.....
Environmental.....
Economic.....
Political.....
Psychological.....

DESIRABLE OUTCOMES

Now what I'd like you to do is imagine a future in which all of those issues that you've just raised had all developed in a way that you would consider desirable. I'd like us to work within realistic boundaries, but if you can imagine a good and bad extreme for each issue, i'd like you to describe the good scenario to me. So let's go back through the four categories and I'll just remind you of some of the ideas you raised as we go through each of those.

At home.....
What we eat.....
Getting around.....

Getting away.....
Social.....
Technological.....
Environmental.....
Economic.....
Political.....
Psychological.....

UNDESIRABLE OUTCOMES

Now I'd like to flip the whole question on it's head and ask you to imagine a future in which all of those issues developed in a way that you would consider *undesirable*. Again, I'd like us to work within realistic boundaries, but this time describe your idea of a plausible, bad scenario to me. I'll go through the four categories again and remind you of the issues.

At home.....
What we eat.....
Getting around.....
Getting away.....
Social.....
Technological.....
Environmental.....
Economic.....
Political.....
Psychological.....

CHALLENGES AND OPPORTUNITIES AHEAD

What are the challenges and opportunities then, in veering away from what we might consider the undesirable world, towards the desirable world outlined earlier? What are the challenges, opportunities or other implications for different actors?

Individuals and Households.....
Firms.....
Government .....
NGO's.....

That's great, and thanks again for your time.

Appendix III. Introduction to the RESOLVE scenario framework

Short primer document sent to external experts ahead of the interview process:

Introduction to RESOLVE Lifestyle Scenarios Framework

As part of the Research Group on Lifestyles, Values and Environment (RESOLVE), a set of scenarios are being developed to explore the carbon-intensity of UK lifestyles through to 2030. These scenarios will depict potential changes in our relationship with energy, goods and services at the household level and the carbon impact associated with those changes. So far, a provisional framework has been developed comprising two key uncertainties, the significance of which will be discussed during the interview, as well as the policy relevance of the four scenarios thus generated. In this primer, relevant background work in RESOLVE is explained along with an introduction to the framework.

Background

Among the multitude of factors relevant to this study, the legally-binding emissions target is of particular interest (currently 80% reduction on 1990 levels by 2050). Policy measures such as those set out in the Government's Low Carbon Transition Plan, include efforts to reduce emissions from the power, transport and residential sectors among others. Importantly though, this 80% target accounts for emissions from a 'production' rather than a 'consumption' perspective.

- In the ***production perspective***, a country is responsible for emissions arising from the production of energy, goods and services within its borders, regardless of where those goods are eventually consumed. In this way, emissions arising from the production of goods are counted even if those goods are exported, while emissions from imported goods are not.

- In the ***consumption perspective***, responsibility is attributed on the basis of emissions arising from energy, goods and services consumed within that country. Therefore, emissions arising from the production of imported goods are counted, while emissions from exported goods are not.

- The difference between production and consumption emissions has been referred to as the ***CO_2 trade balance***.

Although the production perspective is important in many respects, a study focused on the carbon intensity of lifestyles needs to consider the impact of energy, goods and services consumed at the household level, regardless of where these are produced. Thus, a consumption perspective is adopted in this study.

Consumption emissions trends

Previous work in RESOLVE analysed the historical data through these two perspectives, showing that production emissions fell 9% from 1990-2004 (when aviation and shipping are included). Although consumption emissions also fell through the early 1990s (during the dash for gas), emissions then took a sharp upward trend, averaging 2% p.a. from 1995. To examine these trends further, consumption emissions can be disaggregated into:

- emissions from ***direct energy use*** such as gas, personal vehicle fuel and electricity[7];
- emissions embedded in goods and services produced in the UK, or ***UK embedded*** emissions;
- emissions embedded in goods and services produced abroad, or ***ROW embedded*** emissions.

Seen in this way, emissions from direct energy use fell by 3.7% from 1992-2004. UK and ROW embedded emissions are estimated to have grown by around 12% and 33% respectively over the same period[8].

International emissions regime

Although UK decarbonisation would have an obvious impact on direct energy use and UK embedded emissions, the absence of equivalent international measures could mean that:

- UK consumption emissions fall far short of production perspective targets;
- the share of consumption emissions attributable to UK production would shrink, meaning further domestic efforts would have a diminishing impact;
- higher costs of UK goods and services resulting from decarbonisation may even exacerbate the offshoring trend.

The effectiveness of any international emissions regime is therefore considered a key uncertainty for the carbon intensity of UK lifestyles, made all the more significant by the increased domestic target (90%) that an effective international regime would imply for the UK.

Transition timing

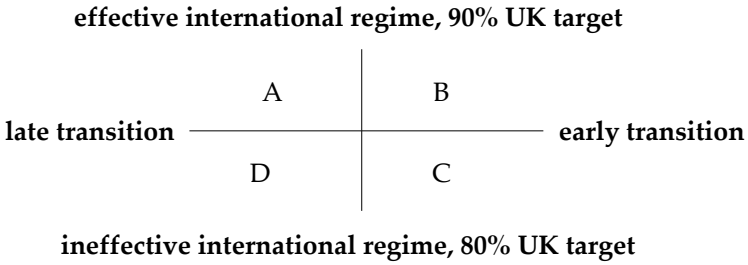
Another significant factor for this study is the recent economic recession and the impact on investment for a low carbon transition. The recession has led to reduced energy demand, and thus lower emissions over this period. In the short term this implies that the current carbon budget (2008-2012) will be easily met. However, the Committee on Climate Change has warned that without sufficient investment now in the measures required for the long term, eventual economic recovery will put pressure on later carbon budgets. Economic factors over the period

7 Although electricity is not a fuel as such, it is commonly perceived in this way by consumers.

8 For embedded emissions growth, the relative share of UK and ROW CO2 emissions is known, but not the relative share of overall GHG emissions. The CO2 proportions have therefore been 'scaled up' to give indicative figures for overall GHG emissions.

to 2030 will be significant in a number of ways, including the direct impact of demand on emissions levels and the role of taxation and public spending, both in stimulating the economy in the short term and ensuring the necessary measures are put in place to enable increasingly stringent carbon budgets to be met in the medium and long term. These factors must therefore be portrayed in the scenarios. Perhaps most significantly though, is the uncertainty around the availability of credit and the role of private sector investment for the transition to a low carbon economy. To explore this uncertainty in this study, two provisional pathways have been selected. An 'early transition' pathway, facilitated by high investment in appropriate technologies from the early 2010s, continuing through to 2030. In this pathway 2020 interim targets are met. A 'late transition' pathway sees insufficient investment through the 2010s, meaning that 2020 interim targets are missed. This, combined with relatively high exposure to increased global energy prices, incentivises a rapid low carbon transition through the 2020s.

The two uncertainties identified, when placed as axes on a diagram, generate four scenarios:



Discussion areas

The aim of the interview is to explore the suitability of the uncertainties chosen, and the plausibility of the scenarios thus generated. Some of the key areas to be explored include:

- The nature of an 'effective international regime' in the aftermath of Copenhagen. How wide a range of possible outcomes can we now contemplate for this uncertainty? What level of emissions reduction seems feasible in the 'effective' case? How might these responsibilities be shared? When would this become operational? In the absence of an international regime, how realistic is it that the UK government would retain existing reduction targets? How might the UK take advantage of carbon trading and offsetting under a new regime or in the absence of one?

- What assumptions would be suitable in the case of a late and early transition with regards to GDP, consumer expenditure, taxation, public spending, private investment etc?

- If, as has been suggested above, the scenarios will examine UK exposure to increased global energy prices, what would be an appropriate set of assumptions to use?

Appendix IV. Template of key points for narratives

The following list of key points was collected from the interview data for use in drafting outlines for the four scenarios:

political

international emissions regime

legally binding is a prerequisite. so complex, need umbrella agreement. UNFCCC consensus approach problematic. yet consensus keystone of international democracy.

we need an international regime. bottom up approaches will not deliver the business certainty we need.

without balanced global regime, we may have carbon leakage.

best to have domestic legislative measures in place first.

international top down coordination through UN too difficult.

the political orthodoxy suggests no global regime without US legislation

chinese not yet made the leap from seeing UNFCCC as a burden sharing exercise to seeing it as opportunity to lead the creation of a low carbon economy.

international regime is for coordination, communication and consistency (in accounting methods).

importance of consistent carbon accounting methods.

led by domestic legislation - informed by international negotiation

transparency in accounting is key in strong scenario

countries choosing own: reduction targets, target years, baseline years, accounting methodology. punitive measures unclear for developed countries. developing countries making voluntary (not legally binding) targets. in developing countries, some action self-financed and not open to international measurement, other internationally financed action open to verification.

no more stringent targets set, over time as countries are missing those other countries give up too, reestablishing new targets further off into the future etc.

any cap and trade system lacking supplementarity principle would mean actors simply rush to buy permits at end of commitment periods, meeting targets but at cost, and with lack of infrastructure investment.

varying standards across trading schemes, we get bogged down in disputes over quality of credits.

accounting methodology consistency is key. weak means flimsy targets, varying methodologies, actors biasing accounts in their favour.

credits from different jurisdictions having different values

with carbon markets, if there's an economic collapse somewhere, growing economies will buy credits from there to avoid low carbon investment.

maybe the situation is simply too difficult for any process to succeed.

equally, if the situation was clarly understood as win-win-win, UN process might be unnecessary.

an international regime is dependent on the political decision that low carbon transition is necessary and possible equally, part of the belief that it is possible is the belief that an international deal can be reached. circular feedback is operating here.

cynically - there may be a link between desire to avoid a regime, and the focus on fixing the process

piecemeal carbon market integration very hard... need whole framework to make it effective.

we bounce back from copenhagen quickly but need to keep political momentum.

international regimes tend to emerge from existing practice

UNFCCC trying to install a top down regime out of nothing

could argue copenhagen was the last chance of top down.

legally binding with high cap or poor compliance regime, no good.

does a strong regime meet scientific recommendation? which one?! 1.5 or 2C?

extremely complicated to reach international agreement with current (consensus based) procedures.

regime may be single agreement or multiple concurrent agreements.

in a non treaty world - no surpassing of existing commitments.

US/EU/China/bloc measures

in treaty world, will EU, US, china ambitions match those of SK, brazil and japan?

norway and EU as a model for non-legally binding US interaction with an international regime.

no US legislation in first term of Obama, but eventually a cap n trade scheme geared towards the interests of financial sector, trading, offsetting etc.

even in weak there will be pressure in US for some kind of legislation.

US will not be negotiated into a position through UN process. requires a change in domestic political outlook that sees benefits for prosperity, jobs, national security.

no credible international regime without US and no US action until there is the domestic will.

US less exposed to global international trade, might deal better with a crisis, although food market price shocks an example of true global interdependency

US able to meet current targets without cap n trade bill

china reluctant to sign up to per capita emissions lower than developed countries, US legislation falls far short of what's necessary.

chinese not yet made the leap from seeing UNFCCC as a burden sharing exercise to seeing it as opportunity to lead the creation of a low carbon economy.

optimistically - perhaps china simply hasn't figured out how it can benefit from climate regime as yet.

china's offer was compatible with a 2degree world, have stated that they wish to sign up to an international framework, they moved on reporting and verification .

EU has small way to go, US will cap n trade or be regulated by 2012

US, EU, Japan, Oz, NZ coordinated carbon markets. China etc national emissions intensity goals, but with specific sectoral targets geared around meeting carbon requirements of developed markets.

EU had ambitious targets but lacked the political strategy necessary to secure equivalent commitments from other blocs.

consider regional and bilateral agreements backed up by trade measures against 'laggards' as alternative to legally binding agreement?

carbon trading at subnational level. a bottom up driver for national level trading schemes?

domestic carbon trading schemes inevitable.

action from developed countries required first... followed by demands for commensurate action in developing countries

developed countries fail to take sufficient action to pressure developing countries to act.

high degree of EU action on economic planning e.g. infrastructure. focus on creating areas of concurrent opportunity. brings about a race dynamic between EU, US and China. already happening at meso level in electric and low carbon vehicles.

no race dynamic, ambition falls apart, activism has a smaller voice. industry sees less govt intention to decarbonise, capital flows elsewhere.

makes little sense for EU not to go to 30% target. some sectors would be more competitive as a result.

Korean case is interesting - have bet their economy on low carbon. developing countries e.g. china watching closely.

a sense of common cause more consistent with strong outcomes than US/EU ganging up on china

support for action from developing world

assumption that industrialised countries will lead is wrong

countries who will lead anything in 21st century are china, korea, brazil

Korea: previous success in rapid development has been able to follow the OECD as a model. green growth phase has no precedent. forging ahead. exemplar for strong domestic action w/o regime.

EU may have more power, but lacks believability, noone believes they will do anything

trade

attempted US/EU trade measures against china etc followed by social backlash against higher prices, then abandonment of measures?

for carbon intensive sectors offshoring may be problematic due to set up costs and transport costs, but possibly less so for more 'day to day' products

global trade is reduced as china turns to domestic market and south south trade to avoid north's trade measures.

consider regional and bilateral agreements backed up by trade measures against 'laggards' as alternative to legally binding agreement?

strong leadership from US/EU followed up by threat of carbon trade measures... but could backfire if developing countries turn inward, or if encourages south-south trade.

trade measures would mean increased domestic production, reduced imports from developing countries, increased prices.

a reduction in global trade could reduce technology learning

preferential treatment for low carbon goods and services?

any US legislation will require commensurate action from trading partners, else border tariffs will come into play

US will lead on demands for commensurate action from developing countries, rather than EU.

EU industry likely to threaten to leave unless imported competitors goods are blocked/taxed appropriately.

pre-Copenhagen, trade measures were kept on the shelf in case of failure to secure deal.

attempts to use trade measures would be bad for openness of global economic system.

no legally binding agreement, so we resort to trade measures.

costs of tariffs outweigh the objectives by breaking the international economic system.

threat of tariffs vs creation of incentives... which is better to motivate change?

US trade measures against china can only happen with US legislation, (unlikely).

does the EU have the guts to face down US on trade measures? more significant than vs china/india etc

domestic action

best to have domestic legislative measures in place first... international regime is for coordination, communication and consistency (in accounting methods).

accepted that there's a problem, but no consensus on solution, so focus political energy domestically.

led by domestic legislation - informed by international negotiation

limits on extent of targets include concerns over prices, competitiveness, fuel poverty.

lack of transparency over energy policy i.e. fossil fuel credit auctioning subsidies vs clean energy subsidies.

UK vs the world not credible, so weak scenario has to see UK action consistent with rest of EU.

climate scepticism among public prevents robust policy.

domestic action is necessary anyway - to demonstrate the economic viability of a low carbon transition. can also create the confidence to do a deal.

domestic action so far is poor. incidental benefits from non-climate policy

UK has been waiting for international regime before acting, other countries leading through action

domestic action as a result of national or individual self-interest

there's nothing the UK alone can do to china.

sectoral measures

China etc national emissions intensity goals, but with specific sectoral targets geared around meeting carbon requirements of developed markets.

need clearer sectoral targets or road map en route to long term % reductions.

opportunities for virtuous policy incentives for consumer and producer can produce beneficial rather than antagonistic relationship.

use of carbon market without clear sectoral targets may means overuse of financial mechanisms without structural change.

'governance' led by private sector, motivated by public attitudes

economic

global

if economy is in decline, people are less prepared to spend money on doing things properly, e.g. if you can't afford clean energy you revert to coal

'inflation is over' view han't been realised as sunk investments mean that relocation is 'lumpy'

regardless of ethical/environmental perspective, investors still need to participate. pension funds etc must spread their investments and this includes to environmental technology.

recession means lower replacement rate for technologies, less public funding available to provide incentives.

some action involves state/private sector retooling of infrastructure of consumption without much input from consumers

need for more secure investment for pensions - equities too volatile, pension funds need long term safe assets

question is how can investment in renewables and low carbon be packaged in a way that's attractive for the long term

rapid turnover of the capital stock required.

regardless of 'peak', fossil fuel prices will increase due to increased production costs and increased demand.

