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**The University of Southampton**  
Faculty of Natural and Environmental Sciences  
Centre for Biological Sciences

# **Environmental Risk Analysis of Crops for Biofuels in the UK**

By

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Thesis for the degree of Doctor of Philosophy  
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UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF NATURAL AND ENVIRONMENTAL SCIENCES

Centre for Biological Sciences

Doctor of Philosophy

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The past two decades have witnessed significant growth in attention and investment in renewable energy technologies. Replacement of fossil fuels that have long dominated our energy production is favoured as resources are known to be finite and dwindling, leading to increasing prices, as well as the link between their use and global climate change.

In 2011, transport accounted for 38% of total national energy consumption with petroleum being the single most used fuel. In terms of how energy use by transport relates to greenhouse gas (GHG) emissions; in 2011 transport consumed around 55.19 million tonnes of oil equivalent and provisional estimates put emissions of carbon dioxide (CO<sub>2</sub>) at 119 million tonnes (over one quarter of total national CO<sub>2</sub> emissions).

As a result, biofuels have been increasingly appearing on the agendas of both governments and scientists, and have been picked up by the media and various environmental organisations as a possible means for reducing the GHG contribution from transport. However, the issue is not simple, and there are many who oppose the use of biofuels for various reasons. There are concerns that without a concerted effort to improve

the state of knowledge of potential risks and benefits of biofuels, the appropriate long-term development of the technology in the UK may be hindered.

The project presented in this thesis was designed to undertake an investigation to identify relevant risks and issues that could inform a risk analysis of the future development, production and use of biofuels in the UK. In the context of biofuels, there is a large and increasing literature in which the associated risks are characterised and assessed scientifically. However, very little research has been done looking at stakeholder opinions, particularly with the public as stakeholders. Increasingly, the media, non-governmental organisations (NGOs) and the public are concerned about environmental issues and large technological developments that affect the environment and themselves. If any of these groups oppose plans and decisions made then it is possible that they can cause significant disruption or halt progress, despite scientific evidence.

Through a series of social science methods involving stakeholders, this project has endeavoured to cast light on the broader understanding and perception of biofuels beyond the academic and research communities and their publications.

The primary novel contribution of the thesis is in the insights provided into public awareness, attitudes and perceptions of biofuels, which have previously not been studied in any depth. The data collected and issues identified could potentially be very useful in informing a risk analysis exercise.

Working in collaboration with the general public, through focus groups and questionnaires revealed widespread, low level awareness and knowledge of biofuels but little in the way of accurate detailed knowledge of impacts and risks. Public concerns were largely focussed on environmental impacts and personal financial impacts, and their views

were almost exclusively informed by mass-media sources such as newspapers and television. There was also some evidence of misinformation and awareness of issues that were not considered to be risks by the scientific literature, as well as notable exaggeration of known risks.

Public attitudes were deemed to be quite dated, strongly reflecting the view of biofuels presented by the media around 2008, when a number of critical studies were published and shook global confidence in biofuels. With the onset of the global recession, media coverage of biofuels has dropped significantly, and as such, the public have not been exposed to developments in the field.

Interviews with expert stakeholders revealed a different picture to the public, and highlighted a completely different perspective – that of threats and risks to the future of biofuels, rather than biofuels as a threat or risk themselves. There was a strong perception amongst the expert stakeholders that the UK and EU governments presented a significant barrier to the potential for biofuels to develop and expand in Europe. Lack of government interest, confidence and action were cited as significant failings that hindered investment necessary to grow a strong biofuel industry.

Recommendations for future developments and expansion of biofuels within the EU, should this be deemed appropriate and acceptable, focus on increased government involvement and support to encourage investments that will allow further improvements in the biofuel production process, as well as significant changes in the way scientific information is communicated to the public.

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**Academic Thesis: Declaration Of Authorship**

I, **Elizabeth Shepherd**, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

**“Environmental Risk Analysis of Crops for Biofuels in the UK”**

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Signed:.....

Date: .....

***Hofstadter's Law: It always takes longer than you expect, even when you take into account Hofstadter's Law.***

Douglas Hofstadter, Gödel, Escher, Bach: An Eternal Golden Braid

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## **List of Acronyms**

DDGS – Dried Distillers Grains and Solubles

DECC – Department for Environment and Climate Change

DfT – Department for Transport

GMOs – Genetically Modified Organisms

NGOs – Non-Governmental Organisations

RED – Renewable Energy Directive

RTFO – Renewable Transport Fuel Obligation

## **1. General Introduction**

### **1.1 Introduction**

The past two decades have witnessed significant growth in attention and investment in renewable energy technologies. Replacement of fossil fuels that have long dominated our energy production is favoured as resources are known to be finite and dwindling, leading to increasing prices, as well as the link between the carbon dioxide emitted by their combustion and the impact on global climate change (Jessup, 2009, Koh and Ghazoul, 2008, Chapple et al., 2007, The Royal Society, 2008).

As a result, biofuels have been increasingly appearing on the agendas of both governments and scientists, and have been picked up by the media and various environmental organisations (Hisano et al., 2009). However, the issue is not simple, and there are many who oppose the use of biofuels for various reasons. There are concerns that without a concerted effort to improve the state of knowledge of potential risks and benefits of biofuels, the long-term development of the technology in the UK may be damaged.

Much attention has been paid to the risk assessment of various aspects of biofuels and their impacts. Understandably, this is due to the desire to produce the most sustainable and least damaging new fuels to replace fossil fuels. However, although many scientific risk assessments are being carried out, they are largely fragmented and do not take into consideration stakeholder perspectives (Delshad et al., 2010). Stakeholder engagement on issues of national importance is increasingly believed to be an important factor in reaching informed, acceptable and effective decisions. An approach that considers the range of risk assessments alongside stakeholder opinions is known as a risk analysis. Risk analysis goes beyond simple risk assessment, to manage and communicate risk and risk related decisions (Johnson et al., 2007, European Commission Health and Consumer Protection Directorate-General, 2000). A risk analysis considers the scientific evidence and risk

assessments as well as concerns of relevant stakeholders, aiming to manage risk in a way that is acceptable both scientifically and socially (Johnson et al., 2007).

## **1.2 The importance of biofuels**

In 2011, transport accounted for 38% of total national energy consumption with petroleum being the single most used fuel (Department of Energy and Climate Change, 2012b, Department of Energy and Climate Change, 2012c). Of the energy consumed by the transport sector, 72% went into road transport, and of this, two thirds was for road passenger transport with the remaining third being for road freight (Department of Energy and Climate Change, 2012c).

Recent years have seen some reduction in energy consumption by transport, with decreased usage in 2008-2009 and 2009-2010, at least partly attributable to the recession (Department of Energy and Climate Change, 2012c). However, the overall trend for energy use in transport is one of increase; between 1990 and 2010, energy consumption by the transport sector rose by 13%, 6.5 million tonnes of oil equivalent (Department of Energy and Climate Change, 2012b).

In terms of how energy use by transport relates to greenhouse gas (GHG) emissions; in 2011 transport consumed around 55.19 million tonnes of oil equivalent and provisional estimates put emissions of carbon dioxide (CO<sub>2</sub>) at 119 million tonnes (over one quarter of total national CO<sub>2</sub> emissions) (Department of Energy and Climate Change, 2012c, Department of Energy and Climate Change, 2012a). Whilst overall national CO<sub>2</sub> emissions have declined since 1990, the emissions from transport actually rose between 1990 and 2007 and the decline since 2007 has only returned CO<sub>2</sub> emissions to their 1990 levels (Department of Energy and Climate Change, 2012a).

Within the context of general energy usage in the UK and their associated GHG emissions, transport is clearly not performing and improving at the same rate as other sectors. As such, it would seem that the transport sector is in need of significant innovation and change in order to better contribute to UK national

and international emission reduction targets. With this in mind, biofuels could prove to be of pivotal importance in future energy strategies due to their potential to reduce overall carbon dioxide emissions from transport (Pragya et al., 2013, Hammond et al., 2008, Affuso and Hite, 2013). However, a full and well informed risk analysis would be desirable to ensure biofuels can deliver improvements to the emission performance of the transport sector as well as ensuring their development and use is sustainable and socially acceptable. The work set out in my thesis aims to identify the relevant issues, management and communication options to inform such a risk analysis.

### **1.3 Risk, Risk Perception and Risk Analysis**

In scientific terms, risk is assessed based on the outcome of an equation where the likelihood of an impact occurring (probability) is multiplied by the magnitude of the impact (consequences) (Fiorino, 1985, The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997). However, for those who are neither scientists nor risk experts, the perception of risk is decidedly more complex, nuanced and subjective (Fiorino, 1985). The non-expert may base their perception of a risk on a range of factors such as familiarity, voluntary exposure, impact on future generations, issues of particular personal dread as well as a personal assessment of cost and benefits (Fiorino, 1985, United States Environmental Protection Agency, 2007). Familiar risks are often considered to be less severe and therefore more acceptable, as are those which individuals are exposed to voluntarily (Fiorino, 1985, United States Environmental Protection Agency, 2007). Good examples of both familiar risks and voluntary exposure include driving cars and smoking cigarettes. In both cases, the risks are known but are not considered to be serious enough to be avoided (by some) due to familiarity and choice of exposure. However, risks that may impact on future generations or which benefit those creating the risk scenario while causing suffering of others are often considered to be much more severe and less acceptable (Fiorino, 1985, United States Environmental Protection Agency, 2007). Examples of these may include; nuclear power, weapons and the storage of nuclear waste, or other industrial activities that cause environmental pollution.

Due to these differing means of perceiving and assessing risk, it is easy to see how decisions about the acceptability and management of a risk based on only one of these perceptions is likely to lead to discord between the groups and potential rejection of the risk management decisions by the other group. There is an increasing realisation that stakeholder opinions are a valid and important means for assessing risk and should be part of decision making regarding risks incorporated from an early stage (The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997, Popay and Williams, 1996, Henderson, 2010, Karpouzoglou and Zimmer, 2012).

Risk analysis allows for both expert/scientist and non-expert/stakeholder positions to be considered in characterising the risk(s) and making appropriate management decisions, in conjunction with properly managed communication with and between all parties (Johnson et al., 2007, Society for Risk Analysis, 2009). In theory, such an approach should avoid conflict and increase acceptance of management decisions.

The process of conducting a risk analysis has three main stages; risk characterisation, risk management and risk communication (Society for Risk Analysis, 2009, Johnson et al., 2007).

### **1.3.1 Risk Characterisation**

During risk characterisation, the potentially dangerous situation needs to be thoroughly described and understood, based on the available science as well as stakeholder concerns (Stern and Fineberg, 1996). In the case of this project, risk characterisation will involve a full and on-going review of the literature, as well as the involvement of a range of stakeholders, to identify the known and perceived risks inherent to the use and production of biofuels. It is important to understand both the scientific evidence as well as if the general public have any perception of biofuel related risks, in order to fully understand the scope of the issue and allow for a comprehensive understanding of issues relevant to risk management decisions (Stern and Fineberg, 1996). Lay knowledge is

increasingly recognised as a valid source for informing decision making alongside expert assessments, particularly in relation to risk (Popay and Williams, 1996, Karpouzoglou and Zimmer, 2012, Henderson, 2010, The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997). As such, investigating public knowledge of biofuels and biofuel risks will form a major part of this project.

In this context, perceived risks are as important as those tested and proven scientifically (Stern and Fineberg, 1996). All perspectives must be properly understood and taken into account to increase the acceptability of risk management decisions (Stern and Fineberg, 1996). In fact, any risk characterisation that does not fully incorporate stakeholder perspectives should be considered as deficient and ineffectual (Stern and Fineberg, 1996).

### **1.3.2 Risk Management**

Risk management involves the selection and deployment of necessary risk reduction measures based on an assessment of all possible available actions and the evidence collected during risk characterisation phase (The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997). For my project, risk management will involve gathering information on action required, desired and practical to mitigate against potential risks associated with biofuels from the literature, relevant agencies and stakeholders involved in the process. Such data will be evaluated and used to make recommendations on the best course of action, in line with the requirements and expectations of all stakeholders. A well conducted and thorough Risk Characterisation phase is essential to ensure that the Risk Management phase has a set of well defined issues that are thoroughly and clearly explained on which to base sound management decisions (The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997). In making Risk Management decisions, a range of options should be assessed, based on scientific, societal, cultural, ethical, political, legal and technological considerations (The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997).

### **1.3.3 Risk Communication**

As part of a risk analysis, Risk Communication is an ongoing exchange of information about the relevant risk(s), between decision makers/researchers and stakeholders to ensure all parties are fully informed about the nature of the risk, all relevant concerns as well as how and why any management decisions are reached and will be implemented (United States Environmental Protection Agency, 2007). The Risk Communication element of my project includes determination of stakeholder opinions on biofuels and their key sources of information. For effective Risk Communication, stakeholder opinions and input must be held as an integral and valid source of information and genuinely considered during decision making, both because it will benefit decision making and because it will increase trust in and credibility of decision makers (United States Environmental Protection Agency, 2007). Transparency and honesty will also benefit the credibility of the communication and potentially boost acceptance of decisions taken (United States Environmental Protection Agency, 2007). The specific audience for the communication must be considered to ensure language and information are appropriate and do not confuse or alienate those you wish to communicate with (United States Environmental Protection Agency, 2007). All parties should benefit from the Risk Communication process, gaining knowledge, increasing understanding and creating a positive forum for discussion (United States Environmental Protection Agency, 2007).

### **1.4 Social Science and Mixed Methods Research**

This project made use of a mixed methods approach. The inclusion of social science methods into the project is considered to be of pivotal importance to both the field of risk analysis and the original contribution of this thesis. There is increasing recognition that science does not occur in isolation from society and its morals and values (Broerse and Buning de Cock, 2012) – as such, the inclusion of stakeholders and lay people within assessments and analyses of risk, and to inform related decision making, is now seen as a valid and beneficial component of the success of such a process (Henderson, 2010,

Karpouzoglou and Zimmer, 2012, Popay and Williams, 1996, Johnson et al., 2007, Fiorino, 1985). As such, this thesis makes a unique contribution to knowledge through investigation into the previously un-explored area of public knowledge, perception and attitudes towards biofuels.

The field of science communication, both in theory and practice, is complex and much debated (Mellor et al., 2008). There are many theories and models of science and risk decision making and communication that are potentially relevant to this project and are discussed at length in the literature (Kim, 2007, Hart and Nisbet, 2012, Bostrom and Lofstedt, 2010, Ahteensuu, 2012, United States Environmental Protection Agency, 2007, Petersen and Dan, 2007, Wynne, 1991). Understanding these theories and models is important for developing a comprehensive and effective communication strategy that meets the needs of all parties involved.

#### **1.4.1 The Deficit Model and Public Education Model**

The deficit model and Public Education models are amongst the earliest theories of science communication and are based on the idea that scientists are experts with good knowledge of scientific issues, in comparison the general public as non-experts have much lower knowledge, or, a deficit of knowledge (Kim, 2007, Čada and Ptáčková, 2012, Wynne, 1991). They were formulated around increasing interest in 'Public Understanding of Science' in the 1980s and 1990s and informed by a belief that the public were largely ignorant of science and scientific developments (Mellor et al., 2008). Based on such beliefs, these models involved a one-way flow of information from the experts to the non-experts, providing education to those of lesser knowledge (Kim, 2007, Čada and Ptáčková, 2012, Wynne, 1991).

Whilst the idea of lack of public knowledge of science still persists to some extent, developments in models of science and risk communication have at least partially moved away from this deficit model towards a more collaborative approach as a result of the increased recognition of the validity of lay knowledge and experiences (Popay and Williams, 1996, Henderson, 2010, Karpouzoglou and Zimmer, 2012, Mellor et al., 2008). Similarly, the idea of 'public understanding of science' has been superseded to some extent by

'public engagement with science and technology', again recognising a shift from the deficit model to a more collaborative and interactive approach to science (Mellor et al., 2008).

#### **1.4.2 Analytic-Deliberative Model**

The analytic-deliberative model has a greater consideration for the input of non-scientists, with the theory's name being derived from a combination of analysis and communication (Renn, 1999, Stern and Fineberg, 1996). The model is concerned with improving the quality of risk decision making process through the inclusion of stakeholders as well as apportioning responsibility for risk management amongst those involved in the decision making (Renn, 1999, Stern and Fineberg, 1996).

#### **1.4.3 Cooperative Discourse Model**

The cooperative discourse model is again a step away from the uni-directional deficit approach, comprising three main stages; the identification of issues from all relevant stakeholder groups, the measurement of the impacts arising from potential management options and the discussion of possible options by a Citizens' Jury (see section 3.2.1) (Renn, 1999).

The cooperative discourse model has been used successfully for assessing public priorities for policy planning and development strategies in both Germany and Switzerland (Renn, 1999).

#### **1.4.4 Co-production of Knowledge Model**

Within the co-production of knowledge model, there is less emphasis on the differences between experts and lay-people (Čada and Ptáčková, 2012, Wynne, 1991). All relevant stakeholders are considered to have valuable contributions based on their experiences and should be actively encouraged to take a role in decision making (Čada and Ptáčková, 2012, Wynne, 1991).

This project aims to encompass the ideals of the Co-production of Knowledge Model through the incorporation of knowledge from a range of experts and the lay public. Whilst scientific knowledge and the knowledge of many corporate and other public body stakeholders are reasonably well known, this project aims to make a significant contribution to understanding of the knowledge and perceptions of public stakeholders.

## **1.5 The Project**

Funding for the research was provided by BBSRC with Syngenta as CASE funding partners.

The project presented in this thesis was designed to identify issues relevant to the development, production and use of biofuels in the UK from the perspectives of a wide range of stakeholders, as well as information relating to risk management and risk communication. The purpose of such an issue identification exercise would be to inform a more comprehensive risk analysis of the development, production and use of biofuels in the UK that could not be adequately served within the constraints of this PhD.

In the context of biofuels, there is a large and increasing literature in which the associated risks are characterised and assessed scientifically. However, very little research has been done looking at stakeholder opinions, particularly with the public as stakeholders. Increasingly, the media, non-governmental organisations (NGOs) and the public are concerned about environmental issues and large technological developments that affect the environment and themselves. If any of these groups oppose plans and decisions made then it is possible that they can cause significant disruption or halt progress, despite scientific evidence. The genetically modified (GM) crop debate and resulting moratorium on growth of GM crops in the EU is a clear example of this (Johnson et al., 2007, The Office for Science and Technology and Wellcome Trust, 2000).

This project aims to establish a broad and detailed base of knowledge on stakeholder perceptions and opinions of biofuels that can be taken into consideration alongside the existing scientific evidence. This approach will better enable a positive decision making process regarding the future of biofuels in the UK, without encountering barriers like those experienced in the development of GM crops (Davison, 2010, Johnson et al., 2007, Williams, 2002, The Office for Science and Technology and Wellcome Trust, 2000). The work will be presented in 5 sections.

Chapter 2 examines the existing scientific knowledge on biofuels, investigating the known risks and barriers identified by scientific risk assessments. In the context of this project's aims to identify issues and management and communication options for a Risk Analysis this stage constitutes the beginning of issue identification for Risk Characterisation as well as potentially outlining options to be considered in Risk Management.

Chapter 3 is a continuation of Risk Characterisation and presents a first stage stakeholder involvement, consisting of an initial scoping of public awareness and opinion to pave the way for the development of a questionnaire. This work is necessitated by the lack of baseline information on public attitudes to biofuels.

Chapter 4 builds on chapter 3, to extend the public involvement to a wider and more representative sample. Alongside the findings of chapters 2 and 3, this will inform the Risk Characterisation and contribute to decisions on Risk Management and Risk Communication.

Chapter 5 moves beyond the public as stakeholders to include more 'expert' stakeholders – those involved in or with an interest in becoming involved in the research, growth, production, sale and commercial use of biofuels. The work will add a further dimension to the Risk Characterisation process and potentially present further options for Risk Management and Risk Communication phases.

Chapter 6 is a synthesis chapter; bringing together the outcomes of the previous chapters in identifying issues, management options and communication options that may be used to inform a risk analysis. The chapter makes recommendations on Risk Management and Risk Communication decisions that will best serve the relevant stakeholders in light of the existing science and national energy requirements.

## **1.6 Research Aims**

### **Research Aim 1 (Chapters 3, 4, 5 & 6)**

Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent

### **Research Aim 2 (Chapter 6)**

To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels of awareness and knowledge of biofuels effectively

### **Research Aim 3 (Chapters 3, 4, 5 & 6)**

Highlight the key concerns of the different stakeholders

### **Research Aim 4 (Chapters 2, 3, 4, 5 & 6)**

Investigate aspects of biofuels in need of development and improvement (environmental or technical), how these aspects are prioritised by different stakeholders and what management goals/options are preferred

### **Research Aim 5 (Chapter 2, 3, 4, 5 & 6)**

Compare acceptability of and concerns about biofuels with those related to other energy generation options

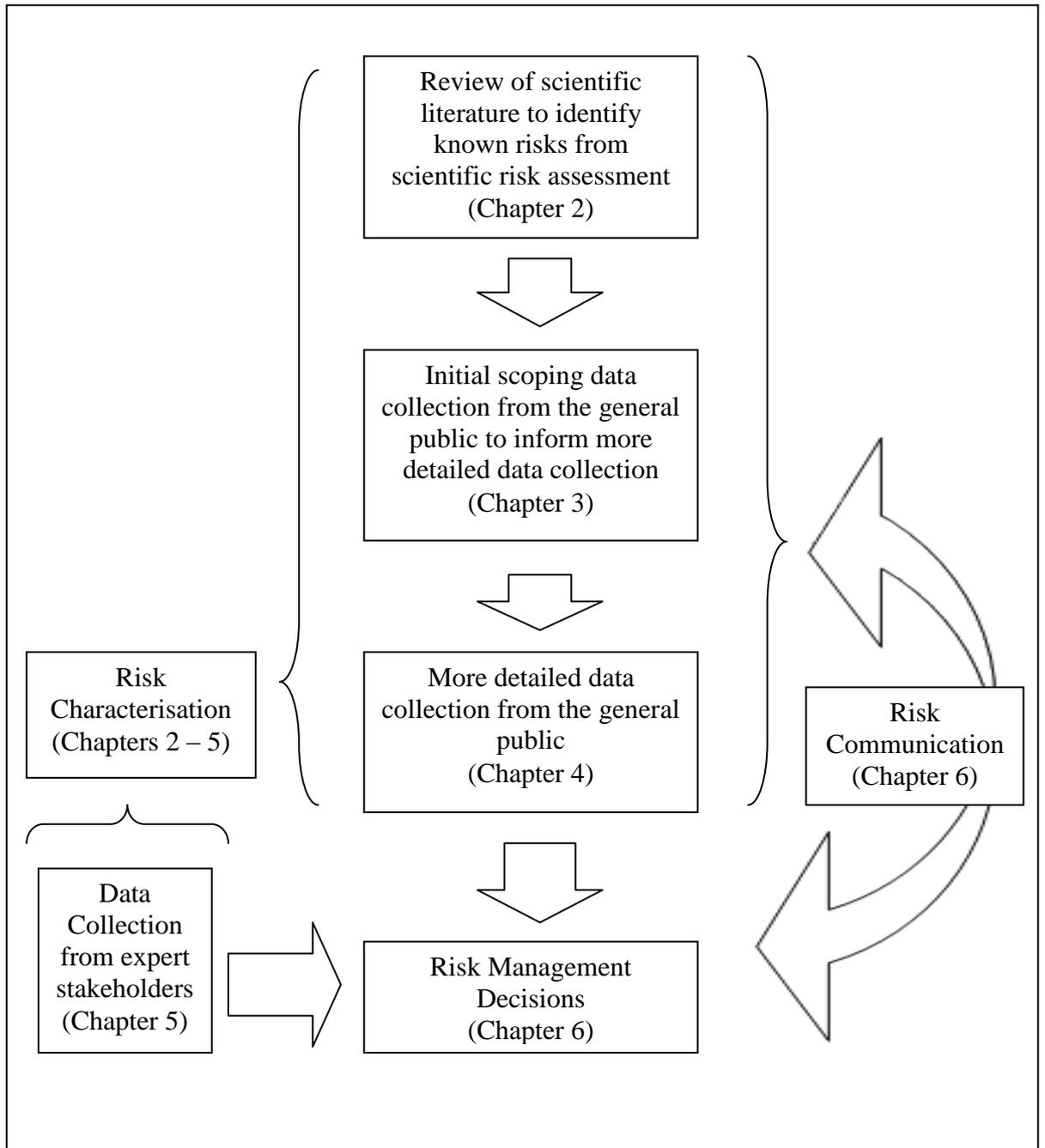
## **Research Aim 6 (Chapters 2, 3, 4, 5 & 6)**

Determine awareness of different stakeholder groups and their position on government action on biofuels, including recommendations for improvements or more appropriate actions

### **1.7 Research Plan**

The research adopted a mixed method approach, combining a number of social science methods in order to gain a fully comprehensive understanding of stakeholder perspectives. The main stages of the research are laid out graphically in Fig 1.

- Risk Characterisation in four stages
  - Examination of literature (Chapter 2)
  - Initial scoping review of public opinions (Chapter 3)
  - More detailed examination of public opinions (Chapter 4)
  - Examination of expert opinions (Chapter 5)
- Risk Management and Risk Communication strategies
  - Discussed in chapter 6



**Fig 1. Research Development Process including details of chapters in which each stage is discussed**

## **2. Biofuels: An Introduction to and Evaluation of Risks**

### **2.1 Introduction**

The term biofuel covers a wide range of different fuels and technologies, as well as being subject to many different policies around the world and the subject of much scientific risk analysis. This chapter will introduce the concept of biofuels, covering terminology, production and existing legislation, before discussing the existing scientific literature on the topic.

Within the context of the project's aim to gather information to inform a Risk Analysis, this chapter forms the beginning of the issue identification for Risk Characterisation– building understanding of what risks are involved in biofuel production, development and use, in this case, from a scientific perspective.

Aims of the chapter;

- Review existing government interests and policies relating to biofuels (RA6)
- Review the risks, areas and issues of concern discussed in the literature (RA3 & RA4)
- Review suggestions for solutions or mediation measures for identified risks (RA3 & RA4)

### **2.2 An Introduction to Biofuels**

#### **2.2.1 Biofuel**

The term biofuel generally refers to a liquid fuel for use in transport that is derived from organic matter, usually plants (Bioenergy Feedstock Information Network, 2009). This differs from the term “bioenergy”, which can be used as a general term for all forms of energy derived from organic matter, or more specifically to refer to solid organic fuels such as wood chips, which are better suited for heat and electricity production (Bioenergy Feedstock Information Network, 2009).

This project is primarily concerned with biofuel as a liquid transport fuel, of which there are three main forms;

### **Bioethanol**

Bioethanol is a biofuel produced by the fermentation of the sugar and starch contents of plants, such as sugarcane, sugar beet, maize and grasses (Morrone et al., 2009, Demirbas, 2009) by yeast (*Saccharomyces cerevisiae*) (Pfromm et al., 2010). Bioethanol can be blended with conventional mineral petrol.

### **Biodiesel**

Biodiesel is a form of biofuel produced from the oil contents of plants, such as oil seed rape and oil palm (Demirbas, 2009, Morrone et al., 2009) through a process known as transesterification (Tao and Aden, 2009). Biodiesel can be blended with conventional mineral diesel.

### **Biobutanol**

Biobutanol is produced from the fermentation of sugars and starches, as with bioethanol; however the use of *Clostridium acetobutylicum* bacteria instead of yeast results in production of butanol rather than ethanol (Pfromm et al., 2010, Durre, 2008, Qureshi et al., 2009).

## **2.2.2 First Generation Biofuels**

First generation biofuels are currently the most widely used form (Rubin, 2008, FAO and OECD, 2012). Bioethanol is attractive as a fuel for transport, having been praised for being “greener, cheaper and more secure than gasoline” (Srinivasan, 2009). Another factor in favour of first generation biofuels is that they are the only currently available alternative fuel that can be used in the transport sector as it exists at present (Charles et al., 2007).

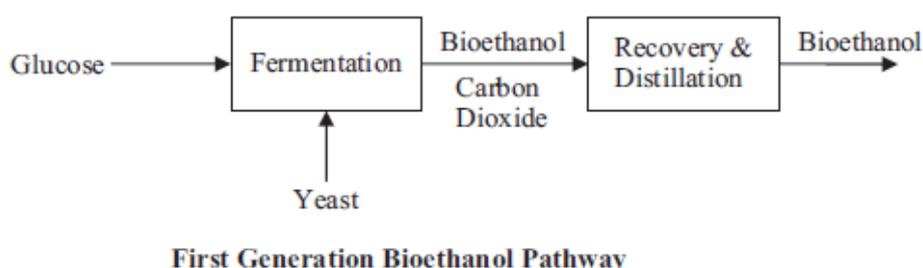
### **Production**

Current technology makes use of the sugar or starch content of crops to make bioethanol, or the oil contents of crops and plants to make biodiesel (Morrone

et al., 2009, Demirbas, 2009). In both cases, most of the current production utilises plants that also serve as food stuffs (Tan et al., 2008).

Fig. 2 illustrates the production process for first generation bioethanol. The process involves the use of yeast to metabolise the sugar or starch to ethanol. The ethanol is then concentrated by distillation before it can be used (Larson, 2008).

Biodiesel production involves transesterification of the triglycerides from the plant oils in the presence of alcohol, usually methanol or ethanol (Stephenson et al., 2008). This process produces a fatty acid alkyl ester, otherwise known as biodiesel, with glycerine as a by-product (Stephenson et al., 2008).



**Fig.2. Production process for first generation bioethanol (Larson, 2008)**

### **2.2.3 Second Generation Biofuels**

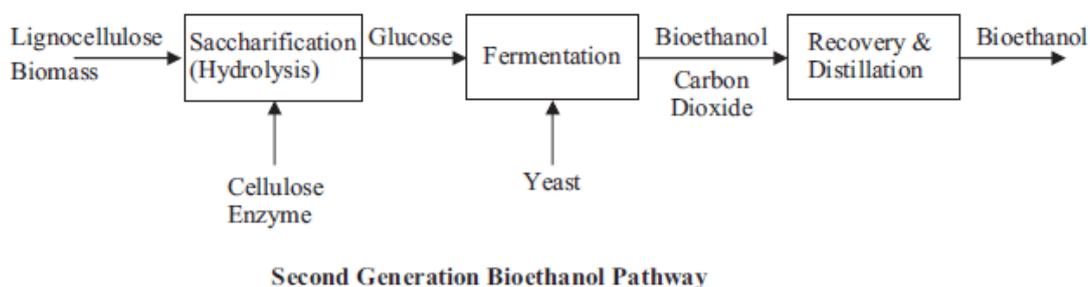
Second generation biofuels are a more advanced technology, but are not yet produced on a large scale (Koh and Ghazoul, 2008, European Commission Joint Research Council, 2007). It is felt that second generation biofuels will be more sustainable than the first generation fuels, and as such their development and deployment is subject to much attention (European Commission Joint Research Council, 2007).

#### **Production**

Second generation biofuels are produced from “lignocellulosic biomass”, generally perennial grasses and woody crops such as; *Miscanthus* grass,

switchgrass and short rotation coppice willow and poplar (Rothamsted Research, 2008).

Unlike first generation fuels, these feedstocks are not food crops. The second generation lignocellulosic bioethanol production process is illustrated in Fig. 3. Lignocellulosic biofuels are produced from fermentation of complex sugars in the form of cellulose (hexose) and hemicelluloses (pentose) within plant cell walls (Himmel et al., 2007, Tan et al., 2008, Rüschen. Klaas and Schöne, 2009). Production is complicated by difficulties breaking down the lignin (a polymer that strengthens the cell walls) content of plant cell walls to access the cellulose (Himmel et al., 2007, Tan et al., 2008, Rüschen. Klaas and Schöne, 2009, Liu et al., 2009, Chen and Dixon, 2007, Hamelinck et al., 2005). Pre-treatment of feedstocks with high temperatures and acid is required to break down the lignin and allow access to the sugars (Liu et al., 2009, Chapple et al., 2007, Sanderson, 2006, Kaparaju et al., 2009). Once sugars are accessible they are processed in the same way as first generation fuels.



**Fig 3. Production process for second generation lignocellulosic bioethanol (Larson, 2008)**

## **2.3 Governments and Biofuels – Motivating Factors and Existing Policies**

### **2.3.1 Policy Drivers**

More than 50 countries and regions have policies in place to promote the use of biofuels, including the United States and throughout the European Union (IUCN, 2008). The three principal biofuel producing regions at present are the United States, Brazil and Europe (Pilgrim and Harvey, 2010, BP, 2012).

However, there are notable differences in the underlying interests and motivations of each of these nations/regions, reflected in the different policies, incentives and fuels they have pursued (Pilgrim and Harvey, 2010).

Taking the literature as a whole, there are three main underlying motivations for the development and production of biofuel, known as policy drivers: improved energy security, benefits for rural areas and people and the potential to reduce emissions of greenhouse gases that contribute to global climate change (Department for Trade and Industry, 2007, Gill, 2005, Department for Trade and Industry, 2003, Pacific Economic Cooperation Council, 2008, Koh and Ghazoul, 2008, The Royal Society, 2008, Chapple et al., 2007, Pilgrim and Harvey, 2010)

#### **i) Improved Energy Security**

Energy security is a growing concern for industrialised nations that do not have adequate fossil fuel reserves within their borders to be self sufficient for fuels (BERR, 2008). In many cases, energy security is considered to be an important part of national security (Charles et al., 2007).

The main threats to energy security are increases in demand for finite resources and potentially volatile political situations in many oil exporting nations (Morrone et al., 2009, Koh and Ghazoul, 2008, The Royal Society, 2008, Commission of the European Communities, 2007, Srinivasan, 2009). Much of the EU relies on oil imports to meet their energy needs and, as such, the Commission of the European Union consider oil to be the most significant problem for European energy security (Commission of the European Communities, 2007).

Between 2002 and 2010, annual net imports of oil into the EU-27 increased by around 94.75 million tonnes of oil equivalent (approximately 857 million tonnes of oil equivalent in 2002 to approximately 952 million tonnes of oil equivalent in 2010) and dependence on crude oil increased from 75.6% in 2002 to 85.2% in 2010 (Eurostat, 2012). Over the same period the percentage of crude oil

imported to the EU-27 increased from countries including Russia, Libya, Iran, Kazakhstan, Nigeria, Azerbaijan and Iraq (Eurostat, 2012).

Biofuels could improve energy security through diversification of energy sources as well as reduced reliance on oil and less exposure to its turbulent market (BERR, 2008, Commission of the European Communities, 2007).

## **ii) Benefits for Rural Areas and People**

Development of biofuels has potential to provide significant financial benefits for rural communities in both developed and developing nations (Groom et al., 2008). Increased demand for biofuel feedstock crops will create a new market for crops and increase prices, providing higher incomes for farmers (Sims et al., 2006). Particularly in developing nations, being able to produce biofuel crops to export could create a significant source of income and create development opportunities (Commission of the European Communities, 2007).

Biofuel development also has potential to create jobs in rural areas. Production of sugarcane for biofuel in Brazil has reportedly resulted in 1 million new agricultural jobs in the country (Macedo et al., 2004). Figures from the European Union anticipate 144,000 new jobs in the biofuel sector by 2020, if biofuels achieve a 14% market share (Commission of the European Communities, 2007).

## **iii) Greenhouse Gas Emission Reduction**

The potential for biofuels to reduce greenhouse gas (GHG) emissions in comparison to fossil fuels has prompted a great deal of interest around the world due to the obligation to reduce contributions to atmospheric carbon levels under international agreements such as the Kyoto protocol as well as domestically set targets (The Royal Society, 2008, Koh and Ghazoul, 2008, Demirbas, 2009, Srinivasan, 2009, Ragauskas et al., 2006). However, there has also been a significant degree of controversy surrounding the GHG emission savings that biofuels can deliver.

The potential for biofuels to deliver reduced GHG emissions and/or contribute to reduced atmospheric GHG concentrations is based on two main factors; the different chemical characteristics of biofuels compared with oil and the differences in their production.

Biofuels have an oxygen content of between 10% and 45%, in comparison conventional oil based transport fuels have a 0% oxygen content; this higher oxygen content allows for more efficient combustion of the fuel which produces fewer hydrocarbon emissions (Demirbas, 2009). In addition, biofuels have a higher octane rating than fossil fuel oil fuels – a higher octane rating allows for biofuels to be subjected to higher pressure in car engines which also contributes to greater combustion efficiency and reduced carbon emissions (Demirbas, 2009).

The ability for biofuels to reduce the contribution to overall atmospheric GHG concentrations, when used in place of fossil fuels, is also related to the fact that biofuels are produced from biomass that absorbs carbon from the atmosphere as part of its growth (Pool, 2006). As a result of this, biofuels have previously been referred to as “carbon neutral”, only emitting carbon that the biomass had previously absorbed from the atmosphere (Tan et al., 2008). However, more extensive research has shown that biofuels are not carbon neutral as inputs to their production, such as fertilisers and transport of biomass, and the effects of land use change, contribute to associated emissions that negate some of the emission savings the fuels deliver (Hill et al., 2006, Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008, Hammond et al., 2008).

There remains debate over the extent of the emission savings that biofuels can deliver. Whilst early models and emission projections predicted across the board savings (European Environment Agency, 2006), current thinking suggests that the extent of any savings are dependent on multiple factors including the specific feedstock, the land used and the production process, amongst other things (Hill et al., 2006, Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008, Hammond et al., 2008, Soimakallio et al., 2009). While there are some who argue that biofuels can never deliver

emission reductions and we should not pursue their development and use, there is still acceptance by many that biofuels can be beneficial when produced with careful consideration for these factors (Hill et al., 2006).

As the degree of variation in feedstock, land use and production processes is high, there is also a large degree of difference between published emission scenarios and estimates (Soimakallio et al., 2009). Despite this, general trends suggest that second generation fuels produced from perennial crops and wastes, as well as fuels from feedstocks grown on marginal land, deliver greater GHG benefits (Hill et al., 2006, Soimakallio et al., 2009).

### **2.3.2 EU/UK Biofuel Legislation**

Initial EU interest in biofuels stemmed from discussions of uses for surplus agricultural produce dating back to 1983 (Londo and Deurwaarder, 2007). Whilst a number of EU member states took action to begin producing biofuels in the early 1990s, it wasn't until 1997 that biofuels were first mentioned in the European Commission's White Paper "Energy for the Future: Renewable Sources of Energy" as an important part of future EU energy policy (Londo and Deurwaarder, 2007). At this stage, EU interest in biofuels had shifted focus to the environmental and climate change related benefits biofuels could deliver, partly spurred on by talks at the Kyoto Climate Conference (Londo and Deurwaarder, 2007, Pilgrim and Harvey, 2010). However, further action was limited by the realisation that the low cost of oil rendered biofuels uncompetitive financially (Londo and Deurwaarder, 2007).

It was not until concerns about energy security became more prominent in 2000 that biofuels made a return to European consideration in the Green Paper "Towards a European strategy for the security of energy supply" (Londo and Deurwaarder, 2007). This marked the introduction of an additional motivating factor alongside environmental and agricultural considerations, with biofuels coming to be considered the only option for reducing dependency on oil (Londo and Deurwaarder, 2007).

In 2003, EU Directive 2003/30/EC, “*On the promotion of the use of biofuels or other renewable fuels for transport*”, set targets for the inclusion of biofuels in total fuel use in EU member states – 2% by 2005 rising to 5.75% by 2010 (Amezaga et al., 2010, Londo and Deurwaarder, 2007). Whilst the Directive had been intended to bring together the three driving forces of agriculture, emission reduction and energy security, the emission reduction element had come to be the most prominent driver during pre-implementation discussions (Londo and Deurwaarder, 2007).

In response to the EU Directive, the UK government implemented the Renewable Transport Fuel Obligation (RTFO) in 2008 (European Parliament, 2003, Renewable Fuels Agency, 2009). The UK was not the only member state where implementation of the Directive was delayed – only Germany and Sweden, who had existing biofuel production programmes, met the 2005 target (Londo and Deurwaarder, 2007). In these circumstances, the European Commission published “Biomass Action Plan” (Commission of the European Communities, 2005) and “An EU Strategy for Biofuels” (Commission of the European Communities, 2006) which reiterated and strengthened the underlying motivations of rural development, reduced greenhouse gas emissions and improved energy security (Londo and Deurwaarder, 2007).

However, later the same year the publication of a number of scientific papers that cast doubt over the benefits biofuels could deliver (Searchinger et al., 2008, Fargione et al., 2008, Danielsen et al., 2008) prompted the UK government to commission an investigation into the indirect effects of biofuel production (Gallagher, 2008). The resulting report, known as the Gallagher review, recommended a scaling back of the pace of adoption of biofuels (Renewable Fuels Agency, 2009, Gallagher, 2008, Boucher, 2012).

EU legislation was further amended in 2009 with the introduction of the Renewable Energy Directive (RED) which supplanted the existing 2003 Biofuels Directive (Boucher, 2012). The RED brought reduced usage targets, a requirement for biofuels to deliver emissions at least 35% lower than fossil fuels and rules preventing the growth of biofuel feedstocks on environmentally

sensitive land (Boucher, 2012). The new Directive was incorporated into UK policy by The Renewable Transport Fuel Obligations (Amendment) Order 2009 (Boucher, 2012, Department of Energy and Climate Change, 2012c).

### **2.3.3 US Biofuel Legislation**

In 2011, the United States was the world's largest producer of biofuels, with an output of around 28.25 million tonnes of oil equivalent, making up 48% of total global production (BP, 2012).

Unlike the threefold motivations of the EU, in the United States, the primary motivation for investing in and promoting biofuels has always been focussed on energy security (Pilgrim and Harvey, 2010). For the US, energy security is closely related to national security and a priority for government (United States Energy Security Council, 2012).

Since 1992, the US government has introduced several policies that aimed to promote and support the development and production of biofuels domestically. Initially, policies only set out general promotional programmes for alternative energies (Energy Policy Act, 1992). Later policies led to the creation of a technical advisory committee and board to manage biomass research and development - Biomass Research and Development Act, 2000 - and instituted grants for the development of biofuel processing facilities -The Farm Bill, 2002 (U.S. Department of Energy, 2009). In addition, government put in place a Renewable Fuel Standard requiring 7.5 billion gallons (approximately 28.39 billion litres) of renewable fuel to be included in petrol sales by 2012, increasing to 250 billion gallons (approximately 946.25 billion litres) (from lignocellulosic biomass) by 2013 supported by a range of tax credits and other incentives (Energy Policy Act, 2005) (U.S. Department of Energy, 2009).

US biofuel policy suffered slightly during the Presidency of George W. Bush, who (unsuccessfully) attempted to veto the provision of investments in excess of \$1.7 billion to help reduce fossil fuel consumption of bioethanol production facilities, expand and develop second generation biofuels amongst other things

- The Food, Conservation and Energy Act 2008 (110th Congress, 2007, House Committee on Agriculture, 2008).

#### **2.3.4 Brazil Biofuel Legislation**

Based on figures from 2011, Brazil is the world's second largest producer of biofuel, with an output of approximately 13.2 thousand tonnes of oil equivalent making up 22.4% of total global production (BP, 2012).

Brazil has long standing interest in the use of biofuels, with their first requirement to blend ethanol with petrol dating back to the 1920s (USDA Foreign Agricultural Service, 2010, Wilkinson and Herrera, 2010, Pousa et al., 2007). As in the United States, Brazilian motivations for developing biofuels have been primarily for reasons of energy security, but also as a means of developing their economy (Pilgrim and Harvey, 2010).

The most significant piece of biofuel policy in Brazil is the 1975 The National Alcohol Program (Proalcool) which was established in reaction to high oil prices, as a move to make the nation energy independent (USDA Foreign Agricultural Service, 2010, Wilkinson and Herrera, 2010, Pohit et al., 2009). The program required all petrol to be blended with bioethanol at 4.5% volume by 1977 (USDA Foreign Agricultural Service, 2010). A number of incentives were put in place by the Brazilian government to encourage both the production and the use of biofuels. To encourage consumers to use bioethanol the fuels were subsidised in line with their energy ratio, bioethanol was exempt from sales tax, there was a compulsory requirement for petrol stations to supply ethanol and tax on ethanol fuelled vehicles was reduced (Wilkinson and Herrera, 2010, USDA Foreign Agricultural Service, 2010, Pohit et al., 2009). To encourage production, incentives were put in place to encourage expansion of sugarcane cultivation and for construction of ethanol distillation facilities to allow for increased production (USDA Foreign Agricultural Service, 2010)

It is estimated that the Brazilian government invested a total of US\$8.5 billion on their biofuel incentives and subsidies between 1975 and 1989 (USDA Foreign Agricultural Service, 2010).

As a result, total sales of ethanol vehicles between 1980 and 1989 were more than twice those of gasoline vehicles, with 94% of vehicle production in 1984 being ethanol vehicles (USDA Foreign Agricultural Service, 2010).

The Brazilian biofuel program expanded in the early 1980s in response to a further period of high oil prices, which prompted the development of ethanol as a petrol substitute rather than a blended additive (USDA Foreign Agricultural Service, 2010). The policy created a requirement for all cars to be capable of running on 100% ethanol and the installation of the necessary supply network (USDA Foreign Agricultural Service, 2010).

Removal of government incentives in the late 1980s, high sugar prices and deregulation of the sector in the 1990s had negative impacts on bioethanol supply and sales of ethanol vehicles (USDA Foreign Agricultural Service, 2010, Wilkinson and Herrera, 2010, Pohit et al., 2009). However, the requirement for 22% ethanol to be blended with petrol was left in place and ethanol and ethanol vehicles continued to be produced, although at a much reduced level (USDA Foreign Agricultural Service, 2010).

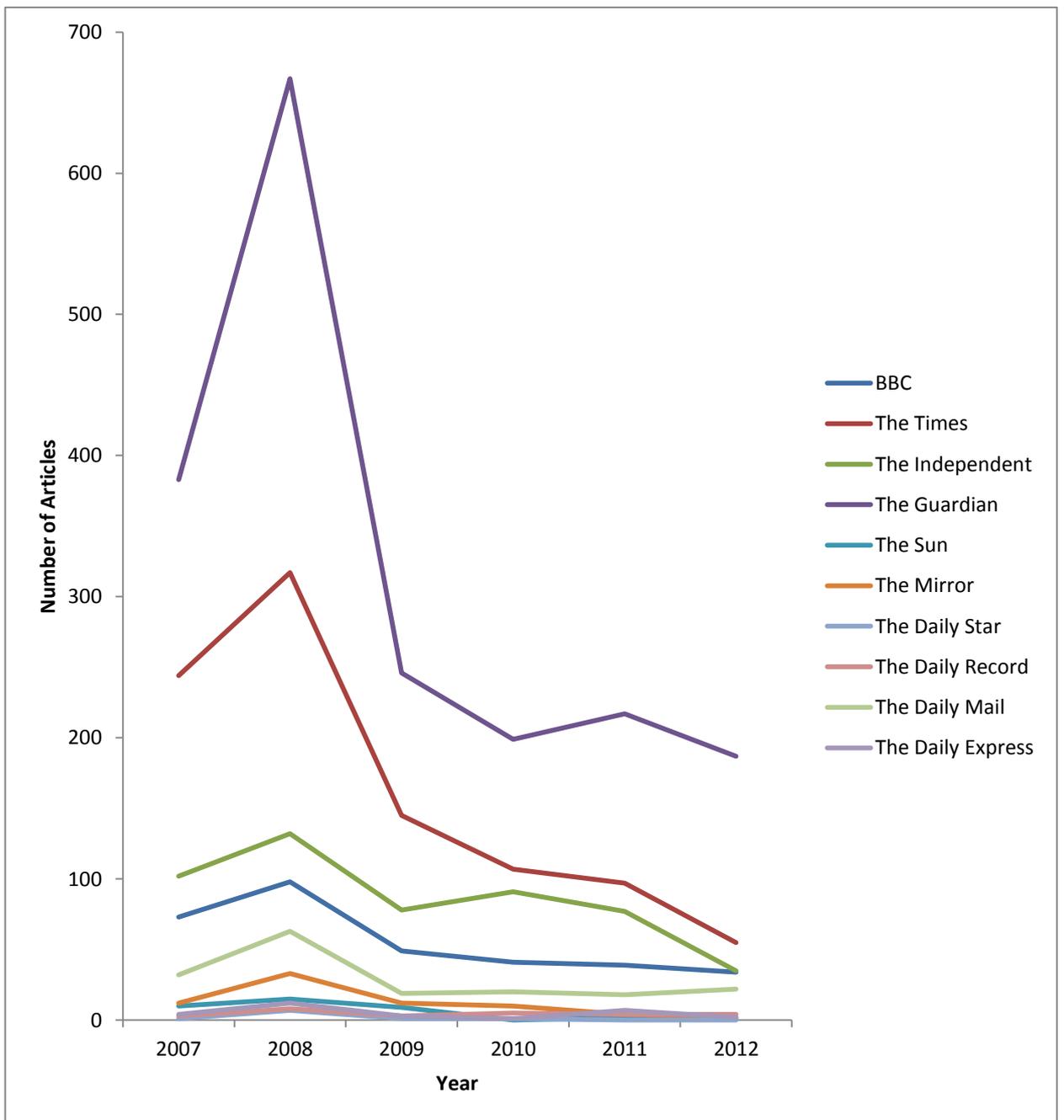
In line with increased interest in biofuels elsewhere in the world, biofuels in Brazil have experienced a resurgence since 2000 with private sector interest leading to the development of flex-fuel vehicles (vehicles capable of running on both petrol and ethanol) (USDA Foreign Agricultural Service, 2010, Wilkinson and Herrera, 2010). As a result of private sector interest the Brazilian government also renewed their interest in biofuels with reintroduced subsidies for production of sugarcane, investment and financial support for ethanol production through the National Bank for Social and Economic Development, tax breaks on biofuels and reduced tax on flex-fuel vehicles (USDA Foreign Agricultural Service, 2010).

## **2.4 Reduction in interest in biofuels 2007-2012**

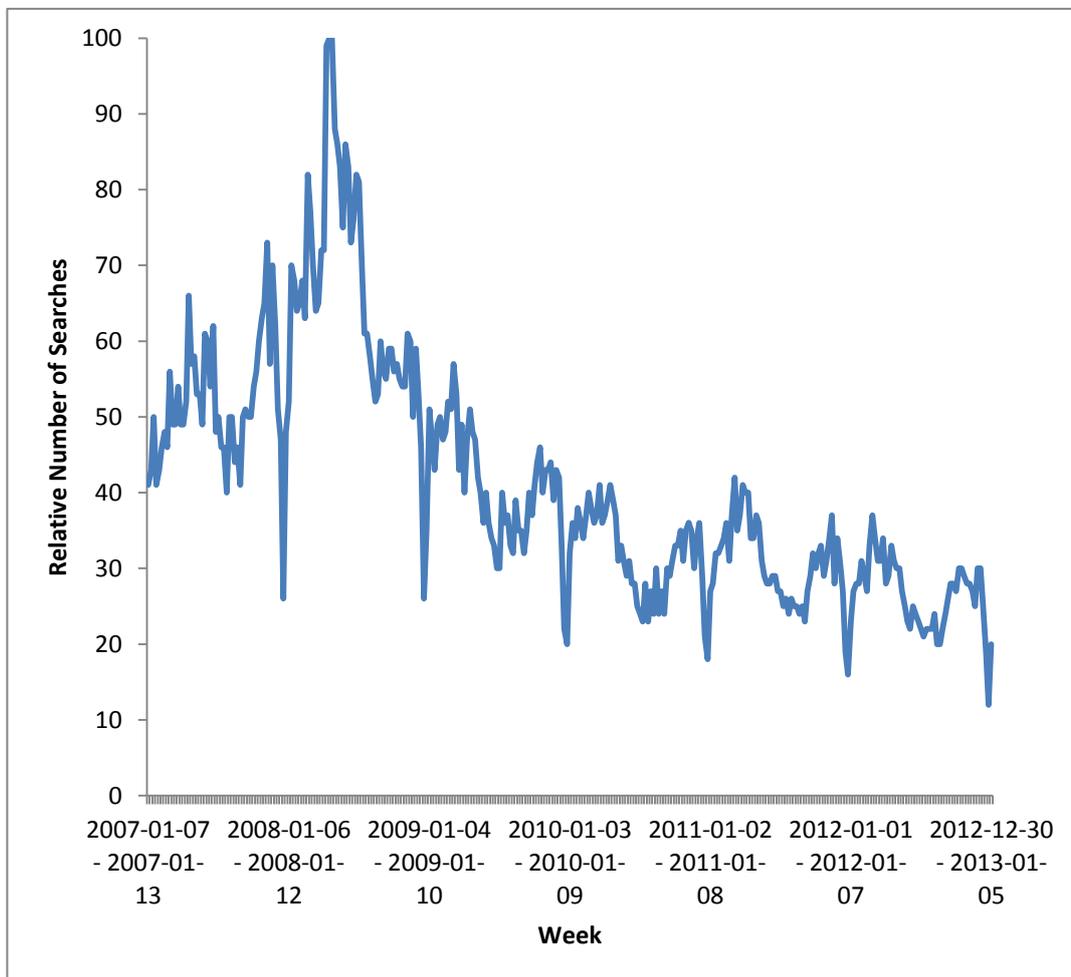
As can be seen in the review of the relevant legislation, the political situation with regard to biofuels has been in consistent flux for many years. In addition to the political changes (Londo and Deurwaarder, 2007, Boucher, 2012) and economic difficulties of recent years (Scruggs and Benegal, 2012, Weber, 1997), over the course of this project there have also been significant changes in biofuel knowledge and technology (Tilman et al., 2006, Durre, 2008, Rothamsted Research, 2008, van der Merwe et al., 2013) as well as attitudes towards biofuels (Scruggs and Benegal, 2012). It would seem that this has had, and is expected to continue to have, knock-on effects on interest in biofuels and those who would consider themselves stakeholders in the issue. It is felt that this contributed to the difficulties that were experienced in recruiting expert stakeholder interviewees as part of Chapter 5, as a large number of those contacted did not wish to discuss the issue. It is possible that if expert stakeholder engagement had been undertaken at an earlier stage in the research then more experts may have been interested in participating and the results may have been different. However, it is my opinion that the changes in attitudes and opinions relating to biofuels in recent years mean that expert opinions gathered earlier may no longer have been relevant at the time of compiling the information on identified risks to inform a full risk analysis. I believe that public knowledge and opinion will have changed less over the same time period, as results suggest that the public view was more reflective of a 2008 biofuel position.

The future of biofuels in the UK is in part dependent upon how levels of interest change across stakeholder groups in the coming years, which is hard to predict.

Such changes in the level of general interest in biofuels over recent years can be clearly seen in Fig 4 and Fig 5.



**Fig 4. Number of articles published on the subject of 'Biofuels' by the UK's leading newspapers and the BBC**



**Fig 5. Results from Google Trends showing the number of searches for the term 'biofuel' relative to the maximum, for the UK (Google Trends, 2013)**

As can be seen in Fig 4, media interest in biofuels spiked in 2008 (represented by the number of articles published) and then declined across the board, with the exception of a few minor increases in certain publications. Results were obtained from keyword searches for 'biofuel' on the individual publications websites. The publications shown were selected as the most popular UK newspapers based on the most up-to-date national circulation figures, from October 2012 (The Guardian, 2012), with the addition of the BBC as a major television and online news provider.

A similar trend can be observed in Google searches shown in Fig 5, which is more a reflection of public interest in biofuels. Google Trend is a service offered by Google that provides details of the extent of searches for key words using the Google search engine (Google Trends, 2013). Exact figures are not provided; rather data is displayed as a proportion relative to the maximum

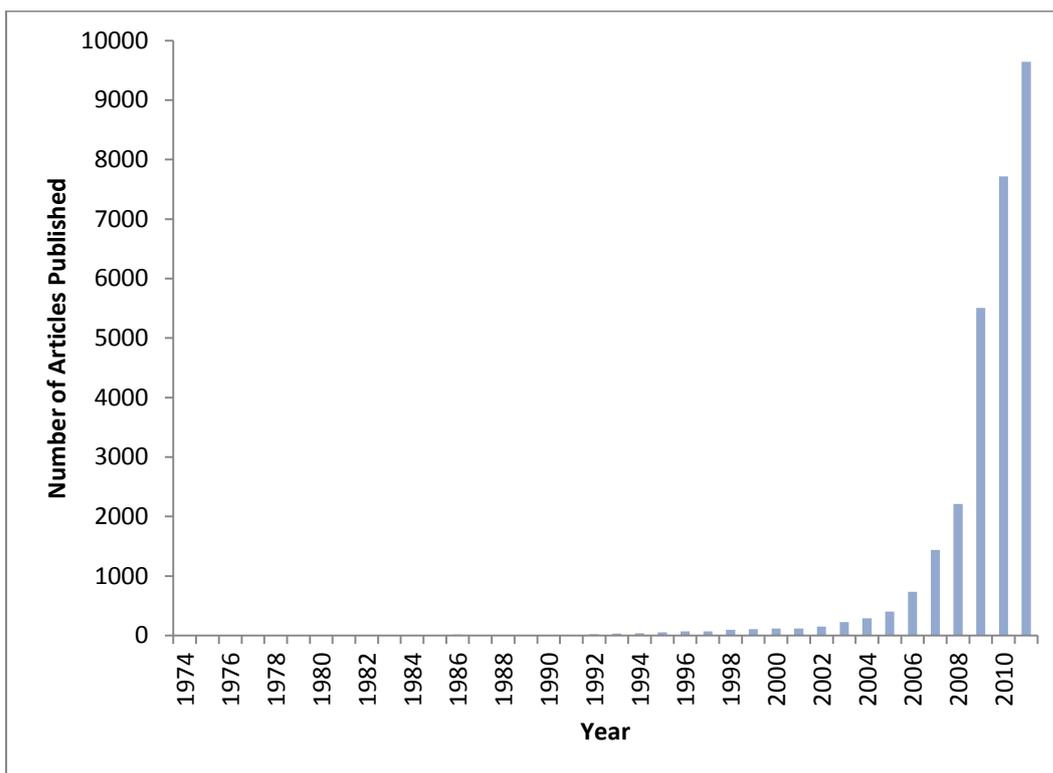
number of searches in any week during the time period of interest, which in this case occurred in April 2008. Data can be provided based on global results or for specific countries. In this case, data represents searches for the term 'biofuel' in the UK between January 2007 and January 2013.

These results reflect a general trend in attitudes towards biofuels. Since the publication of the papers by Searchinger et al. (2008), Danielsen et al. (2008), and Fargione et al. (2008), that uncovered previously unconsidered risks related to biofuel production; governments, particularly in the EU, have stepped back their interest in biofuels which has impacted on investment and development, with knock-on effects for media coverage and public interest.

## **2.5 Biofuel in Scientific Literature**

A bibliometric review using keywords was conducted to evaluate trends in the publication of biofuel information over time (Tian et al., 2008, Li et al., 2009). The Web Of Knowledge online database of academic publications was used to conduct the review (Tian et al., 2008, Li et al., 2009). The database was searched for any of the keywords 'biofuel', 'biofuels', 'bioethanol' or 'biodiesel' in article titles and abstracts .

Overall, the search returned approximately 37,302 relevant publications. The earliest publications dated back to 1974. As opposed to the bibliometric study of media coverage, analysis of scientific publication by year shows a clear trend of increased publications per year (Fig 6).



**Fig 6. Number of articles referring to ‘biofuel’, ‘biofuels’, ‘bioethanol’ or ‘biodiesel’ by year, from the Web of Science database**

As can be seen in Fig 6, the number of publications per year has increased dramatically since the year 2000. Until 1990, annual numbers of biofuel related publications remained in single figures. Only in 1999 did numbers pass 100 annually. By 2011, annual numbers of biofuel publications reached nearly 10,000.

This pattern of increase, with a particularly noticeable jump since 2008, can be observed in the number of publications across the range of issues considered below.

### **2.5.1 Identifying Biofuel Risks in Scientific Literature**

While, initially, biofuels were hailed as a green solution to all our energy and related environmental concerns, there were soon voices of doubt over the claims.

Today, there is a large amount of literature examining the drawbacks and problems associated with the production and use of biofuels. However, in 2008, three scientific papers, Searchinger et al. (2008), Fargione et al (2008) and Danielsen et al. (2008) were amongst the first to highlight serious flaws in the biofuel production process; bringing them to wider attention and prompting a dramatic loss of confidence in the new fuel.

The paper by Searchinger et al. (2008) performed analyses of the biofuel production process, from land conversion through to fuel use, which suggested that current biofuel production may actually be responsible for greater carbon emissions than associated with the use of fossil fuels, rather than the reduced emissions promised.

Fargione et al (2008) also examined the carbon debt incurred by land conversion for the production of biofuel crops. As with Searchinger et al (2008), results suggested that biofuels grown on land that was previously rainforest, savanna or grass land may release as much as 420 times more CO<sub>2</sub> than fossil fuels.

The Danielsen et al (2008) publication echoed these concerns, as well as discussing the negative impacts biofuel plantations were having on biodiversity in tropical regions.

These publications caused particular concern in the UK, due to their focus on the environmental benefits of biofuels (Pilgrim and Harvey, 2010). As a result, the UK government commissioned a review into such 'indirect effects' of biofuel production. Lead by Ed Gallagher of the then Renewable Fuel Agency, the report became known as the Gallagher Review (Gallagher, 2008). As a result of one of the report's recommendations, the UK's RTFO targets were scaled back and capped at 5% by volume until such time as the sustainability of biofuels could be assured (Gallagher, 2008).

## 2.5.2 Common Issues Documented in the Literature

While the Searchinger et al. (2008), Fargione et al. (2008) and Danielsen et al. (2008) papers, along with the Gallagher Review (Gallagher, 2008), were significant publications raising the profile of the less preferable aspects of biofuels, they were by no means the only publications on the subject. Since 2008, a great deal of work has been conducted and published examining the issues raised by these publications, as well as other issues relevant to the production and use of biofuels.

As a whole, the issue is complex with many inter-related aspects. However, it is possible to identify a number of key themes in the literature, these can be seen in Table 1.

<b>Issue</b>	<b>Number of Publications</b>
Land Use	825
Loss of Biodiversity	452
Land Use Change and ILUC	373
Food Prices and Food Supply	237
Air Quality	230
Deforestation	157
Carbon Balance	41
Increased Emissions	36
Inputs to Production	18
Habitat Loss	13
Vehicle Compatability	7

**Table 1. Issues documented in peer-reviewed scientific literature by number of publications returned by a key word search of Web of Knowledge (from earliest publications to end of December 2012)**

### **i) Land Use**

Land use for the production of biofuel has become an issue of significant concern in recent years. Over a period of ten years the number of publications

making reference to land use in relation to biofuels has increased from two, in 2001, to two hundred and twenty two, in 2011.

The primary basis for the concern is that the surge in interest in and production of biofuels requires a large amount of land for the growth of feedstocks as well as the construction of processing facilities which prevent the land being used for the production of food (Charles et al., 2007, Tan et al., 2008, Tilman et al., 2006, Knocke and Vogt, 2009). Issues already exist with providing sufficient food for all the people on Earth, along with the added pressures of population growth, there are apprehensions about the diversion of crop land for biofuel production (Chakravorty et al., 2009, Conceicao and Mendoza, 2009).

Further discussions of how the rapid increase in demand for land to produce biofuels will require a large amount of land use change are addressed in section iii.

In addition, the literature details concerns about other impacts of extensive land use for biofuel production, including; deforestation and habitat destruction (Danielsen et al., 2008, Charles et al., 2007, Tan et al., 2008, Jessup, 2009), loss of biodiversity (Groom et al., 2008, Firbank, 2005, Danielsen et al., 2008), and the displacement of local peoples in land grabs (Cotula et al., 2008, Hall, 2011, Wilkinson and Herrera, 2010).

## **ii) Biodiversity**

Land use change, along with climate change, is believed to be one of the most significant factors in the loss of biodiversity and extinction of species (Firbank, 2005). Due to the extent of land use change associated with biofuel production, there are serious concerns about the impact of biofuels on biodiversity and the ecosystem as a whole. Work by Danielsen et al (2008) investigating biodiversity in oil palm plantations in South East Asia found that areas converted to oil palm cultivation contained less than one quarter of the vertebrate species that would be found in the same area of unconverted rainforest.

Land use change and deforestation are also known to disrupt ecosystem services, altering weather patterns and influencing erosion (Charles et al., 2007).

### **iii) Land Use Change and Indirect Land Use Change (ILUC)**

Discussions of land use change and indirect land use change are somewhat related to the issue of land use that has already been discussed.

It was in 2008 that three papers were published that highlighted the previously over-looked effects of land use change on actual emission savings from biofuels which began the significant rise in scepticism and loss of confidence in biofuels (Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008). These papers reported that the conversion of land from one use to another - whether that be from one crop to another or from being forest or grassland to fields for crop productions – incurred a carbon debt that had not previously been accounted for in predictions of emission savings for biofuels (Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008). The removal of existing biomass, ploughing of soils, fuel for machinery and the production of inputs such as fertilisers, pesticides and herbicides all have associated carbon emissions that need to be considered in the life-cycle analysis of the biofuel and which detracts from the carbon saving they can deliver – in some cases the extent of the emissions associated with the land conversion process resulted in completely negating any emission saving, leaving the biofuel with a worse carbon footprint than oil (Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008).

There has also been discussion of indirect land use change (ILUC) in the literature. ILUC occurs when biofuel crop growth takes over an area that was previously used for another purpose, usually food production, and so that land use activity is displaced and causes land use change elsewhere (European Environment Agency, 2008, Steinfeld, 2006). Indirect land use change is considered to be a particular problem as it is difficult to monitor, quantify and attribute to a particular cause (Steinfeld, 2006).

#### **iv) Inputs to Production**

The literature on the subject of inputs to the production of biofuels focuses on analysis of how these inputs affect the overall carbon balance of the end product (Bastianoni and Marchettini, 1996). Since the peak in interest in the full range of factors affecting the carbon balance in biofuel in 2008, there has been an increase in the number of publications considering the impacts of these inputs. In general, the literature seems to be largely in agreement that increased inputs and lack of proper consideration for their application has negative impacts on the carbon balance of the final biofuel product (Bastianoni and Marchettini, 1996).

As a result of the recognition of the negative impacts of excessive inputs to production, there are also many papers that review the relative benefits of other feedstocks that do not require so many inputs, such as algae and *Miscanthus* (Kraan, 2013).

#### **v) Food Supplies and Prices**

A keyword search of the Web of Knowledge online database returned 99 publications dealing with the issues of biofuels and food prices at the end of 2011.

The potential for the production of biofuels, particularly first generation biofuels, to cause increases in food prices by competing for agricultural land and diverting food crops into food production has been widely discussed in the literature (Koh and Ghazoul, 2008, Tan et al., 2008, Demirbas, 2009, Gilbert, 2010, Ajanovic, 2011a). The discussion was fuelled by significant increases in the prices of staple food stuffs in the period between 2005 and 2008, while the production of biofuels was being heavily promoted (Gilbert, 2010, Mueller et al., 2011, Timilsina and Shrestha, 2011).

The discussion within the literature can be characterised into three main arguments; biofuel production as a significant and indisputable cause of increased food prices (Timilsina et al., 2012, Demirbas, 2011, Serra et al., 2011, Martin, 2010), biofuel production as an insignificant and uncertain factor

in increased food prices (Diffenbaugh et al., 2012, Ajanovic, 2011a, Wetzstein and Wetzstein, 2011, Neves, 2010) and biofuel production as one of a range of factors contributing to increased food prices (Misselhorn et al., 2012, Tirado et al., 2010, Weis, 2010, Rathmann et al., 2010, Armah et al., 2009).

The literature also sees discussion of how use of marginal lands and second generation feedstocks can help mitigate the impact of production on food prices and potentially reduce food costs (Swinton et al., 2011, Regalbuto, 2010, Campiche et al., 2010, Randelli, 2009)

#### **vi) Air Quality**

Although not as widely discussed as other potential impacts, there are concerns about the impact of biofuels on air quality. The emissions resulting from the combustion of biofuel differ in composition from those produced by combustion of petrol or diesel. There are data that suggest biofuel emissions may contain higher levels of certain harmful compounds including nitrous oxides, sulphur dioxide, acetaldehyde, formaldehyde and peroxyacetyl nitrates (PANs) (Charles et al., 2007, European Environment Agency, 2008, Gaffney and Marley, 2009). Such compounds are potentially harmful to both human health and the environment; formaldehyde is carcinogenic, an irritant and contributes to the formation of ozone (Gaffney and Marley, 2009, Charles et al., 2007).