US/EU/China/blocs

europe has an ageing population, has impacted adversely on japan's economy. more resources will go towards supporting old people from a proportionally smaller cohort of working aged people.

younger economies have more consumption to drive the economy. europe disadvantaged, relative to US/emerging economies.

reflation of renminbi will result in increased chinese labour costs

maybe growth for a time (for developed countries to decarbonise), followed by steady state

perhaps low/no growth in developed countries will happen anyway. green growth may be the only significant growth

national

localised recession in UK = reduced interest rates = weak currency = higher prices for imported resources and fuels

over next 20 years, pound will be weak against emerging market currencies, hence long term impact on fuel costs

UK manufacturing could rapidly pick up again in event of weak currency

end of UK's economic dependence on consumption - accept there's no more public sector jobs, finance jobs, retail jobs, construction etc... instead, with energy security and climate change as main priorities, let's employ those builders and do green infrastructure

possible convergence of UK manufacturing and green capitalists - finance needs to be smaller part of economy, need less consumption more investment, thus a call for green infrastructure bank to fund green infrastructure.

shift to renewables and low carbon in primary sector can support many more second and third tier jobs

wind farm production, unlike e.g. solar, makes sense to be localised

with most low carbon technology, higher up front cost, so channelling capital into infrastructure but then not having to buy anything. potentially: rebound effect, or lower consumption.

impression of rising living standards based on: cheap credit/debt and falling prices from trade liberalisation.

through offshoring - people felt as though living standards were rising. can it continue? revaluation of chinese currency might suggest a slowing or reversal of price trend.

prices either static or rising. noticeable impact on consumers.

more savings means more financial sector activity

financial transaction tax - way to tame the size of financial sector, ensure higher proportion of money stays in real economy/people's wallets

social/psychological

stop where we are now with momentum being lost due to concerns over economy and economic impact of climate legislation.

without a positive vision of low carbon lifestyles, we cannot achieve the political support we need.

scientific/activist coalition continue calling for radical cuts but are marginalised(?)

if economy is in decline, people are less prepared to spend money on doing things properly, e.g. if you can't afford clean energy you revert to coal

need to get back to basics, restate case for impact of climate change on prosperity and security.

the green premium lifestyle shifts are on the margins

might be a shift in public thinking away from premium lifestyle changes towards green as engine of growth and jobs. away from green consumerism to green jobs.

'i will if you will' implies 'they won't so i won't'. low carbon transition has to be a shared enterprise, shared upfront costs, shared benefits.

climate change may be the wrong banner under which to achieve low carbon transition. too distant. instead, green economy delivering security, jobs, innovation and btw lower emissions. hits at people's basic concerns.

period of economically irrational exuberance giving way to a rethink. shift in sentiment from 'economy in equilibrium with strong growth engine, but unfortunate environmental externalities' to 'economy out of equilibrium, environmental issues indicate system shortcomings, let's generate economic advantage out of that '

technological

key target for EV: 400 mile capacity, rechargeable in 15mins

investment might give rise to some 'just makes sense' technologies and practices, but some technologies, e.g. coal CCS, will require restrictions on carbon to incentivise R&D.

stagnant economy could mean lack of investment in low carbon, thus extending the life of dirty technology

observations

carbon leakage may be overstated - differentials may not be large enough to impact on short term evaluation cycles of management - all the more so if a global regime is anticipated.

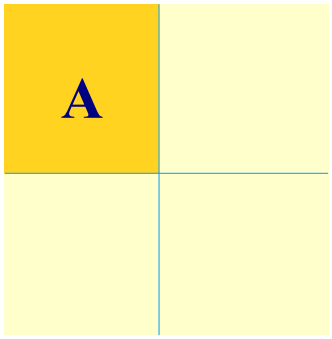
range between 80% and 90% (for UK in 2050) probably not great enough.

strong but late transition seems implausible

effective vs ineffective regime replaced by high vs lw autonomy

do I want to represent a weak regime as being: a) nothing stronger than copenhagen accord? b)copenhagen promises being reneged upon over time or c) the attempt by developed nations to use trade measures to force developing nations to act, only to see those countries turn to their domestic markets to avoid action? or some combination in the order a.. c... b?

Appendix V. Scenario A: data tables and charts



Better late than never

Little significant change in efforts to tackle emissions up to 2020, when increasing calls for climate action combine with rising fuel and commodity prices to bring things to a crisis point. Out of the crisis, international leaders build consensus on a comprehensive programme of emissions cuts. Although there is little improvement in the carbon intensity of UK lifestyles before the crisis, the securing of a global deal instills a sense of common purpose that encourages proactive behavioural change.

Illustrative Expenditure Figures

Household disposable income: 1.7% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2015 Expenditure (m£)
Electricity	*3.00*	0.43	-0.82	*0.41*	0.10	9200
Gas	*2.00*	-	-1.07	*1.48*	0.37	9697
Vehicle fuels and lubricants	*0.63*	0.13	-0.14	*2.51*	2.51	28495
Other fuels	*3.50*	0.46	-0.09	*-4.87*	-4.46	832
Other transport	*0.13*	0.84	-0.15	*2.25*	2.94	111382
Food and non-alcoholic drinks	*-0.50*	0.30	0.21	*0.25*	0.74	71075
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	26052
Clothing and footwear	*-3.94*	0.58	3.25	*0.95*	4.82	72252
Restaurants and hotels	*1.38*	1.10	-1.27	*0.92*	0.75	84129
Recreation and culture	*-1.88*	0.61	0.42	*4.13*	5.15	146117
Other housing	*3.56*	0.24	-1.50	*2.18*	0.92	139029
Communication	*-3.63*	0.25	0.71	*5.17*	6.11	28689
Furnishings; HH eqpt & maint	*-0.88*	1.17	0.85	*-0.16*	1.86	46179
Education	*3.63*	-0.35	0.77	*3.52*	4.29	13915
Health	*2.13*	0.13	-0.47	*2.27*	1.84	13094
Misc. goods and services	*0.13*	0.67	-0.03	*1.53*	2.17	127082

Table V.1: Scenario A, 2010-2015: Income, Price and Expenditure Changes

Notes: Household disposable income grows at 0.2-0.3% through to 2012, before picking up to rates of 2-2.25%, thus a rate of 1.7% averaged over the period. The low rate of growth over the early part of this period reflects concerns that any economic recovery in the UK will be export led, with household disposable incomes lagging behind.

Prices for the four direct energy use categories over this period were derived from DECC projections.

Price changes for the remaining categories reflect historical trends, with appropriate adjustment made for a rise in VAT in early 2011.

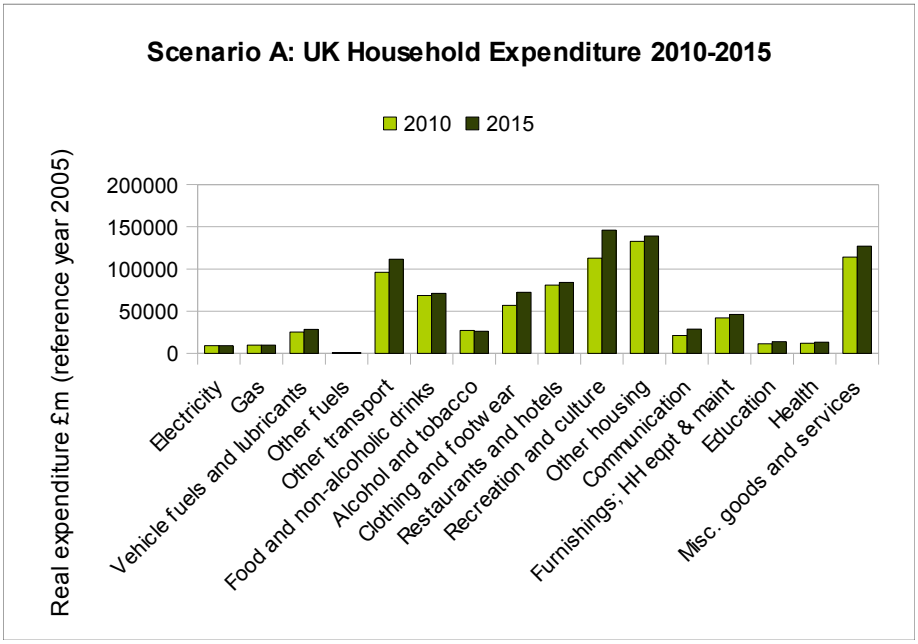
In each category, the sensitivity of expenditure to changes in income and price has been derived from the historical data, and those same levels of sensitivity are applied here. Thus, given the income and price assumptions and the corresponding sensitivities in each category, the actual impact in terms of changes in expenditure are shown in the first two grey columns. In the third grey column, the contribution of behaviour change not associated with income and price effects (exogenous non-economic factors, or exnef) is shown. These might include impacts of a shift in environmental attitudes and values, and subsequent lifestyle changes. In this initial period, the historical trends for exnef have been used in each case. Most notably, 'other fuels' continues a historical decline, while 'recreation and leisure' and 'communication' see a strong increase in expenditure primarily through lifestyle factors.

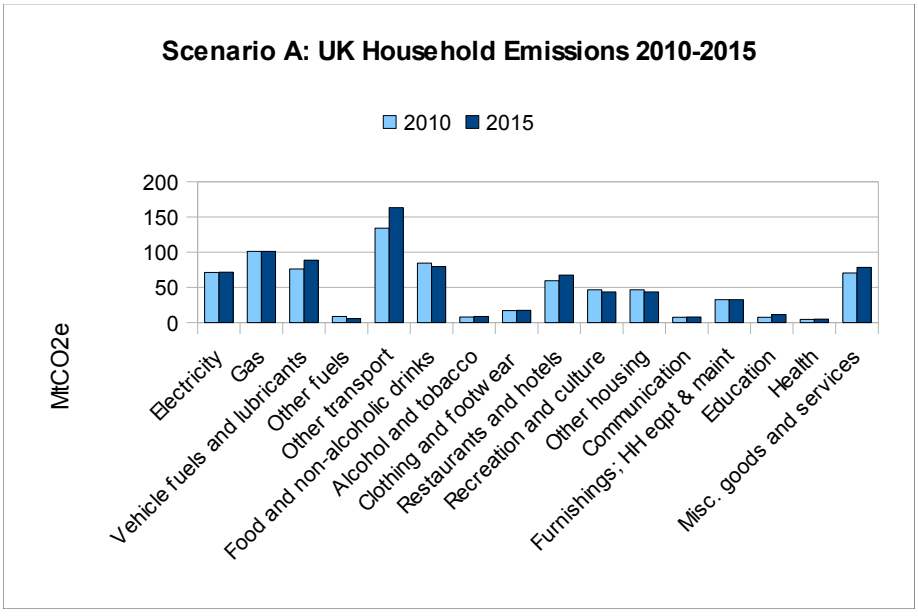
Illustrative Emissions Figures

		in 2015		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*0.00*	7.79	9200	72
Gas	*0.00*	10.43	9697	101
Vehicle fuels and lubricants	*0.58*	3.11	28495	89
Other fuels	*-2.74*	7.05	832	6
Other transport	*1.03*	1.46	111382	163
Food and non-alcoholic drinks	*-1.92*	1.12	71075	79
Alcohol and tobacco	*2.72*	0.33	26052	9
Clothing and footwear	*-4.14*	0.24	72252	17
Restaurants and hotels	*1.78*	0.80	84129	67
Recreation and culture	*-5.49*	0.30	146117	44
Other housing	*0.00*	0.35	139029	49
Communication	*-4.91*	0.27	28689	8
Furnishings; HH eqpt & maint	*-1.91*	0.70	46179	32
Education	*3.86*	0.81	13915	11
Health	*0.53*	0.39	13094	5
Misc. goods and services	*0.00*	0.62	127082	78

Table V.2: Scenario A, 2010-2015: Carbon intensity and emissions

Notes: With regards to emissions intensity, the historical trends have once again been used in this period, in the absence of any significant drivers of change. The direct energy use categories, electricity, gas, vehicle fuels and other fuels remain significant in terms of carbon intensity and total emissions. 'Other transport' encompasses the purchase of new vehicles, public transport by rail, road and sea, and aviation, the last of which is the fastest growing of the subcategories. As such, the carbon intensity of the category increases over the period in line with the growth in aviation. Despite a relatively low carbon intensity, 'other transport' has a significantly higher level of expenditure, bringing it to the top of the list for total emissions.


Scenario A: UK Household Expenditure 2010-2015
2010
2015
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario A: UK Household Emissions 2010-2015
2010
2015
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 1.8% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2020 Expenditure (m£)
Electricity	*10.00*	0.55	7.00*	0.47	8.05	13772
Gas	*10.00*	-	-2.21	11.98*	9.96	15874
Vehicle fuels and lubricants	*10.00*	0.15	5.03*	1.98	7.15	40740
Other fuels	*10.00*	0.67	5.59*	-4.87	2.84	957
Other transport	*3.00*	0.88	-3.56	*2.25*	-0.42	109070
Food and non-alcoholic drinks	*2.50*	0.31	-1.04	*0.25*	-0.46	69451
Alcohol and tobacco	*1.75*	0.52	-0.84	*-0.53*	-0.86	24961
Clothing and footwear	*-2.00*	0.64	2.16	*0.95*	3.76	87141
Restaurants and hotels	*3.25*	1.22	-2.94	*0.92*	-0.81	80789
Recreation and culture	*0.00*	0.67	-0.29	*4.13*	4.50	183021
Other housing	*3.50*	0.27	-1.47	*2.19*	0.98	146010
Communication	*-1.75*	0.31	0.37	*5.30*	5.98	38696
Furnishings; HH eqpt & maint	*1.00*	1.25	-0.94	*-0.16*	0.14	46507
Education	*5.50*	-0.43	-0.03	*3.73*	3.14	16277
Health	*4.00*	0.15	-0.88	*2.35*	1.77	14306
Misc. goods and services	*2.00*	0.73	-0.55	*1.53*	1.71	138427

Table V.3: Scenario A, 2015-2020: Income, Price and Expenditure changes

*For electricity, vehicle fuels and lubricants and other fuels, the price coefficients in the model have been adjusted from those that fit the historical data over the whole period to values which better reflect activity during short term price shocks. For gas, given the difficulties with the formula (explained elsewhere by Chitnis and Hunt ref), the desired shift in expenditure due to price has been achieved instead through adjustment of exnef.

Notes: Economic slowdown means annual growth in household disposable income drops from 2% to 1.5% over the period, with an average rate of 1.8%.

Prices for the four direct energy use categories of electricity, gas, other fuels and vehicle fuels are impacted considerably by global demand, with an increase of 10% annually used in the model. In the model, a fixed coefficient was originally used which – in light of these price shocks – would have implied an immediate and drastic reduction in expenditure for these categories. Instead, the coefficient has been adjusted to better reflect short term expenditure changes in the event of a price shock.

These impacts are also assumed to feed through onto the price of other goods and services, with average adjustments of 2-3% upwards for most categories, made according to the carbon intensity of the category (as a proxy for energy intensity). 'Other housing' is the exception, with price changes held at the historic trend, as the majority of the category consists of actual and imputed rentals, which are assumed to be held back on account of the economic slowdown.

In this period, the historical trends for exnef have broadly been continued, to reflect the absense of any meaningful attitudinal or behavioural change.