Research into emissions from biofuels conducted by Gaffney and Marley (2009) compared emissions arising from the combustion of a blend of 85% methanol and 15% petrol known as M85. Results found the M85 emissions to contain less carbon monoxide, benzene, 1,3-butadiene, and acetaldehyde, but more nitrous oxides and formaldehyde, than petrol alone. Biodiesel generally has lower carbon monoxide emissions but increased nitrous oxides, benzene, aldehydes and particulate matter (Gaffney and Marley, 2009).

#### **vii) Deforestation**

The issue of deforestation as an impact of biofuel production is closely linked with other concerns such as extensive land use, land use change and loss of

biodiversity (Gao et al., 2011, Havlík et al., 2011, Linares and Pérez-Arriaga, 2013, Kim et al., 2013, Gibbs et al., 2008, Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008).

Concerns surround the potential for release of carbon from longstanding forest sinks and removal of important and often unique habitats if forest is removed through direct or indirect land use change arising from the push for increased biofuel production (Gao et al., 2011, Searchinger et al., 2008, Danielsen et al., 2008, Fargione et al., 2008). In addition, these concerns are often heightened by the propensity to cultivate biofuel feedstocks in tropical areas, due to better growing conditions, where deforestation is likely to affect rainforests (Danielsen et al., 2008, Fargione et al., 2008).

Danielsen et al., (2008) calculated the carbon debt associated from deforestation of rainforest in south-east Asia to have a payback time of between 75 and 93 years. Fargione et al., (2008) calculated a comparable figure of around 86 years. Estimates such as these certainly cast doubt on the ability of biofuels to fulfil one of their main objectives – reducing GHG emissions.

#### **viii) Reduced Emissions**

Much research has focussed on the carbon balance of the biofuel production process, and was the focus of the Searchinger et al (2008) and Fargione et al (2008) publications. Carbon balance relates to the overall quantity of carbon that the fuel emits to the atmosphere, set against the amount of carbon it absorbs (Tan et al., 2008). Initially biofuels were believed to be carbon neutral; making no net contribution of carbon to the atmosphere, based on the assumption that the only carbon they emitted when burned was the carbon that the plants had absorbed through photosynthesis (Johnson, 2009). However, numerous publications have presented evidence that shows the idea of carbon neutrality is poorly founded, and that there are cases where biofuel production may be responsible for greater carbon emissions than fossil fuels (Searchinger et al., 2008, Charles et al., 2007, European Environment Agency, 2008, Demirbas, 2009, Danielsen et al., 2008, Jessup, 2009, Fargione et al., 2008).

Some of the key factors identified as contributing to carbon emissions associated with biofuels included land clearance, land use change and the removal of carbon sinks (Demirbas, 2009, Searchinger et al., 2008, Jessup, 2009, Danielsen et al., 2008), disturbance of soil carbon stores (Searchinger et al., 2008) and intensive production requiring fossil fuel based inputs ranging from use of machinery and equipment to application of chemical fertilisers and pesticides (Groom et al., 2008, Charles et al., 2007).

Certain feedstocks and production methods were singled out as having particularly poor carbon balances. Searchinger et al, (2008) focussed on growth of maize in the US for ethanol production, suggesting that such an approach could lead to a doubling of carbon emissions by 2040 instead of the previously anticipated decrease. Danielsen et al, (2008) researched the growth of oil palm in plantations in South East Asia; again producing results that suggested higher emissions than are associated with existing fossil fuels.

#### **ix) Practical Barriers**

There is also considerable literature that deals with other, more practical barriers to the development and expansion of use of biofuels. Some of these issues include lack of awareness (BERR, 2008, Gill, 2005), lack of confidence to invest (Trust, 2005, Gill, 2005, BERR, 2008), the planning system (Sims et al., 2006, Gill, 2005, BERR, 2008), price of fossil fuels (BERR, 2008, Commission of the European Communities, 2007), compatibility with existing vehicles (Sims et al., 2006, BERR, 2008, The Royal Society, 2008, Pacific Economic Cooperation Council, 2008) and, perhaps most significantly in the UK, and aspects of the British political system including deficiencies in the policy process and ability to recognise links between objectives and outcomes (Slade et al., 2009).

## **2.6 Finding Solutions**

In tandem with the volume of literature published on negative aspects of biofuels, and the impact this has had on biofuel policy in the UK, there is also much work being undertaken to improve biofuels and overcome these problems. These solutions range from scientific research and development to

government policy and changes in land management and agriculture. The most significant development in improving biofuels is widely thought to be the development of advanced second-generation fuels.

#### **i) Lignocellulosic Bioethanol**

Lignocellulosic bioethanol is a second-generation biofuel produced from woody biomass, as discussed in section 2.2.2.2. A great deal of literature considers that the development of second generation fuels would help overcome many of the negative issues currently associated with first generation fuels. Beneficial properties of second generation feedstocks include; reduced requirements for inputs including fertilisers, water, pesticides and herbicides, during cultivation (Rothamsted Research, 2008, Groom et al., 2008, Jessup, 2009, Tilman et al., 2006), ability to be cultivated on marginal land (Tilman et al., 2006, Field et al., 2008, Groom et al., 2008), higher yields (Sanderson, 2006) and the fact that they are not food crops (Charles et al., 2007, Demirbas, 2009). These properties could mean that second generation biofuels will not compete with food production and will not require extensive areas of land or land conversion that create problems such as deforestation, loss of biodiversity and negative carbon balances.

#### **ii) Biobutanol**

There is much discussion of the benefits of using biobutanol in preference to bioethanol (Durre, 2008, Pfromm et al., 2010, Qureshi et al., 2009, van der Merwe et al., 2013, Cheng et al., 2012). Biobutanol can be produced from both first generation and second generation feedstocks, as with bioethanol. However, unlike bioethanol, butanol does not absorb water, resulting in no phase separation of biofuel/petrol blends (Durre, 2008, van der Merwe et al., 2013, Cheng et al., 2012) a higher energy content (Durre, 2008, van der Merwe et al., 2013) and, due to higher oxygen content, cleaner burning than ethanol (Qureshi et al., 2009). Perhaps more significantly, use of biobutanol would not require engine modifications, being less corrosive than ethanol and a lower vapour pressure, making it less volatile particularly in warm weather (Durre, 2008, Cheng et al., 2012).

Based on this evidence, it would seem that biobutanol could help overcome a number of issues with the use of bioethanol, particularly issues with engine compatibility.

### **iii) Improved Agricultural Practises**

Many of the criticisms levelled against the cultivation of biofuels, are actually applicable to our system of agricultural production more generally. Intensification of agricultural production, including the expansion of croplands, increased use of chemical fertilisers and pesticides and increased water inputs, which all contribute to environmental degradation (Tilman, 1999) apply to our food production as much as to the production of biofuels.

As such, general improvements to agricultural practices would provide environmental benefits not limited to biofuel production. However, making changes to agriculture at large is unlikely to be an easy task (European Environment Agency, 2008). As a new market that is likely to require a large amount of regulation and management, biofuels may provide an opportunity for introducing new farming practices as an example for wider agriculture and food production.

## **2.7 Summary**

Interest in biofuels as a means of delivering environmental, social and economic benefits has increased substantially within the past decade. In the US and EU particularly, this interest has been translated into many policies intended to promote their production and use – although the underlying drivers have differed, with the US being primarily concerned with energy security and the EU being more environmentally focussed.

Alongside this increase in political interest, there has also been an increase in the research and publications on biofuels and their potential benefits and risks. Since the initial surge in interest, the number of publications has increased as studies become more in-depth and the full extent of the potential impacts is better understood. The examination of the literature conducted here has revealed that the issues of land use, loss of biodiversity, ILUC, Food Prices and

Food Supply, Air Quality and Deforestation to be of particular interest and concern to researchers.

Whilst the extent of the discussion of the risks and problems associated with biofuels may make them seem like a wholly undesirable option, such research into the potential risks of biofuels has allowed for reconsideration of policies and the development of solutions to the issues. In particular, the development of second generation biofuels produced from perennial feedstocks and wastes seem to hold particular hope for delivering on the early promise of biofuels. In addition, highlighting aspects of biofuel production that have caused harm allows for improvements to be made to the process.

The evidence gathered from the literature in this chapter forms the basis of issue identification and risk analysis, informing the initial risk characterisation and, later on, risk management and communication stages. The information gathered is taken forward through the incorporation of stakeholder perceptions and opinions. It also serves as a point of comparison for stakeholder understanding of biofuel issues.

Further chapters discuss if and how this information has been translated to the relevant stakeholders and the impacts it has had on their awareness and attitudes towards biofuels.

### **3. Initial Public Stakeholder Involvement: Establishing a base knowledge of stakeholder awareness and concerns in relation to biofuels and the environment**

#### **3.1 Introduction**

To achieve the research aims set out in chapter one, it was necessary to establish a basic understanding of stakeholder awareness and knowledge of biofuels. While most relevant stakeholders in the non-governmental organisation (NGO), industrial, governmental and scientific sectors have published information on their stance in the biofuel debate that is available through their websites, there is little information available on the position of the general population. It was therefore necessary to focus on the public as a stakeholder group, and develop an understanding of their perceptions of biofuels.

A number of methods for engaging with the public were considered, including interviews, citizens' juries and questionnaires. However, due to their suitability for early stage research and ability to explore attitudes and opinions it was decided to collect the initial data through focus groups. Consequently, six individual focus group sessions were held with members of three distinct groups; environmental science students, general students and employees from Ordnance Survey, with discussions recorded and transcribed for analysis. The major themes from the focus groups were identified and analysed both qualitatively and quantitatively to establish relative importance of different aspects of the discussions. These focus groups are the first step in achieving the research aims relevant to the general public as stakeholders. As such, this chapter is considered to be an exploratory exercise to inform the development of the later investigations.

Aims of this chapter;

- To determine the level of awareness of biofuels and specific knowledge in relation to the biofuel debate, in the general public (RA1)

- To identify key concerns about the use of biofuels in the general public (RA3 & RA5)
- To identify general opinion of biofuels in the general public (RA1 & RA6)
- To identify sources of information that the general public use and trust (RA2 & RA6)
- To determine relevant issues and terms that the public are familiar with, which can be developed into a questionnaire for further research (RA1)

### **3.2 Engaging the Public**

Interest in engaging the general public in decision making, particularly in relation to environmental issues, has increased in recent years as decision makers aim to increase the legitimacy of their work (Pidgeon et al., 2005, Fiorino, 1985, DEFRA, 2000, Rowe et al., 2005, Smith, 2001, Jasanoff, 2011). This may be due to increasing awareness of environmental issues amongst the general public, accompanied by increased concern and desire to be informed and involved in discussions about risks that may affect them and their surroundings (DEFRA, 2000). However, it is likely that the reported benefits of public engagement in risk decision-making have also influenced the increased interest in such an approach.

Decisions taken on risks must be deemed acceptable by society (Stern and Fineberg, 1996, Blamey et al., 2000) or taken accepting the oppositions and reviews that can incur financial and time related costs as well as damage to the reputations of institutions involved (Rowe et al., 2005). As experience has shown, most notably with the public campaign against genetically modified (GM) crops in Europe (Burke, 2004) but also in the cases of climate change, stem-cell research and vaccinations such as for measles-mumps-and-rubella (MMR) (Mikulak, 2011), not considering the wider societal views can be problematic. It is therefore evident that engagement and involvement of stakeholders can help decision makers to better understand how the risk is perceived by society, which aspects are of most concern and what mitigation measures or other actions would be most acceptable to the stakeholders concerned (DEFRA, 2000, Johnson et al., 2007).

Non-expert stakeholder risk perceptions are often notably different from expert, scientific assessments of risk, and therefore expert opinion alone cannot be considered adequate when making decisions that affect other stakeholders (United States Environmental Protection Agency, 2007, Fiorino, 1985, DEFRA, 2000). Reported benefits of the use of stakeholder engagement methods include: increased credibility of decisions, greater effectiveness of decisions, greater likelihood of decisions being accepted by stakeholders, increased social awareness and interest in the relevant issues and, potentially, increased public trust in the institutions involved (Chess and Purcell, 1999, Gundersen, 1995, Barnes et al., 2003, Smith, 2001, Smith, 2003, Chadwick et al., 2008, The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997, United States Environmental Protection Agency, 2007).

Involvement of the public was considered a key component of this research, allowing the investigation of existing public knowledge and perceptions of biofuels that could help in the identification of relevant assessment endpoints and management goals and working to avoid unnecessary controversies in decision-making.

### **3.2.1 Stakeholder Involvement**

A number of different methods for involving stakeholders were considered for the research. The advantages, disadvantages and suitability of these methods were assessed against the requirements of the research. Exploratory interviews, standardised interviews, citizens' juries and focus groups were all considered. Such methods were included for selection as, being qualitative research methods, they are best suited to studies aiming to generate hypotheses, as is the case in the initial stages of this research (Auerbach and Silverstein, 2003).

After reviewing available methods, focus groups were selected as the most appropriate method. This decision was based on the requirements of the research, being at an early, exploratory stage and the need to collect data from a large and diverse population to inform later aspects of the project. While

exploratory interviews and citizens' juries may have been appropriate to gather such initial data, exploratory interviews were dismissed as too time-consuming and complicated to organise a sufficient number whilst citizens' juries were excluded on grounds of costs, difficulties in arrangements and likely problems in finding participants willing to spend two days considering biofuel issues.

### **i) Exploratory Interviews**

An exploratory interview, also known as a Free-style interview, is an exercise for gathering information on the thoughts, feelings and experiences of an individual in relation to the research topic (Oppenheim, 2005). These interviews are often called free-style as they do not follow any pre-defined structure and there should be minimal input from the interviewer with the exception of reassurances, encouragement and a small amount of guidance if required to ensure discussions remain relevant (Oppenheim, 2005).

The intended outcome of an exploratory interview is to help inform the research plan and help develop hypotheses and questions to be answered at a later stage (Oppenheim, 2005). As such, exploratory interviews could have been appropriate for initial research into public attitudes and opinions on biofuels. However, the method was rejected because the one-to-one basis of interviews would be too time-consuming and likely to be off-putting to potential participants. In addition it was not clear how individuals could be identified and invited to participate from a vast and diverse population.

### **ii) Citizens' Juries**

A citizens' jury is a group of randomly selected individuals, brought together to discuss and take decisions on a specific issue, usually over a period of two or three days (Smith and Wales, 1999, Ward et al., 2003). During the course of a citizens' jury, selected individuals are presented with information on the issue by expert 'witnesses' (Ward et al., 2003, Smith and Wales, 1999). After all relevant information has been presented, the group have a period of discussion during which they are expected to reach decisions and make recommendations in relation to the topic, ideally in consensus (Smith and Wales, 1999, Ward et al., 2003). The conclusions of the group discussions are presented to the

official body convening the jury, who are in turn required to respond to the group's findings (Ward et al., 2003, Smith and Wales, 1999).

Although a citizens' jury could potentially yield a large amount of useful information, the costs and time involved were prohibitive and the length of time needed from participants was likely to be a disincentive. In addition, the need to draw conclusions and make decisions was not required at this stage of my research.

### **iii) Focus Groups**

A focus group is defined as a specifically designed discussion, or series of discussions, intended to gather views and experiences, in relation to a topic of interest, from a range of people (Berland et al., 2008, Kitzinger, 1994, McConnell, 2000). The main difference between a focus group and an interview is the inclusion of multiple participants in one session and the ability to observe how individuals formulate opinions and assess priorities, through the exchange of ideas and perspectives during the discussions (Barbour, 2007, Bloor, 2001, Clapper and Massey, 1996, Kitzinger, 1995). This enables investigation of not only what people think, but why they think the way they do (Clapper and Massey, 1996). Many authors consider the group interaction to be one of the most important outcomes of the focus group process (Barbour, 2007, Kitzinger, 1995, Berland et al., 2008). Kitzinger (1995) states, the principle of the focus group is to enable exploration and clarification of participants' ideas, encouraging them to raise and address aspects of the topic that are of importance to them. The ability to probe responses to gather more detailed information in a less structured way than in an interview is widely considered a key benefit of a focus group approach (Nagle et al., 2008, Reed and Payton, 1997).

Focus groups are considered to be useful tools in the early stages of a research project, and well suited to the investigation of attitudes, knowledge and opinions of people in relation to a specific topic, making them particularly suitable for the purposes of this project (Berland et al., 2008, Barbour, 2007, Kitzinger, 1995). While focus groups are rarely used as a sole research

method, the outcomes of a focus group can be useful in developing questionnaires for use at a later stage of the research project (Barbour, 2007, Bloor, 2001, McConnell, 2000). The absence of any other data on which to base a questionnaire survey of public knowledge and attitudes in relation to biofuels, made focus groups and their ability to identify and assess public concerns the most desirable method for the project.

### **3.3 Focus Group Theory**

There is a large amount of literature available providing advice on how to best plan, set up and run focus groups (Barbour, 2007, Beyea and Nicoll, 2000, Bloor, 2001, Clapper and Massey, 1996, Greenbaum, 1998, Kitzinger, 1994, Kitzinger, 1995, Klein et al., 2007, Kyle and Marks-Maran, 2008, Litosseliti, 2003, McConnell, 2000, Reed and Payton, 1997, Webb and Kevern, 2001). However, within such a large range of sources, there are many areas on which authors are not agreed in relation to best practice. In general, the optimum number of participants for a focus group is between 4 and 12 individuals, with certain authors preferring larger or smaller groups (Clapper and Massey, 1996, Easton et al., 2003, Greenbaum, 1998, Kitzinger, 1994, Kitzinger, 1995, Kyle and Marks-Maran, 2008). There are dangers associated with both under and over-recruitment. A group that is too small may suffer from a limited range of discussions but enable each individual more time to express their opinions; a group that is too large may cover a wider range of issues but not be able to explore them in sufficient depth and potentially deny some participants time to express themselves (Bloor, 2001). In addition it is also common practice to recruit more participants than required to compensate for the potential that some recruits may not attend the focus group session (Bloor, 2001). As such, desired numbers of participants needs careful consideration and management. As well as numbers, group composition and diversity need to be considered during recruitment of participants. On this matter, authors are divided between the benefits of homogenous and diverse group composition (Bloor, 2001, Easton et al., 2003, Kitzinger, 1995, Kitzinger, 1994).

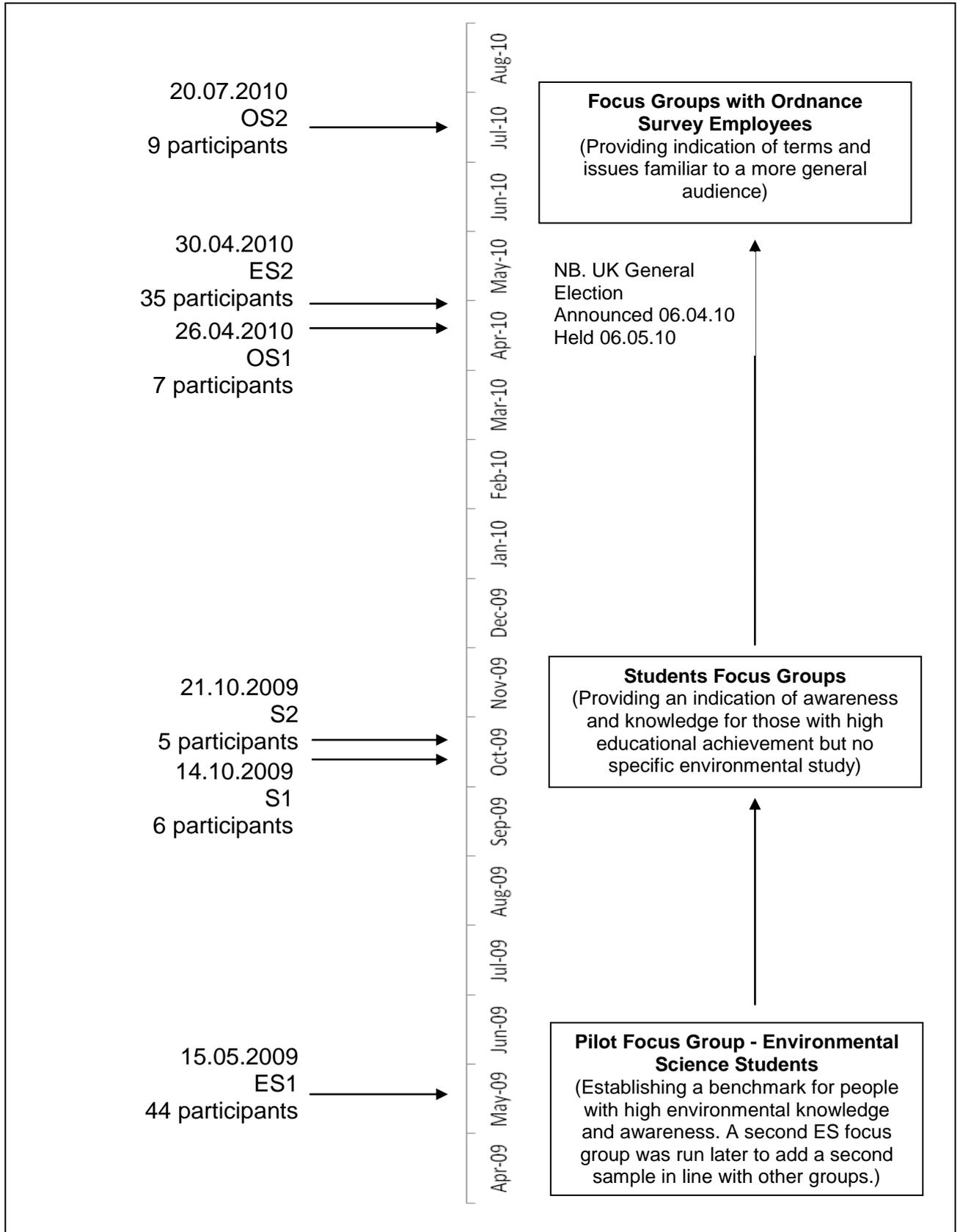
### **3.4 Qualitative Data**

The data collected using focus groups is referred to as qualitative data. Qualitative data is data in the form of words, as opposed to data in the form of numbers, which is known as quantitative data (Auerbach and Silverstein, 2003). Traditionally, qualitative and quantitative methods and data were considered to be fundamentally different and, therefore, incompatible (Howe, 1988). However, the increase in mixed methods studies has seen combinations of qualitative and quantitative methods, data and analysis become more widely accepted (although not universally) and more frequently used (Jick, 1979, Abeyasekera, 2002, Howe, 1988, Sandelowski, 2000, Sale et al., 2002). The use of quantitative analytical techniques on qualitative data is believed to aid in the identification of useful results in what is often a huge volume of qualitative data (Abeyasekera, 2002). The term 'quantitizing' was coined to refer to the process of converting qualitative data into factors that can be considered numerically (Sandelowski, 2000). In order to quantitize qualitative data it is necessary to be able to identify clearly distinct units within the data, that have no ambiguous meaning (Sandelowski, 2000).

There is still some debate about the appropriateness of combining quantitative and qualitative techniques in a study. However, the combination of the two methods is increasingly seen as acceptable as long as they are intended to be complementary to each other; providing different perspectives on an issue, rather than one being used as validation for findings of the other (Sale et al., 2002).

While qualitative methods have been selected as the most appropriate methods for the nature of the research at this stage, it is believed that the use of quantitative techniques would provide a useful complementary analysis for the data collected from the focus groups.

### 3.5 Methodology



**Fig 7. Timeline of Focus Groups and their role in the development of the project**

Fig 7 lays out the timeline of focus groups held as part of the project. A total of six focus groups were run for this chapter, with 2 groups for each of 3 classifications.

It was decided that all focus group sessions would be set-up and run within the Southampton area. This decision was based on limited time and resources as well as evidence from the literature which suggested that use of multiple geographic locations would be of limited benefit without express reason to suspect it would affect results (Greenbaum, 1998). Due to the early stage of the investigation, there was no reason to suspect multiple locations would be of benefit.

An initial pilot session was held with a group of Environmental Science students (ES1) at the University of Southampton. As well as serving as a trial of the method, the group would provide a benchmark for attitudes of people likely to have higher awareness and concern for environmental issues. In line with the second purpose, a second session was run with a different group of Environmental Science Students (ES2) so that each type of group was represented by two separate sessions. Two focus groups were run with groups from the general student population (S1 and S2) to collect data from people with high educational achievement but no specific exposure to environmental issues. A further two focus groups were run with employees from Ordnance Survey in Southampton (OS1 and OS2), providing a general and older sample. Although efforts were made to involve a wider range of external organisations, only Ordnance Survey were willing to provide access to their staff.

### **3.5.1 Question Guide Design**

While a focus group is not a rigidly structured method governed by set questions, it was necessary to create a question guide to help the moderator and ensure important topics were covered consistently in all sessions. Use of a question guide is discussed in focus group theory literature, and considered to be particularly useful (Greenbaum, 1998, Greves et al., 2007, Krueger, 1998).

The initial question guide (Appendix 1) set out 12 questions to be covered during the session and was designed to meet the aims detailed in Chapter 1.

**i) Assessing Awareness of Biofuels (RA1)**

Questions 1 and 2 assess existing awareness of biofuels. Question 1 was based on the assumption that participants would name all energy generation options they are aware of and that the order in which options were named had relevance to degree of awareness. Question 2 was a more direct approach and aimed to provide an assessment of awareness for each individual. However, it must be acknowledged that the group setting presents the potential for over representation of awareness, as participants may feel pressured or intimidated to conform with the majority view (Barbour, 2007, Kitzinger, 1995).

**ii) Assessing Knowledge of Biofuels (RA1)**

Questions 2, 3 and 6 assess knowledge of biofuels. Each question was designed to encourage participants to share their knowledge of biofuels, and provoke discussions of differences and similarities in opinions. Depth of knowledge can potentially be assessed by length of time an issue is discussed for and how much detail is provided.

**iii) Identifying Trusted Sources of Information (RA2)**

Question 5 and its subsidiary parts were designed to identify the sources of information participants used and which of these were considered to be more or less trustworthy. It is considered important to assess levels of trust in different sources of information, as trust is an essential component in how effective the communication of information is (Thiede, 2005).

**iv) Identifying Issues of Most Concern (RA3/RA4)**

Questions 2, 3 and 9 aimed to identify issues of most concern through the discussion of known positive and negative issues associated with biofuels.

**v) Comparing Biofuels to Other Energy Options (RA5)**

Question 4 was included to compare opinions of other energy generation options with those of biofuels. The question aimed to encourage comparison of

different energy generation options with the hope that participants would state or develop preferences. Comparisons could also be made through the comparison of the overall proportion of positive/negative comments made about biofuels with those made about other energy generation options.

**vi) Assessing Awareness of Government Biofuel Position (RA6)**

Question 7 was aimed at assessing awareness of the government position on biofuels and relevant policies, with particular interest in public awareness of the RTFO.

**3.5.2 Pilot Focus Group – validating the process**

A pilot focus group was undertaken with a group of third year Environmental Sciences students at the University of Southampton. The aim was to test the suitability of the question guide and enable the moderator to become familiar with the focus group process. Audio and visual recordings were made of the session for transcription in addition to manual note taking by an assistant moderator. Multiple recording methods ensured that no data was lost in the event of a device failure or lack of clarity in one recording (Sims, 1998). The session was attended by forty four students. All participants were required to read and sign a consent form for recording.

Interactive ‘zapper’ pads were used for the session, with each participant being provided with a pad to respond to certain questions. As well as generally piloting the technology to assess its usefulness in a large focus group setting the ‘zappers’ made it easier to collect and collate data for certain questions. There is some literature that specifically deals with the use of technology in focus groups (Clapper and Massey, 1996, Easton et al., 2003), which shows that the technology can aid the focus group process by providing anonymity in answering that can increase the truthfulness of answers by reducing peer pressure and fear of judgement by other group members (Clapper and Massey, 1996, Easton et al., 2003).

The session lasted for 45 minutes. Whilst this was shorter than intended and the literature recommends, all questions were covered to the greatest extent possible. Upon conclusion, participants were asked to complete an evaluation questionnaire as part of the pilot process.

### **i) Changes as a result of the pilot session**

Pilot session feedback was largely positive, more than 90% of participants were happy with the length of the session and none felt it was too long. Most participants (58%) felt the group size was too large. This was to be expected as 44 participants made the group larger than the recommended 4 to 12. The size of this group was dictated by the size of the class rather than recruitment. Future sessions would not be as large. Almost all the students (97%) felt that the introduction to the session was useful. None reported lack of understanding of the purpose of the session or what their participation involved.

In terms of individual involvement, 84% of respondents felt fully or mostly able to participate in discussions. Three individuals reported feeling “*Mostly Unable*” to participate, with group size being the most cited factor affecting ability to contribute. Other factors reported as affecting contribution included: dominance of other participants, fear of or intimidation by the group as well as not having anything to contribute. These are in line with factors highlighted in the literature (Greenbaum, 1998, Kitzinger, 1994, Morgan, 1998) and are unsurprising in such a large group.

The vast majority of participants (94%) felt responses were recorded accurately. Overall moderator performance was considered to be good or very good by almost all respondents (94%). Almost three quarters (74%) were happy with how the moderator tried to ensure equal participation. Three individuals rated the moderator’s efforts as “*Quite Bad*”, although provided no further explanation. As no conflict incidents occurred during the session, it is unsurprising that almost half of participants (45%) expressed no opinion on the moderator’s ability to diffuse conflict.

As a result it was felt that apart from group size which was a known issue and the inadequate room the process was sound and could be more widely used in the other focus groups

## **ii) Question Guide and Session Revisions**

As a result of feedback from participants and experiences of the moderator, changes were made to the question guide. Section one of the question guide, with the introduction to the session and the moderator were kept the same. Question 2 was changed to only consider naming known energy options, excluding the question of preference as this duplicated a later question that explored opinions of different energy generation options in relation to biofuels.

Questions 3 – 6 were merged into one question covering who had heard of biofuels and what was known about them. It was felt that the original questions 5 and 6, about positive and negative aspects of biofuels, were potentially leading and that getting participants to discuss what they knew about biofuels without positive/negative prompts would yield more valuable data and potentially provide greater insight into whether their knowledge was predominantly concerned with one aspect over the other.

Question 7, regarding sources of information, was largely unchanged. Question 8, about acceptability of biofuel problems, was removed as an individual question, with the issue being included in a question about improvements to biofuels.

Question 9 comparing different energy generation options was mostly unchanged, although further probing questions on reasons for preferences were added to the revised question guide.

Question 10, regarding government support for biofuels, was changed as the initial wording was felt to be potentially leading. Instead of asking why government support biofuels, the question was reworded to ask if the government were supportive of biofuels and, if so, how. The question was also expanded with more probing options in the revised guide.

Question 11, asking about potential improvements to make biofuels more acceptable was expanded to include questions about acceptability and comparison of negative impacts with benefits that biofuels may provide. The additional questions were added to provide greater depth of answers.

Question 12, about biofuel availability and knowledge of the RTFO was changed slightly, to ask if participants knew about biofuel availability rather than focussing on willingness to use biofuels.

As well as changes to questions new questions were added including asking whether participants felt well informed about biofuels, if they would like to be better informed, what their opinion was of other measures that may potentially reduce emissions from transport, opinions on certification and sustainability standards and willingness to pay extra for biofuels. The new questions were created to fill gaps noticed in the pilot session. Asking if participants felt well informed was felt to be important as an indicator against which to assess their actual level of knowledge.

### **3.5.3 Recruitment to Focus Groups**

#### **i) Screening Questionnaire**

Many focus groups preselect members to ensure they are properly configured. A screening questionnaire is typically used during recruitment of participants to collect person details to be used for the purposes of structuring and managing the group composition, to ensure the desired representation and targeting of the research (Bloor, 2001, Greenbaum, 1998). Screening can also be used to assess if potential participants have existing knowledge/experience of the topic of interest, if this is important. Prior knowledge and experience were not necessary in this case, and so screening was only concerned with demographic information, contact details and availability for participation. For this work, the screening questionnaire only collected information on age, gender, hometown, ethnic and religious background, ability to drive, contact email address and availability to attend a focus group session. This information was collected to aid group composition. Respondents were assured that the information

provided would be confidential. Overall response to the recruitment campaign was low.

## **ii) Recruitment**

Due to the variety of recruitment methods available (Greves et al., 2007, Skinner et al., 2003, Wilson et al., 2008, Wittenberg et al., 2007, Morgan, 1998), different recruitment methods were trialled on students within the University of Southampton to ensure selection of the most effective recruitment method. Methods trialled included poster advertisements, email contact via existing email lists, as well as face-to-face recruitment, in a public area.

For posters and email contact, individuals were requested to contact via email or telephone, after which they would be sent a short (screening) questionnaire. In the case of the face-to-face recruitment, the screening questionnaire was delivered by the recruiter on the spot, with contact details recorded to inform participants of their selection at a later date.

Email contact was the most successful recruitment method, in terms of number of expressions of interest and number of interested parties attending their assigned session. None of the face-to-face recruits attended their allocated session or made contact to inform of non-attendance.

The low number of volunteers for the student sessions limited the potential for selection of participants based on the screening questionnaire. Due to the low number of recruits, all those who had completed screening questionnaires were allocated to one of two focus group sessions, attempting to create groups with as much diversity as possible.

All participants were informed by email of their selection with information about their session including when and where the session would be held. It was made clear that sessions were not compulsory and that volunteers were under no obligation to attend. A reminder email was sent two days prior to each session, reminding participants that they were under no obligation to attend if they did not wish.

Due to the lack of success of face-to-face recruitment, plans for wider recruitment were based on posters and emails. Due to the broad nature of the population from which a sample needed to be taken (the general public) the decision was taken to focus recruitment efforts through large employers in the Southampton area. Twenty such employers were approached and asked about displaying posters advertising focus groups or if information could be circulated via internal email lists. Of those contacted, only one company was forthcoming in providing assistance and displayed posters and emailed employees regarding the research.

While such an approach to recruitment potentially limited the demographic range of participants, it was considered to be a necessary step to ensure an adequate number of participants for this stage of the research.

As the final participant sample was limited in its demographic representation of the wider Southampton and UK populations, it was not possible to draw conclusions that can be generalised and applied to the broader population from the results of the focus groups. However, as this stage of the research was designed as an exploratory exercise to inform a questionnaire to then be distributed to a more extensive and representative sample, the group of participants was considered adequate for the purpose.

### **3.5.4 Data Analysis Methodology**

#### **i) Transcription**

Following each focus group the audio recordings were transcribed using the software NVivo. To ensure accuracy, audio recordings were played through once with initial transcriptions being made. Following this first round, recordings were played a second time to check transcriptions already made, make corrections and fill in any gaps. Transcription was checked a third time for remaining gaps and unclear identities using video recordings.