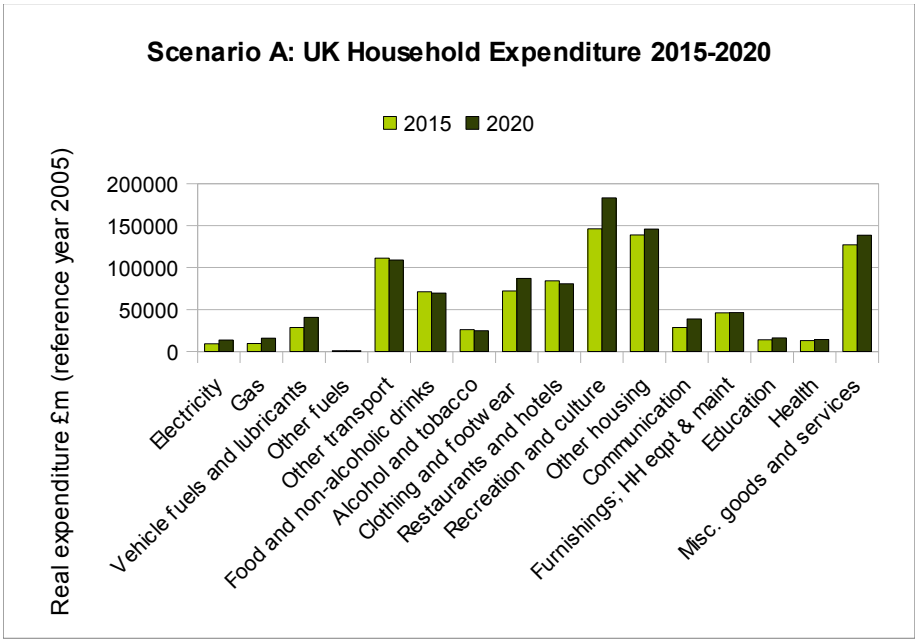
Illustrative Emissions Figures

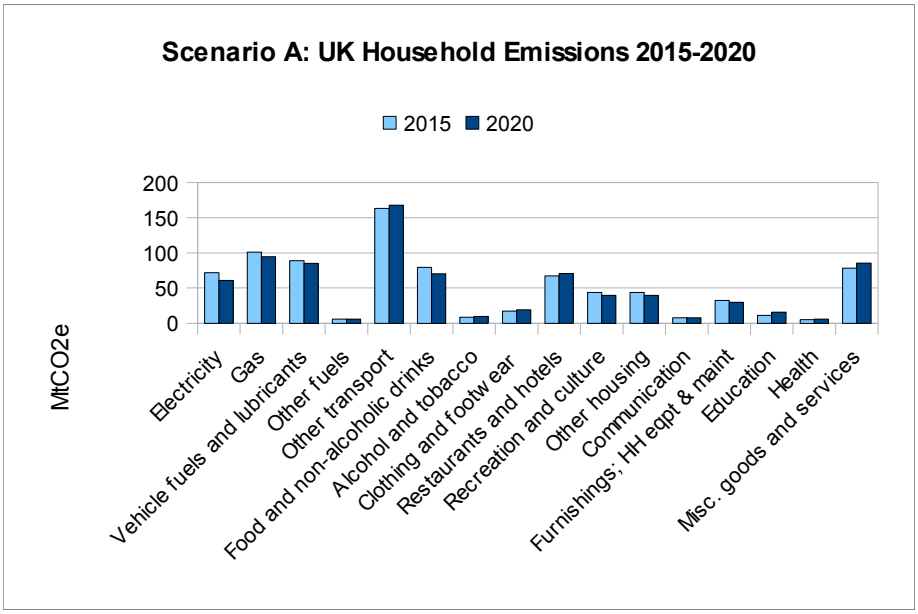
		in 2020		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	-8.69	4.41	13772	61
Gas	-8.58	5.96	15874	95
Vehicle fuels and lubricants	-6.59	2.09	40740	85
Other fuels	-2.74	6.09	957	6
Other transport	1.03	1.54	109070	168
Food and non-alcoholic drinks	-1.92	1.01	69451	70
Alcohol and tobacco	2.72	0.38	24961	9
Clothing and footwear	-1.90	0.22	87141	19
Restaurants and hotels	1.78	0.87	80789	71
Recreation and culture	-5.49	0.22	183021	40
Other housing	0.00	0.35	146010	52
Communication	-4.91	0.20	38696	8
Furnishings; HH eqpt & maint	-1.91	0.64	46507	30
Education	3.86	0.96	16277	16
Health	0.53	0.40	14306	6
Misc. goods and services	0.00	0.62	138427	85

Table V.4: Scenario A, 2015-2020: Carbon intensity and emissions

Notes: The emissions intensity has been adjusted considerably for the four direct energy use categories which undergo abrupt price changes. This is necessary to prevent the significant increase in expenditure (driven by the price shocks) from implying an increase in 'quantity' consumed. Although quantity data does not form part of this modelling framework, it is assumed that some curtailment of consumption would indeed take place. Thus, for electricity (which undergoes some decarbonisation through this period) and for vehicle fuels (which begins to see a slight shift in exnef towards the end of the period as per the narrative of increased car sharing and cycling), there is a measurable drop in total emissions. For gas, which must accomodate an accelerated shift from 'other fuels', consumption has been held more or less constant.

Once again, the emissions intensity of 'Other transport' continues to increase in line with growth in aviation, thus despite a modest reduction in expenditure, total emissions for this category increase over the period. For the remaining categories, historical trends have once again been used.


Scenario A: UK Household Expenditure 2015-2020
2015
2020
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario A: UK Household Emissions 2015-2020
2015
2020
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 2% p.a.

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2030 Expenditure (m£)
Electricity	0.00	0.58	-0.51	0.93	1.06	15308
Gas*	3.00	-	-1.42	-5.84	-4.86	9671
Vehicle fuels and lubricants	5.00	0.17	-0.75	-3.09	-3.67	28234
Other fuels	2.00	0.68	-0.19	9.79	10.71	2786
Other transport	*2.00*	0.98	-2.38	*3.93*	2.53	140477
Food and non-alcoholic drinks	*2.00*	0.35	-0.83	*-0.38*	-0.84	63866
Alcohol and tobacco	*1.75*	0.57	-0.84	*-0.53*	-0.80	23044
Clothing and footwear	*-3.00*	0.70	2.26	*0.95*	3.91	128901
Restaurants and hotels	*2.25*	1.34	-2.07	*0.92*	0.18	82257
Recreation and culture	*-1.00*	0.73	0.29	*4.13*	5.15	306185
Other housing	*3.50*	0.29	-1.47	*4.64*	3.46	206303
Communication	*-2.75*	0.33	0.52	*5.30*	6.16	71622
Furnishings; HH eqpt & maint	*0.00*	1.38	0.00	*1.23*	2.60	60340
Education	*4.50*	-0.45	0.42	*3.73*	3.56	23234
Health	*3.00*	0.16	-0.69	*2.35*	1.97	17416
Misc. goods and services	*1.00*	0.80	-0.28	*1.53*	2.05	169915

Table V.5: Scenario A, 2020-2030: Income, Price and Expenditure changes

*due to lag effects in the model, price increases from the previous period continue to have a considerable impact on gas expenditure.

Notes: Having recovered from the economic slowdown approaching 2020, annual growth in household disposable income averages 2% over this period.

Prices for the four direct energy use categories no longer experience substantial year on year increases as in the previous period. Electricity in particular begins to stabilise as alternatives to traditional sources of generation become more economically viable. Increased global demand leads to some increase in prices for gas and vehicle fuels, with supply shortages placing further pressure on prices in the case of vehicle fuels.

As the fuel price shocks abate, price changes for other goods and services also shift back towards their historical trends, although these are kept somewhat higher due to the cost of investment in low carbon production methods. In particular, food prices continue to rise, reflecting a shift in consumer attitudes around the carbon intensity of food production, with consumers prepared to spend more to ensure a lower environmental impact. The price of 'other transport' also continues to rise above the historical average, due to increased expenditure on higher priced fuel-efficient vehicles, and higher costs due to aviation fuels and investment in rail infrastructure.

Gas and vehicle fuels experience significant reduction in expenditure due to exnef, thanks to efficiency and conservation measures in home heating and private car use, and a shift towards public transport. For other fuels, the rapid rise in alternative heating solutions such as biomass or district heating leads to a substantial exnef increase. The exnef effect on electricity expenditure remains relatively stable as conservation measures are counteracted by electrification of home heating and private cars. The impact of behavioural change on 'other transport' expenditure increases over this period, above an already high historical trend. This is due to the shift towards public transport use, although slower growth in aviation disguises this shift to some extent. An increase in 'other housing' expenditure attributable to exnef represents the cost of retrofit measures.

Illustrative Emissions Figures

		in 2030		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	-3.93	2.67	15308	41
Gas	0.00	5.96	9671	58
Vehicle fuels and lubricants	-2.21	1.62	28234	46
Other fuels	-6.32	2.24	2786	6
Other transport	*-1.45*	1.32	140477	185
Food and non-alcoholic drinks	*-2.59*	0.75	63866	48
Alcohol and tobacco	*-0.49*	0.36	23044	8
Clothing and footwear	*-3.71*	0.14	128901	18
Restaurants and hotels	*-1.22*	0.77	82257	63
Recreation and culture	*-5.03*	0.11	306185	33
Other housing	*0.00*	0.35	206303	73
Communication	*-5.03*	0.10	71622	7
Furnishings; HH eqpt & maint	*-2.59*	0.47	60340	28
Education	*0.51*	1.01	23234	23
Health	*-0.95*	0.37	17416	6
Misc. goods and services	*-1.39*	0.53	169915	90

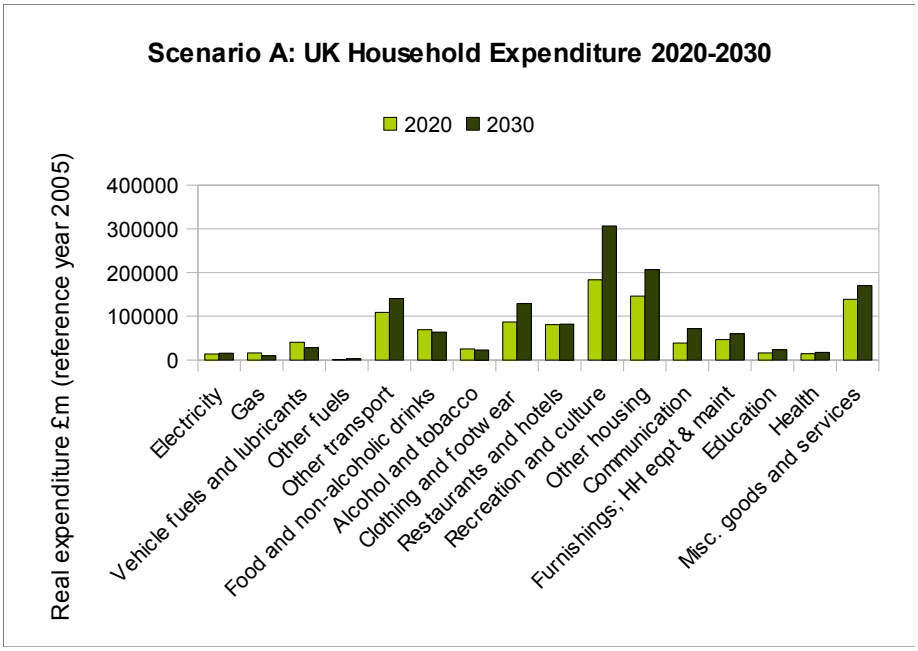
Table V.6: Scenario A, 2020-2030: Carbon intensity and emissions

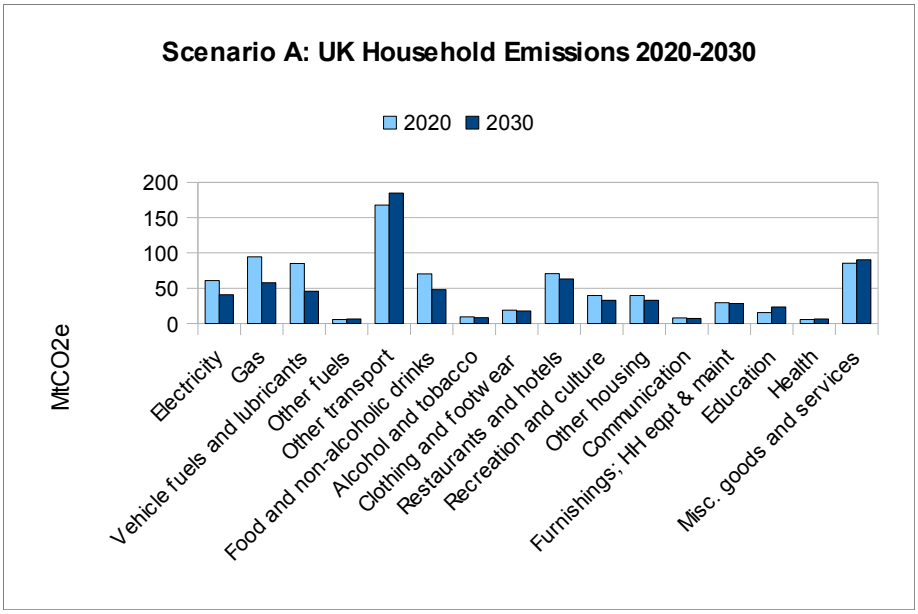
Notes: Electricity undergoes significant decarbonisation over this period in line with emissions reduction targets. The carbon intensity of gas is assumed to remain constant, while that of vehicle fuels falls as biofuels are introduced to some extent into the fuel mix. Combined with the effect of expenditure changes, total emissions fall substantially over the period. The category of 'other fuels' undergoes a more rapid decarbonisation as expenditure on heating oil etc falls at the same time as biomass and district heating expenditure rises. A significant increase in expenditure on such solutions means a small absolute increase in emissions for other fuels.

Total emissions from 'other transport' rise over the period. The carbon intensity of that category falls over the period due to a shift in the balance of expenditure on public transport versus aviation, however an overall increase in expenditure on both means higher total emissions (emissions savings from public transport use are seen in the reduced expenditure on personal vehicle fuels).

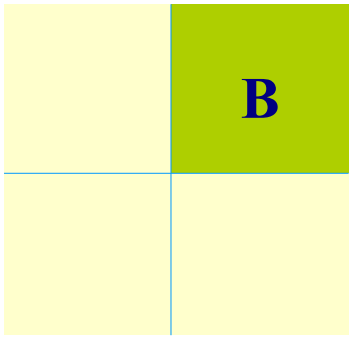
For the remaining categories, a change in carbon intensity is assumed to take place as a result of the overall shift toward decarbonisation of the global economy. The rate of change assumed in each case relates to the historical trend as well as to the absolute carbon intensity so that, for example 'recreation and culture', which has a relatively low carbon intensity compared to other categories, sees little improvement on an already strong historical decarbonisation trend. Meanwhile, miscellaneous goods and services, which has a higher carbon intensity to begin with, experiences a significant shift towards decarbonisation.

For 'food and non-alcoholic beverages' as well as 'restaurants and hotels', in addition to supply side innovations, a stronger decarbonisation trend can be attributed to exnef as consumers undergo a shift in attitudes to food purchasing.


Scenario A: UK Household Expenditure 2020-2030
2020
2030
Real expenditure £m (reference year 2005)
400000
300000
200000
100000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario A: UK Household Emissions 2020-2030
2020
2030
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Appendix VI. Scenario B: data tables and charts



All together, now

Voluntary climate action by different countries, including through green job programmes to aid economic recovery, helps to lay the groundwork for a comprehensive and equitable global deal in 2015. The cooperative approach observed at the international level is reflected in the behavioural change undertaken at the household level.

Illustrative Expenditure Figures

Household disposable income: 1.7% p.a.

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2015 Expenditure (m£)
Electricity	*3.60*	0.43	-0.89	*0.36*	-0.02	9143
Gas	*2.60*	-	-1.15	*1.01*	-0.18	9425
Vehicle fuels and lubricants	*0.63*	0.13	-0.14	*1.60*	1.60	27223
Other fuels	*3.50*	0.46	-0.09	*-4.87*	-4.46	832
Other transport	*0.13*	0.84	-0.15	*2.75*	3.44	114166
Food and non-alcoholic drinks	*0.10*	0.30	-0.04	*0.13*	0.38	69780
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	26052
Clothing and footwear	*-3.44*	0.58	3.09	*0.95*	4.66	71659
Restaurants and hotels	*1.38*	1.10	-1.27	*0.92*	0.75	84129
Recreation and culture	*-1.88*	0.61	0.42	*4.13*	5.15	146117
Other housing	*3.56*	0.24	-1.50	*2.87*	1.61	143912
Communication	*-3.63*	0.25	0.71	*5.17*	6.11	28689
Furnishings; HH eqpt & maint	*-0.88*	1.17	0.85	*0.41*	2.43	47523
Education	*3.63*	-0.35	0.77	*3.52*	4.29	13915
Health	*2.13*	0.13	-0.47	*2.27*	1.84	13094
Misc. goods and services	*0.13*	0.67	-0.03	*1.53*	2.17	127082

Table VI.1: Scenario B, 2010-2015: Income, Price and Expenditure Changes

Notes: Household disposable income grows at 0.2-0.3% through to 2012, before picking up to rates of 2-2.25%, thus a rate of 1.7% averaged over the period. The low rate of growth over the early part of this period reflects concerns that any economic recovery in the UK will be export led, with household disposable incomes lagging behind.