Transcriptions were written verbatim, containing everything said by interviewees, in the interests of thorough and unbiased analysis and to ensure

the researcher was fully familiar with the contents of the interview (Halcomb and Davidson, 2006). However, for the benefit of the reader, where quotes are presented as illustrations in the results or discussion sections, appropriate punctuation and corrections have been made to aid clarity.

## **ii) Quantitative Analysis**

The use of quantitative techniques in the analysis of qualitative data is considered by some to be an important method for handling data such as those examined by this study (Abeyasekera, 2002, Hayashi, 1952).

It is considered that, for some aspects of the data collected here, such as number of biofuel issues discussed as an indication of breadth of knowledge and number of positive versus negative comments about biofuels as an indication of overall opinion, quantitative methods can be appropriately applied. While the sample selection for each group would not be adequate to allow for any results to be projected onto the wider population, the structure of the data should be suitable for some quantification. While some data were subjected to quantitative analysis, these methods were not suitable for all the data collected.

Comments were assigned as being positive, negative or neutral as part of the transcription process. Personal judgement based on both knowledge of the impacts of biofuels and the context of the comments within the discussion were used to assess and assign the positive, negative and neutral labels to the comments. As an example, discussion of the ability for biofuels to reduce carbon dioxide emissions would have been considered positive - due to its positive impact on reducing human contributions to climate change - whilst discussion of biofuels leading to increased food prices would have been considered negative – due to the negative impacts of this on the ability of people to feed themselves.

On the whole, comments and topics were easily identified and separated as participant knowledge was limited and, as such, they seemed unaware of the complexities and interlinking of issues. The result of this was a conversation in which considerations of individual issues were notably distinct and identifiable

as individual components that could be coded and assigned positive, negative or neutral labels. Separating comments and topics was facilitated by the use of NVivo for coding.

### 3.5 Results

Results are presented and discussed by question.

In the interests of brevity, each focus group has been assigned a code that will be used throughout the results and discussion: ES1 – First Environmental Sciences Group, ES2 – Second Environmental Sciences Group, S1 – First Student Group, S2 – Second Student Group, OS1 – First Ordnance Survey Group, OS2 – Second Ordnance Survey Group.

#### 3.6.1 Question 1: What ways of generating energy can you think of?

Named Energy Generation Technologies/Fuels	ES1	ES2	S1	S2	OS1	OS2
Air Source Heat						X
Anaerobic Digestion					X	
Biofuel	X	X		X		X
Biomass	X	X				
Coal	X	X	X	X	X	X
Combined Heat and Power						X
Electricity						X
Gas	X	X	X	X	X	X
Geothermal	X	X	X	X	X	X
Ground Source Heat		X			X	X
Hydroelectric		X		X		X
Hydrogen			X	X		X
Hydrolysis			X			
Incineration			X			
Landfill Gas					X	
Methane					X	
Nuclear	X	X	X	X	X	X

<b>Oil</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>		<b>X</b>
<b>Petrol</b>			<b>X</b>	<b>X</b>		
<b>Photovoltaics</b>		<b>X</b>				
<b>Solar</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Tidal</b>		<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	
<b>Water Source Heat</b>						<b>X</b>
<b>Wave</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>		<b>X</b>
<b>Wind</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>

**Table 2. All mentioned energy generation technologies/fuels and the groups in which they were raised**

As can be seen in Table 2, a total of 25 different fuels/energy technologies were named across the six groups. However, only four named biofuels without prompting.

In considering when biofuels were named in discussion; ES1 named biofuels 7<sup>th</sup> of ten options, S2 named them 1<sup>st</sup> of twelve options, OS2 named them 14<sup>th</sup> of sixteen options and ES2 named them 9<sup>th</sup> of fourteen options. Other than S2, who named biofuels first, the other three groups named a number of other fuels before biofuels.

Coal and Gas were each named by all six groups; oil was named by five of the six. Other options named by all six groups included; Geothermal, Nuclear, Solar and Wind.

### **3.6.2 Question 2: Have you heard the term Biofuel before today?**

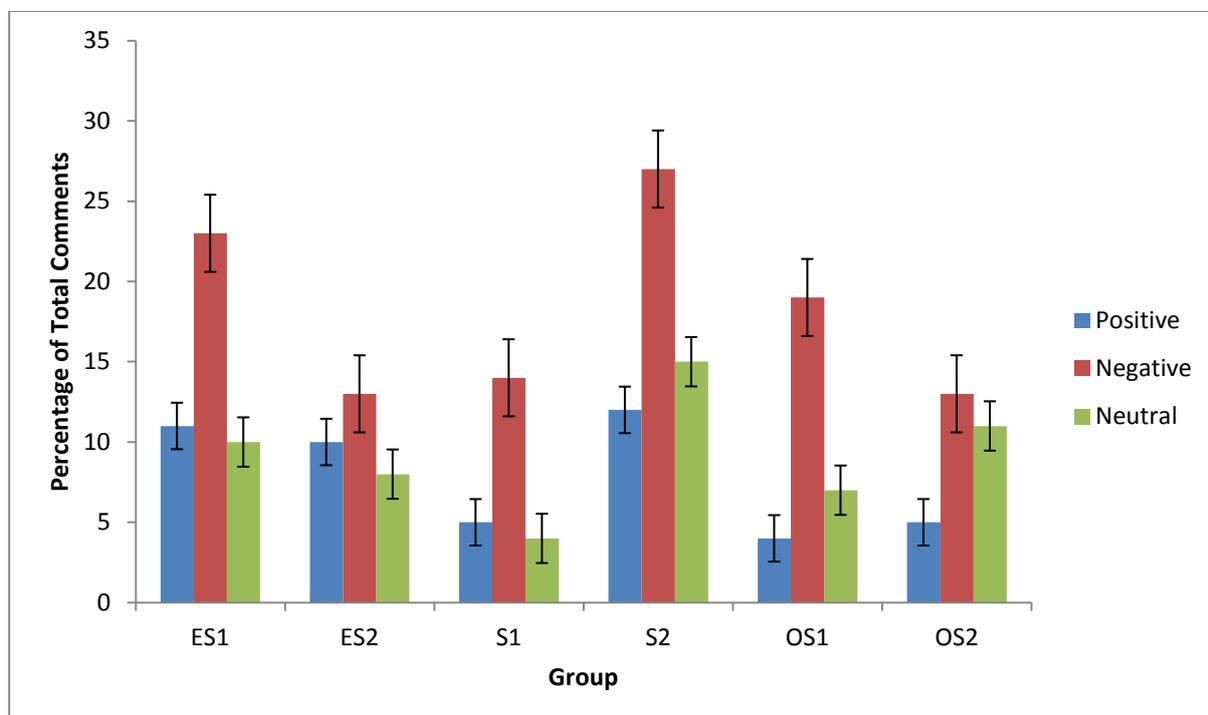
Despite only four of the six groups having named biofuels as a known energy generation option, all members of all groups said they had heard of biofuels previously when asked directly. Further to the findings of question one, these results suggest that awareness of biofuels is wide spread. However, taken in conjunction with the previous results, it would seem that, although wide spread, biofuel awareness is low in some groups, explaining why some groups did not name biofuels without prompting.

### 3.6.3 Question 3: What do you know about biofuels?

As the data collected on knowledge of biofuels could be separated into clearly distinguishable units - the individual issues related to biofuels, and whether they were positive, negative or neutral – and participants were given equal opportunity to name negative, positive or neutral issues, it was considered that this data was suitable for some quantification. As such, numbers of issues raised, in each group and across the six groups, were taken and proportions of positive, negative and neutral comments were calculated.

Overall, 122 biofuel related issues were raised across the course of the six focus groups. Of these issues, 56 were negative (45.90%), 31 were positive (25.41%) and 35 were neutral (28.69%).

A chi squared test produced a statistically significant result ( $X^2=8.869$ , d.f. =2,  $p<0.05$ ). As such, it appears that the participants were aware of significantly more negative biofuel issues than positive or neutral issues.



**Fig 8. Percentage of biofuel related comments classified as positive, negative or neutral for each session**

Fig 8 shows the percentage of positive, negative and neutral comments made in each of the focus group sessions. For ES1, S1, S2 and OS1, results of statistical testing revealed significant differences, suggesting a significant trend towards a greater proportion of negative comments. For ES2 and OS2 statistical testing showed no significant difference. Full results of statistical tests can be found in Appendix 2.

#### **i) Most Discussed Topics**

It was considered important to identify which of the issues raised were most widely known, for the purposes of drawing conclusions about knowledge of biofuels as well as for the design of a questionnaire. As such, all issues raised were assessed on the basis of the number of groups that had discussed them.

#### **ii) Themes of Discussions**

During the process of assessing frequency of discussion of the different issues, a number of broad categories of discussion were developed from the list of individual issues raised. It was hoped this might be helpful in identifying broad areas of concern which might correlate with areas of greatest concern.

From the 122 issues discussed, seven broad themes of the focus of discussions were identified (full list can be found in Appendix 3); Humanitarian Issues, Technological Issues, Environmental Issues, Knowledge of Feedstocks, Knowledge of Brazil's use of biofuels, Financial Issues, Issues related to Fossil Fuels and Issues of Access to biofuels. While the majority of issues could be assigned to one or more of these categories, not all topics of discussion could be assigned to a broader category.

'Environmental Issues' accounted for the greatest number of the issues discussed (39). 'Technological Issues' were second most discussed, with 17 issues, followed by 'Feedstocks' (14), 'Financial Issues' (11), 'Humanitarian Issues' (11), 'Fossil Fuels' (6) and 'Access to Biofuels' (4). A chi squared test showed this difference to be statistically significant ( $X^2=55.846$ , d.f. =6,  $p<0.001$ ).

### iii) Individual Issues

In terms of individual issues raised, each topic was considered on the basis of the number of groups that raised and discussed it, creating a hierarchy of issues. It is assumed that the greater the number of groups that discussed an issue, the greater the extent of awareness amongst the participants as a whole.

Issues discussed are displayed in Table 3.

Issue	ES1	ES2	S1	S2	OS1	OS2
Extensive land use required for biofuel production	X	X	X	X	X	X
Deforestation resulting from the need to produce biofuels	X	X	X	X	X	X
Increased food prices and reduced food supplies resulting from biofuel production	X	X		X	X	X
Brazil as a user and producer of biofuel	X	X		X	X	X
The potential to recycle chip oil as a biofuel	X	X	X		X	X
High levels of inputs to agricultural production	X	X			X	X
Impacts of biofuel production on biodiversity	X	X		X	X	
The idea that biofuels are carbon neutral	X	X	X			X
Use of monoculture in biofuel production	X	X			X	X
Humanitarian issues, relating to native peoples right to land and access to benefits of biofuel	X	X		X		
Use of algae in biofuel production	X	X				X
Negatives of using GMOs in biofuel production	X	X		X		
The absence of other options for fuelling transport	X				X	X
The need to modify cars in order to utilise biofuels	X		X	X		
Biofuels as a renewable fuel	X	X		X		
The availability of biofuels in a few petrol stations		X	X	X		
Use of Sugar Cane for producing biofuel		X		X		X
Inability to produce sufficient biofuel			X	X		X
Inability to buy biofuels at petrol stations in the UK			X	X	X	
Potential for biofuels to cause damage to vehicles			X	X		X

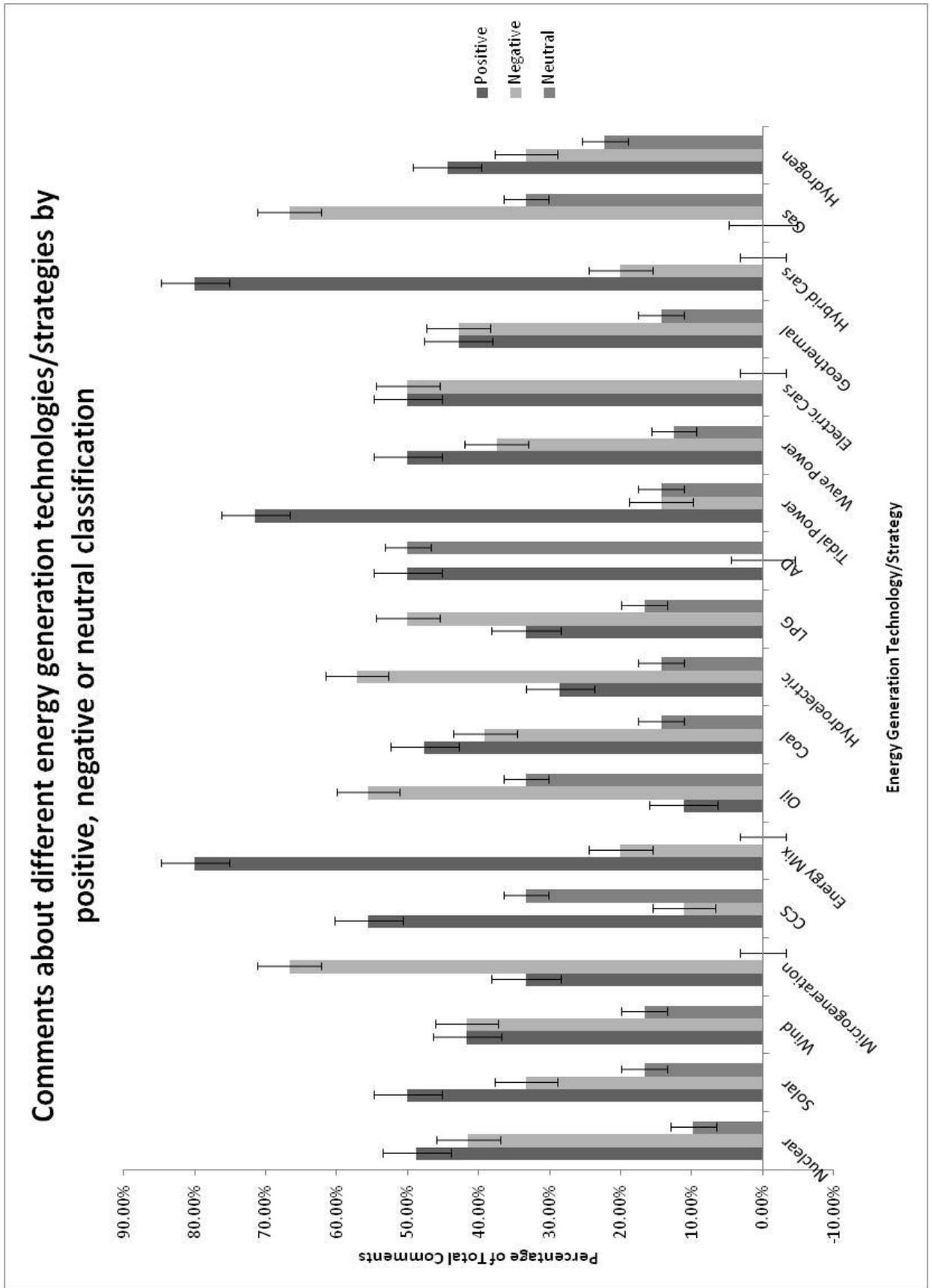
**Table 3. Most frequently raised topics of conversation relating to biofuels by session**

As can be seen in Table 3, the most discussed issues cover a range of themes; however, seven of the twenty most discussed issues are concerned with environmental impacts.

#### **3.6.4 Question 6: What are your opinions of other energy generation options? How do they compare to biofuels?**

In total, across all focus group sessions, discussions relating to eighteen different energy generation options (technologies or fuels), in addition to biofuels, were identified; Nuclear Power, Solar Power, Wind Power, Microgeneration, Carbon Capture and Storage (CCS), Mixed Energy Sources, Oil, Coal, Hydroelectric Power, Liquid Petroleum Gas (LPG), Anaerobic Digestion (AD), Hybrid Cars, Wave Power, Electric Cars, Tidal Power, Geothermal Energy, Gas and Hydrogen.

Fig 9 shows the percentage of time spent discussing the positive, negative and neutral aspects of each of these fuels and technologies.



**Fig 9. Comments about different energy technologies/fuels/systems by proportion of positive, negative and neutral comments**

Data relating to each of these energy generation options were examined separately to identify and code aspects of each discussion that could be classified as being positive, negative or neutral towards the energy option in question.

Whilst CCS and Electric Vehicles do not actually fall under the category of energy generation options or technology, they were retained as evidence of lack of moderator interference in discussions.

For full data tables please see Appendix 4: Focus Group Question 6 Results

### **Comparison with opinion of Biofuels**

While it would not be possible to compare total numbers of comments made about the different energy options and biofuels, due to the greater number of biofuel related prompts during the focus group process, the proportions of positive, negative and neutral comments can be examined.

To aid comparison, all options discussed are displayed in Table 4 according to their relative rank; their rank based on the proportion of negative and positive comments made, relative to the other options discussed.

Energy Option	Positive Comments (%)	Negative Comments (%)	Neutral Comments (%)	Relative Rank
Energy Mix	80.00%	20.00%	0.00%	1
Hybrid Cars	80.00%	20.00%	0.00%	2
Tidal	71.43%	14.29%	14.29%	3
AD	50.00%	0.00%	50.00%	4
CCS	55.56%	11.11%	33.33%	5
Solar	50.00%	33.33%	16.67%	6
Wave	50.00%	37.50%	12.50%	7
Hydrogen	44.44%	33.33%	22.22%	8
Coal	47.62%	38.10%	14.29%	9
Nuclear	48.78%	41.46%	9.76%	10
Electric Cars	50.00%	50.00%	0.00%	11
Geothermal	42.86%	42.86%	14.29%	12
Wind	41.67%	41.67%	16.67%	13
LPG	33.33%	50.00%	16.67%	14
<b>Biofuel</b>	<b>25.41%</b>	<b>45.90%</b>	<b>28.69%</b>	<b>15</b>
Hydroelectric	28.57%	57.14%	14.29%	16
Microgeneration	33.33%	66.67%	0.00%	17
Oil	11.11%	55.56%	33.33%	18
Gas	0.00%	66.67%	33.33%	19

**Table 4. Percentage of comments classed as being positive, negative or neutral for each energy option discussed, with relative rank**

As can be seen in Table 4, biofuels ranked as the fifteenth of the 19 options discussed. While biofuels did not receive the lowest rank their position suggests they were certainly not one of the most well thought of options. ‘Traditional’ renewable energies, such as wind, solar and wave, all ranked more highly than biofuels. Two of the three fossil fuels, oil and gas, were ranked lower than biofuel. Coal was an exception to this, ranking more highly than biofuel. This is likely to be due to the large amount of support for coal from a few members of

certain focus groups and also the potential of CCS to reduce the emissions produced by the combustion of coal that was discussed.

### **3.6.5 Question 7: Where have you/do you find out about biofuels? Which sources do you think are trustworthy/reliable?**

Overall, participants mentioned eleven different sources of information across the six sessions; Newspapers, Television, Scientific Articles and Journals, Friends and Relatives, The Internet, The News, Magazines, School and University, NGOs, Radio and the Biofuels Watchdog. No one source was discussed by all six groups. In addition to these, a further three potential sources were raised for discussion by the moderator; the Government, Scientists and the Oil Industry. These sources were introduced by the moderator as it was felt they were important potential sources, the opinions of which were relevant to the research, despite the groups not raising them themselves.

#### **i) Newspapers**

Newspapers were discussed by five of the six groups, with the exception being ES2. The general opinion of newspapers seemed to lean towards distrust, although there were discussions about specific titles that were considered to be more or less trustworthy.

*“It depends what newspaper”* – ES1

*“You wouldn’t trust like The Mirror or The Sun, The Sport, The Express”* – ES1

*“You’d be selective about the newspapers, not The Sun or The Daily Mail”*  
– OS2:1

*“I read The Independent, that has more [pause] it had more environmental issues in”* – S1:6

*“I wouldn’t trust The Sun as far as I could throw it. Whether if I read something in The Guardian or The Independent you you sort of trust it a little bit more” – S1:2*

In general, tabloid newspapers, such as The Sun and The Daily Mail were considered untrustworthy. Broadsheets, including The Guardian and The Independent were considered more trustworthy.

## **ii) Television**

Five of the six groups discussed television as a source of information, with the exception being ES1. In addition to television news, there were discussions about television programmes and documentaries, with specific references to Panorama and Countryfile. General opinion suggested a lack of trust in television as a source of information, although the BBC was highlighted as a potentially more reliable source. There was also acknowledgment that the general public were likely to rely on media sources such as these.

*“In my dissertation I did something about reliability of the media [inaudible] public awareness a lot. In general my questionnaire, I found that television and broadcast media is what they [the public] deem to be the most reliable” – ES2*

*“I don’t, I don’t know, I mean knowing some of my just peop[le] talking to, people they’re more likely to trust the BBC over another, you know, other or ITV or other organisation because they are they’re funded by the licence payer” – OS2:9*

There was also concern expressed about conspiracy type documentaries on television, such as ‘The Great Global Warming Swindle’ that promote an anti-environmental point of view and may confuse or misinform the public.

*“There was [inaudible] environmental conspiracy that there, we were like um like to believe yeh is climate change a complete myth” – S1:1*

### **iii) Scientific Articles and Journals**

Scientific articles and journals as a source of information on biofuels were discussed in five of the six groups, with the exception being OS1.

For the groups that discussed them, journals and articles were considered to be a trusted source of information.

*“Journals are usually fairly reliable but you have to make sure they’re peer reviewed” – ES2*

*“If it’s something that’s peer reviewed or something that that’s probably a more trustworthy source than someone appearing on Horizon or something” – OS2:6*

*“Unless it’s a journal done with scientific evidence, it’s not really going to be unbiased” – S1:1*

However, there was also an opinion expressed in some groups that, while reliable, journals were less suitable for a general audience such as the general public.

*“It’s quite difficult yeh, articles are very long, it’s very time consuming and when you do other studies er are non relative not related so you won’t really like take the time to like make your own opinion cos obviously articles als [sic] also you have to read with critical mind” – S2:1*

### **iv) Friends and Relatives**

Five of the six groups discussed friends and relatives as sources of information on biofuels, with the exception being ES1. For some groups, friends and relatives were named as a source they personally had obtained information from, while for others, they were named not as a

source they used personally, but as a source that the general public may utilise.

*“[where do you think the majority of people get their information from?] um just talking to each other, you know like peers and Mrs Smith down the road talks to Mrs Jones” – ES2*

*“A lot of people just get their information from people they know” – OS2:1*

*“Cos I discuss that [biofuels] sometimes with my friends” – S2:1*

*“Parents. My dad’s a biologist so [tails off]” – S2:2*

In relation to how trusted friends and relatives are as a source of information, opinions were mixed. Whilst not explicitly stated, it seems reasonable to assume that those who made use of information from friends and relatives personally, considered them to be a reliable source. Others were more sceptical.

*“[Getting information from friends or relatives is] not necessarily always the right thing” – ES2*

#### **v) The Internet**

The Internet as a source of information on biofuels was discussed by four of the six groups, the exceptions being both ES1 and ES2. General opinion about the internet as a source of information seemed to be that it was convenient, easy to use, accessible by a large number of people and a good way of finding out more about an issue of interest.

*“We haven’t actually got Google on there [the list] but if there was something I wanted to know about that’s where I would do the next step” – OS2:7*

*“There’s Wikipedia because it’s available for everyone when you search about any topic on Google it usually comes up as one of the top results” – S2:1*

**vi) The News**

The News, referring to television news, was discussed by four of the six groups, with the exceptions being ES1 and OS1. Again, general opinion of the news as a source of information was mixed. While there were some who felt the news was trustworthy, a large number considered it to be wholly untrustworthy and liable to report incorrect information.

*“Just the general sort of BBC news, you know, what they hear but generally they’re [TV News] just reporting the stories rather than the facts” – OS2:9*

*“I think English tv’s pretty balanced by law they’ve got to be so, I don’t know” – S2:4*

*“They [TV News] might sometimes either get the wrong information or like, conclude wrongly, just because they [TV News] don’t see the whole picture when they do their reports” – S2:1*

*“I always think the news is biased” – S1:6*

There was also a middle ground, where it was felt that the news, taken as a whole rather than individual broadcasts or stories, was probably reliable and a good starting point for finding out about a subject.

*“I say it [TV News] was good for main points, sort of thing, but any detail it tells you can’t be trusted really” – S2:2*

*“I would say TV news very good for er, information though as in new information, that’s where you’ll get it from and if you get interested you might check it out yeh” – S2:1*

*“If you kind of take it [TV News] as a whole you might get somewhere” – S1:3*

Despite mixed feelings, there was acknowledgement that the news has great power to inform a large number of people.

*“But you can reach more people through TV news than you ever would through scientists or something” – S2:4*

Another interesting point made in the discussions about the news was the fact that many participants felt biofuels (and other environmental issues) had not received as much coverage as previously. Many attributed this to the greater importance given to coverage of the recession and global financial crisis.

*“I don’t think it [biofuels and the environment] has, it’s not in the news that much that I’ve noticed” – S1:3*

*“The focus has moved away from climate change quite a lot” – S1:6*

*“[The] financial crisis is more important” – S2:1*

As an extension of discussions of television news, news websites were also mentioned, but not discussed further.

#### **vii) Magazines**

Four of the six groups discussed magazines as a source of information on biofuels, with the exceptions being ES1 and S2. Specific titles referred to included; National Geographic, Permaculture Magazine and BBC Focus. Views on reliability of magazines were mixed. Again, it is reasonable to assume that those who made use of magazines considered them to be a trustworthy source. There was an expression of concern that magazines, like newspapers, had the potential to be biased.

*“I’d say, well, the magazine I read [BBC Focus] I’d er trust a lot for information” – S1:4*

*“er BBC focus [pause] it’s mostly sort of scientific, but it it doesn’t sort of try and cause any social argument, it more the facts” – S1:4*

*“Magazines and newspapers could be said to be biased” – S1:1*

#### **viii) School and University**

School and University were discussed by three of the six groups, ES2, OS2 and S1. Due to the number of students involved in the focus groups, it is not surprising that university was mentioned as a source of information. School was also mentioned by one, younger, participant from the OS2 group as somewhere they had heard about biofuels. It was acknowledged by older members of the group that this wasn’t a source of biofuel information for them, as *“there wasn’t biofuel when I was at school it wasn’t invented”* (OS2:6).

In terms of reliability of the information; there was a feeling that people would accept information given to them in a school. However, there was also awareness that the person delivering the information may also have their own agenda that may affect the overall message.

*“To a certain extent I think there’s sometimes, the the person who’s giving the lecture has a view on something” – ES2*

*“Most people would probably accept what they’re told at school, up to a certain point, as truth, or at least the majority of it as true” – OS2:6*

#### **ix) NGOs**

Non-Governmental Organisations (NGOs) as a source of information were only discussed by one group, ES2. While it was mentioned that NGOs are

good at publicising causes, it was generally felt that they were a biased source of information promoting their own point of view.

*“NGOs or green groups, cos they get onto something and they generally publicise it quite well” – ES2*

*“Well, the facts they may be giving you may be correct but they’re an NGO and they’re trying to sell an idea to you, so the facts may be correct but they’re not giving a really really balanced view cos they want you to fund them” - ES2*

**x) Radio**

Only one group, OS2, discussed the radio as a source of information on biofuels. Specifically, they mentioned the BBC Radio 4 programme Material World. No further comments were made about reliability of this source, although it could be assumed the source was considered trustworthy by those who used it.

**xi) Biofuels Watchdog**

The Biofuels Watchdog, as a source of information was only raised and discussed by one member of one group, S1:1. Despite naming the watchdog as a source of information they had used, the participant seemed unclear as to its actual role.

*“There’s a watchdog for, I don’t know what they actually do but I know there is one” – S1:1*

Due to lack of further elaboration, it is not clear what body or organisation the participant was referring to.

**xii) Government**

Four of the six groups (ES2, OS2, S1, and S2) went on to discuss the government as a source of information after the idea was introduced by the moderator. Opinions of the reliability of government information were

mixed. For some, the government were considered to be completely untrustworthy, while others felt that the reliability would be dependent on who had actually conducted the research. There was also a feeling that while the information may be reliable, government could not be relied upon to act appropriately on that information.

*“[The Government are] quite biased possibly” – OS2:9*

*“I’d trust it [information from the Government] more than most other sources” – S1:4*

*“I’d trust them [The Government] as long as I saw what their um research bodies were” – S1:1*

*“Their [The Government’s] motive to find things out, to report things, is for the general public’s benefit” – S1:4*

*“But what they [The Government] actually do half the time doesn’t even follow the reports” – S1:3*

### **xiii) Scientists**

Three of the six groups (ES2, OS2, and S2) went on to discuss scientists as a source of information after the idea was introduced by the moderator. General opinion seemed to be that scientists were trustworthy, due to the provision of evidence to back up their findings. However, there was some concern that sources of funding may affect findings and that it could be possible for scientists to *“find out like anything about anything”* (S2:1).

*“I think, with the scientists though, you actually know it’s [the information] proven” – S2:5*

*“Of course there’s going to be some bias, but it’s [information from scientists] going to be better than an oil company just giving you a leaflet saying this is what’s happening” – S2:5*

*“It depends who they’re [the scientists] being funded by” – ES2*

*“It depends who employs them [the scientists] really doesn’t it. Who’s paying them to do their research” – OS2:4*

**xiv) Oil Industry**

Five of the six groups (ES2, OS1, OS2, S1, and S2) went on to discuss the oil industry as a source of information, after the idea was introduced by the moderator. The general opinion of information from oil companies was that it could not be trusted.

*“They [oil companies] choose statistics that’s good for them” – S2:5*

*“There’s a lot of distrust I’d reckon” – S2:5*

**3.6.6 Question 8: What do you know about the government position on biofuels?**

**i) Existing Government Policies**

In general, knowledge of the government position on biofuels was low and vague. Some participants had some awareness while others seemed to have none.

The existence of targets for the use of renewable energies was addressed in four of the six groups (ES1, ES2, OS1, S1), with some specific references to the use of biofuel.

*“Doesn’t the government want to have a certain percentage [of biofuel] by, I can’t remember the date and stuff, but they want it in policy now beginning to reduce fossil fuel consumption” – ES1*

*“You have, the Climate Change Act has about renewable transport [inaudible] fuel that they want, it’s a tiny percent though of biofuel in our fuel, you know, combined” – ES1*

*“Yeh they [the Government] support [biofuels] they’ve got, you know, targets” – ES2*

*“UK government got a ten percent aim, is it for wind farm or er green power generation?” – OS1:6*

*“Basically, the government have like made targets that we should get, I think something like about ten percent of our energy from biofuels” – S1:1*

## **ii) Policy Drivers and Government Motivations**

While no participants seemed certain about reasons why the government would support the development and use of biofuels, some suggestions were made.

*“Emission reduction targets” – ES1*

*“It makes them [The Government] look like they’re doing something, makes them look like they’re taking a pos [sic] step, positive step forward towards, you know, green society” - ES1*

*“There’s a lack of a better alternative [to biofuels] at the moment, they’re [The Government] maybe just grabbing hold of what they can and running with it” – ES1*

*“Europe as a whole sort of supports it [biofuels]” – ES2*

*“People are always fearful that we’re going to run out of fossil fuels” – OS2:9*

*“Sustainability” – OS2:1*

*“I say as part of the EU, do they [The UK Government] support it?” – S1:6*

When presented with the three official policy drivers, opinions were mixed. Once the drivers had been explained, initial reactions were positive,

however, began to become more sceptical in terms of how practical and achievable they were.

*“At first they [the policy drivers] seem ok” – ES1*

*“I think you can see what the government are thinking of, like sustainable development with like economic environmental and social things” – ES1*

*“Well it depends as much on the, like, the practicalities of it [the policy drivers]” – ES1*

*“I think they’re [the policy drivers], you know, pretty decent [pause] initiatives” – S1:1*

*“It’s [the policy driver for Rural Economic Development] economic for humans but it’s not the ecosystems view, and and that’s what’s misleading about rural development. You hope to think they [The Government/Policy Drivers] were improving the countryside and adding diversity but if they’re just gonna knock more down and have more crops and stuff [tails off]” – S2:2*

*“It [the policy drivers] sounds good but it says none of the bad points like the increase in prices and things like that” – S2:2*

### **iii) Other Issues**

As in discussions about sources of information, there was also a feeling that the environment had become a less important issue to government, most likely due to the economic crisis.

*“Certainly if the economy hadn’t collapsed quite recently I think [the environment] would probably be an even bigger issue” – OS1:5*

*“Green hasn’t been on the radar at all in this election [UK General Election 2010]” – OS1:6*

*“It’s [the environment] not an issue, if if we weren’t in a slump maybe there’d be more questions” – OS1:6*

*“Everything just got taken over by the budget though, not just green issues but everything got drowned out by the money” – OS2:3*

### **3.6.7 Question 9: Do you know if/where you can buy biofuels in the UK? Were you aware of the RTFO?**

While there was some low-level awareness of government policies relating to biofuels; awareness/knowledge of the RTFO was almost non-existent across all groups. Only two participants in two separate groups expressed any awareness of the addition of biofuels to conventional fuels under the legislation.

*“[There are biofuels in all in all petrol sold these days [pause]. Were any of you aware of that?] Yep, I was” – ES1*

*“[That’s it, there is actually already biofuel in every litre of petrol or diesel sold in the UK] Yes that’s right, it’s something I remember hearing about and then completely forgetting” – OS1*

#### **ES1**

When the issue of the Renewable Transport Fuels Obligation (RTFO) was raised, only one member of the group seemed to have any knowledge. They were aware that there had been media coverage at the time of its introduction and that people had been unhappy that they would not have a choice about using biofuels.

#### **S2**

When the RTFO was discussed, the group had no prior knowledge of the policy or the presence of biofuel in UK petrol and diesel. Although there was some disbelief, the group felt that people in general wouldn’t mind the fact that they have been using biofuels without their knowledge, as long as the biofuels didn’t cause any damage to vehicles. There was also a question raised over the point of only using 5% biofuel.

## **OS1**

Although the group all seemed to be unaware of the fact that there was biofuel in all UK petrol and diesel, after raising the issue and mentioning the RTFO, one group member remembered having heard about it.

## **OS2**

When asked about the RTFO, none of the group members were aware of the fact that all UK petrol and diesel contains biofuel. There was a feeling that it should be something the government would want to promote more.

## **ES2**

When asked about the RTFO, no-one in the group had heard of it and were unaware of the presence of biofuel in petrol and diesel in the UK. There was a feeling that not having a choice in using biofuels was a bad thing. It was also acknowledged that driving using conventional fossil fuels is detrimental to the environment, and as such the presence of biofuels can't make driving any worse.