Over this period, prices for the four direct energy use categories of electricity, gas, other fuels and vehicle fuels are guided by DECC projections, but increased slightly in the case of electricity and gas to reflect the increased costs associated with early decarbonisation efforts. Price changes for the remaining categories reflect historical trends, with adjustment made for a rise in VAT in early 2011.

In each category, the sensitivity of expenditure to changes in income and price has been derived from the historical data, and those same levels of sensitivity are applied here. Thus, given the income and price assumptions and the corresponding sensitivities in each category, the actual impact in terms of changes in expenditure are shown in the first two grey columns. In the third grey column, the contribution of behaviour change not associated with income and price effects (exogenous non-economic factors, or exnef) is shown. These might include impacts of a shift in environmental attitudes and values, and subsequent lifestyle changes.

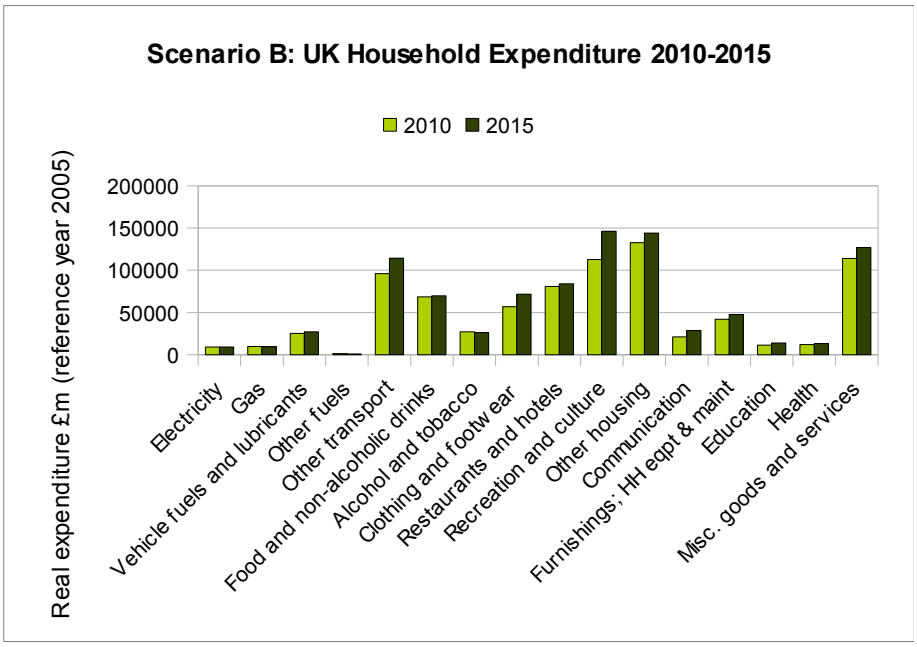
In this scenario, some shifts in exnef begin to take place, notably for gas and vehicle fuels. Additionally, the cost of retrofit measures is reflected in slightly increased exnef contributions towards expenditure on other housing, (which includes maintenance and repair of the dwelling), and furnishings (which includes carpets and floor coverings, a potential factor in any retrofit involving underfloor heating etc). It is important to note that in this scenario such retrofit schemes are adopted precisely because these are funded by government subsidies, meaning the expenditure would not necessarily show up as household consumption. *Nevertheless, in keeping with the illustrative nature of these figures, the expenditure has been accounted for within household consumption to reflect the final goods and services expected to be affected by such schemes.*

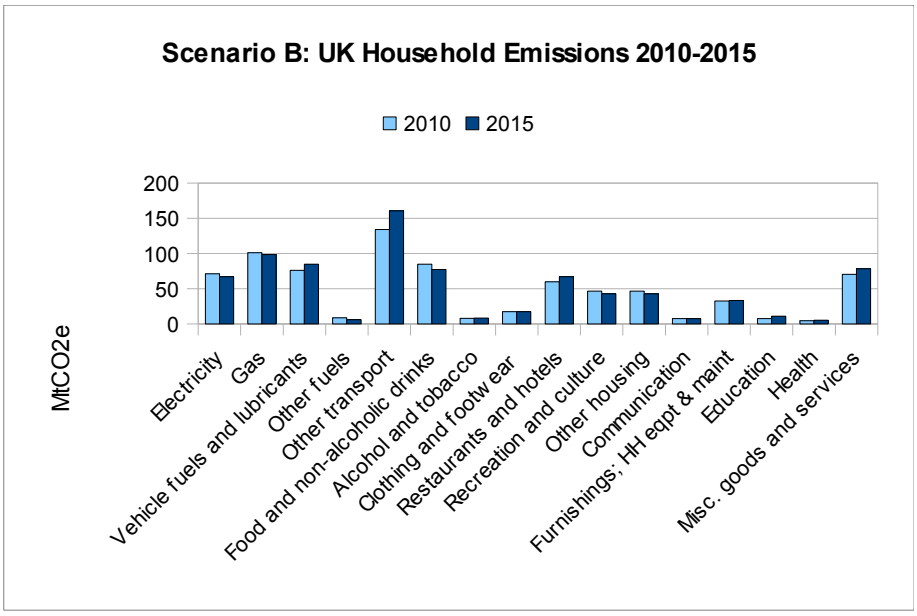
Illustrative Emissions Figures

		in 2015		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-1.16*	7.34	9143	67
Gas	*0.00*	10.43	9425	98
Vehicle fuels and lubricants	*0.58*	3.11	27223	85
Other fuels	*-2.74*	7.05	832	6
Other transport	*0.20*	1.41	114166	161
Food and non-alcoholic drinks	*-2.09*	1.11	69780	77
Alcohol and tobacco	*2.00*	0.32	26052	8
Clothing and footwear	*-4.14*	0.24	71659	17
Restaurants and hotels	*1.60*	0.79	84129	67
Recreation and culture	*-5.82*	0.29	146117	43
Other housing	*0.00*	0.35	143912	51
Communication	*-5.71*	0.26	28689	7
Furnishings; HH eqpt & maint	*-1.91*	0.70	47523	33
Education	*3.36*	0.79	13915	11
Health	*0.53*	0.39	13094	5
Misc. goods and services	*0.00*	0.62	127082	78

Table VI.2: Scenario B, 2010-2015: Carbon intensity and emissions

Notes: With regards to emissions intensity, some deviation from historical trends takes place in this scenario as a result of early decarbonisation efforts, the so called low hanging fruit. In particular, electricity begins a gradual decarbonisation of just over 1% p.a., while other transport sees a slowing of its 'carbonisation' trend, although a return to growth in aviation expenditure prevents any absolute or even relative drop in carbon emissions. Generally, some slight improvements begin to be felt across most categories.


Scenario B: UK Household Expenditure 2010-2015
2010
2015
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario B: UK Household Emissions 2010-2015
2010
2015
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 1.85% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2020 Expenditure (m£)
Electricity	*8.00*	0.56	5.36	*1.81*	7.73	13470
Gas	*10.00*	-	-2.32	*11.48*	9.22	14868
Vehicle fuels and lubricants	*10.00*	0.16	5.03	*-0.34*	4.84	34675
Other fuels	*10.00*	0.67	5.59	*0.76*	8.44	1264
Other transport	*3.00*	0.91	-3.56	*3.97*	1.32	121952
Food and non-alcoholic drinks	*2.50*	0.32	-1.04	*-0.06*	-0.76	67174
Alcohol and tobacco	*1.75*	0.53	-0.84	*-0.53*	-0.84	24979
Clothing and footwear	*-2.00*	0.66	1.91	*0.95*	3.53	85440
Restaurants and hotels	*3.25*	1.25	-2.94	*0.92*	-0.78	80903
Recreation and culture	*0.00*	0.68	-0.29	*4.13*	4.52	183170
Other housing	*3.50*	0.27	-1.47	*4.89*	3.68	173028
Communication	*-1.75*	0.31	0.37	*5.30*	5.99	38704
Furnishings; HH eqpt & maint	*1.00*	1.28	-0.94	*1.44*	1.77	51925
Education	*5.50*	-0.43	-0.03	*3.73*	3.13	16272
Health	*4.00*	0.15	-0.88	*2.35*	1.77	14308
Misc. goods and services	*2.00*	0.75	-0.55	*1.53*	1.73	138553

Table VI.3: Scenario B, 2015-2020: Income, Price and Expenditure Changes

Notes: Economic slowdown means annual growth in household disposable income drops from 2% to 1.75% over the period, with an average rate of 1.85%, slightly higher than in e.g. Scenario A, due to earlier efforts to curb dependence on imported fossil fuels.

Prices for the four direct energy use categories are impacted considerably by global demand, with an annual increase of 10% for gas, vehicle fuels and other fuels used in the model. The annual increase for electricity is lower than in e.g. Scenario A, at 8%. This is because some of the cost increases are associated with decarbonisation efforts which – due to having been brought forward in this scenario to the previous five year period – are spread out more evenly than in that alternate scenario.

In the model, a fixed elasticity was originally used which - in light of these price shocks - would imply an immediate and drastic reduction in expenditure for these categories. Instead, this has been adjusted to better reflect short term expenditure changes in the event of a price shock.

These impacts are also assumed to feed through onto the price of other goods and services, with average adjustments of 2-3% upwards for most categories, made according to the carbon intensity of the category (as a proxy for energy intensity). 'Other housing' is the exception, with price changes held at the historic trend, as the majority of the category consists of actual and imputed rentals, which are assumed to be held back on account of the economic slowdown.

Adjustments to the historical trend for exnef have been made to several categories, including vehicle fuels, where a series of factors including more fuel efficient vehicles and changing attitudes towards car sharing and alternative means of transport begin to make a significant difference on fuel consumption (allied with an increase in expenditure on 'other transport').

Also, whereas 'other fuels' historically experienced a significant downward trend for exnef, this scenario sees a significant reversal, with the exnef contribution increasing slightly during this period, as reduced expenditure on heating oils is replaced with equivalent expenditure on biomass and district heating. Other significant exnef deviations include a continuation of increased expenditure on other housing and furnishings to reflect ongoing take up of retrofit solutions.

Illustrative Emissions Figures

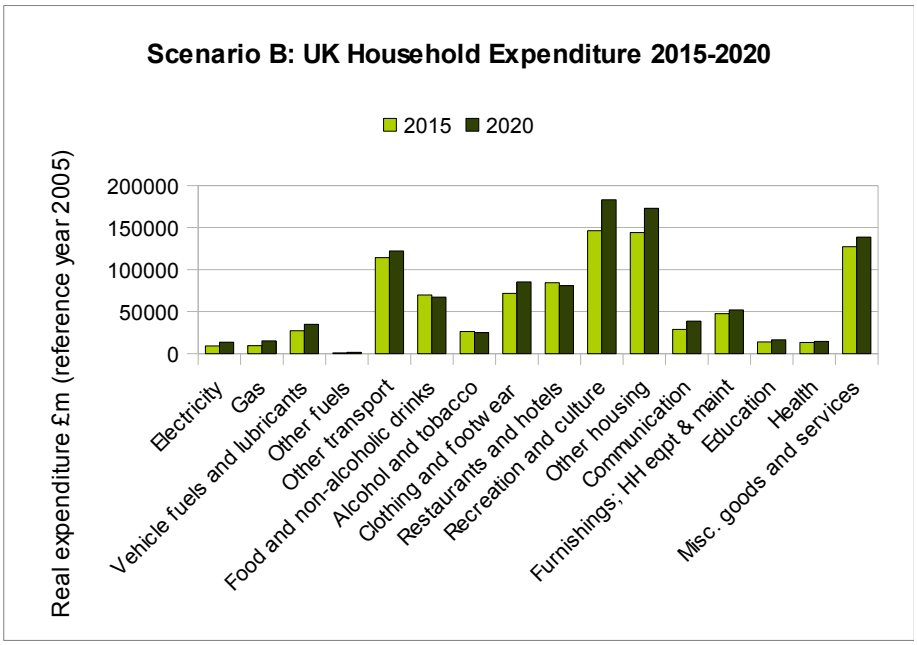
	carbon intensity change (% p.a.)	in 2020 Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-8.80*	4.11	13470	55
Gas	*-9.87*	5.28	14868	79
Vehicle fuels and lubricants	*-6.59*	2.09	34675	72
Other fuels	*-7.87*	4.28	1264	5
Other transport	*-0.49*	1.37	121952	167
Food and non-alcoholic drinks	*-2.79*	0.95	67174	64
Alcohol and tobacco	*0.00*	0.32	24979	8
Clothing and footwear	*-4.14*	0.19	85440	16
Restaurants and hotels	*-0.59*	0.77	80903	62
Recreation and culture	*-5.91*	0.21	183170	38
Other housing	*0.00*	0.35	173028	61
Communication	*-5.91*	0.18	38704	7
Furnishings; HH eqpt & maint	*-1.91*	0.64	51925	33
Education	*2.33*	0.88	16272	14
Health	*-0.98*	0.37	14308	5
Misc. goods and services	*-0.98*	0.59	138553	81

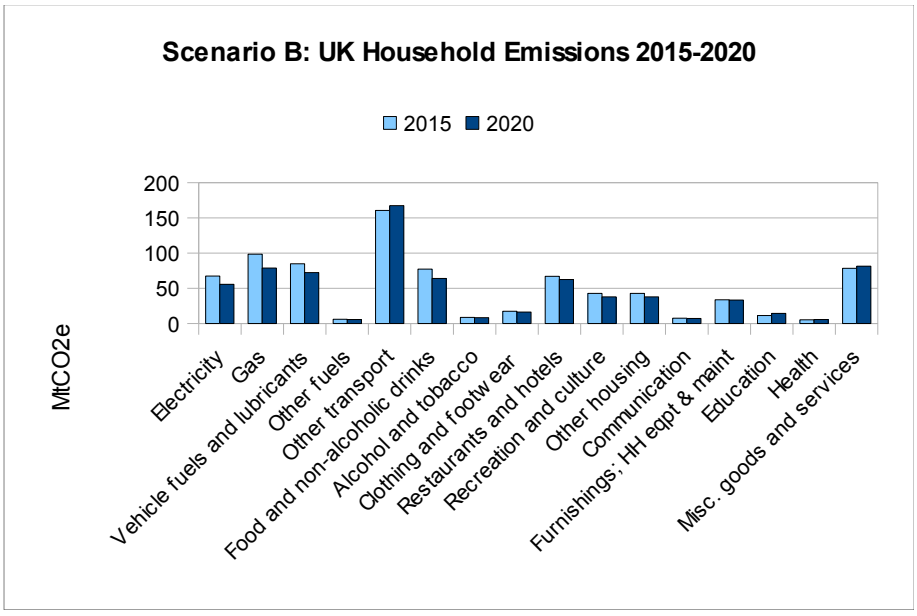
Table VI.4: Scenario B, 2015-2020: Carbon intensity and emissions

Notes: The emissions intensity has been adjusted considerably for the four direct energy use categories which undergo abrupt price changes. This is necessary to prevent the significant increase in expenditure (driven by the price shocks) from implying an increase in 'quantity' consumed. Although quantity data does not form part of this modelling framework, it is assumed that some curtailment of consumption would indeed take place. Thus, for electricity (which undergoes continued decarbonisation through this period), vehicle fuels (which sees a shift in exnef as discussed above) and gas (as a result of significant investment in retrofit measures and some behavioural change) there is a substantial reduction in total emissions.

For 'other transport', decarbonisation efforts for public transport marginally outweight the growth in aviation to ensure a reduction in emissions intensity for the overall category. Nevertheless, increased total expenditure outweighs these intensity savings, leading to a slight increase in total emissions from this category.

Across the remaining categories, historical increases in emissions intensities are slowed, while historical reductions are accelerated, to reflect continued decarbonisation of the economy.