### **3.7 Discussion**

The main aims of this chapter were to begin characterising biofuel risks from the public perspective and to aid in the design of a questionnaire for more detailed data collection from a larger number of participants. In this discussion, the data will be broken down and discussed under a number of headings relating to the research aims; Assessing Awareness and Knowledge of Biofuels (RA1), Awareness of Specific Biofuel Issues (RA1), Identifying Key Concerns about Biofuels (RA3 & RA4), Comparing Biofuels to Other Energy Generation Options (RA5), Important and Trusted Sources of Information, Awareness of Government Position on Biofuels (RA6) and Identifying Items for Inclusion in a Questionnaire.

### **3.7.1 Assessing Awareness and Knowledge of Biofuels (RA1)**

The results presented in this chapter suggest that there was reasonably wide spread awareness of biofuels across all groups, however, this was mostly low-level awareness, especially in comparison with other energy generation options. Other studies have commented on similar observations, wide spread but under-developed knowledge of scientific and environmental issues (Fletcher et al., 2009, Bostrom and Lofstedt, 2010, Read, 1999).

Both groups of environmental science students demonstrated awareness of biofuels, which was to be expected based on the nature of their studies. The fact that one general student group and one OS group were also aware of biofuels suggests that, while biofuel awareness is not total, it does span different age groups, levels of education and gender differences.

The extent of awareness beyond the environmental science students is not surprising, as biofuels have been the subject of news coverage, on television and in newspapers, as well as having been featured in television programmes, on the radio, in magazines and other sources of information known to be accessed by the participants, which would generate awareness. However, more recently, the coverage of biofuels has declined (see 6.5), likely due to factors including: unfavourable reports and their impact on the government position as well as seemingly more immediately pressing issues, such as the global financial crisis. Other research has shown a correlation between the economic downturn and reduced belief in and concern about climate change (Scruggs and Benegal, 2012, Whitmarsh, 2011, Weber, 1997).

Past exposure to information on biofuels but without recent reinforcement, is a possible explanation for the low level of awareness of biofuels amongst the groups. Various publications on the impact of media coverage on issue salience suggest that the impact of media messages on a given issue rarely exceeds four weeks (Brulle et al., 2011, McCombs, 2004, Sampei and Aoyagi-Usus, 2009, Wanta and Hu, 1994).

It is possible that biofuels, either as an individual issue or as part of wider energy use and generation issues, are not very important or interesting to people, therefore they do not pay a great deal of attention to biofuels or any information about them. The association between interest in a topic and the knowledge and awareness acquired on the topic has been well documented (Tucker-Drob and Briley, 2012, Chamorro-Premuzic and Furnham, 2010, Ackerman, 1996).

The low level awareness may have implications for future progress in the productions and use of biofuels in the UK. It is possible that low level concern could disguise the true extent of concern, as people may not have adequate awareness to voice their concerns generally, but if a national programme of biofuel discussion or development were launched, such a trigger of latent awareness may provoke unexpected opposition. Other studies have reported a correlation between low knowledge and lower levels of concern about issues such as climate change (Milfont, 2012, Malka et al., 2009).

As such, low level awareness could be more troublesome than either high awareness or even no awareness. It may be necessary to act to increase biofuel awareness amongst the general population to ensure that concerns are properly represented in order to be understood and considered, or ensure that research into public opinion is in-depth enough to register the concerns that exist despite low overall awareness. While a relationship between increased knowledge and improved attitudes has been documented in relation to other topics, particularly medicine (Al Bathi et al., 2012, Ibrahim et al., 2013, Abdul-Mutalib et al., 2012), evidence from issues related to biotechnology, particularly GMOs, suggests that increased knowledge leads to increased belief in previously held opinions (INRA (Europe) - ECOSA, 2000, Marris, 2001, Marris et al., 2001). It is important that this is kept in mind when considering communications and information sharing in relation to biofuels.

### 3.7.2 Awareness of Specific Biofuel Issues

While results suggest awareness was low overall, group discussions did reveal awareness and some knowledge of a large number of biofuel related issues once prompted. In total, one hundred and twenty two distinct issues were raised across the groups, however, of these only 20 were raised in more than half of the sessions.

Of all the issues discussed, analysis revealed that the largest group (almost half) were negative, whilst positive and neutral issues each represented approximately one quarter of total comments, with the difference being shown to be statistically significant. This suggests that the participants had much greater awareness of negative issues compared with positive or neutral issues. Other research has found similar evidence suggesting negative perceptions of biofuels dominate public opinion (Aerni, 2012).

As the issues people are aware of are likely to influence their opinions (Ibrahim et al., 2013, Al Bathi et al., 2012, Abdul-Mutalib et al., 2012, Knight et al., 1990), it seems quite likely that the participants would be more likely to have negative opinions of biofuels due to the higher proportion of negative issues discussed here. If this is the case, and people are more aware of negative biofuel issues resulting in a negative opinion of biofuels, then this is likely to be detrimental to any future expansion and development of biofuels in the UK. It would be important to work to improve the public opinion of biofuels if it is decided to continue to develop and use them, to avoid a public backlash as occurred in the case of GMOs (Johnson et al., 2007, The Office for Science and Technology and Wellcome Trust, 2000) . As an observation of the group discussions, despite the prevalence of negative issues raised, general opinion did not seem to be definitively negative; rather people seemed confused about biofuels with a tendency towards doubt rather than support (Ibrahim et al., 2013, Al Bathi et al., 2012, Abdul-Mutalib et al., 2012, Knight et al., 1990). With this in mind, it would seem that biofuels are far from a lost cause in terms of public opinion, despite the extent of negative knowledge.

From the issues raised, a series of broad discussion themes were identified. Amongst the seven themes, the groups had most awareness of Environmental Issues, followed by Technological Issues, Feedstocks, Financial Issues, Humanitarian Issues, Fossil Fuel Issues and Issues with Access to Biofuels. Such a range of themes of discussion could be interpreted to suggest that, overall, participants had a very broad knowledge base in relation to biofuels, even if they lacked depth of knowledge.

The fact that more issues categorised under the Environmental theme were discussed than under any other theme might suggest a greater awareness, knowledge or level of concern associated with the environment. However, this may equally be due to there being a larger number of biofuel issues related to the environment as opposed to the other themes or the inclusion of a large number of Environmental Sciences students in the focus groups. In either case, this result reflects the finding from the focus groups, that participants were more aware of environmental issues than any other broad category. There is certainly evidence in the literature that shows public concern for the environment is increasing (Mohai et al., 2010, Givens and Jorgensen, 2011).

### **3.7.3 Identifying Key Concerns about Biofuels**

Key concerns were considered to be the negative issues that were most discussed across the groups, possibly better referred to as most prevalent concerns. As has already been mentioned, participants' awareness and knowledge of biofuels appeared to be dominated by negative issues rather than positives.

Of all the negative issues raised, the most discussed were: extensive land use, deforestation, increased food prices and reduced food supply.

The majority of concerns expressed fell under the theme of 'Environmental Issues'. This may suggest that the participants were more concerned about environmental issues than other areas. However, the greater prevalence of environmental issues in the list of concerns may be due to the greater

awareness of environmental issues, over other themes, as has already been discussed. The result may also be a reflection of the large number of Environmental Sciences students involved at this stage of the investigation.

Despite extensive discussions of perceived negatives of biofuels, there was no mention of means for resolving or mitigating these, such as those outlined in 2.5. This lack of discussion is taken as an indication of a lack of knowledge of the potential options for improving biofuels that already exist.

#### **3.7.4 Comparing Biofuels with other Energy Options**

Results of discussions of other energy options in comparison with biofuels do not present a positive picture of the participants' opinions of biofuels. A ranking exercise placed biofuel 15<sup>th</sup> of nineteen options, only above Hydroelectric power, Microgeneration, Oil and Gas. This reflects the general tendency towards less support for biofuels amongst participants suggested by the prevalence of negative knowledge. Of the options that were rated more highly than biofuels, almost half were more commonplace renewable means of energy generation (Tidal, Anaerobic Digestion, Solar, Wave, Geothermal, Wind).

These results are similar to those produced by a study of biofuel opinion in Greece, conducted by Savvanidou et al (2010). The study reported only 27.3% of participants felt biofuels should be prioritised over other renewable energy options (Savvanidou et al., 2010).

A preference for traditional renewable energy sources is not unexpected, and is fitting with the findings of other studies. A study conducted in the US by Greenberg (2009), found that up to 90% of participants favoured renewables, particularly solar and wind, over other options,. Another study in Germany, based on willingness-to-pay, found evidence to suggest a preference for renewable energies (Grosche and Schroder, 2011). The absence of renewable energy developments in the study area removed the influence of any NIMBY (Not In My Back Yard) (Tait, 1999) opinions that may have impacted on the positive feelings towards the renewables discussed.

Of all the alternative options for transport, biofuels were ranked lowest, suggesting that the participants would be more in favour of a move towards hybrid cars, hydrogen vehicles or electric cars than the use of biofuels. Similar results, showing public preference for electric and hydrogen vehicles over biofuels, were reported by Ziegler (2012).

This is not a good indication for any future expansion of the use of biofuels in transport in the UK. Logistically, a move to biofuels would be simpler and likely cheaper than any of the other options discussed by the group, due to the compatibility of existing distribution infrastructure and the capabilities of existing vehicles. Equally, each of the three other options relies on electricity generation from a fuel source, which could include fossil fuels and contribute to carbon emissions and climate change. Such issues did not seem to have been considered in the discussions by the groups, possibly due to a lack of knowledge or lack of related coverage in the media.

It is possible that the low ranking of biofuels in relation to other energy options may be related to the fact that a much greater proportion of time was spent discussing biofuels than the other options. However, as the ranking was calculated based on the proportions of negative and positive comments, there is no reason to assume that discussing biofuels for a longer time would distort the group's overall view of biofuels. Equally, while less time was given to discussing other energy options, no discussion was cut short by the moderator, allowing for as much consideration of each option as was necessary for the group and their level of knowledge and opinions of each option.

### **3.7.5 Important and Trusted Sources of Information**

Results showed that participants used and trusted a range of sources of information. Media sources, including television news, newspapers and magazines, were most widely named as used sources, with some aspect of the media being discussed within all six groups.

Many other studies have also shown the media to be the most widely used source of information for the public, on a range of issues (Gould et al., 2009, Conesa et al., 2004, Greenberg and Truelove, 2010).

Whilst it was recognised that most people, within the groups and in the wider public, were most likely to receive information from media sources, there was also scepticism about how much trust could be placed in them. Similar conclusions have been drawn by other studies, which found that media sources, such as newspapers, receive low trust ratings from the public (Lang and Hallman, 2005, Van de Velde et al., 2011, Bråten et al., 2011).

While magazines were generally trusted, opinions on newspapers and TV news were less positive. It was clear across the groups that different newspapers were subject to different levels of trust, generally on the basis of whether the newspaper in question was a broadsheet or tabloid. Tabloids were universally distrusted, while broadsheets were more likely to be trusted, with still some uncertainty over the extent to which they could be trusted. Similar results showing less trust in tabloids than better quality newspapers were reported by Frewer (1996) and Hunt and Frewer (2001, 2011).

TV News, in the form of individual news stories were most likely considered to be untrustworthy, while there was a feeling that the news as a whole probably presented a more holistic picture of the biofuel situation. As a caveat to this, it was acknowledged that most people were unlikely to watch all news coverage of biofuels, or any other specific issue. The BBC was considered to be more trustworthy than other news sources. Higher levels of trust in the BBC over other media sources has been reported in other studies (Gunter, 2005). Despite general mistrust, the ability of television news and newspapers to reach such a large number of people led to them being considered important sources for the general public, with a key role in generating awareness and raising areas of new information.

There was no trust in oil companies as a potential source of information. Distrust in oil companies has been documented in other research (Spangler

and Pompper, 2011) as has distrust in other areas of industry (Lang and Hallman, 2005). The government were not as widely distrusted but were not widely considered to be trustworthy. Low, and declining, levels of trust in government are documented in the literature (Grimmelikhuijsen, 2012, Hunt and Frewer, 2011, Frewer et al., 1996, Lang and Hallman, 2005). Low levels of trust in a source of information have been attributed to perceived vested interests in presenting biased information (Hunt and Frewer, 2011, Schwartz et al., 1986), which could be applicable to the government and oil industry in the case of biofuel information.

Opinion of scientists as a source of information was spilt. While the fact that scientific information is backed up by evidence was acknowledged, the potential for sources of funding to influence findings was a wide spread concern. Similar concerns about the accountability of scientists and a perception that scientists conduct research without consideration of risks were reported by The Office of Science and Technology and the Wellcome Trust (2000). There is literature that supports both the idea that the public do not trust scientists (Meyer, 2006, Haerlin and Parr, 1999) but also that the public are interested in and see the benefits of scientific developments (The Office for Science and Technology and Wellcome Trust, 2000). Research conducted in the United States seems to report greater trust in scientists than in the UK (Lang and Hallman, 2005, The Office for Science and Technology and Wellcome Trust, 2000), a fact that must be kept in mind when reviewing the available literature.

The Internet was not widely discussed; however, Wikipedia was felt to be a trustworthy source that was also available and understandable by the general public. Google was also considered to be a useful resource for conducting further research into matters of interest. However, academic literature on the subject of Google and the internet as a source of information expresses concern about the quality, reliability and clarity of information provided (Quinn et al., 2012, Malki et al., 2011). There were no comments made about lack of trust in the internet; however, this may be due to the overall lack of discussion of the internet as a source.

There was an opinion expressed in a number of groups that information on biofuels was not readily available or easily accessible. Many participants expressed that they did not know where they would find out further information. It was acknowledged that seeking out information, from sources other than the media, required time, effort and an amount of personal interest, all of which had the potential to prevent people conducting their own research into a topic. There has been discussion of difficulties and confusion experienced in information seeking, including lack of familiarity with potential sources, in the literature (Kuhlthau, 1991, Arora et al., 2008).

It may be important to address such feelings that information is not easily available to the public from sources other than the media, which was not considered to be wholly trustworthy.

### **3.7.6 Awareness of Government Position on Biofuels**

Across the six groups, there seemed to be extremely limited knowledge of the government position on biofuels, both before, during and after the 2010 general election. Only a few individuals within a few groups had any specific knowledge of the government demonstrating support for the use of biofuels. The issue of greatest awareness in relation to government position on biofuels, identified by the number of groups raising the issue, was the existence of targets for use of biofuels, although there was little knowledge of the targets beyond knowing of their existence.

It may have been expected that the occurrence of the general election in the middle of investigating public awareness of government positions on the environment and biofuels may have increased awareness; however this was not the case. It is felt this may be due to the lack of discussion of the environment as an election issue; Analysis of party positions in the environment during the 2010 election have reported that, while manifestos made reference to environmental policies, discussion of the environment was notably absent from televised debates (Rootes and Carter, 2010). Some focus group participants did make comments to this effect.

In relation to whether the government were supportive of the use of biofuels; there was some acceptance that the government are supportive of biofuels, two groups assumed that the government support biofuels based on the existence of usage targets and one group felt that, as they had not heard any specific information and biofuels are not readily available, that the government are either unsupportive or at least taking no action. One group did not discuss the issue. In combination with the fact that only three groups were aware of existing biofuel usage targets, this would suggest a low and limited level of awareness and knowledge of government position on biofuels. This is not surprising, for a number of reasons.

The origins of current UK biofuel policy are discussed in 2.3.2. Since the beginnings of UK biofuel policy a number of changes have occurred that are likely to have detracted from public awareness of the government position on biofuels, including the publication of a number of scientific studies that have cast doubt on the potential benefits of using biofuel (Searchinger et al., 2008, Danielsen et al., 2008, Friends of the Earth, 2008) which led to the UK government commissioning their own report (Gallagher, 2008) that recommended restrictions on the expansion of biofuel use. As a result of this, the Labour government which introduced the original RTFO revised down the usage targets and, while not completely removing their support from biofuels, notably retrenched on their previous position. As such, less, if any, attention to biofuels has been generated by the government, which will have affected coverage of biofuels in mass media and other sources of information utilised by the public. Also, as was recognised in a number of discussions, news coverage of biofuels and environmental issues has suffered recently as a result of the global financial crisis, further reducing public exposure to biofuel issues. A final factor to be considered is the 2010 general election, as a result of which, the Labour government that introduced the RTFO and related biofuel policies was replaced with a new Conservative-Liberal Democrat coalition government, for whom biofuels did not feature in their Coalition agreement (Cabinet Office, 2010). This change in governance leaves the issue of government support for biofuels unclear, as the environment was vastly overshadowed by finances as an election issue, with biofuels or energy supply not being discussed in terms of

continued support or removal of support for existing policies. With such a range of factors affecting attention given to biofuels it is not surprising to see that the participants in these focus groups lacked awareness and knowledge of the government position on biofuels.

Although the groups demonstrated a notable lack of awareness and knowledge of the government position on biofuels, they were asked to speculate as to possible reasons for any government support. Of the suggested reasons, only one was clearly in-line with the official policy drivers, being the potential for biofuels to help meet emission reduction targets. A number of other suggestions focussed on government interest being based on a desire to appear environmentally concerned and to generate a positive 'green' public image.

While none of the participants were initially aware of a specific set of official policy drivers, they were presented with the three factors and asked for their opinions. In response to learning of the official policy drivers, there was widespread support for the intentions they embodied. There was confusion amongst members of three of the groups with regard to the term 'Rural Development'. There were initial concerns that this referred to urbanisation of rural areas, that was considered to be undesirable. Upon explanation of the intentions of 'Rural Development' there was almost universal support, with the exception of some concerns that a focus on economic development in rural areas may still adversely impact the environment and biodiversity. While initial reactions to the policy drivers were largely positive and supportive, throughout the course of discussions participants expressed growing uncertainty. There was recognition that, in general, the aims of the policy drivers were positive and well intentioned; however, there was expression of concern that the aims were unlikely to be achieved through the use of biofuels. This correlates with the overall negative view of biofuels that the participants expressed, as discussed previously. As the group opinions of biofuels are more informed by negative facts than positive ones, it is understandable that they do not feel that biofuels have the potential to deliver the benefits that the policy drivers aim for.

### **3.7.7 Identifying Items for Inclusion in a Questionnaire**

The utility of the results obtained from this stage of the research may have some limitations in terms of their representation of the wider population due to the focus on residents of Southampton. As such, conclusions cannot be projected onto a wider population.

There were some difficulties in recruiting participants, resulting in having to use all volunteers and removing the ability to select a demographically representative sample. However, in terms of biofuel awareness and knowledge, results showed no significant variation between the different focus groups. This means the focus groups fulfilled the requirement of saturation – a point at which no new topics of information were discussed, suggesting exhaustion of participant knowledge (Chieh Wu et al., 2013, Abildsnes et al., 2012, Carlsen and Glenton, 2011, Glaser and Straus, 1967). As such, while groups may not be representative enough to allow for the extrapolation of results to the wider population, topic saturation suggests that an extensive range of biofuel issues of which the public are aware have been identified and should allow for the compilation of a comprehensive questionnaire.

However, the main purpose of utilising focus groups was to identify relevant items for inclusion in the questionnaire that was distributed to a much larger number of participants selected using a more robust sampling method. The data collected from a questionnaire was also subjected to a greater degree of quantitative analysis.

The questionnaire was intended largely to ask the same questions as the focus groups, however, the data gathered from the focus groups allowed for the selection of answer options for questions, making them closed rather than open questions. Closed questions are more appropriate for use in questionnaires and make the process of data analysis easier (Oppenheim, 2005). The questionnaire also served to test the findings from the focus groups, to see if a larger and more representative sample shares the same levels of awareness, knowledge and concern about biofuels as the focus group participants.

Design, implementation and analysis of the questionnaire are discussed in Chapter 4.

## **4.0 Extended Survey: Testing established base knowledge on a wider population**

### **4.1 Introduction**

While the focus groups provided a baseline understanding of public attitudes and opinions of biofuels, in isolation the data are insufficient to develop broad, generalised conclusions. It was established at an early stage in the project that it would be necessary to build upon the information gathered from the focus groups through the use of another, broader means of surveying public opinions.

Questionnaires were identified as a potential social science method for gathering data from the public during initial research into the methodologies of social science. While they were not considered to be suitable for the primary data gathering exercise, the use of a questionnaire did seem appropriate for the further development of the project. As such, the focus groups were run not only to provide a basic understanding of public views, but also to elicit relevant terms, phrases, language and concepts that could be utilised in a questionnaire.

Questionnaires provide quantitative data to build on the inferences made from the qualitative output of the focus groups, which are much more suitable for statistical analysis and the formulation of more general conclusions about the public as a whole. The format of a questionnaire also allows data to be gathered from a much larger number of participants and potentially provides a more representative view of society than the focus groups could achieve.

This chapter builds on the previous chapter with quantitative data from a large, representative sample of the general public. This chapter continues to develop the identification of issues and management and communication options to inform a Risk Analysis.

Research aims covered in this chapter and how:

**RA1** Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent

- Examine public awareness of biofuels in general as well as specific issues related to the biofuel debate

**RA2** To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels of awareness and knowledge of biofuels effectively

- Examine sources of biofuel information that the general public use and trust

**RA3** Highlight the key concerns of the different stakeholders

- Examine the biofuel risks and problems that the general public are aware of and which areas are of greater or lesser concern

**RA5** Compare acceptability of and concerns about biofuels with those related to other energy generation options

- Examine how opinions of biofuels affect their relative acceptability in comparison with other options for generating energy

## **4.2 Methodology**

### **4.2.1 Questionnaire Design**

Generally speaking, a questionnaire is a set of questions devised for the purpose of collecting data from individuals that will enable the measurement and analysis of factors relevant to an experimental hypothesis or question (Oppenheim, 2005, Peterson, 2000).

Of the range of questionnaire styles and means of distribution, it was decided the questionnaire for this study would be self-completion, distributed by both

post as well as online. Self-completion questionnaires are often distributed through the post and benefit from lower costs, coverage of a larger geographical area, avoidance of interviewer bias as well as a level of anonymity that may make participants more comfortable (May, 1997). Benefits of an online questionnaire include access to more distant populations as well as requiring less time and resources than postal questionnaires (Wright, 2005, Sax et al., 2003). It was felt that the use of two methods together would combine the benefits of both methods and minimise the potential disadvantages; providing the greatest number of responses with the widest demographic range possible.

A concern for self-completion questionnaires is low motivation to respond, resulting in low response rates and lack of explanation of non-response (May, 1997). This can cause bias in results and reduce representativeness (May, 1997). Although this potential for bias was a concern, it was considered that, as the definition of a stakeholder is 'a person with an investment, share or interest in something' (Dictionary.com, 2012), non-response due to lack of interest was acceptable as it indicated the individual concerned was not interested and therefore not a stakeholder in the issue.

For collecting information on respondents highest level of education, the National Qualification Framework was used as a guide (Ofqual, 2010).

#### **4.2.2 Question Selection**

The main question styles used are the open question and the closed question (also known as a structured question); open questions require the respondent to answer in their own words, while closed questions present participants with choices from which they can select the most appropriate answer (Oppenheim, 2005, Peterson, 2000). It was decided to utilise only closed questions in the questionnaire not only for ease of data entry but because the focus group stage was considered to be the stage at which open questions were used to help define the questionnaire questions.

Questions were drafted based on the project aims as well as incorporating the important themes and relevant terms identified in the output from the focus

groups. Wording of questions and provided answer choices should be well thought out and tested prior to use (Oppenheim, 2005). As such, the initial list of drafted questions was reviewed and some questions were removed or modified to improve clarity, relevance and to minimise the overall length of the questionnaire. The suitability and wording of questions was further tested by piloting (see section 4.2.7 Pilot and Redesign).

The recommended upper limit of four pages (Oppenheim, 2005) was strictly adhered to and question length and answer options were modified to be accommodated within the 4 page layout. For the final version of the questionnaire see Appendix 5.

Inclusion of a covering letter with a self-completion questionnaire is important to ensure informed consent of participants. The level of disclosure in a covering letter is dependent on the study requirements (Peterson, 2000). A covering letter was included with the postal questionnaires and at the beginning of the online questionnaire (Appendix 6). The letter included information on who was conducting the research (Liz Shepherd at The University of Southampton), how the respondents had been selected, what was being asked of them, how to submit their responses as well as assuring them anonymity and confidentiality. It was decided not to name Syngenta as CASE funders of the research in case this affected people's willingness to participate, as the focus groups had highlighted a lack of trust in scientists with regard to their sources of funding.

Recommendations on improving response rate taken from the literature were considered, and those that were appropriate were put into place (Dillman et al., 1993, Linsky, 1975, Asch et al., 1997, Yammarino et al., 1991, Eaker et al., 1998). The establishment of the online questionnaire and the inclusion of a link in the postal covering letter were aimed at boosting response rate by increasing the ease with which people could respond. Similarly, the inclusion of a prepaid, addressed return envelope was intended to encourage response for those who did not wish to use or were unable to use the online version (Oppenheim, 2005). Minimising the overall physical length and time taken to complete and ensuring anonymity were also means utilised to improve response rate.

Although pre-contact and follow-up reminders are often advocated, available resources and the fact that respondents were anonymous prevented this; it was not possible to send reminders to non-responders as there was no way of knowing who had and had not responded.

#### **4.2.3 Questions to meet specific research aims**

For a final version of the questionnaire, as sent to participants, see Appendix 5. A series of five questions intended to collect demographic data on participants was included at the end of the questionnaire. It is recommended to put such questions at the end of a questionnaire, rather than the beginning, to avoid putting respondents off by opening the questionnaire with a raft of personal questions (Oppenheim, 2005).

##### **i) Questions for Assessing Awareness and Knowledge of Biofuels (RA1)**

Question 1 was designed for assessing awareness of biofuels; testing how many people had heard of biofuels in the context of other energy options and terms.

A number of questions specifically assessed knowledge of biofuels. While Question 2 directly asked participants to provide their own assessment of their level of biofuel knowledge, Questions 4, 6 and 8 assessed knowledge through indirect indicators; examining perceptions of potential impacts, both positive and negative, and accurate and false, of biofuel production and use as a proxy measure of biofuel knowledge (Malka et al., 2009, Bord et al., 2000). Knowledge/awareness of the accurate potential impacts of biofuel production and use would suggest knowledge of the biofuel issue, while indicating knowledge/awareness of any false potential impacts would be indicative of lack of knowledge and/or misinformation (Bord et al., 2000, Malka et al., 2009). Similar methods have been used in assessing knowledge of climate change (Malka et al., 2009, Bord et al., 2000).

**ii) Questions to Identify Used and Trusted Sources of Information (RA2)**

Used and trusted sources of information were assessed directly, through Questions 9 and 10; asking participants about the types of sources from which they had gained biofuel information, and separately about the types of sources they felt were trustworthy. Question 9 asked participants to indicate whether they did or did not make use of particular information sources. Question 10 used a 5 point Likert scale (Oppenheim, 2005) to assess to what extent participants agreed or disagreed with statements about trust in various sources.

**iii) Questions for Identifying Key Concerns and Priorities for Action (RA3)**

While Question 4 began with the identification of the potential impacts that participants were aware of, Question 5 was specifically designed for the purposes of identifying which potential impacts were of most concern. Participants were asked to select and rank the five potential impacts that were of most concern to them, on a scale of 1 to 5, with 1 being the issue of greatest concern and 5 being the fifth greatest concern.

**iv) Questions for Assessing Relative Acceptability of Biofuels in Comparison to Other Energy Options (RA5)**

Question 7 asked participants to compare a range of energy options to biofuels, on a three point scale; options could be rated as either more, less or equally preferable to biofuel.

**4.2.4 Sample Selection**

A stratified random sample of 3000 names and addresses was selected from the 2010 electoral roll for the Southampton area. The sample was stratified by postcode area to ensure proportional representation of the selected areas within the sample. An online random number generator was used to select individuals from the roll for each postcode area.

#### **4.2.5 Distribution and Responses**

Copies of the questionnaires were distributed, complete with covering letter and freepost return envelope, via Royal Mail. Franked postage was used for the outgoing questionnaires and addresses on both outgoing and return envelopes were printed.

A time period of one month was allowed for the return of eligible responses. A total of 783 responses were received within the time limit - 512 postal responses and 271 online responses.

#### **4.2.6 Online Questionnaire**

An online version was setup in addition to the paper questionnaire. The website Survey Monkey was used to host the questionnaire. Unfortunately, it was necessary for the design to differ from the paper questionnaire, although the question wording and answer options remained consistent.

The online questionnaire was distributed via social networking sites Facebook and Twitter, using a snowball sampling method (Oppenheim, 2005). Snowball sampling involved an initial distribution to a known group, followed by further dissemination through the networks of respondents. Alongside this, details of the online questionnaire were distributed through social networks, utilising a snowball sampling method, whereby initial respondents pass details on to others, with the size of the sample growing as it is passed on by more respondents (Laerd, 2010).

The website URL for the online questionnaire was included in the covering letter for the postal questionnaire, along with an explanation that the online version was available to complete if preferred.

#### **4.2.7 Questionnaire Pilot**

The questionnaire was distributed to people who responded to a call for volunteers, along with an evaluation form. In total 20 completed evaluations were returned.

Pilot respondents were aged between 20 and 59. Sixty-five percent of pilot respondents were female and 45% male. The majority were educated to Bachelors Degree level or above, although one quarter were at A-levels/NVQ Level 3/Advanced GNVQ, and 5% had achieved GCSEs A\*-C/NVQ Level 2/Intermediate GNVQ. The vast majority of respondents (90%) were White British.

Average completion time was 14 minutes and 57 seconds, although this was raised by one participant who took 60 minutes to complete. All other participants completed in under 20 minutes and, excluding the 60 minute completion time, the average time taken was just under 13 minutes (12.58, 12 minutes 35 seconds). All 30 respondents felt that the time it took them to complete the questionnaire was 'Reasonable'.

Most of the issues that contributed to long completion times were related to the form in which the questionnaire was sent (a word document sent by email). All participants found the majority of questions to be clear and easy to understand. In addition, all felt the questionnaire was appealing and easy to follow.

Other comments provided included: the "Don't Know" option was useful, a request for extra boxes to provide explanations for answers, questioning whether numbers in the boxes of Likert scale questions were necessary, questioning the use of the phrase "Equally preferable", suggestion that fewer questions may improve response rates, and that there was some confusion over the wording in question 7.

#### **4.2.8 Data Analysis Methodology**

The data from the postal questionnaires was coded and entered into an SPSS database manually. Online questionnaire data was downloaded as an Excel spreadsheet and transferred to the SPSS database. Separate codes were used to differentiate the two data sets.

Analysis was undertaken in stages. Initially simple descriptive data (frequencies and percentages) were analysed. Graphs of responses were created and mean responses calculated. Chi squared tests were used to test the significance of the data.

Subsequent analysis involved analysing data for variations caused by factors including: means of response, age, gender, ethnic background and education as well as whether the respondents had heard of biofuels and what sources of information they used. For this analysis, the data were initially tested for normality by a Kolmogorov-Smirnov test. For normally distributed data, either an independent sample t-test or a one-way ANOVA could be used to assess variance, between two groups or multiple groups, respectively. For non-normally distributed data, variance between two groups could be assessed by a Mann-Whitney U test and variance between multiple groups could be tested by a Kruskal-Wallis test followed by a Tamhane's T2 post hoc to identify the specific groups involved.

##### **i) Handling 'Don't Know' responses**

'Don't Know' responses can be difficult to handle, particularly in questions where answers are based on a scale (Lam and Allen, 2010, Weisberg, 2005). From a self-completion questionnaire, it is not possible to know the full meaning behind a 'Don't Know' answer; potential interpretations include genuine lack of ability to answer, boredom with the questionnaire, lack of interest in the subject, an attempt to hide a 'socially undesirable' answer or concern over providing a 'correct' answer, amongst other things (Weisberg, 2005). It is common practice to treat 'Don't Know' responses as missing data and exclude them from

analysis, although it is acknowledged that this does incur the cost of loss of data (Wang, 1997, Rubin et al., 1995, Weisberg, 2005, Brooks, 2004).

In the case of this project, 'Don't Know' responses were considered to be important, as discovering areas where knowledge was lacking was as key as high knowledge. However, inclusion of 'Don't Know' answers with the other scaled answers was complicated. Giving 'Don't Know' responses a score of zero skewed average ratings towards the lower end of the scale; despite the fact that 'Don't Know' is no more equivalent to the low end of a scale than the high end. Including 'Don't Know' responses with the neutral option in a scale, usually "Neither Agree nor Disagree" was considered. However, this option was not used as it was considered that 'Don't Know' and 'Neutral' were not equivalent; if a respondent had intended to provide a neutral answer they had the ability to do so, but had selected 'Don't Know' instead. Research by Lam & Allen (2010) supports this decision, as their results suggested that respondents do differentiate between 'Don't Know' and neutral options and, as such, both options should be included, separately, in Likert scale based questions.

Taking these factors into account, it was decided that 'Don't Know' answers would be excluded from calculations of mean ratings to avoid skewing results, but would not be totally excluded from analysis, instead being considered separately from those who gave definite answers.

### **4.3 Results**

In this section, I present the results of the questionnaire study according to the research aims of this chapter. This chapter is designed to analyse the awareness and opinions of biofuels of a larger and more representative sample of the general public than in the focus groups presented in chapter 3.

Responses were also analysed according to various demographic factors to see if and how these influenced attitudes and opinions.

### 4.3.1 Respondent Demographics

A summary of respondent demographics is presented in Tables 5 – 9.

<b>Means of Response</b>	<b>Number of Respondents</b>
Online	271
Postal	512

**Table 5. Number of Respondents to questionnaire by means of response**

<b>Age Group</b>	<b>Number of Respondents</b>
19 or Under	24
20-29	157
30-39	107
40-49	141
50-59	136
60-69	124
70 or Over	83

**Table 6. Number of Respondents to questionnaire by Age Group**

<b>Gender</b>	<b>Number of Respondents</b>
Male	341
Female	407

**Table 7. Number of Respondents to questionnaire by Gender**

<b>Highest Level of Educational Achievement</b>	<b>Number of Respondents</b>
0 – Other	45
1 – No Qualification	82
2 – GCSE D-G, NVQ Level 1, Foundation Level GNVQ or equivalent	30
3 – GCSE A*-C, NVQ Level 2,	71

Intermediate GNVQ or equivalent	
4 – A Levels, NVQ Level 3, Advanced GNVQ or equivalent	111
5 – Diploma of Higher or Further Education, Foundation Degree, HND or equivalent	99
6 – Bachelors Degree, Graduate Certificate/Diploma or equivalent	165
7 – Masters Degree, Postgraduate Certificate/Diploma or equivalent	119
8 – Doctorate	37

**Table 8. Number of Respondents to questionnaire by Highest Level of Educational Achievement**

<b>Ethnic Background</b>	<b>Number of Respondents</b>
White – British	716
White – Other	26
Mixed – White and Black Caribbean	0
Mixed – White and Black African	0
Mixed – White and Asian	2
Mixed – Other	5
Asian/Asian British – Indian	4
Asian/Asian British – Pakistani	5
Asian/Asian British – Bangladeshi	3
Asian/Asian British – Other	2
Black/Black British – Caribbean	0
Black/Black British – African	2
Black/Black British – Other	0

Chinese or Other – Chinese	2
Chinese or Other – Other	1

**Table 9. Number of Respondents to questionnaire by Ethnic background**

**4.3.2 RA1 - Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent**

- Examine public awareness of biofuels in general as well as specific issues related to the biofuel debate
- 

A key aim of my study was to analyse the awareness and knowledge of biofuels amongst the general public respondents. These aspects of my research were addressed via questions 1, 2, 4, 6 & 8. I shall deal with the analysis of each question in turn

**i) Question 1** assessed awareness of biofuels based on familiarity with the term ‘Biofuels’ and how this compared to familiarity with other energy related terms. The results of this question are presented in Table 10.

From this data we can see that the sample group were able to show knowledge of all of the areas. The most well known terms were Solar Power, Wind Power, Electric Cars, Nuclear Energy and Greenhouse Gases.

In this case, ‘Fossil Fuels’ was used rather than having oil, coal and gas separately due to space constraints.

Term	Number of Respondents who had heard the term previously	Percentage of Respondents who had heard the term previously
Solar Power	774	98.6%
Wind Power	770	98.1%
Electric Cars	764	97.3%
Nuclear Energy	756	96.3%
Greenhouse Gases	738	94.0%
Fossil Fuels	713	90.8%
Hybrid Cars	691	88.0%
Hydroelectricity	684	87.1%
Biofuels	647	82.4%
Geothermal Energy	560	71.3%
Bioenergy	421	53.6%
Carbon Capture and Storage	337	42.9%

**Table 10. Numbers and percentages of respondents who had heard of the terms included on the questionnaire**

'Biofuels' themselves were ranked the 8<sup>th</sup> most well known, with 82.6% of respondents being familiar with the term. Respondents were significantly more aware of fossil fuels and longer standing renewables, such as solar and wind power.

Statistical analysis revealed significant differences in familiarity with the term 'biofuels' by Gender ( $H(2)=26.097$ ,  $d.f.=1$ ,  $p=0.000$ ) and Level of Education ( $H(2)=63.771$ ,  $d.f.=8$ ,  $p=0.000$ ).

In terms of differences by Gender, results suggest that males reported significantly greater awareness of biofuels than females, on average.

Higher levels of education also seemed to be associated with greater familiarity with biofuels. Those at the highest education level (8, Doctorate) had a significantly greater awareness of biofuels than those at levels 0 – 6 (Other qualifications – Bachelors Degree or equivalent). In addition, those at education level 1 (No Qualifications), had significantly lower awareness of biofuels than those at qualification level 4 (A-levels, NVQ level 3, Advanced GNVQ) or above.

**ii) Question 2** required participants to rate their own knowledge of biofuels on a scale of 1 (Very High) to 5 (Very Low).

As a general trend, the greatest number of respondents rated their knowledge as either 'Low' or 'Very Low' (344, 43.9%). This is reflected in the mean knowledge rating of 2.41 when 'Don't Know' answers were included, rising to 2.54 when they were discounted; however, both mean ratings fell within the Low range.

A chi squared test showed the trend towards low ratings to be significant ( $\chi^2=388.155$ , d.f. =5,  $p<0.05$ ).

Statistical testing revealed significant differences by Age ( $H(2)=14.325$ , d.f.=6,  $p=0.026$ ), Gender ( $H(2)=57.990$ , d.f.=1,  $p=0.000$ ), Level of Education ( $H(2)=73.470$ , d.f.=8,  $p=0.000$ ) and Environmental Concern ( $H(2)=39.017$ , d.f.=5,  $p=0.000$ ).

Results suggest that those in the older age group (over 70) had significantly lower reported knowledge of biofuels than those from all other age groups (<18 to 69 years), based on group averages.

On average, males reported significantly higher knowledge of biofuels than females.

As a general trend, those of higher educational attainment had significantly higher reported knowledge of biofuels than those at lower levels of education;

those at the highest education level (8, Doctorate) reported significantly higher mean knowledge than those at levels 1 to 5 (No Qualifications – Diploma of Higher or Further Education, Foundation Degree, HND).

Similarly, those who were most concerned about the environment ('Very Concerned') reported significantly higher knowledge of biofuels than those who were either 'Concerned' or 'Neither Concerned nor Unconcerned', on average.

iii) **Question 4** dealt with knowledge of specific biofuel issues, requiring respondents to indicate familiarity with known potential impacts of biofuels taken from the literature and focus groups. The responses are summarised in Table 11 and show that the different impacts have varied levels of recognition within the sample population.

<b>Potential Impact</b>	<b>Number who have heard of the impact</b>	<b>Percentage who have heard of the impact</b>
<b>Deforestation of the Rainforest</b>	590	75.4% *
<b>Reduced Carbon Emissions from Transport</b>	474	60.5% *
<b>Changes to the Appearance of the Countryside</b>	446	57.0% *
<b>Use of Large Amounts of Land</b>	436	55.7% *
<b>Loss of Plant and Animal Species</b>	420	53.6% *
<b>Use of Genetically Modified Crops</b>	408	52.1%
<b>Increased Food Prices</b>	395	50.4%
<b>More Expensive Fuel</b>	378	48.3%
<b>Reduced Food Supplies</b>	363	46.4% *
<b>Increased Greenhouse Gases</b>	287	36.7% *
<b>Improved Energy Security</b>	196	25.0% *
<b>Less Investment in Other Renewable Transport Options</b>	197	25.2% *
<b>Human Rights Abuses</b>	185	23.6% *

\* Significant results (p<0.05)

**Table 11. Number and percentage of respondents who had heard of the potential impacts of biofuel production and use**

Overall, the responses show that the level of recognition of the potential impacts is reasonably high with some recognised by more than half of the sample. However, although all of the potential impacts listed in the questionnaire were recognised by some of the respondents, not one of the impacts was recognised by all of the respondents. Thirty-five respondents (4.5%) had not heard of any of the listed potential impacts.

As can be seen in Table 11, Deforestation of the Rainforest was the most widely known potential impact amongst the respondents, with more than three quarters having heard of it.

The second most widely known impact was 'Reduced Carbon Emissions from Transport', with almost two thirds of respondents having heard of it. This is interesting as reduced carbon emissions from transport would be considered to be a positive impact of biofuel production and use. As such, this result suggests that the majority of respondents were familiar with the potential for biofuels to deliver desirable results. In comparison, the other positive impact of biofuels included in this section of the questionnaire – 'Improved Energy Security' – had only been heard of by just over one quarter of respondents.

'Changes to the Appearance of the Countryside' as the third most widely known potential impact, heard of by more than half of respondents, is another interesting point. The inclusion of this term was based on discussions from the focus group stage of research which indicated that the term 'countryside' was understood to refer to the British countryside, rather than rural areas in other countries.

Whilst the majority of respondents had heard of this potential impact, its actual occurrence is not substantiated by the literature. As such, although a large proportion of the public seem to believe 'Changes to the Appearance of the

Countryside' to be a possible impact of biofuel production and use, current research and scientific knowledge do not agree.

Statistical analysis revealed more complex relationships associated with age, Gender, Knowledge of Biofuels, Concern for the Environment and Highest Level of Education all affecting familiarity with the potential impacts. Table 12 shows which demographic factors were associated with statistically significant differences in familiarity with the potential impacts included in the questionnaire. Full statistical outputs can be found in Appendix 7 and graphs can be found in Appendix 8.

<b>Potential Impact</b>	<b>Age</b>	<b>Gender</b>	<b>Level of Education</b>	<b>Env. Concern</b>	<b>Biofuel Knowledge</b>
<b>Deforestation of the Rainforest</b>	X				X
<b>Reduced Carbon Emissions from Transport</b>					X
<b>Changes to the Appearance of the Countryside</b>				X	X
<b>Use of Large Amounts of Land</b>		X	X	X	X
<b>Loss of Plant and Animal Species</b>				X	X
<b>Use of Genetically Modified Crops</b>	X	X	X		X
<b>Increased Food Prices</b>		X	X	X	X
<b>More Expensive Fuel</b>					
<b>Reduced Food Supplies</b>		X	X	X	X
<b>Increased</b>					

<b>Greenhouse Gases</b>	X		X		X
<b>Improved Energy Security</b>		X	X	X	X
<b>Less Investment in Other Renewable Transport Options</b>			X	X	X
<b>Human Rights Abuses</b>	X			X	X

**Table 12. Demographic factors associated with statistically significant differences in familiarity with various potential impacts of biofuel production and use (for full statistical outputs see Appendix 7)**

As can be seen in Table 12, Level of Reported Biofuel Knowledge was associated with significant differences for twelve of the thirteen potential impacts. For eleven of these twelve impacts, the general trend shows that higher reported knowledge of biofuels is generally associated with greater familiarity with the impact (indicated by a lower mean awareness rating). The exception to this was in familiarity with Increased Greenhouse Gases as a potential impact of biofuel production and use. In this case, those who did not know how to rate their knowledge of biofuels reported significantly greater awareness of the impact than those who rated their knowledge between ‘Very Low’ and ‘High’

Level of Environmental Concern was associated with statistically significant differences in familiarity for eight of the thirteen potential impacts (Table 12). In the case of all eight potential impacts for which familiarity was significantly affected by Level of Environmental Concern, the general trend shows greater concern to be associated with greater familiarity with the impacts. For seven of the potential impacts, those who were ‘Very Concerned’ about the environment were significantly more aware of the impact than those who were ‘Neither Concerned nor Unconcerned’. In six cases those who were ‘Very Concerned’ were also significantly more aware of the potential impact than those who were ‘Concerned’ or ‘Unconcerned’.

Level of Education was a statistically significant factor affecting familiarity with seven of the thirteen potential impacts (Table 12). For five of these seven potential impacts, the general trend was for those at higher levels of education (6, Bachelors degree or equivalent, or above) to be significantly more familiar with the impact. In the case of the remaining two impacts (Increased GHGs and Use of GM Crops); those at lower levels of education (0, Other, or 1, No Qualifications) were significantly more familiar than those at higher levels.

Gender was shown to be a significant factor affecting familiarity with five of the thirteen potential impacts. In all five cases, males reported significantly greater awareness of the potential impacts than females.

Age was shown to be a significant factor affecting familiarity with three of the thirteen potential impacts. In each of the three cases the general trend was for older respondents, generally those over the age of 70, to be more familiar with the potential impacts than those from younger age groups.

Although data was collected on the ethnic background of participants, it was not included with the other demographic factors in Table 12 as it did not have a significant effect on familiarity with any of the potential impacts listed.

**iv) Question 6** examined knowledge of specific biofuel issues by participant agreement or disagreement with statements relating to biofuels and their impacts. Extent of agreement or disagreement as expressed on a 5 point Likert scale in which 1 represented 'Strongly Disagree' and 5 represented 'Strongly Agree'.

Average scores (agreement ratings) were calculated for each statement, with the exclusion of 'Don't Know' responses which were considered separately. Scores greater than three were taken to represent general agreement, while scores less than three were taken to represent general disagreement.

I will begin by considering the statements for which mean agreement ratings (excluding Don't Know responses) were in excess of 3, indicating a tendency towards agreement;

- **“We can't produce enough biofuel to meet current fuel demands or increased future demands”**

The average agreement rating of 3.91 suggests a strong agreement with this statement, for respondents providing a definite answer. However, with nearly one quarter of respondents (180, 22.9%) answering 'Don't Know', it would seem there is also a large amount of uncertainty about the issue.

This statement is largely supported by the literature. Projections of data suggest that the UK/EU, and potentially further afield, will be unable to produce enough biofuel to substitute all petrol/diesel (Schmidt, 2007, Ruth, 2008). The tendency for respondents to agree with the statement may suggest awareness of this issue.

- **“Biofuels are generally cheaper than petrol/diesel”**

The average agreement rating of 3.17 suggests a slight tendency towards agreeing with this statement.

This statement is not supported by current data that show that production and feedstock costs make biofuels more expensive than petrol/diesel (Commission of the European Communities, 2007, Goldemberg, 2007). The fact that respondents tended to agree with a false statement would suggest that many are not aware of this.

- **“Biofuels can only be used in existing cars if they have specially modified engines”**

An average agreement rating of 3.55 suggest that respondents tended to agree with this statement. However, with more than one quarter of respondents (205, 26.1%) answering 'Don't Know', there would seem to be a large amount of uncertainty about the issue.

This statement is not supported by the current data; when blended with petrol or diesel, up to a certain concentration, biofuels can be used safely in existing car engines (Morrone et al., 2009, The Royal Society, 2008). As such, the tendency of respondents to agree with this statement may suggest a lack of awareness of this.

It is possible there may have been some confusion in answering this question as it is not clear whether biofuel-fossil fuel blends are included or not.

• **“Biofuels will be useful to help reduce our dependence on fossil fuels”**  
(3.75)

An average agreement rating of 3.75 suggests that respondents tended to agree with the statement.

This statement is supported by current evidence and is an underlying driver of government interest in biofuels (Charles et al., 2007, Commission of the European Communities, 2007, Danielsen et al., 2008). The tendency of respondents to agree with the statement would seem to suggest awareness of this issue. However, with nearly one fifth of respondents (154, 19.6%) answering ‘Don’t Know’, there again seems to be a large amount of uncertainty about the issue.

• **“Growing biofuels in the UK will reduce the natural beauty of the countryside”**

An average agreement rating of 3.18 suggests that respondents had a slight tendency to agree with the statement.

There is little evidence to support this statement and it not an issue dealt with at length in the literature (Rothamsted Research, 2008). As such, the tendency towards agreement shown in the results suggests either a lack of awareness of the issue or exposure to inaccurate information sources. In addition, with one quarter of respondents (196, 25.0%) answering ‘Don’t Know’, there seems to be a large amount of uncertainty about the issue.

• **“Biofuel production is contributing to destruction of the rainforest”**

An average agreement rating of 3.63 suggests respondents tended to agree with the statement.

Evidence to support the statement is mixed. While there is literature that has attributed deforestation to expanding biofuel production, there is also literature that believes the extent of deforestation due to biofuel production is not as great as has been suggested (Charles et al., 2007, Danielsen et al., 2008). The tendency towards agreement with the statement suggests lack of accurate knowledge, possibly due to exposure to inaccurate or old information sources. In addition, with more than one third of respondents (276, 35.2%) answering ‘Don’t Know’, there seems to be a large amount of uncertainty about the issue.

• **“Biofuel production is responsible for reduced food supplies and increased food prices”**

An average agreement rating of 3.33 suggests that respondents had a slight tendency to agree with the statement. In addition, with nearly two fifths of respondents (309, 39.4%) answering ‘Don’t Know’, there would seem to be a large amount of confusion about the issue.

The evidence related to the statement is complex and conflicting as attributing impacts on food supplies to biofuels is not straightforward. The literature suggests that, while it is possible biofuel production has contributed to these food issues, it is not certain and is unlikely to be the only factor affecting food supplies and prices (Charles et al., 2007, Field et al., 2008, Koh and Ghazoul, 2008). The tendency towards agreement with the statement suggests a lack of accurate knowledge, possibly due to exposure to inaccurate information. However, the extent of uncertainty seen may be a reflection of the complex and unclear nature of the information on the subject.

	Age	Gender	Level of Education	Env. Concern	Knowledge of Biofuels
<b>We can't produce enough biofuel to meet current fuel demands or increased future demands</b>	X	X	X	X	
<b>Biofuels are generally cheaper than petrol/diesel</b>			X		
<b>Biofuels can only be used in existing cars if they have specially modified engines</b>	X	X	X		X
<b>Biofuels will be useful to help reduce our dependence on fossil fuels</b>					
<b>Growing biofuels in the UK will reduce the natural beauty of the countryside</b>	X		X		
<b>Biofuel production is contributing to destruction of the rainforest</b>				X	
<b>Biofuel production is responsible for reduced food supplies and increased food prices</b>		X		X	

**Table 13. Demographic factors associated with statistically significant differences in agreement or disagreement with statements about biofuels (for full statistical outputs see Appendix 10)**

As can be seen in Table 13, a number of demographic factors were found to have significant effects on the extent of agreement or disagreement with the statements.

Level of Education was the most pervasive of these, with analysis of data showing that level of education had a significant effect on responses to four of the seven statements above. In all four cases there is a trend to suggest that those with higher educational achievement had greater awareness of the issues, being more likely to agree with supported statement or disagree with unsupported statements.

Age, Gender and Level of Environmental Concern were all shown to have significant effects on responses to three of the seven statements.

In the case of Age the groups were less clearly associated with 'right and wrong' answers than with level of education. For each of the three statements for which age was a significant factor, those over the age of 70 were more likely to agree with the statement than those in younger age groups. For two of the three statements this made those over 70 more likely to agree with an unsupported statement, but for the remaining statement they were more likely to agree with a supported statement.

In the case of Gender, Males were shown to be significantly more likely to agree with one supported statement and significantly more likely to disagree with one unsupported statement. For the third statement, regarding reduced food supply, the literature support was mixed; however, males were shown to be significantly more likely to agree with the statement.

In the case of Environmental Concern, those who considered themselves to be 'Very Concerned' about the environment were shown to be significantly more likely to agree with the three statements for which Environmental Concern was a significant factor.

I will now consider statements for which mean agreement ratings (excluding Don't Know responses) were less than three, suggesting a tendency towards disagreement.

- **“It is not possible to buy biofuels in the UK at present”**

An average agreement rating of 2.55 suggests that respondents had a tendency to disagree with the statement.

Under the RTFO, all petrol and diesel sold in the UK currently contains a percentage of biofuel, it is also possible to buy other forms of biofuel in the UK (Gallagher, 2008). The tendency for respondents to disagree with this statement would suggest that they are aware of the availability of biofuels in the UK, although this cannot be extrapolated to suggest awareness of the underlying legislation. However, with more than one third of respondents (293, 37.3%) answering ‘Don’t Know’, it would seem there is a large amount of uncertainty about the issue.

- **“Biofuels are worse for the environment than fossil fuels”**

An average agreement rating of 2.45 suggests that respondents had a tendency to disagree with the statement.

There is some literature to support this statement. While biofuels have been developed with the intention of benefiting the environment, some studies have shown negative environmental impacts and some cases of increased greenhouse gas emissions, although this is not universally true (Charles et al., 2007). The tendency to disagree with the statement suggests that respondents have not been exposed to the negative reports about the environmental impact of biofuels and retain knowledge of previous, positive reports. In addition, with nearly one third of respondents (242, 30.8%) answering ‘Don’t Know’, there would seem to be a large amount of confusion about the issue.

- **“Using biofuels will reduce greenhouse gas emissions from transport”**

An average agreement rating of 2.48 suggests that respondents had a tendency to disagree with the statement.

There is much evidence in the literature that supports this statement. Interest in biofuels has been due in part to the promise of reduced GHG emissions, although there have been reports of poorly produced fuels that do not deliver

such reductions (Commission of the European Communities, 2007, Danielsen et al., 2008).

The tendency to disagree with the statement suggests a lack of knowledge on the subject and/or exposure to negative reports. However, with more than one quarter of respondents (224, 28.5%) answering 'Don't Know', there would seem to be a large amount of uncertainty about the issue.

- **“Biofuels are carbon neutral”**

An average agreement rating of 2.86 suggests participants had a slight tendency to disagree with the statement.

While early work on biofuels may have supported this claim, more recent evidence from the literature does not support the idea of biofuels being carbon neutral, due to inputs to the production process (Charles et al., 2007, Field et al., 2008, The Royal Society, 2008).

The tendency to disagree with the statement suggests awareness of this fact. In addition, with nearly half of respondents (364, 46.34%) answering 'Don't Know', there would seem to be a huge amount of confusion about the issue.

- **“Biofuels are the only available alternative for use in transport”**

An average agreement of 2.00 suggests that participants tended to disagree with the statement.

The literature details many other options for fuelling transport aside from biofuels, including electricity and hydrogen (Okken, 1991).

The respondents' tendency to disagree with this statement suggests awareness of this fact. However, with more than one quarter of respondents (218, 27.8%) answering 'Don't Know', there would seem to be a large amount of confusion about the issue.

	Age	Gender	Level of Education	Env. Concern	Knowledge of Biofuels
<b>It is not possible to buy biofuels in the UK at present</b>		X			
<b>Biofuels are worse for the environment than fossil fuels</b>				X	
<b>Using biofuels will reduce greenhouse gas emissions from transport</b>		X			
<b>Biofuels are carbon neutral</b>	X		X		
<b>Biofuels are the only available alternative for use in transport</b>		X			

**Table 14. Demographic factors associated with statistically significant differences in agreement or disagreement with statements about biofuels (for full statistical outputs see Appendix 11)**

As can be seen in Table 14, Gender and Reported Knowledge of Biofuels were the demographic factors most frequently associated with significant differences in agreement/disagreement with the statements for which average agreement ratings suggested a tendency to disagree.

In the case of Gender, for all three statements for which it was a significant factor, males were shown to be significantly more likely to disagree. Two of the statements were not supported by the literature and as such, males were more likely to give 'correct' answers. However, the third statement, regarding

reducing GHGs through the use of biofuels, is supported by the literature and, as such; females were more likely to give the 'correct' answer in this case.

In the case of Reported Knowledge of Biofuels, results presented a less clear picture. In the case of the statement relating to availability of biofuels in the UK, which was not supported by evidence, those of greater reported knowledge of biofuels were more likely to disagree. However, in the case of the statement relating to the availability of other alternatives for transport, which was again not supported by evidence, those of lower reported biofuel knowledge were significantly more likely to disagree than those of 'Neither High nor Low' reported knowledge.

#### **4.3.3 RA2: To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels awareness and knowledge of biofuels effectively**

- Examine sources of biofuel information that the general public use and trust

##### **i)“I don't know who to believe when it comes to biofuel information” (3.47)**

With an average score of 3.47, results suggest that respondents had a tendency to agree with the statement.

Responses to this statement were shown to be affected by Age ( $H(2)=24.483$ ,  $d.f.=6$ ,  $p=0.000$ ), Gender ( $H(2)=13.276$ ,  $d.f.=1$ ,  $p=0.000$ ), Level of Education ( $H(2)=47.379$ ,  $d.f.=8$ ,  $p=0.000$ ) and Reported Biofuel Knowledge ( $H(2)=61.217$ ,  $d.f.=5$ ,  $p=0.000$ ).

Those aged 70 or over gave significantly higher answers than those aged 20-29 or 50-59, indicating greater agreement with the statement.

On average, males gave significantly lower answers than female, indicating lower agreement.

Those at qualification level 8 and 6 gave significantly lower answers than those at level 1, indicating lower agreement. Those at level 7 gave significantly lower answers than those at levels 5 and 1.

Those who rated their biofuel knowledge as Very High gave significantly lower answers (greater disagreement) than those who rated theirs as Neither High nor Low, Low or Very Low. Those who rated their knowledge as High or Neither High nor Low gave significantly lower answers than those who rated their knowledge as Low or Very Low.

- ii) **Question 9** was concerned with the sources from which respondents obtained information on biofuels.

Of the twelve sources listed on the questionnaire, Television Programmes/Documentaries were the most used (535, 68.2%), followed by Television/Radio News (485, 61.8%) and Broadsheet Newspapers (340, 43.3%).

	<b>Age</b>	<b>Gender</b>	<b>Level Of Education</b>	<b>Env. Concern</b>	<b>Knowledge of Biofuels</b>
<b>Television Programmes/ Documentaries</b>	X	X			X
<b>Television/Radio News</b>	X				X
<b>Broadsheet Newspapers</b>	X	X	X		X
<b>Relatives/Friends</b>	X		X	X	
<b>Work/School/ University</b>	X		X		X
<b>Magazines</b>		X			X
<b>Industry</b>					X
<b>News Websites</b>	X	X	X		
<b>Other Websites</b>	X	X	X		X
<b>Scientific Journals</b>		X	X	X	X
<b>Government Reports</b>				X	X
<b>Tabloid Newspapers</b>	X	X	X		

**Table 15. Demographic factors associated with statistically significant differences in the use of different sources of information (for full statistical outputs see Appendix 12)**

As can be seen in Table 15, Reported Knowledge of Biofuels was the factor most frequently associated with statistically significant differences in the use of the listed sources of information. Reported Knowledge of biofuels was associated with significant differences in the use of nine of the twelve listed sources of information (Table 15). In the case of all but one of these sources, Television/Radio News, results suggest a trend towards significantly greater use of the source amongst those respondents with higher knowledge ratings.

Age was associated with significant differences in the use of eight of the twelve listed sources of information (Table 15). In the case of four of these sources, Television Programmes/Documentaries, Television/Radio News, Broadsheet Newspapers and Tabloid Newspapers, results suggest a trend towards significantly greater use of the source by respondents in older age groups; most frequently those aged 50 or over. For the other four sources, Relatives/Friends, Work/School/University, News Websites and Other Websites, results suggest the opposite – significantly greater use of the source by younger respondents; most frequently those under 40.

Both Gender and Level of Education were associated with significant differences in the use of seven of the twelve sources (Table 15).

For each of the eight sources where Gender was shown to be a significant factor affecting use, males were shown to use the source significantly more than females.

In the case of Level of Education, results suggest a trend towards significantly greater use of Broadsheet Newspapers, Relatives/Friends, Work/School/University, News Websites, Other Websites and Scientific Journals by those at higher levels of education; most frequently Level 6 (Bachelors Degree or equivalent) or above. However, in the case of Tabloid

Newspapers, results suggest the opposite, significantly greater use amongst those of lower levels of education (Level 1, No Qualifications).

Environmental Concern was associated with significant differences in the use of three of the twelve sources (Table 15). In all three cases (Relatives/Friends, Scientific Journals, Government Reports), those who considered themselves to be 'Very Concerned' about the environment made significantly more use of the source than those of lesser concern.

Fifty respondents had not obtained information on biofuels from any source.

iii) **Question 10** examined the extent to which participants trusted a range of sources.

Based on mean agreement with the statements, the most trusted source of information was Scientists (3.64), followed by Television Documentaries (3.30) and Television News (3.05).

	<b>Age</b>	<b>Gender</b>	<b>Level of Education</b>	<b>Env. Concern</b>	<b>Knowledge of Biofuel</b>
<b>Television News</b>		X			X
<b>Tabloid Newspapers</b>			X	X	X
<b>Government</b>	X	X			
<b>Scientists</b>	X			X	X
<b>Television Documentaries</b>		X			

**Table 16. Demographic factors associated with statistically significant differences in trust of different sources of information (for full statistical outputs see Appendix 13)**

As can be seen in Table 16, both Gender and Reported Knowledge of Biofuels were associated with significant differences in trust in three of the five sources.

In the case of Gender, females gave significantly higher answers, indicating greater trust for each of the three sources – Television News, Government and Television Documentaries.

In the case of two of the three sources for which Reported Knowledge of Biofuels was shown to be a significant factor affecting trust (Tabloid Newspapers and Television News), results suggest that trust was significantly higher in those of lower biofuel knowledge. For the remaining source, Scientists, results suggested the opposite, that trust was significantly higher in those of higher biofuel knowledge.

Age and Environmental Concern were both associated with significant differences in trust for two of the five sources (Table 16).

In the case of Age, results suggest that those in their 20s were significantly more likely to trust both the Government and Scientists than older participants.

In the case of Environmental Concern, results suggest that those of greater environmental concern were significantly more likely to trust Scientists and Tabloids than those of lower environmental concern.

Level of Education was only found to be associated with significant differences in trust in Tabloids. Results suggest that those of lower levels of education were significantly more likely to trust Tabloid newspapers than those of higher levels of education.

#### **4.3.3 RA3: Highlight the key concerns of the different stakeholders**

- Examine the biofuel risks and problems that the general public are aware of and which areas are of greater or lesser concern

- i) **Question 5** was designed to specifically identify issues of greatest concern.

Based on Mean Concern Ranks (excluding 'Don't Know' and incorrect responses), the issue of most concern for participants was Deforestation of the Rainforest (3.01), followed by Higher Fuel Prices (4.22) and Increased Food Prices (4.42).

	Mean Concern Rank
Deforestation of the Rainforest	3.01
Higher Fuel Prices	4.22
Increased Food Prices	4.42
Loss of Species	4.52
Reduced Food Supplies	4.71
Use of large amounts of land	5.01
Increased Greenhouse Gas emissions	5.13
Changes in the appearance of the countryside	5.16
Human Rights Abuses	5.29
Less investment in other renewable transport	5.49
Use of GM crops	5.49

**Table 17. Mean concern ranks for each potential impact of biofuel production (1=Number One Concern, 5=Number Five Concern, 6=Not a Top Five Concern)**

For Cutting Down the Rainforest, statistical testing revealed significant differences by Age ( $H(2)=21.234$ ,  $d.f.=6$ ,  $p=0.002$ ), Gender ( $H(2)=14.548$ ,  $d.f.=1$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=21.093$ ,  $d.f.=5$ ,  $p=0.001$ ), Those aged 20-29 rated the concern significantly lower than those aged 60 or over. Females rated the concern significantly lower than males. Those who were Very Concerned about the environment rated the

concern significantly higher than those who were Neither Concerned nor Unconcerned or Very Unconcerned.

For More Expensive Fuels, statistical testing revealed significant differences by Age ( $H(2)=34.852$ ,  $d.f.=6$ ,  $p=0.000$ ), Gender ( $H(2)=4.916$ ,  $d.f.=1$ ,  $p=0.027$ ) and Environmental Concern ( $H(2)=31.002$ ,  $d.f.=5$ ,  $p=0.000$ ).

Those aged 20-29 rated the concern significantly higher than those aged 30 or over. Females rated the concern significantly higher than males. Those who were Very Concerned about the environment rated the concern significantly lower than those who were Concerned or Neither Concerned nor Unconcerned.

For Increased Food Prices, statistical testing revealed significant difference by Environmental Concern ( $H(2) =20.695$ ,  $d.f. =5$ ,  $p=0.001$ ) Those who were Very Concerned about the environment rated the concern significantly lower than those who were Concerned or Neither Concerned nor Unconcerned.

For Use of Large Areas of Land, statistical testing revealed significant differences by Age ( $H(2)=14.070$ ,  $d.f.=6$ ,  $p=0.029$ ), Gender ( $H(2)=11.122$ ,  $d.f.=1$ ,  $p=0.001$ ) and Reported Biofuel Knowledge ( $H(2)=13.161$ ,  $d.f.=5$ ,  $p=0.022$ ).

Those aged 20-29 rated the concern significantly lower than those aged 60-69. Males rated the concern significantly higher than females. Those who rated their knowledge as Very High rated the concern significantly lower than those who rated their knowledge as High, Neither High nor Low, Low or Very Low.

For Human Rights Abuses, statistical testing revealed significant differences by Gender ( $H(2) =9.154$ ,  $d.f. =1$ ,  $p=0.002$ ). Females rated the concern significantly higher than males.

For Loss of Plant and Animal Species, statistical testing revealed significant differences by Gender ( $H(2) = 9.002$ , d.f.=1,  $p=0.003$ )

Females rated the concern significantly higher than males.

For Use of GM Crops, statistical testing revealed significant differences by Environmental Concern ( $H(2) = 16.275$ , d.f. =5,  $p=0.006$ )

Those who were Concerned or Very Concerned about the environment rated the concern significantly lower than those who did not know how concerned they were.

For Less Investment in Other Renewable Transport Options, statistical testing revealed significant differences by Level of Education ( $H(2) = 25.899$ , d.f. =8,  $p=0.001$ ), and Reported Biofuel Knowledge ( $H(2) = 27.567$ , d.f. =5,  $p=0.000$ ).

Those at qualification level 2 rated the concern significantly lower than those at levels 4, 6 and 7. Those at level 6 rated the concern significantly higher than those with 'Other' qualifications. Those who rated their biofuel knowledge as Very High rated the concern significantly higher than those who rated their knowledge as High, Neither High nor Low or Low. Those who rated their knowledge as High rated the concern significantly higher than those who rated their knowledge as Low, Very Low or Don't Know.

#### **4.3.3 RA5: Compare acceptability of and concerns about biofuels with those related to other energy generation options**

- Examine how opinions of biofuels affect their relative acceptability in comparison with other options for generating energy

i) **Question 7** assessed relative preference for biofuel in comparison with other energy generation options. Respondents were required to state whether they felt an energy generation option was more, less or equally preferable to biofuels.

In average preference ratings, scores less than two indicate an option was considered to be more preferable than biofuels and scores of more than two indicate an option was less preferable. As such, three of the seven options were more preferable than and four were less preferable (See Table 18).

Energy Option	Average Preference Rating (excluding 'Don't Know' responses)
Solar	1.30
Wind	1.41
Hydroelectric	1.42
Nuclear	2.30
Gas	2.34
Oil	2.57
Coal	2.66

**Table 18. Average Preference Ratings for a range of energy options when compared to biofuel (1=More Preferable than Biofuel, 2=Equally Preferable to Biofuel, 3=Less Preferable than Biofuel)**

Based on the average preference ratings displayed in Table 13, on average, Solar, Wind and Hydroelectric were the options considered to be more preferable than biofuels and Nuclear, Gas, Oil and Coal were the options considered to be less preferable than biofuels.

However, statistical analysis showed that relative preferences were affected by a number of demographic factors (Table 19).

	Age	Gender	Level of Education	Env. Concern	Biofuel Knowledge
Oil/Petrol			X	X	X
Nuclear		X	X		X
Coal			X		X
Hydroelectric		X			X
Solar				X	
Wind	X			X	
Gas			X		X
Tidal/Wave		X	X		

**Table 19. Demographic factors associated with significant differences in preference for various other energy technologies/fuels in comparison to biofuels (for full statistical outputs see Appendix 14)**

As can be seen in Table 19, Level of Education and Reported Biofuel Knowledge were the factors most frequently associated with significant differences in preference, each associated with five of the eight fuel/technology options listed.

In the case of Level of Education, results suggest that those of higher levels of education were significantly more likely to feel oil/petrol, coal and gas were less preferable than biofuels and that nuclear and tidal/wave power were more preferable than biofuels.