Scenario B: UK Household Expenditure 2015-2020
2015
2020
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario B: UK Household Emissions 2015-2020
2015
2020
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 2.00% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2030 Expenditure (m£)
Electricity	*1.50*	0.59	0.24	*4.9*	5.78	24022
Gas*	*3.00*	-	-1.42	*-7.55*	-6.94	7365
Vehicle fuels and lubricants	*5.00*	0.17	-0.75	*-3.24*	-3.81	23689
Other fuels	*2.00*	0.69	-0.19	*10.13*	11.07	3820
Other transport	*2.50*	0.98	-2.97	*4*	2.01	149101
Food and non-alcoholic drinks	*2.25*	0.35	-0.93	*-0.39*	-0.95	61071
Alcohol and tobacco	*2.00*	0.57	-0.96	*-0.53*	-0.92	22788
Clothing and footwear	*-1.50*	0.70	1.19	*0.95*	2.85	113608
Restaurants and hotels	*2.25*	1.34	-2.07	*0.92*	0.18	82394
Recreation and culture	*-1.00*	0.74	0.29	*4.13*	5.15	306465
Other housing	*3.50*	0.29	-1.47	*5.14*	3.96	257126
Communication	*-2.75*	0.33	0.52	*5.30*	6.16	71652
Furnishings; HH eqpt & maint	*0.50*	1.38	-0.49	*1.44*	2.33	65564
Education	*4.50*	-0.45	0.42	*3.73*	3.56	23221
Health	*3.00*	0.16	-0.69	*2.35*	1.97	17420
Misc. goods and services	*1.00*	0.80	-0.28	*1.53*	2.05	170085

Table VI.5: Scenario B, 2020-2030: Income, Price and Expenditure changes

*due to lag effects in the model, price increases from the previous period continue to have a considerable impact on gas expenditure.

Notes: Having recovered from the economic slowdown approaching 2020, annual growth in household disposable income averages 2% over this period.

Prices for gas, electricity and other fuels no longer experience the substantial year on year increases as in the previous period. Electricity slows to an average 1.5% p.a. price increase as the historically high price has made alternatives to traditional sources of generation more economically viable, although the rapid deployment of alternative energy prevents electricity price from stabilising completely. Increased global demand leads to some increase in prices for gas and vehicle fuels, with supply shortages placing further pressure on prices in the case of vehicle fuels.

As the fuel price shocks abate, price changes for other goods and services also shift back towards their historical trends, although these are kept somewhat higher due to the cost of investment in low carbon production methods. In particular, food prices continue to rise, reflecting a shift towards methods of food production with a lower environmental impact. Other transport rises faster than e.g. Scenario A, due to the higher cost of more fuel efficient vehicles, including EVs, the higher cost of aviation and substantial investment in rail.

Regarding exnef, efficiency and conservation measures in home heating and private car use, and a continued shift towards public transport use, lead to significant annual reductions for gas and vehicle fuels.Other fuels sees a strong annual average increase from exnef, as alternative home heating solutions are adopted. For electricity, the mass electrification of transport and home heating is represented through a substantial annual increase in exnef. The exnef contribution to changes in expenditure for 'other transport' remains high through this period, reflecting a shift towards public transport use, even as aviation growth slows. An increase in 'other housing' expenditure attributable to exnef reflects continued investment in retrofit measures.

Illustrative Emissions Figures

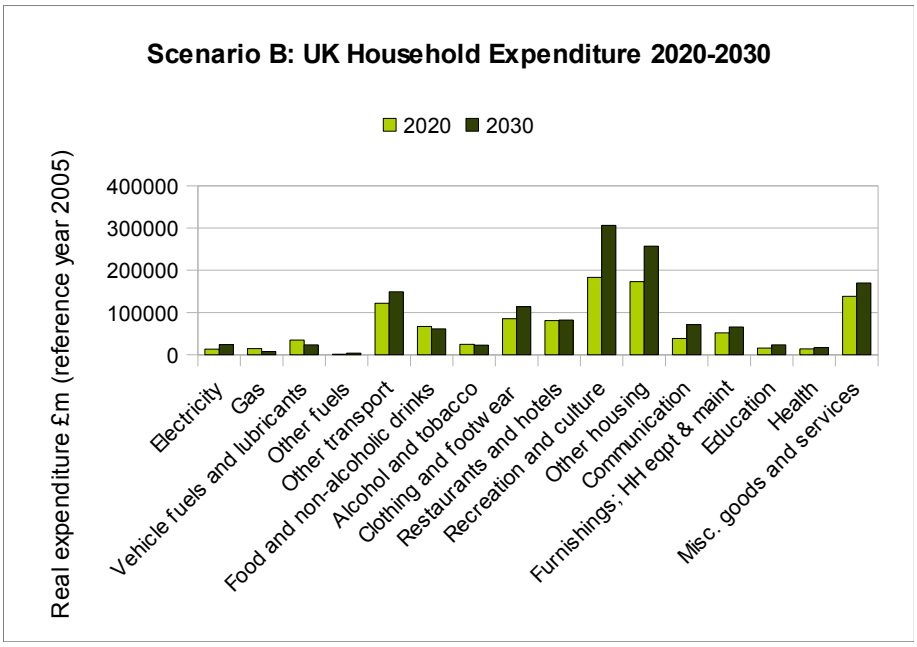
		in 2030		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-7.77*	0.92	24022	22
Gas	*0.00*	5.28	7365	39
Vehicle fuels and lubricants	*-2.21*	1.62	23689	38
Other fuels	*-6.32*	1.57	3820	6
Other transport	*-2.53*	1.03	149101	153
Food and non-alcoholic drinks	*-2.59*	0.71	61071	43
Alcohol and tobacco	*-0.95*	0.29	22788	7
Clothing and footwear	*-3.93*	0.12	113608	13
Restaurants and hotels	*-1.81*	0.63	82394	52
Recreation and culture	*-5.03*	0.10	306465	31
Other housing	*-2.21*	0.28	257126	71
Communication	*-5.03*	0.09	71652	6
Furnishings; HH eqpt & maint	*-3.30*	0.43	65564	28
Education	*-1.97*	0.71	23221	16
Health	*-1.81*	0.31	17420	5
Misc. goods and services	*-1.81*	0.48	170085	82

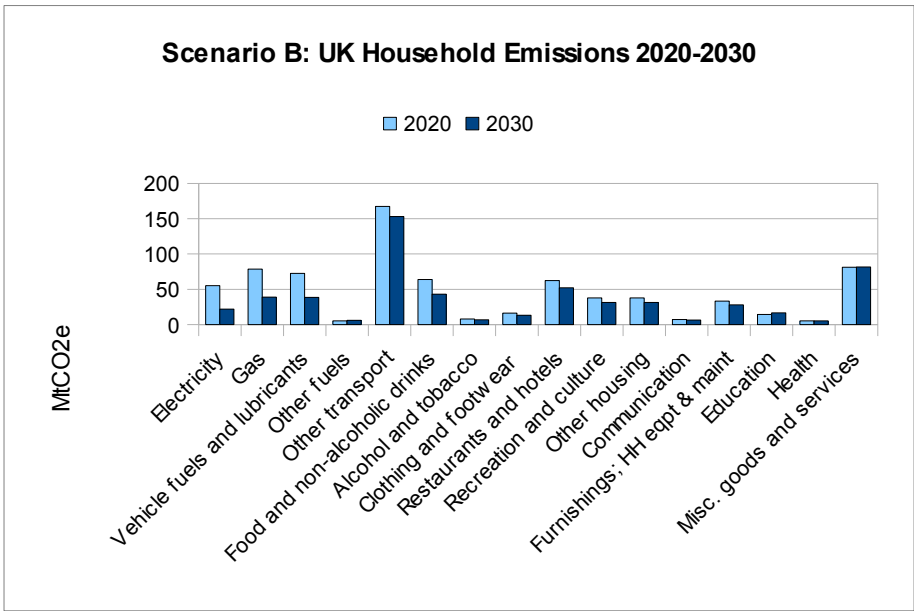
Table VI.6: Scenario B, 2020-2030: Carbon intensity and emissions

Notes: As a result of the early push towards decarbonisation, electricity sees a substantial average annual carbon intensity reduction of 7.7%. The carbon intensity of gas is assumed to remain constant, while that of vehicle fuels falls as biofuels are introduced to some extent into the fuel mix. Combined with the effect of expenditure changes, total emissions fall substantially over the period. The category of 'other fuels' continues to undergo rapid decarbonisation as expenditure on heating oil etc falls at the same time as biomass and district heating expenditure rises. A significant increase in expenditure on such solutions means a small absolute increase in emissions for other fuels.

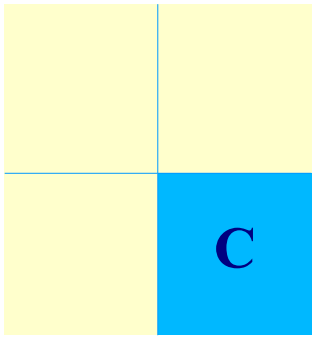
Total emissions from 'other transport' fall over the period. The category enjoys a significant decarbonisation over the period, due to a shift in the balance of expenditure on public transport versus aviation. Even an overall increase in expenditure is counteracted by the rate of decarbonisation. Furthermore, emissions savings from a shift to public transport use are seen in the reduced expenditure on personal vehicle fuels.

For the remaining categories, a change in carbon intensity is assumed to take place as a result of the overall shift toward decarbonisation of the global economy. The rate of change assumed in each case relates to the historical trend as well as to the absolute carbon intensity so that, for example 'recreation and culture', which has a relatively low carbon intensity compared to other categories, sees little improvement on an already strong historical decarbonisation trend. Meanwhile, miscellaneous goods and services, which has a higher carbon intensity to begin with, experiences a significant shift towards decarbonisation.


Scenario B: UK Household Expenditure 2020-2030
2020
2030
Real expenditure £m (reference year 2005)
400000
300000
200000
100000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario B: UK Household Emissions 2020-2030
2020
2030
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Appendix VII. Scenario C: data tables and charts



Trading woes

Unilateral climate action by the EU is intended to draw further commitments from other parties, but with no such action forthcoming by 2015, the EU threatens the use of trade measures. After a period of heightened political tensions and economic slowdown, a compromise is reached. The result is a series of bilateral emissions targets that remain insufficient to avoid dangerous climate change. The UK public are cautiously optimistic at first, but without commensurate international action, enthusiasm for pro-environmental behavioural change is weakened.

Illustrative Expenditure Figures

Household disposable income: 1.7% p.a.

		change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2015 Expenditure (m£)
Electricity	*3.60*	0.43	-0.89	*0.36*	-0.02	9143
Gas	*2.60*	-	-1.15	*1.14*	-0.06	9488
Vehicle fuels and lubricants	*0.63*	0.13	-0.14	*2.12*	2.11	27937
Other fuels	*3.50*	0.46	-0.09	*-4.87*	-4.46	832
Other transport	*0.13*	0.84	-0.15	*2.25*	2.94	111382
Food and non-alcoholic drinks	*0.10*	0.30	-0.04	*0.20*	0.45	70037
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	26052
Clothing and footwear	*-3.44*	0.58	3.09	*0.95*	4.66	71659
Restaurants and hotels	*1.38*	1.10	-1.27	*0.92*	0.75	84129
Recreation and culture	*-1.88*	0.61	0.42	*4.13*	5.15	146117
Other housing	*3.56*	0.24	-1.50	*2.65*	1.39	142362
Communication	*-3.63*	0.25	0.71	*5.17*	6.11	28689
Furnishings; HH eqpt & maint	*-0.88*	1.17	0.85	*-0.07*	1.95	46381
Education	*3.63*	-0.35	0.77	*3.52*	4.29	13915
Health	*2.13*	0.13	-0.47	*2.27*	1.84	13094
Misc. goods and services	*0.13*	0.67	-0.03	*1.53*	2.17	127082

Table VII.1: Scenario C, 2010-2015: Income, Price and Expenditure Changes

Notes: Household disposable income grows at 0.2-0.3% through to 2012, before picking up to rates of 2-2.25%, thus a rate of 1.7% averaged over the period. The low rate of growth over the early part of this period reflects concerns that any economic recovery in the UK will be export led, with household disposable incomes lagging behind.

Over this period, prices for the four direct energy use categories of electricity, gas, other fuels and vehicle fuels are guided by DECC projections but increased slightly in the case of electricity and gas to reflect the increased costs associated with early decarbonisation efforts.

Price changes for the remaining categories reflect historical trends, with adjustment made for a rise in VAT in early 2011.

In each category, the sensitivity of expenditure to changes in income and price has been derived from the historical data, and those same levels of sensitivity are applied here. Thus, given the income and price assumptions and the corresponding sensitivities in each category, the actual impact in terms of changes in expenditure are shown in the first two grey columns. In the third grey column, the contribution of behaviour change not associated with income and price effects (exogenous non-economic factors, or exnef) is shown. These might include impacts of a shift in environmental attitudes and values, and subsequent lifestyle changes.

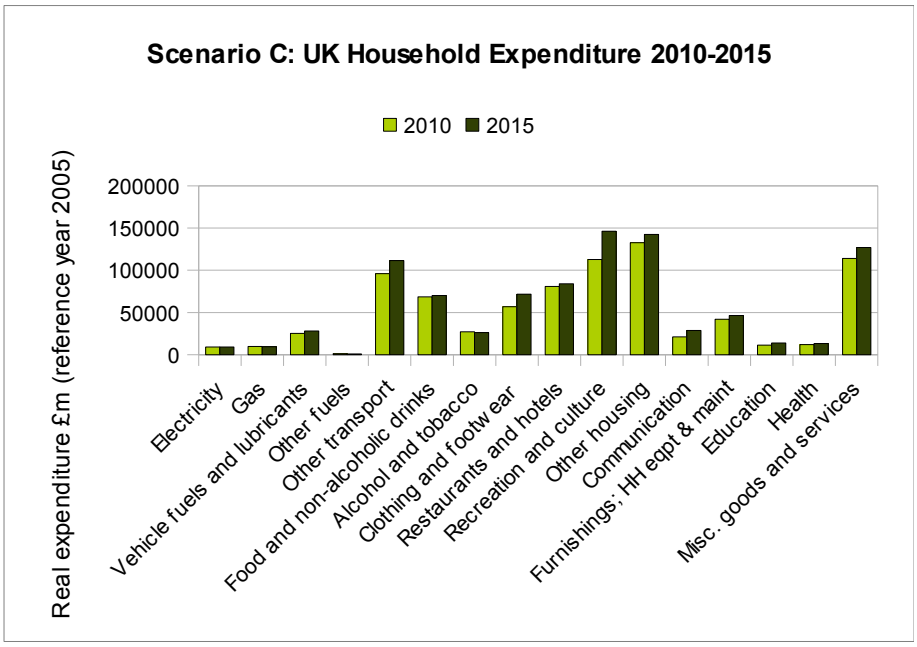
In this scenario, some shifts in exnef begin to take place, notably for gas and vehicle fuels. Additionally, the cost of retrofit measures is reflected in slightly increased exnef contributions towards expenditure on other housing, (which includes maintenance and repair of the dwelling), and furnishings (which includes carpets and floor coverings). While representing a shift in exnef away from the historical trends used in e.g. Scenario A for this period, the shifts are not as extensive as in Scenario B, given the cautious approach taken by householders in this scenario due to the lack of global cooperation.