In the case of Reported Biofuel Knowledge, results suggest that those of greater reported biofuel knowledge ('Neither High nor Low' or above) were significantly more likely to feel oil/petrol, coal and gas were less preferable than biofuels than those of lower reported biofuel knowledge ('Low' or below). Results also suggest that those with greater biofuel knowledge were significantly more likely to feel nuclear and hydroelectric were more preferable than biofuels, than those of lower biofuel knowledge.

These two relationships are of particular interest. The fact that those of greater education and greater reported biofuel knowledge show

preference for biofuels over fossil fuels does suggest that working to improve knowledge of biofuels may help improve their acceptability, at least relative to fossil fuels. Additionally, the fact that these participants showed preference for renewables and nuclear energy could suggest they are more able to assess the options based on relative costs and benefits.

Gender and Environmental Concern were shown to be factors significantly affecting preference for three of the eight fuel/technology options listed.

In the case of Gender, results suggest that females were significantly more likely to feel nuclear, hydroelectric and tidal/wave were less preferable than biofuels, than males.

In the case of Environmental Concern, results suggest that those who were more concerned about the environment ('Very Concerned' or 'Concerned') were significantly more likely to feel Solar and Wind power were more preferable than biofuels, but Oil to be less preferable than biofuels, than those of lesser environmental concern ('Neither Concerned nor Unconcerned' or 'Unconcerned').

Age was only shown to be significant in preference for Wind power. Results suggest that older respondents (over 50) were significantly more likely to feel Wind was more preferable than biofuels than those aged 39 or under.

**ii) "I support the use of biofuels in the UK" (3.42)**

More than one third of total respondents agreed or strongly agreed with the statement (291, 37.07%). A chi squared test produced a statistically significant result ( $\chi^2=308.174$ , d.f. =4,  $p=0.000$ ), suggesting a significantly greater level of agreement with the statement than would be expected.

Responses to this statement were shown to be affected by Gender ( $H(2) = 8.133$ , d.f. =1,  $p=0.004$ ) and whether respondents had heard of biofuels previously ( $H(2) =5.495$ , d.f.-1,  $p=0.019$ ).

On average, males agreed with the statement significantly more than females.

Those who had heard of biofuels previously agreed with the statement significantly more than those who had not.

However, nearly one quarter (192, 24.5%) did not know if they agreed or disagreed with the statement.

## **4.4 Discussion**

### **4.4.1 - RA1 Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent**

When considered in isolation, the level of familiarity with the term 'biofuels' presented in the results suggest quite a high level of public familiarity with biofuels. However, when considered within the context of familiarity with other energy generation terms, awareness of biofuels was actually comparatively low. Similar levels of awareness of biomass as an energy source were reported by Poortinga et al., (Poortinga et al., 2006) and were believed to be due to low media coverage.

Other studies have also reported findings that suggest public awareness of technological, scientific and environmental issues is widespread but at a low level (Lin et al., 2011, Browne et al., 2012, Fletcher et al., 2009). Discussion of public awareness specifically related to biofuels in the literature is limited; however, consideration of public awareness of other similar issues presents similar results of low but widespread knowledge (Fletcher et al., 2009, Read, 1999, Bostrom and Lofstedt, 2010).

Respondents were significantly more aware of fossil fuels and longer standing renewables, such as solar and wind power. As these technologies have been used/developed/discussed over longer periods of time than biofuels, this is not a surprising result. Similar results have been reported in a study from Crete by Zografakis et al. (2010)

Analysis of answers according to demographic factors suggested that awareness of biofuels was significantly greater in males and those of greater educational attainment. Reasons for such demographic differences will be discussed in the chapter's conclusion.

Reported Knowledge of biofuels was also shown to be low on the whole, based on participants' own assessments. This is in-keeping with results and discussion in other studies that suggest public knowledge of scientific issue is generally low (Kim, 2007, Retzbach et al., 2011, Zajko, 2011, Pickersgill, 2011, Mikulak, 2011).

Analysis of results by demographic factors showed that reported knowledge of biofuels was significantly higher in participants under 70, males, those of greater educational attainment and those who were more concerned about the environment. Reasons for such demographic differences will be discussed in the chapter's conclusion.

Such information on variations in reported knowledge by demographic factors may be of use in planning a targeted information campaign. It would seem that focussing efforts on older people and those of lower levels of education and lower environmental concern may be of most benefit. However, as reported knowledge was generally low across the board, it is likely that increased/improved information provision to the general public at large may also be required.

In terms of awareness of specific biofuel issues, the vast majority of respondents reported awareness of at least one of the potential impacts listed in question 4, with only 35 (4.5%) not reporting knowledge of any of the impacts.

Results show that issues relating to environmental impacts were the most widely known. While no one issue was known by all participants; deforestation of the rainforest was the single most known issue, being recognised by more than three quarters of respondents.

The prevalence of environmental issues in the most widely known potential impacts (the top six most known potential impacts were all environmental issues) may be partly due to the greater number of environmental issues present in the list (7 of 13, selection based on focus group discussions), however it is felt that it is also possible that this is due to a greater awareness and/or preoccupation with environmental issues amongst participants. While the high number of potential environmental impacts in the list would be expected to increase the number of environmental issues in the most known potential impacts, their domination as the top six most known potential impacts would support the idea of some other influence on public awareness. It is suspected that greater awareness of potential environmental impacts may be due to either greater exposure to information about these impacts over the financial, social or humanitarian impacts or greater concern about the environment leading to increased interest in information about environmental impacts.

In addition, agreement with statements in question 6 also suggests that knowledge of many specific aspects of biofuels was lacking overall. Average responses show respondents only agreed/disagreed correctly with five of the twelve statements.

This is an issue of some concern, as it suggests that the public are not being adequately/accurately informed about biofuels and that they are basing opinions about biofuels on quite seriously lacking information.

Of particular concern is the fact that respondents tended to disagree with the idea of biofuels' helping to reduce greenhouse gas emissions from transport, one of the central positive tenets of biofuels. This is of greater concern when considered in combination with the tendency for participants to agree with the statements regarding biofuels contribution to deforestation of the rainforest and impacts on food supplies.

In addition, the high number of 'Don't Know' responses suggests a large degree of uncertainty about the facts and issues pertaining to biofuels. It is assumed

that the high number of 'Don't Know' answers were not due to disinterest or boredom due to the fluctuating levels for each statement and the much lower number of 'Don't Know' responses in later questions of a similar format.

It seems clear from the results presented here that steps need to be taken to promote the positive aspects of biofuels, and present a more accurate picture of the potential negatives to the general public.

Analysis of results by demographic factors suggested that; where Age was a significant factor, older groups were less aware of the issues, giving more 'incorrect' answers than younger groups, where Gender was a significant factor, males were more aware of the issues than females, where Level of Education was a significant factor, those at higher qualification levels were more aware of the issues than those at lower levels and where Reported Biofuel Knowledge was a significant factor, those who reportedly knew more about biofuel were more aware of the issues than those who knew less. Reasons for the various demographic variations will be discussed in the chapter's conclusion.

#### **4.4.2 RA2 - To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels of awareness and knowledge of biofuels effectively**

On average, participants agreed with the statement 'I don't know who to believe when it comes to biofuel information', strongly suggesting that the public are confused and conflicted when it comes to biofuel information. It is possible that this is a result of mixed messages being presented on the subject of biofuels. Similar results have been reported in relation to science in general by The Office for Science and Technology and the Wellcome Trust (2000), who found that more than half of their respondents felt the extent of conflicting information on scientific issues confusing.

Whilst none of the listed sources were completely unused, the more mainstream media sources of Television Programmes/Documentaries,

Television/Radio News and Broadsheet Newspapers unsurprisingly dominated as most used sources. These findings are similar to those of other studies which report public information sources (on a range of topics) being dominated by mass media, specifically television and newspapers (Stromberg, 2001, Meissner et al., 1992, The Office for Science and Technology and Wellcome Trust, 2000). However, recent research by the National Science Board in the USA has shown a decline in the use of television and newspapers in favour of the internet (National Science Board, 2012). Whilst the internet was not shown to be a widely used source by participants in this study, it is not possible to say whether the level of use has increased or not because of the absence of data from earlier time points.

The variation in sources used by older and younger participants is interesting, with older participants making significantly more use of traditional sources such as television and newspapers and younger participants making use of the internet significantly more. This finding is also similar to those of the US National Science Board (2012), which reported use of the internet as a source of information being more common amongst younger people as well as those of higher levels of education.

Clearly, any strategy to inform the general public will need to make use of a variety of sources to ensure a good level of penetration across age groups.

In relation to trust in the sources, it was somewhat of a surprise to find that scientists were rated as the most trusted source on average as evidence presented in the literature is somewhat split on the subject, although there are studies that suggest that the public do trust scientists (The Office for Science and Technology and Wellcome Trust, 2000).

A point of particular interest is the difference between level of trust and extent of use of some of the sources. Despite scientists being the most trusted source, scientific journals were only the ninth most used of the twelve sources presented in question 9. This suggests another factor other than trust affects use of sources; in the case of scientists and scientific journals it is likely this factor is related to accessibility – both in terms of ability to get hold of and ability

to understand the information. This was also a conclusion of research by The Office for Science and Technology and the Wellcome Trust (2000) which concluded that the UK lacked a framework for public access to new scientific information.

Analysis of results by demographic factors suggested that, where Gender was shown to be a significant factor, females were more likely to trust a source. Whilst the literature did not yield any direct reference to females being more trusting of sources of information, there are publications that report females to rate risks more highly than males (Gustafson, 1998, Costa-Font and Gil, 2011). As such, it is possible that women's increased concern about risks may mean they more closely relate with sources and are more inclined to believe information reporting the risks of biofuels, as is the case for many sources of biofuel information in recent years. Greater belief in and relation to the sources of information may then result in the greater trust seen reported here.

Where Reported Knowledge of Biofuels was a significant factor, those of lower reported biofuel knowledge were more likely to trust a source, with the exception of scientists, where age was a significant factor, younger participants were more likely to trust a source and where level of education was a significant factor, those of lower educational attainment were more likely to trust the source. A study by Bråten et al (Bråten et al., 2011), did report a correlation between low topic knowledge and greater trust in less trustworthy sources than those with greater knowledge of the topic. As higher levels of education have been shown to be associated with greater knowledge of biofuels in this study, this may be an explanation for these observed differences in trust.

Such information about varied trust in sources according to demographics could again be helpful in ensuring an effectively targeted information campaign, to prevent efforts being wasted in spreading information through sources that the intended audience do not trust. In addition, in areas where trust and use of sources do not match up, particularly in the case of scientists, efforts could be made to increase use, likely through improved access.

#### **4.4.3 RA3 - Highlight the key concerns of the different stakeholders**

While the impacts participants were most aware of were dominated by environmental issues, those same potential environmental impacts are much more dispersed throughout the list of concerns. Although the greatest concern for participants was Deforestation of the Rainforest, echoing its position as most widely known potential impact from question four, the second and third greatest concerns were both financial, Increased Fuel Prices and Increased Food Prices.

In terms of awareness, these two potential financial impacts only ranked seventh and eighth respectively, so although they were not particularly widely known, the prospect of increased financial costs was still particularly concerning for the general public.

A similar pattern of greater public concern and motivation being associated with finances rather than the environment was reported by Whitmarsh (2009). The study into motivations underlying reduced energy use revealed the majority were more concerned with saving money than the environmental benefits (Whitmarsh, 2009). Similar findings have also been published by DEFRA (2002) and Brandon and Lewis (1999).

Taking the results of this study combined with those reported in the literature, it would seem that, while the public report environmental concerns, finances emerge as the most pressing concern in practice. This would support the idea that biofuels will need to present a financial advantage over fossil fuels in order to be fully considered by the public.

#### **4.4.4. RA5 - Compare acceptability of and concerns about biofuels with those related to other energy generation options**

Results showed that, on average, participants found renewable options (solar, wind and hydroelectric) to be the most preferable and more preferable than biofuels. Fossil fuels (gas, oil and coal) were least preferable and less preferable than biofuels. Similar results showing public preference for

renewable fuels over fossil fuels have been reported by other studies (Greenberg, 2009, Poortinga et al., 2006). Based on the results presented by Poortinga et al. (2006), it seems that biofuels may occupy a similar space in public opinion as nuclear energy, being the middle ground between renewables and fossil fuels.

These results suggest potential for a future shift away from fossil fuels towards biofuels. While participants prefer renewable energy technologies over the use of biofuels, these energy sources are less easily applied to the transport sector and would require significantly more change on the part of the consumer. While this is in keeping with results from the focus groups that suggest the public prefer the idea of a move to electric vehicles, it does not appear that they are fully aware of all the necessary developments and changes needed to make genuinely green electric transport a reality.

The fact that more than a third of respondents agreed or strongly agreed with the statement 'I support the use of biofuels in the UK' was an unexpected but interesting result. However, with nearly one quarter of respondents not knowing if they agreed or not, there is clearly still a notable degree of uncertainty and confusion surrounding the issue.

The correlation between having heard of biofuels previously and agreeing with the statement would suggest that increasing public awareness and knowledge of biofuels would lead to increased support for their use. Similar findings regarding the relationship between increased knowledge and increased support have been reported by Clark and Hellwig (2012) in relation to EU governance. Other studies into the effects of increased awareness and knowledge on a range of issues have found that increased awareness and knowledge can lead to favourable behaviour change, such as greater consideration for sustainability in grocery shopping (Hanss and Bohm, 2013) and adherence to a healthier diet (Tsartsali et al., 2008). As such, it is possible that increasing public awareness and knowledge of biofuels may increase both the support for and the use of the fuels.

This is a very important finding that should be used to support the idea of a biofuel information and communication agenda.

#### **4.4.5 Demographic Influences**

Examining the results as a whole, it is possible to identify some key trends in association between responses and demographics.

In general, results suggest that men were more aware of biofuels, knew more about biofuels and were more aware of specific biofuel issues than females. Such a result is in line with other studies which have demonstrated that there remains a gender divide in our society when it comes to awareness and knowledge of current affairs (Slevin and Aday Jr., 1993). Different issues still retain an associated 'gender appropriateness', with men seemingly having greater knowledge and awareness of issues considered stereotypically male (Slevin and Aday Jr., 1993). Within the context of this study, it could be considered that biofuels and the subject of energy generation, transportation and technology are more stereotypically male issues; in keeping with the greater awareness of biofuels amongst males. However, the study by Slevin & Aday Jr. (1993) does not conclude that actual differences in awareness and knowledge exist between males and females, but that reporting of knowledge shows gender bias. As such, it is not possible to conclude that males were actually more aware or knew more about biofuels than females, merely that they were more likely to report awareness and knowledge than females.

Trust in sources of information was also shown to differ by gender, with women being more trusting on average.

In considering the influence of Level of Education, results suggested that, in general, those of greater educational attainment were more familiar with biofuels, knew more about biofuels and were more aware of specific biofuel issues. These findings are in line with those of other studies, which have found that higher education relates to greater environmental knowledge (Ostman and Parker, 1987) as well as concern (Van Liere and

Dunlap, 1980). As such, these results suggest that those with greater educational attainment are more aware of biofuels, possibly due to increased interest in, knowledge of and concern for the environment.

Analysis of the data showed a statistically significant correlation between level of education and environmental concern, with a general trend showing greater environmental concern amongst those at higher levels of education (See Appendix 15: Environmental Concern by Level of Education for full results tables). As an extension of this, results also suggested that, in general, those of greater environmental concern were more aware of biofuels, knew more about biofuels and were more aware of specific biofuel issues. Those with greater concern for the environment are likely to be more interested in environmental issues and may be more likely to seek out and absorb information related to environmental issues, such as renewable fuels and biofuels.

A significant relationship between use of sources and reported knowledge of biofuels was also highlighted by statistical tests. For the most part, greater reported knowledge of biofuels was associated with use of a greater number of different sources of information. However, from these results it is not possible to say whether greater knowledge of biofuels encourages greater use of the sources, or if the greater use of sources of information leads to greater biofuel knowledge. However, a study into knowledge and information-seeking in PhD and MA students by Khosrowjerdi & Iranshahi (2011) found a positive relationship between prior knowledge and information-seeking behaviour.

## **5.0. Expert Stakeholder Opinions: Expanding the breadth of stakeholder contributions**

### **5.1 Introduction**

The previous chapters of this thesis have focussed on the attitudes and opinions of the general public; however, this is only one aspect of stakeholder opinions of biofuel relevant to this study. The focus on the general public was based on the notable absence of available data on public attitudes and opinions on biofuels. However, because stakeholder consultation needs a complete picture from the full range of stakeholders, it was necessary to expand the research to incorporate the expert stakeholders. It is likely that the concerns and opinions of the expert stakeholders would differ from those of the general public and would be an important aspect to consider in the risk analysis process. In the biofuel field, aside from the general public, the expert stakeholders can be divided into several broad categories; Advisory/Consultancy Groups, Biofuel Production/Blending Industry, Oil Industry, Research & Development/Academic, Commercial Users, Engine/Vehicle Manufacturers, Government and NGOs. Given the significant role these stakeholders can play in the use and development of biofuels in their various capacities, it is important that their opinions and ideas are incorporated within the issue identification for informing a risk analysis. Actions taken and advice given by these groups have the potential to influence government, consumers and other stakeholders to increase or decrease the development, acceptability and use of biofuels in the UK.

To complete this analysis this chapter sets out to establish how representatives of each of these categories are involved with biofuels and what their opinions are on the matter.

Aims of this chapter;

- To understand how different groups and organisations perceive biofuels
- To understand why these stakeholders are/not involved in biofuels at present and if this is likely to change in the future

- To identify what these stakeholders believe to be the key barriers to the greater use of biofuels
- To identify whether these stakeholders believe the barriers can be overcome and how
- To assess how these stakeholders feel biofuels compare to other options for fuelling transport
- To understand the importance of public opinion to these stakeholders and their decisions

## **5.2 Methodology**

### **5.2.1 Conducting Interviews**

From the literature, it is easy to identify three main types of interview; structured, semi-structured and unstructured (Arksey and Knight, 1999, Gillham, 2005). The difference between the three types is the extent to which question wording and the flow of the interview adhere to a pre-set framework (Arksey and Knight, 1999, Gillham, 2005). In a structured interview, the interviewer will follow a set script without deviation, whilst an unstructured interview requires the interviewer to conduct a freeform conversation around the topic(s) of interest (Arksey and Knight, 1999, Gillham, 2005). A semi-structured interview falls between these two methods, where the interviewer has a question guide but can improvise and guide the conversation as necessary, adding in further probing questions to obtain more detail or allowing the interviewee to talk at greater length about a particular areas (Arksey and Knight, 1999, Gillham, 2005). Semi-structured interviews still require a question guide to be prepared to aid the interviewer in managing the conversation and ensuring key areas are covered in a consistent way across multiple interviews (Arksey and Knight, 1999).

Semi-structured interviews are the most useful and widely used form of interview for research purposes (Arksey and Knight, 1999, Gillham, 2005) and given the nature of my work this is the method of choice for this stage of the research.

Semi-structured interviews benefit from being less formal and allow for more flexibility than a structured interview, but also produce data that is more valid and more easily comparable between interviews than a fully unstructured interview (Arksey and Knight, 1999, Gillham, 2005). The flexibility of a semi-structured interview arises from the use of open questions, allowing interviewees to use their own words and provide as much detail as they are able as well as providing opportunity for the interviewer to deviate from set questions to further probe interviewees on areas of particular interest (Gillham, 2005).

Given that comparability and validity are essential, unstructured interviews would not be the best suited. However, it is important to allow flexibility in the interview for interviewees to raise and discuss issues that had not been considered by the researcher, or for the interviewer to focus on any issue of particular interest that may arise, making structured interviews unsuitable as well.

Whilst conducting interviews in person is often considered to be the best method, distance interviewing is often more practical in terms of time, resources and expense, allowing for greater flexibility in scheduling and providing opportunity to interview subjects that may be located a significant distance away (Gillham, 2005).

Telephone interviews have a number of benefits including being quick to conduct, producing higher response rates and more detailed responses than questionnaires or other written communication as well as allowing the interviewer to react and explain any issues or confusion that may arise (Arksey and Knight, 1999, Gillham, 2005). The main disadvantage of telephone interviewing is the loss of the face-to-face element of interviewing that can make establishing a rapport between interviewer and interviewee more difficult as well as missing non-verbal signals from the interviewee (Gillham, 2005).

### **5.2.2 Question Design**

In line with recommendations from the literature, a question guide was prepared for the expert interviews (Arksey and Knight, 1999). To create the guide, questions were developed based on the project aims as well as

questions used during the public research phases. It was important to refer to the public questions in designing the interview questions to ensure that the same issues were covered in order to allow comparison of views between the different groups. Initially, a large number of questions were drafted and refined, edited and cut down to ensure all areas of interest were covered in as few questions as possible. The first stage of question editing was conducted within the research team (including the author and project supervisors), and then questions were piloted to ensure suitability for purpose. The question guide used can be found in Appendix 16.

### **5.2.3 Piloting**

The first interview conducted was treated as a pilot to test the suitability of the questions and method as well as to ensure the length of the interview was appropriate.

### **5.2.4 Interviewee selection and recruitment**

Potential interviewees were identified through literature and online searches as well as through recommendations and referrals. Interviewees were sought under a number of broad expert stakeholder categories – Advisory/Consultancy Groups, Biofuel Production/Blending Industry, Oil Industry, Research & Development/Academic, Commercial Users, Engine/Vehicle Manufacturers, Government and NGOs. Stakeholder groups were defined by a combination categorising known stakeholders from literature and internet searches and existing stakeholders studies (Turcksin et al., 2011, Englund et al., 2012, Michalopoulos et al., 2011, Hammond et al., 2012). Efforts were made to recruit equal numbers of interviewees for each expert stakeholder group; however, no interviews were declined based on over/under recruitment in a group.

A total of sixty six individuals/companies/organisations were approached and invited to participate in this study; unfortunately a list cannot be made available due to assurances of confidentiality and anonymity.

The process of invitation involved the sending of an initial request via email, if no response was received after one week a further message was sent

enquiring about interest in participating. To maximise the number of companies/organisations willing to participate, attempts were made to make participation as flexible to their needs as possible. While preference for face-to-face meetings was expressed, the option to conduct the interview via telephone (or other means of teleconferencing) was also provided to ensure interviews were convenient for participants and help secure consent to be interviewed (Gillham, 2005).

Conducting interviews via the telephone is a well-established method (Gillham, 2005). In this case, where interviewees are pre-selected, use of the telephone will not introduce any sample selection bias based on telephone ownership (Arksey and Knight, 1999, Oppenheim, 2005). Pre-selection also allowed for pre-contact to arrange telephone calls, avoiding any issues associated with unsolicited cold calling (Gillham, 2005).

If there had still been no response after another week (two weeks from initial invitation) investigations were made into alternative means of contact, and if a further week had passed without response (three weeks from initial invitation) a third request was sent. If no response had been received within a week from the third attempt (four weeks from initial invitation), other routes were explored – either through another point of contact or a new individual/organisation/company within the stakeholder group.

Potential interviewees were sent the question guide along with initial invitations to participate, this served multiple purpose: helping the potential interviewee understand what kind of information they would be expected to provide, as an indication of the length of the interview, allowing interviewees to prepare for the interview and to help interviewees keep a certain amount of structure to their responses (Gillham, 2005).

Fifteen of those contacted declined to participate, nine referred me to other individuals who may have been interested and twenty three did not respond to any invitations sent. In four cases, those contacted were interested in participating but ultimately it was not possible to arrange an interview within the available time.

From the individuals/companies/organisations contacted, fifteen interviews were arranged and conducted. Those who did agree to be interviewed covered

six of the eight previously identified stakeholder categories - Advisory/Consultancy Groups, Biofuel Production/Blending Industry, Oil Industry, Research & Development/Academic, Commercial Users, and Engine/Vehicle Manufacturers. These included companies with involvement in large scale haulage/transport of goods, large scale public transport, industrial/commercial crop and agricultural research and development, major international oil/fuel companies and vehicle/engine manufacturers, major UK based biofuel producers/blenders and representatives of farming interests. Unfortunately, no members of the NGO or Government Department groups that were approached were able to participate.

Whilst the fact that the stakeholders interviewed included a number of companies/representatives with commercial interests must be kept in mind when analysing results, it should not detract from their input as legitimate stakeholders in the discussion about biofuels. It is possible that the commercial interests of many of the stakeholders recruited may have introduced biases to their assessments of the potential for and progress in developing and expanding the use of biofuels in the UK – which again needs to be considered in any analysis and conclusions drawn.

### **5.2.5 Conducting the Interviews**

I considered informing the stakeholders of the results from the investigation into public opinion but decided not to introduce such information to other stakeholders at this stage, in case it influenced their responses to interview questions. Within the context of a risk analysis process, there is a place for such a two way exchange of information, but this would likely occur after an initial data collection phase.

For telephone interviews, I chose to use the computer programme Skype primarily because it would be easier for recording the conversations for later analysis. A Skype account with telephone number was set-up, which allowed the calling of landline and mobile phones through a computer. All interviews were recorded using two audio recorders to allow for failure of one device and also to ensure accuracy of transcription. In the case of telephone interviews, one of these recorders was a piece of software that recorded conversations

conducted through Skype. All interviewees were informed of the need to record interviews at the point of invitation to participate and also reminded of the recording and requested to consent to recording at the commencement of each interview (Gillham, 2005).

### **5.2.6 Transcription and Transcript Analysis**

Recorded conversations were transcribed and checked against recordings twice to ensure the transcript was correct. Complete transcripts were sent to interviewees for review and approval prior to analysis.

To analyse, transcripts were imported into NVivo 9 where each conversation was coded by theme for further analysis (Nihat Sad and Ozhan, 2012, Betzner et al., 2012, Dahm, 2012, Kalinowski et al., 2012).

As was discussed in section 3.5 when considering the analysis of the focus group data, it is possible to apply some quantification to qualitative data if it is considered to be beneficial to the analysis (Jick, 1979, Abeyasekera, 2002, Howe, 1988, Sandelowski, 2000, Sale et al., 2002). In the case of the data collected from the expert interviews it was decided that some quantification of topics discussed would add a further dimension to the analysis, considering not only the number of topics or number of interviewees discussing them, but also the length at which they were discussed. Greater length of discussion was assumed to be indicative of greater awareness and knowledge, and, potentially, greater concern/interest.

Outputs produced by NVivo were utilised in the analysis of transcripts, including: number of individuals discussing a topic and percentage of total conversation dedicated to a topic. In the case of analysing results by group, averages were taken from outputs of individual transcripts. The use of percentage outputs from NVivo analysis of transcripts and open questions has been documented in other studies (Marques et al., 2011, Van Cauwenberg et al., 2012, Sandelowski, 2001).

## **5.3 Results**

In this section, I present the results of the semi structured expert interviews. A total of fifteen interviews were conducted over a period of

eight months between February and September 2012. The interviewees were divided into six types according to the sector interests of the participant stakeholders, these were: – Advisory/Consultancy Groups (n=3), Biofuel Industry (n=3), Commercial Users (n=3), Oil Industry (n=3), Research and Development (n=2) and Vehicle/Engine Manufacturers (n=1). It is unfortunate that the sample sizes achieved were low, particularly in the Vehicle/Engine Manufacturer group; the impacts of the small sample size must be kept in mind during analysis of results. The broader applicability of findings from the Vehicle/Engine Manufacturer group may be limited; however, due to difficulties in recruitment, it was not wanted to exclude any data that had been collected.

As a result of both the pre-provision of questions and the greater familiarity of the expert stakeholders with biofuels, the interview process was much less structured and required much less input and guidance from the interviewer compared to discussions with the general public. As such, while all areas of interest were covered, the data gathered was less clearly defined in terms of separate subjects. This is reflected in the presentation of results, with certain research aims being considered together to prevent repetition of information.

Due to confidentiality and anonymity concerns of some expert interviewees, only a limited number of direct quotes from interviews can be provided.

### **5.3.1 Awareness and Concerns relating to Biofuels**

**Research Aim 1: Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent and**

**Research Aim 3: Highlight the key concerns of the different stakeholders**

Unlike with the public stakeholders where the issues of awareness and concerns were handled in distinctly separate sections of the conversation, the greater familiarity of the experts with biofuels resulted in the two issues merging in their discussions. As such, I have considered the issues together in order to avoid repetition. Discussion of the results will, however, be handled separately for each Research Aim.

Unlike when analysing public knowledge and awareness of biofuels, the fact that stakeholders engaged at this stage were selected for their expertise means a high level of knowledge and awareness of biofuels is to be assumed. As such, analysis of data from expert stakeholders will focus on identifying the properties of biofuels discussed by experts as a point of comparison for the 'knowledge' of the general public.

In total, across the fifteen interviews, 73 separate negative issues and problems with biofuels were identified in discussions. In addition, 32 separate positive issues and motivating factors associated with biofuels were also identified.

#### **i) Problems Associated with Biofuels (RA1 and RA3)**

One of the main aims of this study was to identify what those working in the biofuel field believed to be the most significant areas for concern and barriers to the future development and expansion of biofuels in the UK. All fifteen interviews contained some discussion of problems, barriers and challenges related to the use, development and expansion of biofuels. On average across the fifteen interviews, effectively one quarter (24.14%) of the time was spent discussing such barriers. The individual interviewee who discussed barriers most was R&D 1 (43.05%). With the exception of the one Vehicle Manufacturer interviewee with a 'group average' of 39.31%, as a group, the Advisor/Consultant group discussed problems at greatest length (28.84%). The Oil Company group discussed problems for the least amount of time (15.11%).

#### **ii) Most Discussed Problems, Barriers and Challenges**

Coding the interview transcripts in NVivo 9, revealed, on the basis of average percentage of time spent discussing them, 10 issues as major problems, barriers and challenges for the development and expansion of biofuels in the UK. As with the transcripts from the public focus groups, issues were identified based on the context of the conversation and coded using NVivo software. The software allowed for comments to be coded under multiple topics if necessary, which aided the separation, or otherwise, of comments. The issues are summarised in (Table 20).

<b>Problem, Barrier or Challenge</b>	<b>Average Percentage of Total Time</b>
The Government	5.74%
Food versus Fuel	2.60%
ILUC (Indirect Land Use Change)	2.05%
Higher Costs and Need for Investment	1.83%
Food Prices	1.51%
Fuel Duty and Tax	1.06%
Engine Damage	0.96%
NGOs	0.94%
Uncertainty	0.81%
Infrastructure	0.78%

**Table 20. Most discussed Problems, Barriers and Challenges across all interviews, by average percentage of total time**

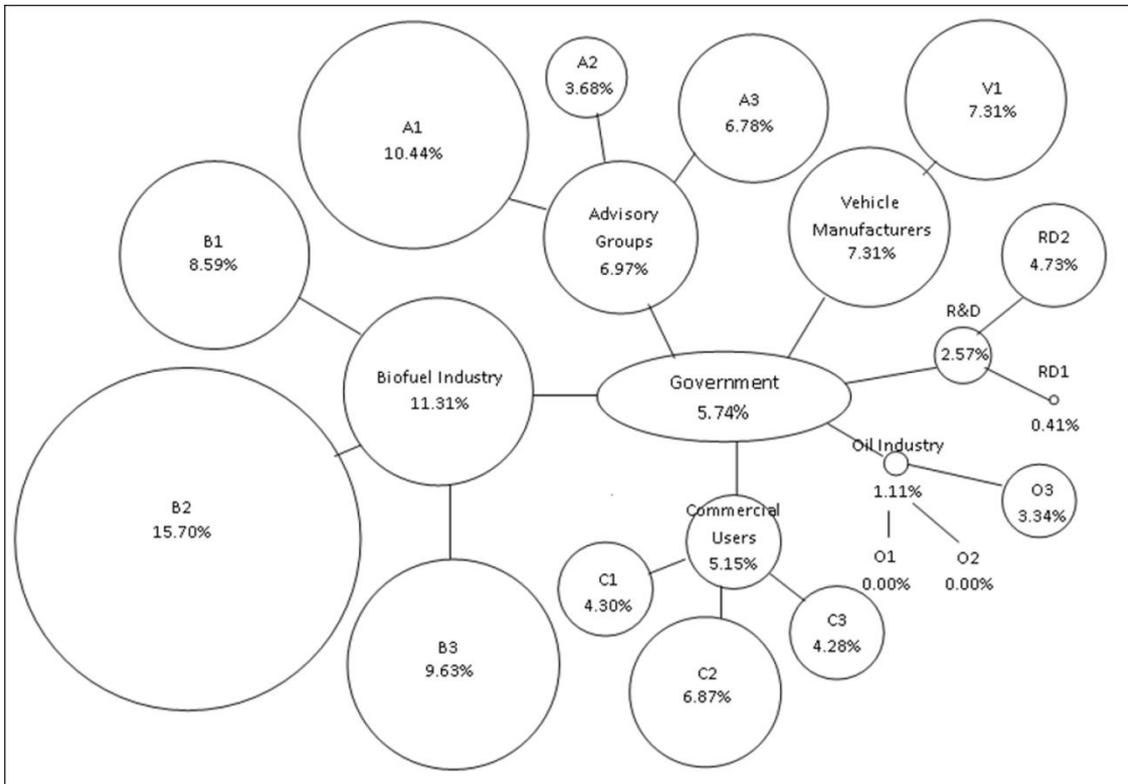
I shall now discuss the three most discussed barriers in greater detail, followed by a summary of the remaining issues.

**a) Government**

The Government was the most discussed problem, barrier or challenge for the further development and expansion of biofuels in the UK, based on average percentage of total time spent discussing the different issues across all fifteen interviews. The Government as a barrier was discussed by thirteen of the fifteen interviewees, with the exceptions being two of the

three Oil Industry representatives (O1 and O2). Furthermore the remaining Oil Industry representative (O3) had the second lowest percentage discussion of the government as a barrier of all interviewees. These results suggest that the government is not perceived by the Oil Industry to be as great a barrier as by the other stakeholder groups.

This conclusion is also evident in Fig 10, which displays the percentage coverage of discussion of government as a barrier by group and individual interviewee graphically. It can be seen that there is greater discussion of government as a barrier in the Advisory group, Biofuel Industry group, Vehicle Manufacturer group and, to a slightly lesser extent, the Commercial User group.