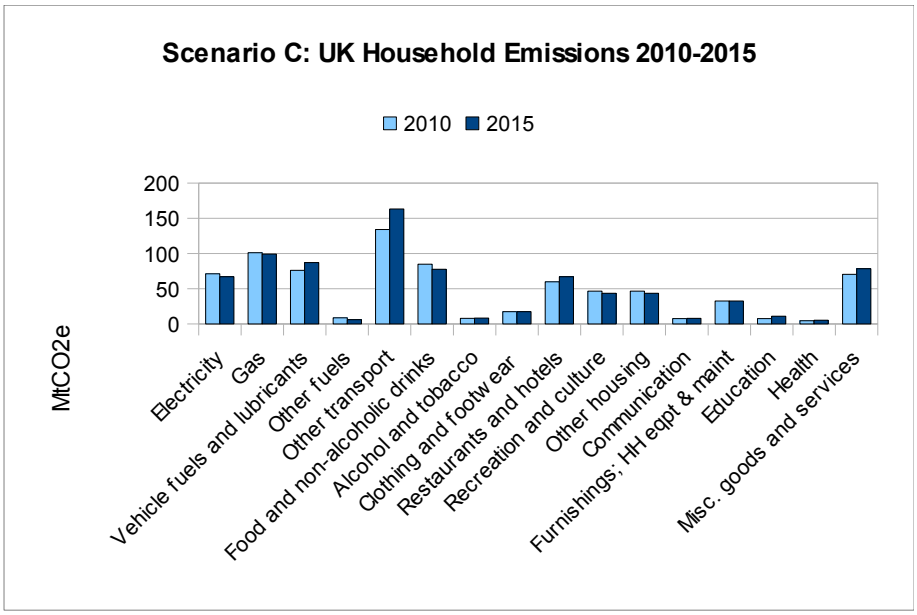
Illustrative Emissions Figures

		in 2015		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	-1.16	7.34	9143	67
Gas	0.00	10.43	9488	99
Vehicle fuels and lubricants	*0.58*	3.11	27937	87
Other fuels	*-2.74*	7.05	832	6
Other transport	*1.03*	1.46	111382	163
Food and non-alcoholic drinks	*-2.09*	1.11	70037	77
Alcohol and tobacco	*2.00*	0.32	26052	8
Clothing and footwear	*-4.14*	0.24	71659	17
Restaurants and hotels	*1.60*	0.79	84129	67
Recreation and culture	*-5.49*	0.30	146117	44
Other housing	*0.00*	0.35	142362	50
Communication	*-4.91*	0.27	28689	8
Furnishings; HH eqpt & maint	*-1.91*	0.70	46381	33
Education	*3.36*	0.79	13915	11
Health	*0.53*	0.39	13094	5
Misc. goods and services	*0.00*	0.62	127082	78

Table VII.2: Scenario C, 2010-2015: Carbon intensity and emissions

Notes: With regards to emissions intensity, some deviation from historical trends takes place in this scenario as a result of early decarbonisation efforts. In particular, electricity begins a gradual decarbonisation of just over 1% p.a., while other transport sees a slowing of its 'carbonisation' trend, although a return to growth in aviation expenditure prevents any absolute or even relative drop in carbon emissions. Generally, some slight improvements begin to be felt across most categories.


Scenario C: UK Household Expenditure 2010-2015
2010
2015
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario C: UK Household Emissions 2010-2015
2010
2015
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: *1.7% p.a.*

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2020 Expenditure (m£)
Electricity	*8.00*	0.54	6.03	*1.31*	7.89	13575
Gas	*10.00*	-	-2.32	*13.16*	10.94	16321
Vehicle fuels and lubricants	*10.00*	0.15	5.03	*1.04*	6.21	38107
Other fuels	*10.00*	0.65	5.59	*-2.54*	5.14	1072
Other transport	*3.00*	0.83	-3.56	*2.25*	-0.47	108804
Food and non-alcoholic drinks	*2.50*	0.30	-1.04	*-0.06*	-0.78	67364
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	24925
Clothing and footwear	*-2.00*	0.61	1.91	*0.95*	3.48	85250
Restaurants and hotels	*3.25*	1.16	-2.94	*0.92*	-0.87	80542
Recreation and culture	*0.00*	0.63	-0.29	*4.13*	4.47	182706
Other housing	*3.50*	0.25	-1.47	*3.85*	2.63	162372
Communication	*-1.75*	0.30	0.37	*5.30*	5.97	38673
Furnishings; HH eqpt & maint	*1.00*	1.18	-0.94	*0.66*	0.89	48504
Education	*5.50*	-0.41	-0.03	*3.73*	3.15	16290
Health	*4.00*	0.14	-0.88	*2.35*	1.76	14300
Misc. goods and services	*2.00*	0.69	-0.55	*1.53*	1.67	138164

Table VII.3: Scenario C, 2015-2020: Income, Price and Expenditure Changes

Notes: Significant economic slowdown due to higher fuel and commodity prices and international trade disputes means annual growth in household disposable income drops from 2% to 1.25% over the period, with an average rate of 1.7%.

Prices for the four direct energy use categories are impacted considerably by global demand, with an annual increase of 10% for gas, vehicle fuels and other fuels used in the model. The annual increase for electricity is lower than in e.g. Scenario A, at 8%. This is because some of the cost increases are associated with decarbonisation efforts which – due to having been brought forward in this scenario to the previous five year period – are spread out more evenly than in that alternate scenario.

In the model, a fixed elasticity was originally used which - in light of these price shocks - would imply an immediate and drastic reduction in expenditure for these categories. Instead, this has been adjusted to better reflect short term expenditure changes in the event of a price shock.

These impacts are also assumed to feed through onto the price of other goods and services, with average adjustments of 2-3% upwards for most categories, made according to the carbon intensity of the category (as a proxy for energy intensity). 'Other housing' is the exception, with price changes held at the historic trend, as the majority of the category consists of actual and imputed rentals, which are assumed to be held back on account of the economic slowdown.

Adjustments to exnef have been made for several categories, to reflect a series of behavioural factors, although these adjustments are not as extensive as in Scenario B, where a stronger sense of cooperation internationally leads to greater attitudinal and behavioural change. Perhaps most notably, in this scenario there is no increase in the exnef trend for 'other transport' as there is in Scenario B, to reflect the accelerated modal shift that takes place under those conditions. Accordingly, the shift in exnef away from expenditure on vehicle fuels is less pronounced here. Other significant exnef deviations include a continuation of increased expenditure on other housing and furnishings to reflect ongoing take up of retrofit solutions, although these shifts are once again less pronounced than in Scenario B.

Illustrative Emissions Figures

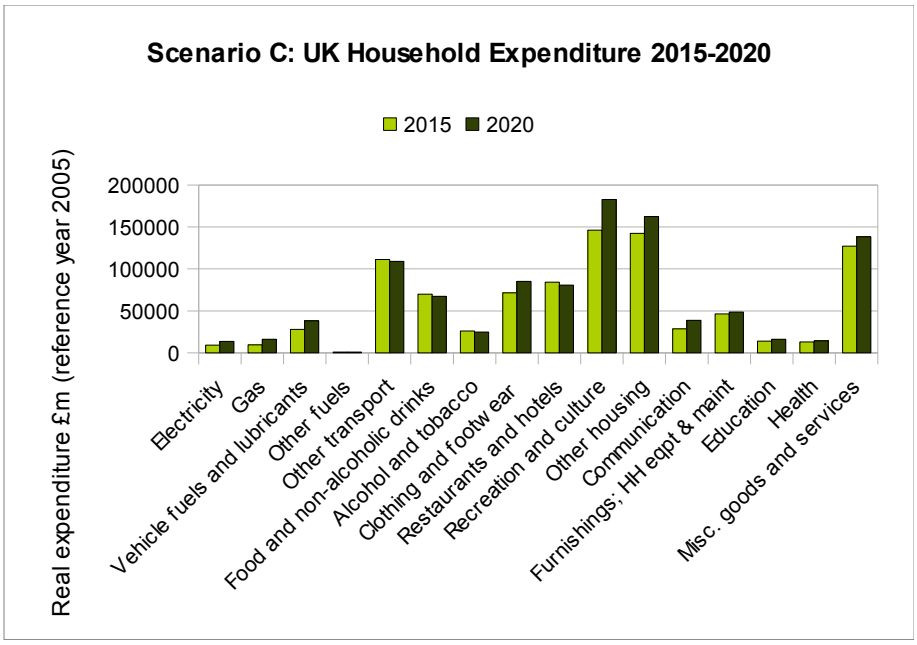
		in 2020		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-8.46*	4.23	13575	57
Gas	*-9.87*	5.28	16321	86
Vehicle fuels and lubricants	*-6.59*	2.09	38107	79
Other fuels	*-7.87*	4.28	1072	5
Other transport	*1.03*	1.54	108804	167
Food and non-alcoholic drinks	*-2.79*	0.95	67364	64
Alcohol and tobacco	*0.61*	0.33	24925	8
Clothing and footwear	*-4.14*	0.19	85250	16
Restaurants and hotels	*0.00*	0.79	80542	64
Recreation and culture	*-5.91*	0.21	182706	38
Other housing	*0.00*	0.35	162372	58
Communication	*-5.91*	0.19	38673	7
Furnishings; HH eqpt & maint	*-1.91*	0.64	48504	31
Education	*3.24*	0.92	16290	15
Health	*0.00*	0.39	14300	6
Misc. goods and services	*0.00*	0.62	138164	85

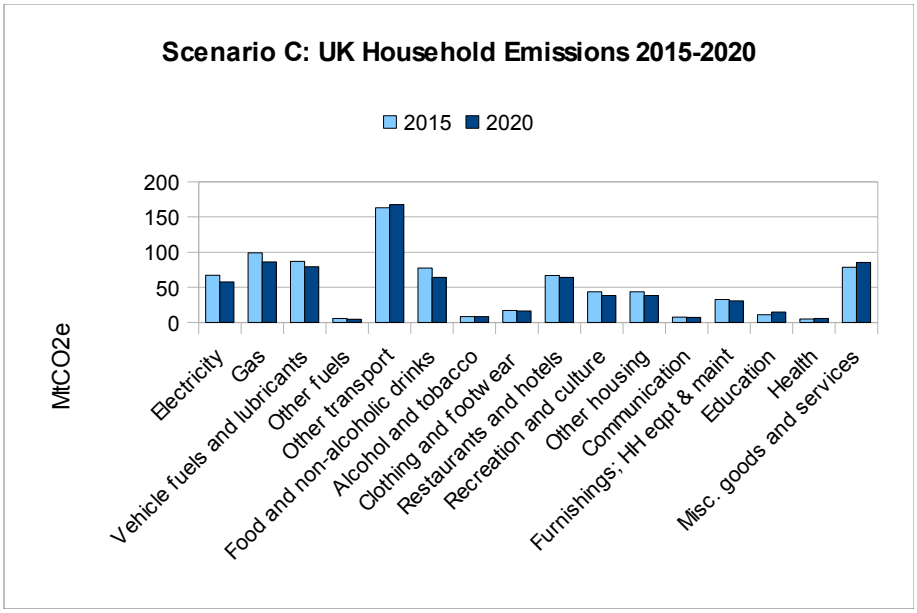
Table VII.4: Scenario C, 2015-2020: Carbon intensity and emissions

Notes: The emissions intensity has been adjusted considerably for the four direct energy use categories which undergo abrupt price changes. This is necessary to prevent the significant increase in expenditure (driven by the price shocks) from implying an increase in 'quantity' consumed. Although quantity data does not form part of this modelling framework, it is assumed that some curtailment of consumption would indeed take place. Thus, for electricity (which undergoes continued decarbonisation through this period), vehicle fuels (which sees a shift in exnef as discussed above) and gas (as a result of investment in retrofit measures and some behavioural change) there is a measurable reduction in total emissions.

For 'other transport', decarbonisation efforts for public transport are outweighed by the continued growth in aviation to ensure an increase in emissions intensity for the overall category. Thus, despite a small reduction in total expenditure, there is a slight increase in total emissions from other transport.

Across the remaining categories, historical increases in emissions intensities are slowed, while historical reductions are accelerated, to reflect continued decarbonisation of the economy.


Scenario C: UK Household Expenditure 2015-2020
2015
2020
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario C: UK Household Emissions 2015-2020
2015
2020
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 2.1% p.a.

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2030 Expenditure (m£)
Electricity	*1.50*	0.60	-0.10	*4.33*	4.88	22128
Gas*	*3.00*	-	-1.42	*-5.21*	-3.87	10965
Vehicle fuels and lubricants	*5.00*	0.17	-0.75	*-2.25*	-2.82	28735
Other fuels	*2.00*	0.70	-0.19	*5.29*	6.24	1999
Other transport	*2.50*	1.02	-2.97	*2.25*	0.30	112130
Food and non-alcoholic drinks	*2.00*	0.36	-0.83	*-0.20*	-0.65	63111
Alcohol and tobacco	*1.75*	0.60	-0.84	*-0.53*	-0.78	23060
Clothing and footwear	*-1.50*	0.73	1.19	*0.95*	2.87	113606
Restaurants and hotels	*2.25*	1.38	-2.07	*0.92*	0.23	82391
Recreation and culture	*-1.00*	0.76	0.29	*4.13*	5.17	306460
Other housing	*3.50*	0.30	-1.47	*5.08*	3.90	239874
Communication	*-2.75*	0.34	0.52	*5.30*	6.17	71651
Furnishings; HH eqpt & maint	*0.50*	1.43	-0.49	*1.41*	2.35	61369
Education	*4.50*	-0.47	0.42	*3.73*	3.54	23221
Health	*3.00*	0.17	-0.69	*2.35*	1.97	17420
Misc. goods and services	*1.00*	0.83	-0.28	*1.53*	2.08	170081

Table VII.5: Scenario C, 2020-2030: Income, Price and Expenditure changes

*due to lag effects in the model, price increases from the previous period continue to have a considerable impact on gas expenditure.

Notes: After a slowdown in growth brought on by trade disputes in the previous period, the dismantling of trade barriers brings a boost in the short term, before stabilising, meaning an average annual growth in income of 2.1% over this period.

Prices for the direct energy use categories also come down from the substantial year on year increases of the previous period. Electricity prices grow at 1.5% p.a. as new price levels mean that alternative sources of generation become viable. Due to continuing increased global demand, prices for gas and vehicle fuels continue to increase annually, at 3% and 5% respectively.

Generally, after the price shocks of the previous period, annual price changes for other categories are lower. For food, prices rise 2% p.a., down from 2.5% in the previous period. Cheaper imported food (and a slowing of fossil fuel price increases) contributes to the slower increase, while continued efforts to decarbonise food production, globally as well as domestically ensures that prices rise nevertheless. For other transport, prices continue to rise at 2.5% p.a., as the cost of aviation fuel, more fuel efficient vehicles and decarbonisation of public transport all take their toll.

Changes in expenditure due to exnef include a rise for electricity due to increasing electrification of heating and transport. For gas and vehicle fuels, exnef contributes to a fall in expenditure, again due to electrification of heating and transport, but also due to further efficiency and conservation measures. Other fuels see a large exnef increase, as as result of increased expenditure on biomass and district heating. Exnef also contributes to a significant increase in expenditure for 'other housing', to reflect the cost of retrofit measures.

Illustrative Emissions Figures

		in 2030		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-6.83*	1.34	22128	30
Gas	*0.00*	5.28	10965	58
Vehicle fuels and lubricants	*-2.21*	1.62	28735	47
Other fuels	*-6.32*	1.57	1999	3
Other transport	*-0.95*	1.39	112130	156
Food and non-alcoholic drinks	*-1.39*	0.82	63111	52
Alcohol and tobacco	*-0.49*	0.32	23060	7
Clothing and footwear	*-3.93*	0.12	113606	13
Restaurants and hotels	*1.62*	0.92	82391	76
Recreation and culture	*-4.74*	0.11	306460	34
Other housing	*-0.49*	0.34	239874	81
Communication	*-4.51*	0.10	71651	8
Furnishings; HH eqpt & maint	*-2.21*	0.49	61369	30
Education	*-0.91*	0.83	23221	19
Health	*-0.49*	0.37	17420	7
Misc. goods and services	*-0.95*	0.56	170081	95

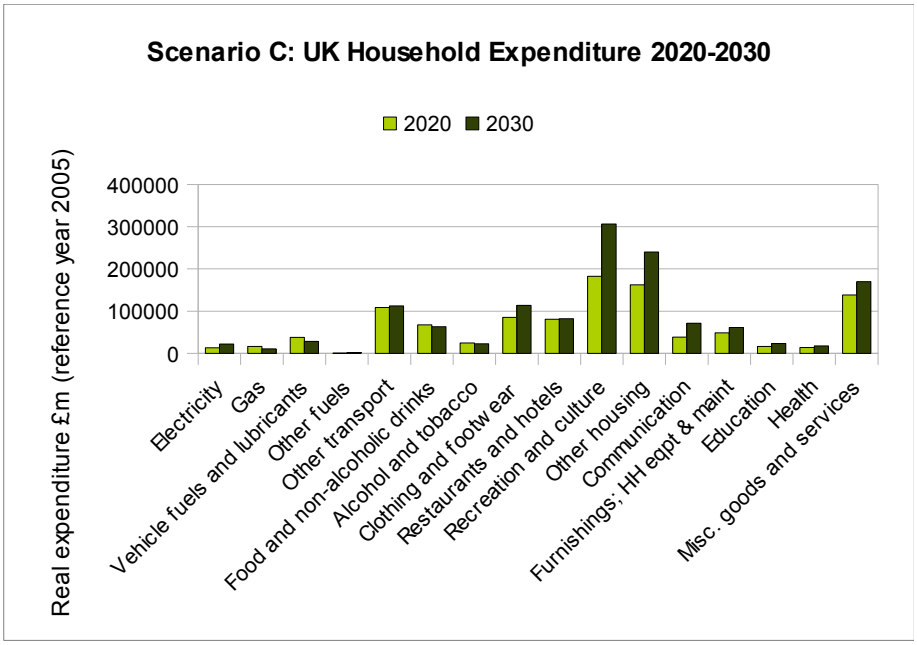
Table VII.6: Scenario C, 2020-2030: Carbon intensity and emissions

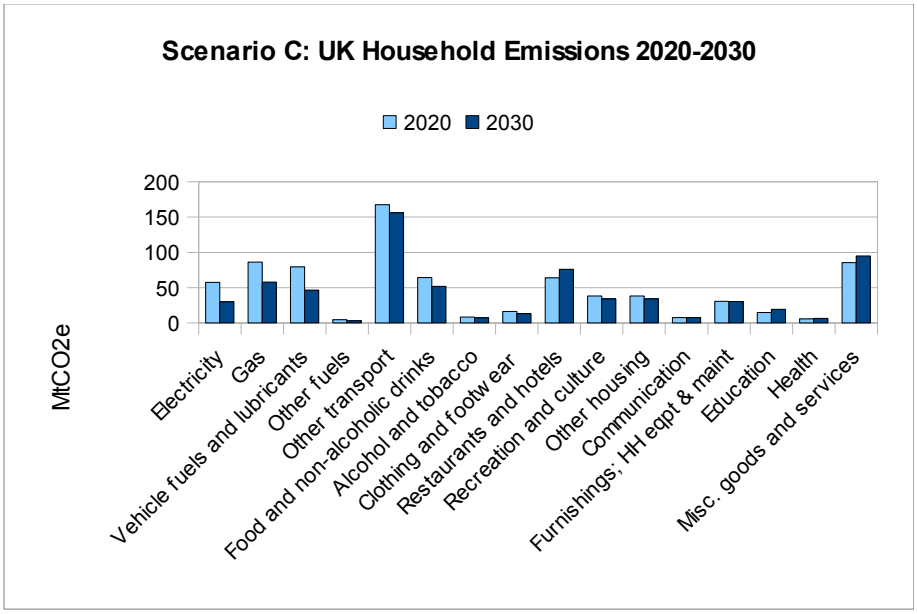
Notes: Electricity continues to be decarbonised, although at a slightly slower rate than in Scenario B, which enjoyed a head start. Also, in that alternate scenario, more rapid electrification of heating and transport takes place over this period, meaning greater overall expenditure on electricity, thus the differences in total emissions are not as sharp as the carbon intensity levels might suggest. Precisely because electrification has been slower in this scenario though, total emissions for gas and vehicle fuels do not fall as fast.

Since the resurgence of expenditure on 'other fuels' has been largely focused on biomass and district heating, while expenditure on heating oil continues to fall, the carbon intensity drops accordingly over this period.

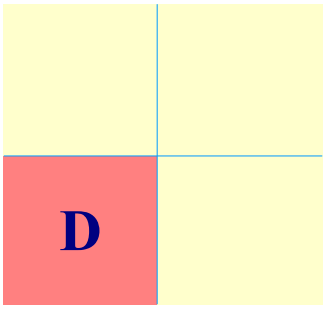
For 'other transport', which sees little increase in total expenditure over the period, and some decarbonisation (held back by the continued growth in aviation), total emissions fall accordingly. Although total emissions for 'other transport' are only slightly higher by 2030 than they are in Scenario B, in that alternate scenario 'other transport' was also absorbing much of the shift away from private car use, thus the contribution to total reduction in household emissions was much greater there.

For other categories, any efforts at decarbonisation in the previous period are played off against the resurgence of international trade in the first half of this period, before decarbonisation efforts in producer countries make a contribution towards the end of the period. Combined with increased expenditure in most of these categories, the result is a mixture of some increases and some decreases in total emissions.


Scenario C: UK Household Expenditure 2020-2030
2020
2030
Real expenditure £m (reference year 2005)
400000
300000
200000
100000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario C: UK Household Emissions 2020-2030
2020
2030
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Appendix VIII. Scenario D: data tables and charts



Scenario D: Over the edge

With little effort on emissions reduction, the global economy is exposed to increasing fuel prices towards 2020. With intensified social pressure to reduce fuel prices, and unable to work cooperatively on establishing an equitable emissions regime, countries instead pursue divergent, often conflicting energy security policies. The persistence of fossil fuel extraction as part of those policies extinguishes any hope of a low carbon transition, and leads to international conflict.

Illustrative Expenditure Figures

Household disposable income: 1.7% p.a.

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2015 Expenditure (m£)
Electricity	*3.00*	0.43	-0.82	*0.41*	0.10	9200
Gas	*2.00*	-	-1.07	*1.48*	0.37	9697
Vehicle fuels and lubricants	*0.63*	0.13	-0.14	*2.51*	2.51	28495
Other fuels	*3.50*	0.46	-0.09	*-4.87*	-4.46	832
Other transport	*0.13*	0.84	-0.15	*2.25*	2.94	111382
Food and non-alcoholic drinks	*-0.50*	0.30	0.21	*0.25*	0.74	71075
Alcohol and tobacco	*1.75*	0.49	-0.84	*-0.53*	-0.88	26052
Clothing and footwear	*-3.94*	0.58	3.25	*0.95*	4.82	72252
Restaurants and hotels	*1.38*	1.10	-1.27	*0.92*	0.75	84129
Recreation and culture	*-1.88*	0.61	0.42	*4.13*	5.15	146117
Other housing	*3.56*	0.24	-1.50	*2.18*	0.92	139029
Communication	*-3.63*	0.25	0.71	*5.17*	6.11	28689
Furnishings; HH eqpt & maint	*-0.88*	1.17	0.85	*-0.16*	1.86	46179
Education	*3.63*	-0.35	0.77	*3.52*	4.29	13915
Health	*2.13*	0.13	-0.47	*2.27*	1.84	13094
Misc. goods and services	*0.13*	0.67	-0.03	*1.53*	2.17	127082

Table VIII.1: Scenario D, 2010-2015: Income, Price and Expenditure Changes

n.b. Assumptions for this period are identical to those in Scenario A, with the figures beginning to diverge from 2015 onwards.

Notes: Household disposable income grows at 0.2-0.3% through to 2012, before picking up to rates of 2-2.25%, thus a rate of 1.7% averaged over the period. The low rate of growth over the early part of this period reflects concerns that any economic recovery in the UK will be export led, with household disposable incomes lagging behind.

*Prices for the four direct energy use categories over this period were derived from DECC projections from early 2010.***

Price changes for the remaining categories reflect historical trends, with appropriate adjustment made for a rise in VAT in early 2011.

In each category, the sensitivity of expenditure to changes in income and price has been derived from the historical data, and those same levels of sensitivity are applied here. Thus, given the income and price assumptions and the corresponding sensitivities in each category, the actual impact in terms of changes in expenditure are shown in the first two grey columns. In the third grey column, the contribution of behaviour change not associated with income and price effects (exogenous non-economic factors, or exnef) is shown. These might include impacts of a shift in environmental attitudes and values, and subsequent lifestyle changes. In this initial period, the historical trends for exnef have been used in each case. Most notably, 'other fuels' continues a historical decline, while 'recreation and leisure' and 'communication' see a strong increase in expenditure primarily through lifestyle factors.

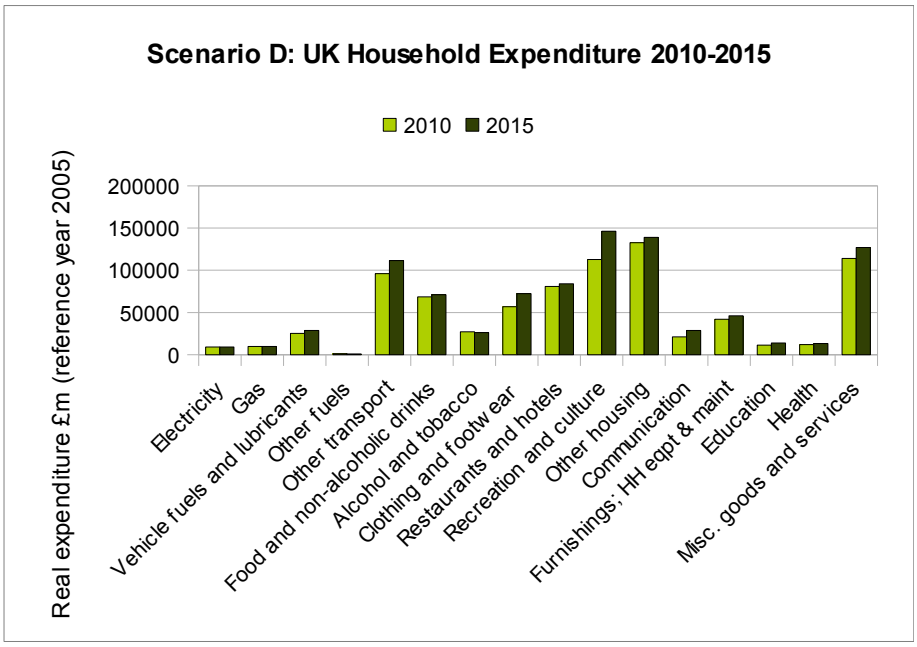
Illustrative Emissions Figures

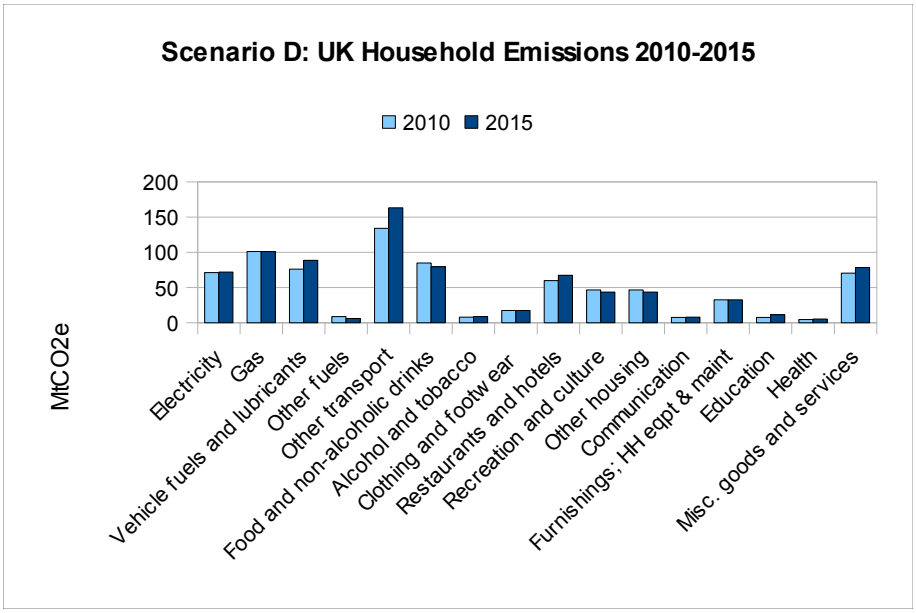
		in 2015		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*0.00*	7.79	9200	72
Gas	*0.00*	10.43	9697	101
Vehicle fuels and lubricants	*0.58*	3.11	28495	89
Other fuels	*-2.74*	7.05	832	6
Other transport	*1.03*	1.46	111382	163
Food and non-alcoholic drinks	*-1.92*	1.12	71075	79
Alcohol and tobacco	*2.72*	0.33	26052	9
Clothing and footwear	*-4.14*	0.24	72252	17
Restaurants and hotels	*1.78*	0.80	84129	67
Recreation and culture	*-5.49*	0.30	146117	44
Other housing	*0.00*	0.35	139029	49
Communication	*-4.91*	0.27	28689	8
Furnishings; HH eqpt & maint	*-1.91*	0.70	46179	32
Education	*3.86*	0.81	13915	11
Health	*0.53*	0.39	13094	5
Misc. goods and services	*0.00*	0.62	127082	78

Table VIII.2: Scenario D, 2010-2015: Carbon intensity and emissions

n.b. Assumptions for this period are identical to those in Scenario A, with the figures beginning to diverge from 2015 onwards.

Notes: With regards to emissions intensity, the historical trends have once again been used in this period, in the absence of any significant drivers of change. The direct energy use categories, electricity, gas, vehicle fuels and other fuels remain significant in terms of carbon intensity and total emissions. 'Other transport' encompasses the purchase of new vehicles, public transport by rail, road and sea, and aviation, the last of which is the fastest growing of the subcategories. As such, the carbon intensity of the category increases over the period in line with the growth in aviation. Despite a relatively low carbon intensity, 'other transport' has a significantly higher level of expenditure, bringing it to the top of the list for total emissions.


Scenario D: UK Household Expenditure 2010-2015
2010
2015
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario D: UK Household Emissions 2010-2015
2010
2015
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income:	*2% p.a.*	change in expenditure (% p.a.), due to:				
	Price change (% p.a.)	Income	Price	*ExNEF*	total	2020 Expenditure (m£)
Electricity	*7.00*	0.59	5.43*	*0.47*	6.52	12752
Gas	*7.00*	-	-1.82	10.92*	9.29	15329
Vehicle fuels and lubricants	*7.00*	0.17	2.24*	*2.57*	4.96	36512
Other fuels	*7.00*	0.70	-1.12*	*-4.87*	-4.11	677
Other transport	*2.60*	0.98	-3.09	*2.25*	0.15	112203
Food and non-alcoholic drinks	*2.50*	0.35	-1.04	*0.25*	-0.43	69569
Alcohol and tobacco	*1.75*	0.57	-0.84	*-0.53*	-0.80	25032
Clothing and footwear	*-2.00*	0.71	2.16	*0.95*	3.82	87411
Restaurants and hotels	*2.95*	1.34	-2.68	*0.92*	-0.42	82355
Recreation and culture	*0.00*	0.74	-0.29	*4.13*	4.57	183653
Other housing	*3.50*	0.29	-1.47	*2.19*	1.00	146194
Communication	*-1.75*	0.33	0.37	*5.30*	6.01	38742
Furnishings; HH eqpt & maint	*1.00*	1.38	-0.94	*-0.16*	0.28	46819
Education	*5.50*	-0.46	-0.03	*3.73*	3.10	16250
Health	*4.00*	0.16	-0.88	*2.35*	1.79	14317
Misc. goods and services	*2.00*	0.80	-0.55	*1.53*	1.79	138954

Table VIII.3: Scenario D, 2015-2020: Income, Price and Expenditure Changes

*For electricity, vehicle fuels and lubricants and other fuels, the price coefficients in the model have been adjusted from those that fit the historical data over the whole period to values which better reflect activity during short term price shocks. For gas, given the difficulties with the formula (Chitnis & Hunt, 2010), the desired shift in expenditure due to price has been achieved instead through adjustment of exnef.

Notes: As a result of increased investment in fossil fuel extraction, an economic slowdown like that in Scenario A is avoided. Instead, household disposable income continues to grow at 2% p.a.

Although prices for electricity, gas, other fuels and vehicle fuels are impacted by global demand, consistent with all four scenarios for this period, the massive investment in fossil fuel extraction means supply is less constrained here than in those other scenarios. As a result, prices increase but at a slightly lower rate of 7%. In the model, a fixed coefficient was originally used which – in light of these price shocks – would have implied an immediate and drastic reduction in expenditure for these categories. Instead, the coefficient has been adjusted to better reflect short term expenditure changes in the event of a price shock.

The impact of high global demand also feeds through onto the price of other goods and services, with average adjustments of 2-3% upwards for most categories, made according to the carbon intensity of the category (as a proxy for energy intensity).

In this period, the historical trends for exnef have broadly been continued, to reflect the absense of any meaningful attitudinal or behavioural change.

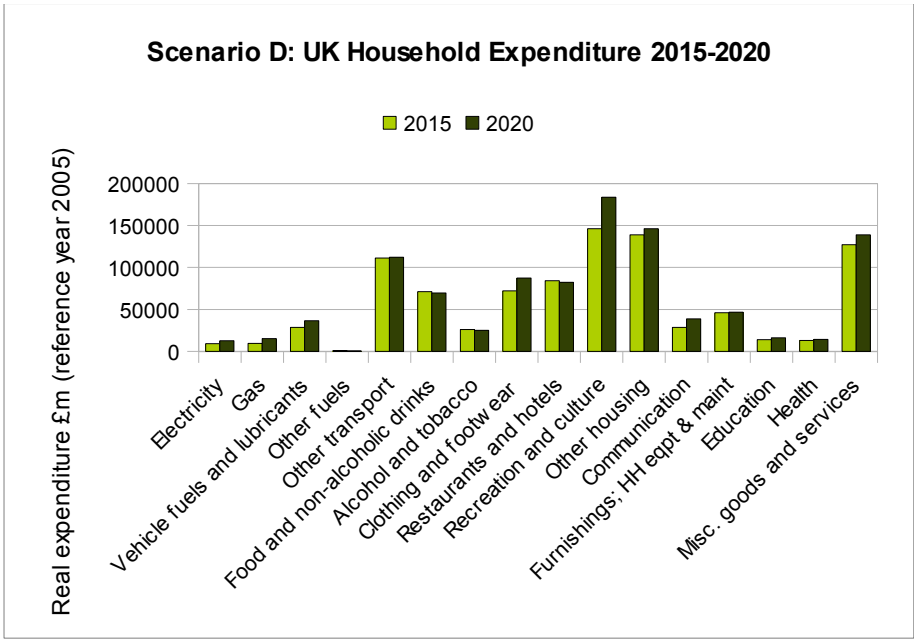
Illustrative Emissions Figures

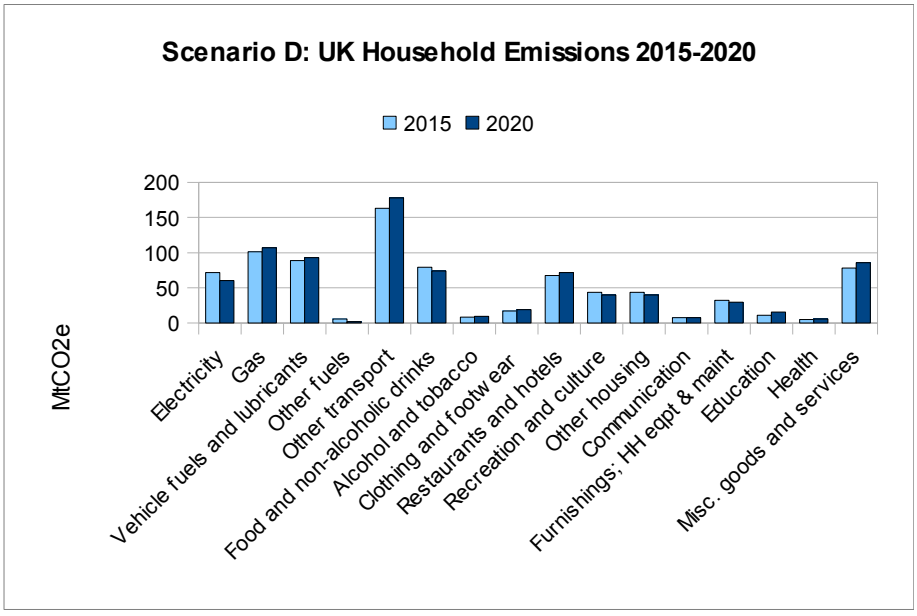
		in 2020		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-7.87*	4.73	12752	60
Gas	*-6.59*	6.99	15329	107
Vehicle fuels and lubricants	*-3.63*	2.55	36512	93
Other fuels	*-11.45*	3.01	677	2
Other transport	*1.67*	1.59	112203	178
Food and non-alcoholic drinks	*-0.98*	1.06	69569	74
Alcohol and tobacco	*2.72*	0.38	25032	9
Clothing and footwear	*-1.90*	0.22	87411	19
Restaurants and hotels	*1.78*	0.87	82355	72
Recreation and culture	*-5.49*	0.22	183653	40
Other housing	*0.00*	0.35	146194	52
Communication	*-4.91*	0.20	38742	8
Furnishings; HH eqpt & maint	*-1.91*	0.64	46819	30
Education	*3.86*	0.96	16250	16
Health	*0.53*	0.40	14317	6
Misc. goods and services	*0.00*	0.62	138954	86

Table VIII.4: Scenario D, 2015-2020: Carbon intensity and emissions

Notes: The emissions intensity has been adjusted considerably for the four direct energy use categories which undergo abrupt price changes. This is necessary to prevent the significant increase in expenditure (driven by the price shocks) from implying an increase in 'quantity' consumed. Although quantity data does not form part of this modelling framework, it is assumed that some curtailment of consumption would indeed take place._Thus, for electricity (which undergoes some decarbonisation through this period) there is a drop in total emissions. For vehicle fuels, efforts to keep prices from rising at the rate they do in other scenarios, along with the persistence of behavioural factors in increasing expenditure, both contribute to a rise in total emissions. For gas, which absorbs an accelerated shift from 'other fuels', total emissions rise slightly.

In comparison to all other scenarios during this period, the emissions intensity of 'other transport' increases sharply, in line with growth in aviation. Thus despite a steady level of expenditure, total emissions for this category increase over the period. For most of the remaining categories, historical trends in emissions intensity – in combination with trends in expenditure – lead to a continuation of trends in total emissions.


Scenario D: UK Household Expenditure 2015-2020
2015
2020
Real expenditure £m (reference year 2005)
200000
150000
100000
50000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario D: UK Household Emissions 2015-2020
2015
2020
MtCO2e
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footwear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services

Illustrative Expenditure Figures

Household disposable income: 1.1% p.a.

	Price change (% p.a.)	change in expenditure (% p.a.), due to: Income	Price	*ExNEF*	total	2030 Expenditure (m£)
Electricity	*3.60*	0.42	0.05	*0.48*	1.00	14101
Gas*	*5.60*	-	-1.72	*3.06*	4.20	23092
Vehicle fuels and lubricants	*7.20*	0.1	-3.31	*2.57*	-0.66	34182
Other fuels	*7.20*	0.48	-1.45	*-4.87*	-4.62	427
Other transport	*2.00*	0.51	-2.38	*3.06*	1.19	126405
Food and non-alcoholic drinks	*2.50*	0.18	-1.04	*-0.05*	-0.88	63689
Alcohol and tobacco	*1.75*	0.30	-0.84	*-0.66*	-1.20	22210
Clothing and footwear	*-2.50*	0.40	1.99	*0.06*	2.49	112037
Restaurants and hotels	*2.25*	0.74	-2.07	*0.50*	-0.83	75763
Recreation and culture	*-1.00*	0.40	0.29	*3.07*	3.76	267270
Other housing	*3.50*	0.16	-1.47	*1.24*	-0.07	145169
Communication	*-2.75*	0.20	0.52	*4.28*	5.01	63930
Furnishings; HH eqpt & maint	*0.00*	0.74	0.00	*-0.16*	0.57	49558
Education	*4.50*	-0.28	0.42	*3.73*	3.73	23594
Health	*3.00*	0.09	-0.69	*1.34*	0.81	15517
Misc. goods and services	*1.00*	0.43	-0.28	*0.84*	0.99	153356

Table VIII.5: Scenario D, 2020-2030: Income, Price and Expenditure changes

*due to lag effects in the model, price increases from the previous period continue to have a considerable impact on gas expenditure.

Notes: This time period is a story of two halves in keeping with the narrative. Growth in household disposable income of 2% annually over the first half is followed by a steady decline into negative territory by the end of the period, meaning an average rise of 1.1% p.a. over the period.

The price of electricity climbs gradually over the first half of the period and settles on an annual increase of 5% during the second half, giving an average of 3.6%. For gas, a 3% annual increase climbs gradually to a 7% annual increase midway through, and remains at that high rate for the remainder of the period (it should be noted that the increase in expenditure on gas, which fails to match up against the cumulative effects of income, price and exnef, is a result of lag effects, and therefore has had to be balanced out with a reduction in carbon intensity, to arrive at the desired total emissions for this category.) The price change for vehicle fuels starts at 2% and quickly climbs to 10% p.a. by the middle of the period, continuing to rise at that level for the remainder. Other fuels follows the same price rise profile.

Of the remaining categories, 'other transport' sees a significant shift in expenditure, as public transport is adopted in place of private car use. A substantial drop in expenditure on aviation towards the end of the period means that this shift to public transport isn't particularly visible within the aggregated expenditure figures, although this does contribute to a shift in emissions intensity (see below).

Expenditure on other goods and services is affected by changes in household disposable income, according to the income sensitivities identified in the historical data.

Significant changes are seen in the contribution to expenditure from exnef as consumers, fearful of impending economic hardship, reduce their spending. As well as contributing further to the economic downturn, this fall in spending also contributes to keeping prices from increasing as they might have been expected to, given the increased cost of production due to high fuel prices.

Illustrative Emissions Figures

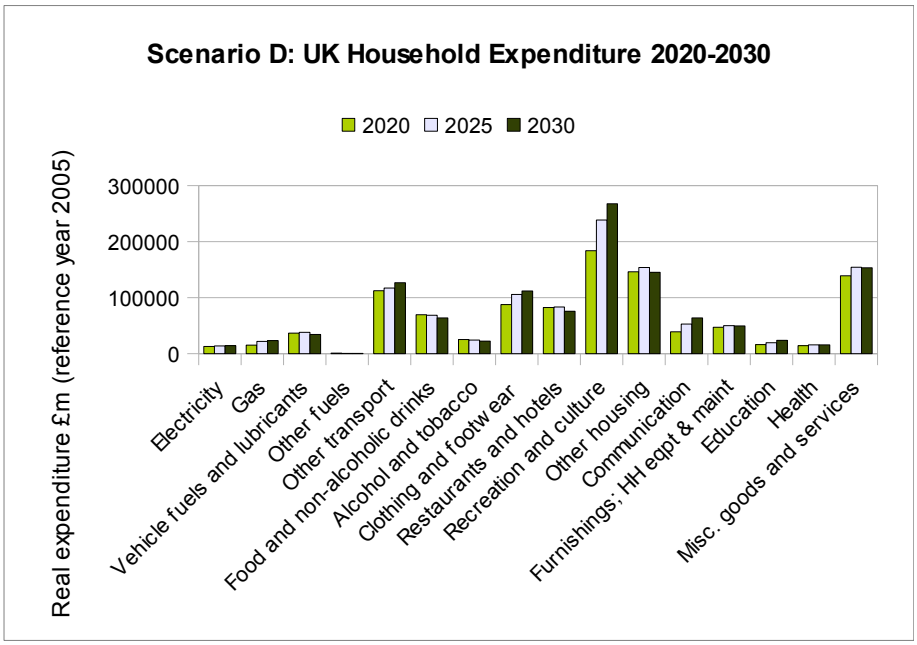
		in 2030		
	carbon intensity change (% p.a.)	Carbon Intensity (tCO2e/m£)	Expenditure (m£)	Emissions (mtCO2e)
Electricity	*-2.59*	3.50	14101	49
Gas	*-3.30**	4.69	23092	108
Vehicle fuels and lubricants	*-1.81*	2.09	34182	71
Other fuels	*-6.32*	1.11	427	0
Other transport	*-0.86*	1.45	126405	183
Food and non-alcoholic drinks	*-1.40*	0.91	63689	58
Alcohol and tobacco	*2.90*	0.49	22210	11
Clothing and footwear	*-1.81*	0.18	112037	20
Restaurants and hotels	*0.00*	0.87	75763	66
Recreation and culture	*-4.74*	0.11	267270	30
Other housing	*0.00*	0.35	145169	51
Communication	*-4.31*	0.12	63930	7
Furnishings; HH eqpt & maint	*-1.82*	0.52	49558	26
Education	*4.23*	1.37	23594	32
Health	*0.53*	0.43	15517	7
Misc. goods and services	*0.00*	0.62	153356	95

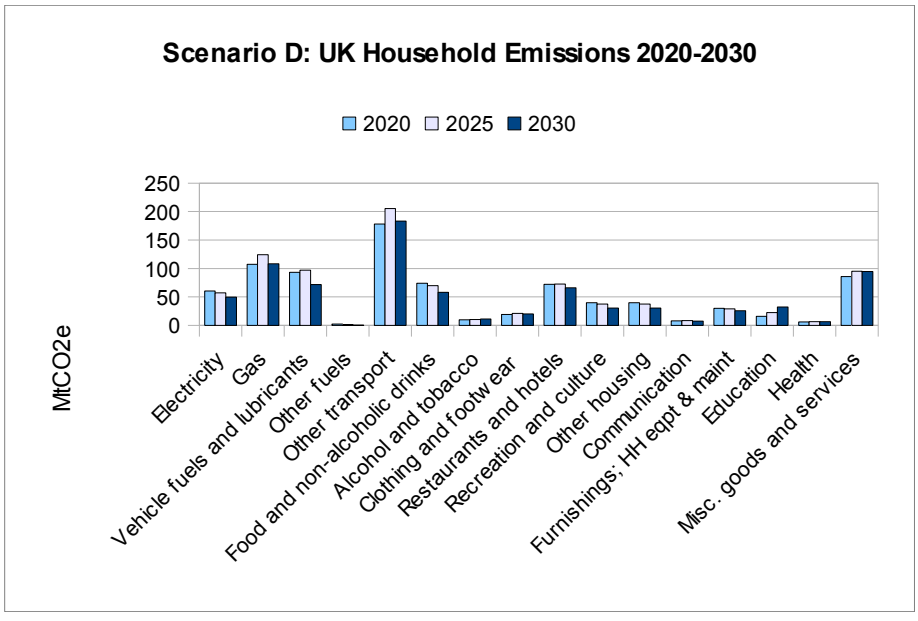
Table VIII.6: Scenario D, 2020-2030: Carbon intensity and emissions

* as a result of lag effects in the model, which lead to an unintended rise in expenditure through the period, it has been necessary in this scenario to manipulate the carbon intensity of the gas category, to balance out this effect.

Notes: Electricity undergoes some decarbonisation over this period, although more slowly than in the other scenarios due to lack of investment. Total emissions for gas climb initially, then fall to remain unchanged by the end of the period. Emissions from vehicle fuels climb slightly before plummeting laregly due to reduced consumption as people shift to public transport use, but also due in part to some decarbonisation of vehicle fuels towards the end of the period in the form of a rapid introduction of biofuels. Other transport sees a slight overall increase in emissions over the period as a massive rise in public transport use manages to outweight any reduction from the collapse in aviation in the second half of the period.

Of the remaining categories, food is the only one that experiences any shift in the trend for carbon intensity, which a slightly higher rate of decarbonisation as food production adjusts to higher oil prices.


Scenario D: UK Household Expenditure 2020-2030
2020 2025 2030
Real expenditure £m (reference year 2005)
300000
200000
100000
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services


Scenario D: UK Household Emissions 2020-2030
2020 2025 2030
MtCO2e
250
200
150
100
50
0
Electricity
Gas
Vehicle fuels and lubricants
Other fuels
Other transport
Food and non-alcoholic drinks
Alcohol and tobacco
Clothing and footw ear
Restaurants and hotels
Recreation and culture
Other housing
Communication
Furnishings; HH eqpt & maint
Education
Health
Misc. goods and services