**Fig 10. Graphical representation of the percentage coverage of discussion of the government as a barrier to the development and expansion of biofuels by group and individual interviewee**

Detailed analysis of the responses identified twenty distinct reasons why the government were perceived to be a barrier to the expansion and

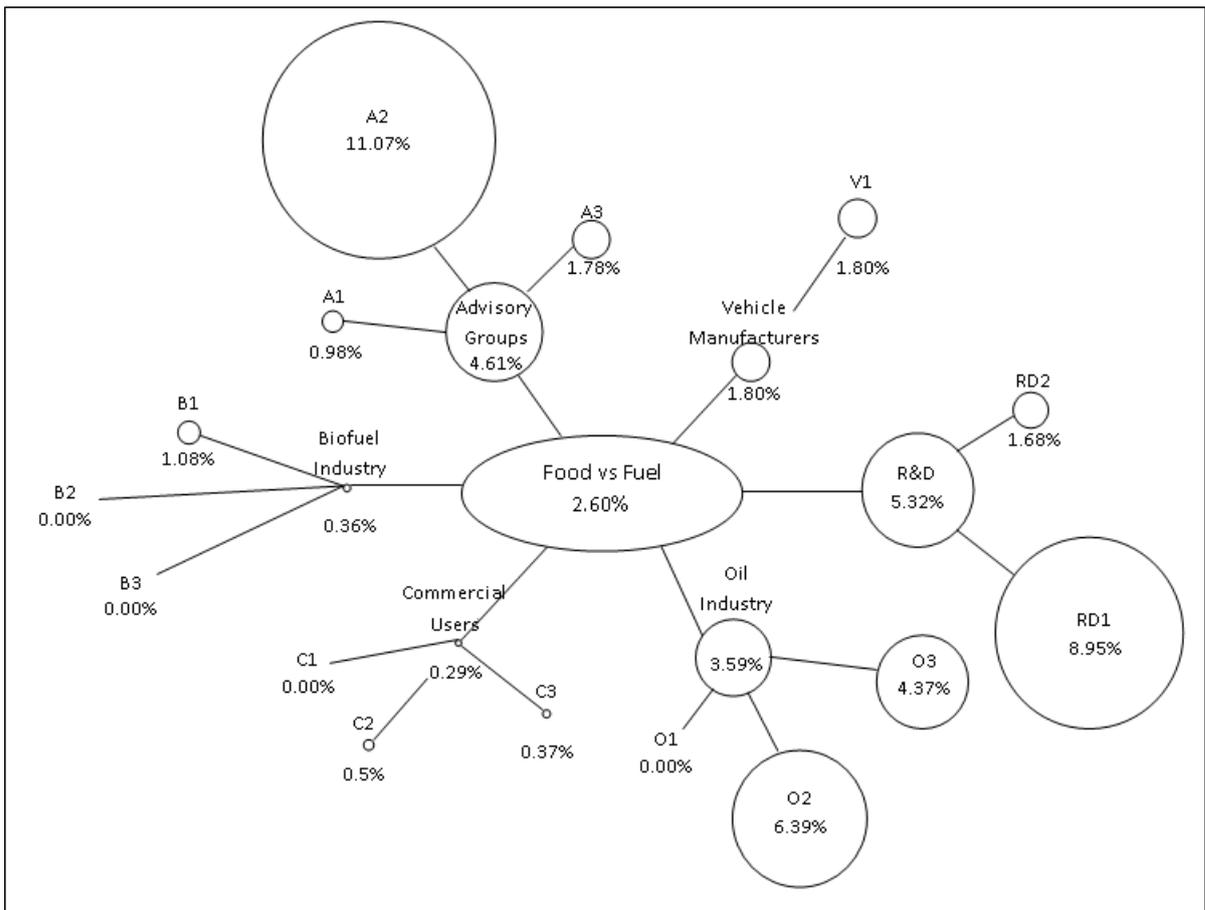
development of biofuels. These issues are detailed and discussed in section 5.3.5.

#### **b) Food versus Fuel**

The issue of Food versus Fuel was the second most discussed barrier to the further use and development of biofuels in the UK, a breakdown of the coverage is summarised in Fig 11. The data show that the Food versus Fuel issue was discussed by eleven of the fifteen interviewees, with the exceptions being Biofuel Industry 2 and 3, Commercial User 1 and Oil Industry 1. Unlike with discussion of the Government as a barrier, however, those who did not discuss Food versus Fuel were not limited to a single group but represent three separate stakeholder groups, namely – Biofuel Industry, Commercial Users and Oil Industry.

Despite being discussed by most groups the percentage of time spent discussing Food versus Fuel was particularly low for Biofuel Industry 1 (1.08%), Commercial User 2 (0.05%) and Commercial User 3 (0.37%). The low levels of discussion of the issue with these individuals alongside the general lack of discussion of the issue in the remaining representatives of the Biofuel Industry and Commercial User groups, suggest that for these user groups the issue of Food versus Fuel is not perceived to be as important a barrier as in the other groups.

Interestingly the discussion of food versus fuel in Advisory/Consultancy group is inflated only by interviewee A2, which makes the group average percentage of time spent discussing the issue seem much higher for the group and inflates the apparent interest of this group. This is a significant effect of low sample size.



**Fig 11. Graphical representation of the percentage coverage of discussion of the food versus fuel debate as a barrier to the development and expansion of biofuels by group and individual interviewee**

Analysis of the discussion topics of the Food versus Fuel debate reveals that the issues can be categorised into four main areas;

- Food versus Fuel as a barrier,

*“If you want to go above seven percent then you’re going to have to use more, um, more, um rapeseed, or something like that, which means we need more land. Then we’re into competition with food” – C2*

*“If you look at the agricultural end, I think they the [sic] there is quite a significant, um, challenge around the the food versus fuel debate” – O2*

- Societal Concern about the food versus fuel issue as a barrier

*“You know, a lot of people are very nervous about food supplies for the future and are trying to acquire land” – A2*

- Overstatement of the food versus fuel issue as a barrier

*“Five years ago, is it six? Two thousand and six, six years ago, the the European Union, um, revised its sugar system under the common agricultural policy and took out near enough six million tonnes of sugar production of the EU. I did not hear anybody at that time talking about world starvation. We could get rid of six million tonnes of a staple product and not a peep. So that proves that somebody somewhere is shooting a line” – A2*

*“Well, at the moment we have a three million tonne surplus that we export. So I guess, I mean that that is as good a place as any to look for for feedstock that could go into biofuel production” – A3*

*“If good agricultural practices continue our belief is there will be enough land for food and there’ll be enough land for biofuels, with the current expanding population of the globe, right out to twenty fifty” – O2*

- The lack of consideration of the production of Dried Distillers Grains and Solubles (DDGS) high protein animal feed in the food versus fuel debate as a barrier.

*“There’s another, again little talked about, element of this food v fuel debate, and it’s the fact that, when you have a biorefinery - so you know one and half million tonnes of wheat comes in - you know you’ve got the wheat straw currently can’t be processed enzymically but could be converted into, along with other things, like the protein content of the wheat grain, can be recaptured in what is then a very nutrient rich animal feed” – R&D 1*

Whilst eight of the fifteen interviewees discussed the problem of food versus fuel as a barrier to the development and expansion of biofuels in the UK, the average discussion coverage was only 0.63%. The overstatement of the extent of the problem of food versus fuel was discussed by six interviewees with an average discussion time of 2.05%. Overall these results present a very mixed picture. Whilst more individuals discussed food versus fuel as a problem, it would seem that, to those who discussed the overstatement of food versus fuel as a problem, this aspect of the issue was more pertinent than the actual risks associated with food versus fuel.

There was also some disparity between the individuals that discussed food versus fuel as a problem and those who discussed the overstatement of the issue as a problem. Only three interviewees discussed both issues (O2, O3 and V1), while three interviewees discussed the overstatement of the issue only (A2, A3 and R1) and five discussed the problem only (A1, B1, C2, C3 and R2). This may suggest that, while it is not unheard of for stakeholders to view both the food and fuel issue and overstatement of the issue as barriers, there are more instances where stakeholders are of one persuasion or the other.

The pattern in these results by stakeholder group is complex. Whilst discussion of the food versus fuel issue showed representation across the six stakeholder groups, discussion of the overstatement of the issue as a barrier was limited to representatives of the Advisory/Consultancy group, Oil Industry group, R&D group and Vehicle Manufacturer group, without any discussion in the Commercial User or Biofuel Industry groups. This suggests that those in the Commercial User and Biofuel Industry groups do not consider that the issue of food versus fuel is overstated, or at least that overstatement is not a barrier in itself.

Analysis of the discussion of those who did perceive the overstatement of the food versus fuel issue indicated that this belief was largely based on knowledge of food crop surpluses and policies put in place that have

reduced production without impact on food supplies. The concern about the overstatement of the food versus fuel issue was largely centred on how over-caution on the part of UK and EU government was limiting willingness to act on developing and supporting biofuels.

**c) Indirect Land Use Change (ILUC)**

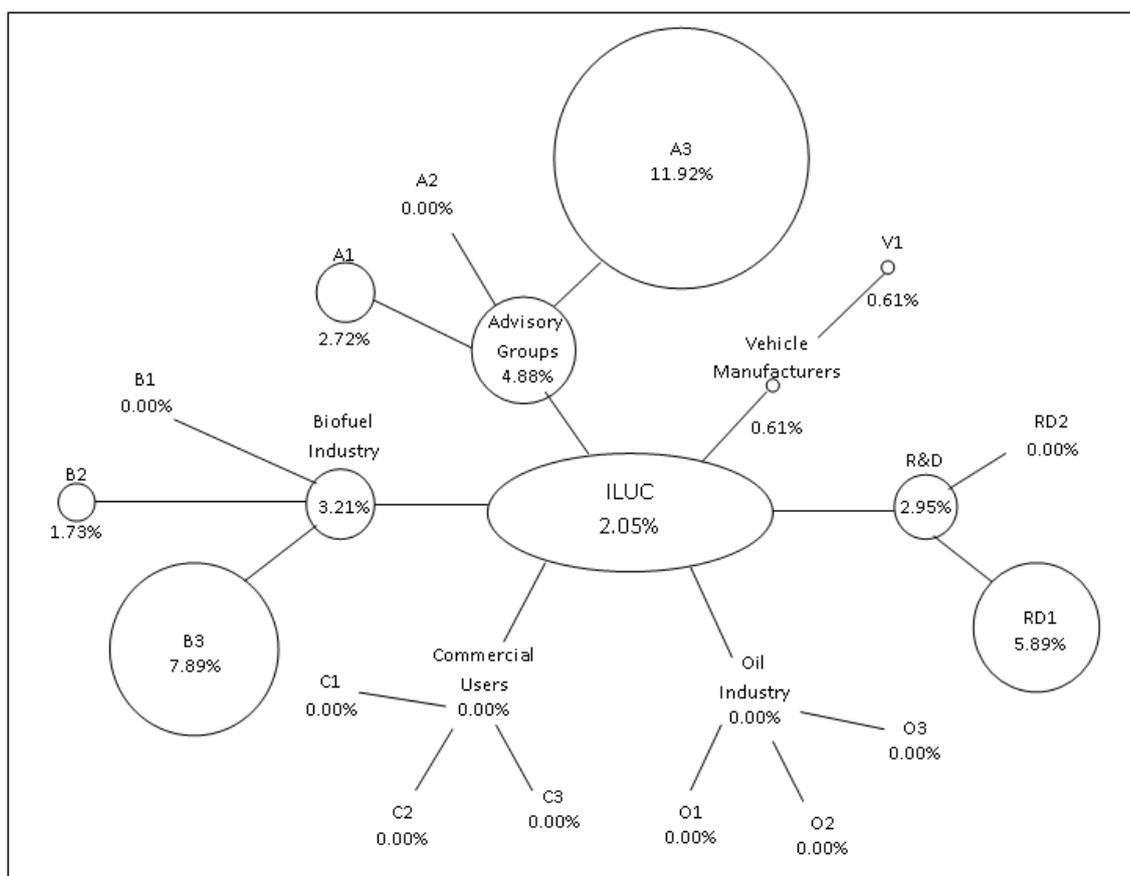
Indirect Land Use Change (ILUC) was the third most discussed barrier (Table 20). Six of the fifteen interviewees discussed this issue. The issue was not discussed at all by the Commercial Users Group or Oil Industry Group. The issue was discussed by two of the three Advisory/Consultancy Group representatives, two of the three Biofuel Industry Group representatives, one of the two Research and Development Group representatives and the one Vehicle Manufacturer representative (Fig. 12). As such, it would seem that ILUC is not universally held to be a barrier to biofuel development and expansion for any one stakeholder group, but is still less of a perceived barrier to those in the Commercial User and Oil Industry groups.

*“I mean, the issue of ILUC has been going on for something like five years now, nearly five years I think certainly before I was doing this job. Um and yet there is, it’s just sort of a perpetual motion, we’re just going round in circles with it. There’s been no sort of political decisions made and unfortunately the argument, or we believe the arguments are being put across are politically based, rather than based on science and based on fact” – A3*

*“They can’t hide behind, um, hide behind issues such as ILUC and essentially at the moment they’re saying that they’re not going to act on targets and adhere to targets because the European Parliament haven’t come to a decision on ILUC. Well this has been a decision that we’ve been waiting on, as I’ve already said, for quite some time now and it’s about time someone bit the bullet. Um, we don’t necessarily need a decision on ILUC in the European Parliament we just need our*

government to realise that these targets are something that need to be achieved” – A3

“The key barrier for the UK and European industry is the lack of a solution to the concept of Indirect Land Use Change for which the European Commission is supposed to make a proposal this year, having taken more than eighteen months to conduct an Impact Assessment of four options and not yet come up with a proposal” – B3



**Fig 12. Graphical representation of the percentage coverage of discussion of ILUC as a barrier to the development and expansion of biofuels by group and individual interviewee**

d) **Higher Costs and the Need for Investment** were discussed as a barrier to biofuel development and use by ten of the fifteen interviewees (A1, A3, B1, B2, C2, C3, O3, R1, R2 and V1) with an average coverage of 1.83%. The perception of costs and investment as a barrier was based on concerns about biofuels costing more than fossil fuels, removal of certain

government incentives further increasing costs and the lack of confidence to invest in the Industry hampering development and improvement.

*“Increased certainty means that inward investment can take place and, therefore, you increase your yields you increase efficiency, um, which which means, in the long term, you can therefore increase output” – A3*

*“Actually, at the moment, because of the way the the political um fields has moved, we’ve actually pulled back some of our biodiesel blending so some areas of the country we’re actually moving back to just supplying pure diesel because it’s not economically um viable to put biodiesel in” – B1*

*“The fuel [biofuel] is a lot more expensive than diesel since the fuel duty rating changed” – C3*

*“I think governments have to think very carefully when they’re encouraging industrial development of that sort that you you do the thinking up front, so that once you’ve done that you don’t then say right we’re encouraging investment in this area, when people put their money in, or companies put their money in, you then say no we didn’t really mean that so we won’t give you the subsidies” – R&D 1*

e) **Food Prices** as a barrier to biofuel development and use were mentioned by eight of the fifteen interviewees (A2, A3, B3, O2, O3, R1, R2 and V1) with an average coverage of 1.51%. Whilst the concern about biofuels causing price rises in staple food commodities was acknowledged by the interviewees, six (A2, A3, O2, O3, R1 and V1) explicitly discussed their opinion that food prices were not a biofuel issue and that blaming biofuels for recent food price crises was unfair and lazy. Although less explicit, comments made by interviewee B3 would suggest they felt the reports of biofuels increasing food prices were of greater concern than any actual impact on food prices. Interviewee R2 made no comments beyond acknowledging the potential for biofuels to impact on food prices. Based on these results it would seem that the barrier is more likely to be the

perception that biofuels cause food price rises, rather than any actual impact on prices.

*“There are some stories in the biofuels issue, for one is one that’s easy to use as a scapegoat, um the general public don’t necessarily recognise that food has been very cheap for the last ten fifteen twenty years” – A3*

*“There’s a degree to which biofuels are kind of being blamed for, um, particularly two years ago when we started to see energy prices and oil prices going up significantly, then biofuels were actually being blamed for the rise in the price of food when in fact the fundamental issue was around - cos actually the price of energy, both to put crops in the ground, to transport crops and, most importantly, the price of energy produce and then move fertiliser” – O2*

*“I think it was in two thousand, and the run up to two thousand eight, when the fuel prices were going up and commodity prices were shooting up, the price of wheat was dramatically going up and biofuels got blamed for all that, but it didn’t seem to coincide, people didn’t seem to notice that the fuel prices had hit an all time high at the same time. Um, so logically you would argue, if biofuels are driving up that why would fuel prices be going up, and inherent fuel prices were going up that were causing primarily, um, the um, the increase in commodity prices” – V1*

f) **Fuel Duty and Taxation** as a barrier to biofuel development and use was discussed by five of the fifteen interviewees (A2, B2, C2, C3 and V1) with an average coverage of 1.06%. Concern focussed on the potential harm that any increase in fuel duty or taxation could do to the biofuel industry as well as lack of certainty over the future of existing commitments and support. As biofuels are already more expensive than fossil fuels interviewees feared poorly considered tax regimes may make biofuels economically un-viable. In addition, there was concern that government wouldn’t recognise the need for a lower rate of tax on biofuel, based on their lower energy content per unit volume compared with petrol

and diesel. Such concerns were based on past experience of government removing fuel duty reduction for biofuels that has caused problems for many companies producing and using biofuels.

*“Because we have a tax regime which charges tax on the litres you buy, rather than the energy, the energy utility carrier. Um, the the UK government will actually benefit from reducing the energy density on fuel”*  
– B2

*“I’m just paying the cost price. The minute the government gets its hand on it it’ll then tax it. So for me, um, the government has to recognise that it wants to invest in a CO<sub>2</sub> reduction policy therefore it has to tax biodiesel less than it does uh normal diesel in order to get users to use it”* – C2

*“If you want to give customers the choice, and the only way of achieving that really, is for lower fuel duty rates to apply”* – V1

g) **Engine Damage** as a barrier to the development and use of biofuels was discussed by three of the fifteen interviewees (C2, R1 and V1) with an average coverage of 0.96%. For interviewees C2 and V1, discussions of engine damage were based on their own experiences of using biofuels. Concerns were based on the potential for biofuels to cause damage that would require increased engine maintenance or frequent replacement of parts, the need for developing better fuel blends and the need to redesign engine parts to be more robust – the common theme of these concerns being increased costs to producers and users.

*“Our early experience of using biofuel was that it, um, basically clogged our filters”* – C2

*“The other thing we discovered is that one of the problems with biodiesel is that it can clog injectors, it can also damage injectors”* – C2

*“The problem for biofuels is, it’s not a problem in the tropics, but if you were to take, you know, a significant blend a, um, say a ten percent or a*

*twenty percent um or a hundred percent of your biofuel based on palm oil to Canada, your tank would freeze solid in the winter” – R&D 1*

*“I know more about ethanol, but these biofuels tend to be more abrasive on engine wear so they do have, we do have to change the engines a little bit, on valves and valve seats and things like that” – V1*

h) **NGOs** as a barrier to the development and use of biofuels were discussed by six of the fifteen interviewees (A2, C3, O2, R1, R2 and V1) with an average coverage of 0.94%. The main concerns about NGOs as a barrier was that they are very vocal and have a lot of power to influence government and public opinion but that the messages they send are often exaggerated and emotive.

*“It was therefore a a an extraordinary blow for us, let’s put it that way, when the NGOs all decided that, you know, we don’t like biofuels after all, and made this big furore. Now I’ve had it said by, um, by a number now that, you know, they are [NGOs] as political organisations, they are opportunists” – A2*

*“We’ve got very powerful environmental groups, NGOs, um, single issue lobbying organisations. Um, and they can influence the outcome and sort of move the dialogue and make the suggestion that they’re representing, potentially, far more people than they really are. But they’re extremely vocal, quite well organised and good communicators” – R&D 2*

*“The NGOs er, and when I say NGOs I mean like Greenpeace, Friends of the Earth and WWF, and even the RSPB, they have been very active in trying to knock back biofuels. Um and I think it’s their activity that primarily persuades, that is primarily tilted, has tilted the balance away from biofuels in in the UK, um they, my impression is that they have done a fantastic job of muddying the water” – V1*

i) **Uncertainty** was the tenth most discussed barrier to the development and use of biofuels, being an issue for nine of the fifteen interviewees (A1, A3, B1, B3, C1, C3, O3, R2 and V1) and accounting for an average 0.81%

of conversations. Uncertainty was coded as a subsidiary issue of Government as a barrier, as concerns were based on how lack of government support and action on biofuels were creating an uncertainty about the future of the biofuels industry and market in the UK. This was perceived to be a barrier as lack of certainty was seen to be preventing investments that would allow for development and improvements that would benefit the industry. Certain specific issues causing uncertainty included: the gap in biofuel policy between the expiry of the RTFO in 2014 and the commencement of the RED in 2020 (A1), potential sudden changes to existing support and incentives as has happened in the past (B1), lack of long term planning on preferred technologies and fuels (C3, O3, R2 and V1).

*“It’s the uncertainty that is also brought about by the conversations that are had within the media, um no-one knows as to whether or not it is going to be a market in which you can invest” – A3*

*“As an example, in the UK we had the RTFO and they they pulled the incentives that were available back to just UCO [Used Cooking Oil], um, and the consequence of that was that the only biodiesel that was actually financially, um, viable as a blend component in diesel was biodiesel made from use cooking oil. Anything else was just priced out of the market basically” – B1*

*“So we’re also looking for consistency of legislation. There’s, there’s, worse case scenario would be if there is a mandate to produce cellulosic ethanol and, you know, we, or somebody else invests billions of pounds in building plants and then that’s all rolled back. Uh, so we need to have consistency” – O3*

j) **Infrastructure** as a barrier to the development and use of biofuels was discussed by five of the fifteen interviewees (C2, C3, O3, R2 and V1) with an average coverage of 0.78%. There were two main concerns about infrastructure based on the different interests of the interviewees. Interviewee C3 was concerned about the lack of refuelling infrastructure

for their vehicles, due to their interest in using gaseous biofuels. Interviewees B3 and V1 were more concerned about upgrading existing infrastructure to handle higher biofuel blends. Part of this concern was related to government, as without clear indications of how and when use of biofuels will change it is hard to plan the upgrading of supply infrastructure.

*“There’s a shortage of refilling infrastructure” – C3*

*“You need to have the infrastructure in place to distribute these things and therefore, uh, if the biofuels are, but with biofuels really need to be compatible with the existing products so that automatically narrows it down” – O3*

*“They have infrastructure, forgetting whether they like biofuels or not, right. They are really, to all intents and purposes, still oil companies right, they indulge in this. [company name removed] and [company name removed] have invested heavily in biofuels, but it’s still small by the percentage invested in oil exploration. But they have infrastructure issues” – V1*

k) **Engine Manufacturers** as a barrier to the development and use of biofuels were discussed by two of the fifteen interviewees (B1 and V1) with an average coverage of 0.73%. Interviewee B1 perceived the engine and vehicle manufacturing industry to be very opposed to the use of biofuels and as such, weren’t developing or producing vehicles capable of running on higher biofuel blends in Europe, despite the existence of flex-fuel vehicles in Brazil. The fact that interviewee V1, a vehicle and engine manufacturer, discussed engine manufacturers as a barrier is interesting. It was the view of interviewee V1 that some engine and vehicle manufacturers, not including themselves, were reluctant to be seen talking about or aiding the use of biofuels due to the prevalence of negative opinion about the fuels.

*“One of the key barriers, particularly to the use of biodiesel, are the motor manufacturers. Motor manufacturers, in particular um one or two of the big German names, are very anti biodiesel” – B1*

*“I think biofuels have acquired a negative aspect and that’s why you don’t hear the car companies talking about it very much anymore, because there was nothing to be gained really about talking about it” – V1*

l) **Blend Limits** as a barrier to the development and use of biofuels were discussed by five of the fifteen interviewees (A1, B1, B2, O2 and V1) with an average coverage of 0.71%. The problem of blend limits is that they restrict the amount of biofuel that can be added into conventional fuels and used in unmodified engines. For Interviewee B2, the issue of blend limits was a political one as they felt the government were doing little to help encourage or support a move towards blends of more than ten percent biofuel. However, for interviewees A1, B1, O2 and V1, the issue was technical based on the capabilities of existing vehicles and the need to design and replace certain engine components to prevent damage from blends in excess of ten percent.

*“My own view is that, at least as we are at present, the ten percent inclusion in mineral into mineral fuels in within Europe is probably the viable limit of the foreseeable future, um the next five or ten years” – B1*

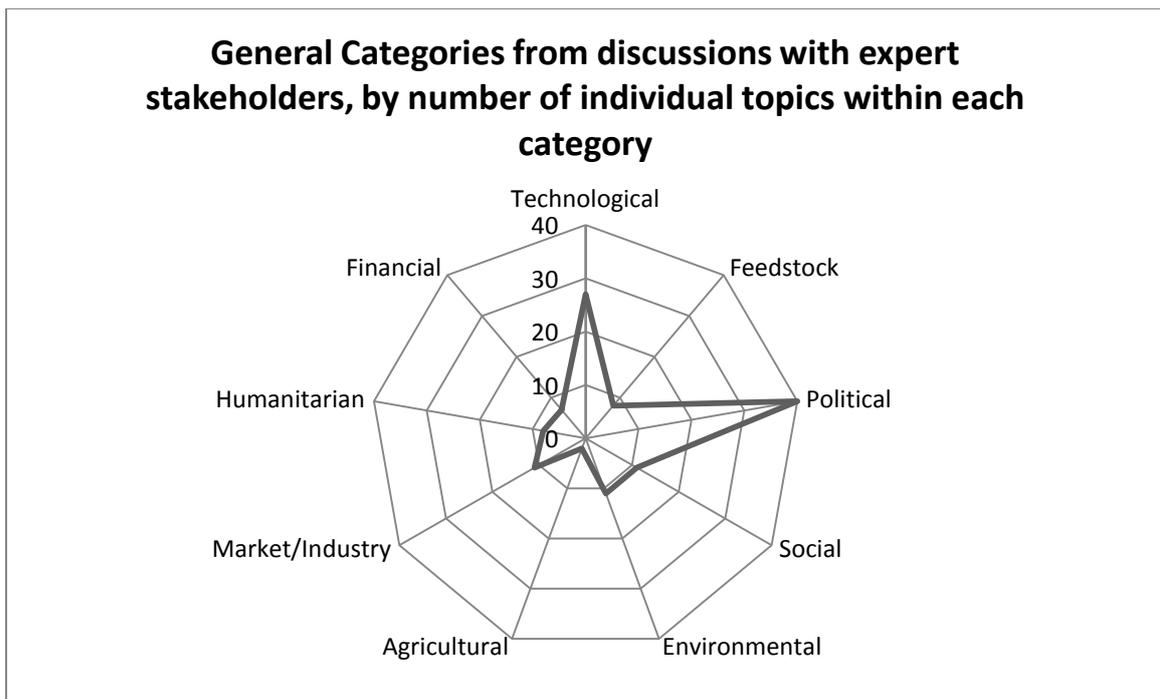
*“Second obstruction is to do with fuel blends. So the UK government is at present very reticent about, um, its support for mandating or enabling what’s called E10, ten percent ethanol ninety percent gasoline, uh, which is a fuel blend that you need to have if you’re going to come anywhere close to achieving the two thousand twenty target” – B2*

### iii) **Major Themes of Discussions**

As was done with the outputs from the public focus groups the coding of topics that were discussed as barriers could be assigned to one of nine general themes.

- Technological
- Feedstock
- Political
- Social
- Environmental
- Agricultural
- Market/Industry
- Humanitarian
- Financial

Fig 13 shows how the individual topics coded in discussions were distributed between the different general categories.



**Fig 13. Extent of discussion of each identified general category, by the number of individual coded topics that fell within the category**

Fig 13 shows the distribution of discussions between the identified general categories and supports the conclusion that politics and the government were the most significant perceived barrier amongst the expert stakeholders. A total of 40 individual coded topics were classified as being

related to political issues, followed by Technological issues with 27 individual coded topics.

**iv) Benefits associated with biofuels (Reasons for supporting or being involved in biofuels)**

Although much of the interviews focussed on the negative views surrounding barriers the interviews also highlighted positives that are pertinent to the debate and deserve further consideration. Coding and analysis of the interviews identified 32 individual positives of biofuels or motivating factors for involvement in biofuels.

All fifteen interviews included some discussion of positives and motivating factors. On average, across the fifteen interviews 9.43% of discussions were given over to consideration of the positives of biofuels. The individual interviewee who discussed positives the most was B3 (21.08%). The individual who spent the least time discussing positives was A1 (1.31%). Based on group averages, the Biofuel Industry group discussed the positives at greatest length (14.83%) whilst the Research and Development group discussed positives least (3.44%).

**v) Most Discussed Positives**

Coding of the transcripts in NVivo identified six positives/motivating factors that were discussed by five or more interviewees. These factors can be seen in Table 21, along with their average percentage coverage.

<b>Positive or Motivating Factor</b>	<b>Average Percentage of Total Time</b>
Carbon Reduction	2.09%
Business	1.45%
Dried Distillers Grains and Solubles	1.44%
Sustainability	0.95%

Financial Motivations	0.77%
Government Legislation	0.73%

**Table 21. Most discussed Positives across all interviews, by average percentage of total time**

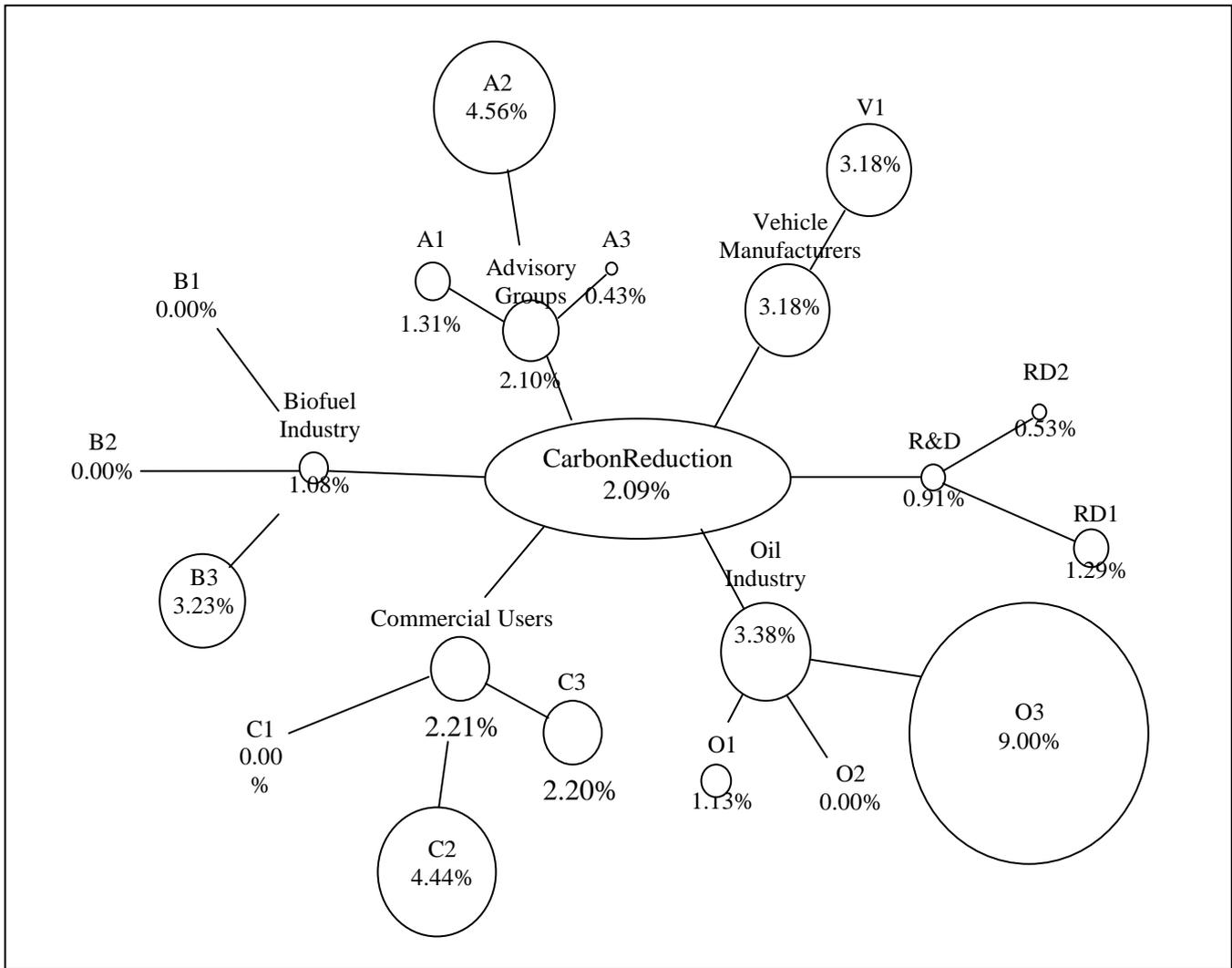
The top three most discussed positives will now be examined in greater detail.

**a) Carbon Reduction**

The potential for biofuels to reduce carbon dioxide emissions from transport was the most discussed positive/motivating factor both in terms of average percentage discussion across the fifteen interviews and the total number of interviewees who raised it (11 of 15).

The potential to reduce carbon dioxide emissions was considered to be a positive/motivating factor for support or involvement in biofuels primarily for environmental reasons. Interest in the environmental benefits originated from both a moral/ethical standpoint as well as government legislation and mandates on energy and climate change.

The percentage coverage for discussion of Carbon Reduction by individual interviewee and group averages are displayed graphically below (Fig 14).



**Fig 14. Graphical representation of the percentage coverage of discussion of Carbon Reduction as a positive/motivating factor for involvement in or support for biofuels, by group and individual interviewee**

As can be seen in Fig 14, there was variance in the amount of time spent discussing Carbon Reduction amongst both the groups and the individual interviewees. The majority of the discussion about Carbon Reduction as a positive/motivating factor for support or involvement in biofuels was focussed in the Advisory Groups, Commercial Users and Oil Industry groups. However, even between the individual interviewees of these groups there was notable variance in the extent of discussions of carbon reduction. Discussions of individuals A2, B3, C2, O3 and V1 were greatest and made notable contributions to their group and overall averages.

*“Where it all started [the development and interest in biofuels] and the motivation is, as far as I’m concerned, is lowering carbon reducing carbon emissions in the power sector” – A2*

*“Essentially [company name removed] view the biofuels industry, obviously, as well as it reducing um greenhouse gas emissions” – A3*

*“We decided that we would embrace biofuels because they they reduced the amount, or theoretically they should reduce the amount of CO<sub>2</sub> that you’re, um, for the same amount of fuel you’re using” - C2*

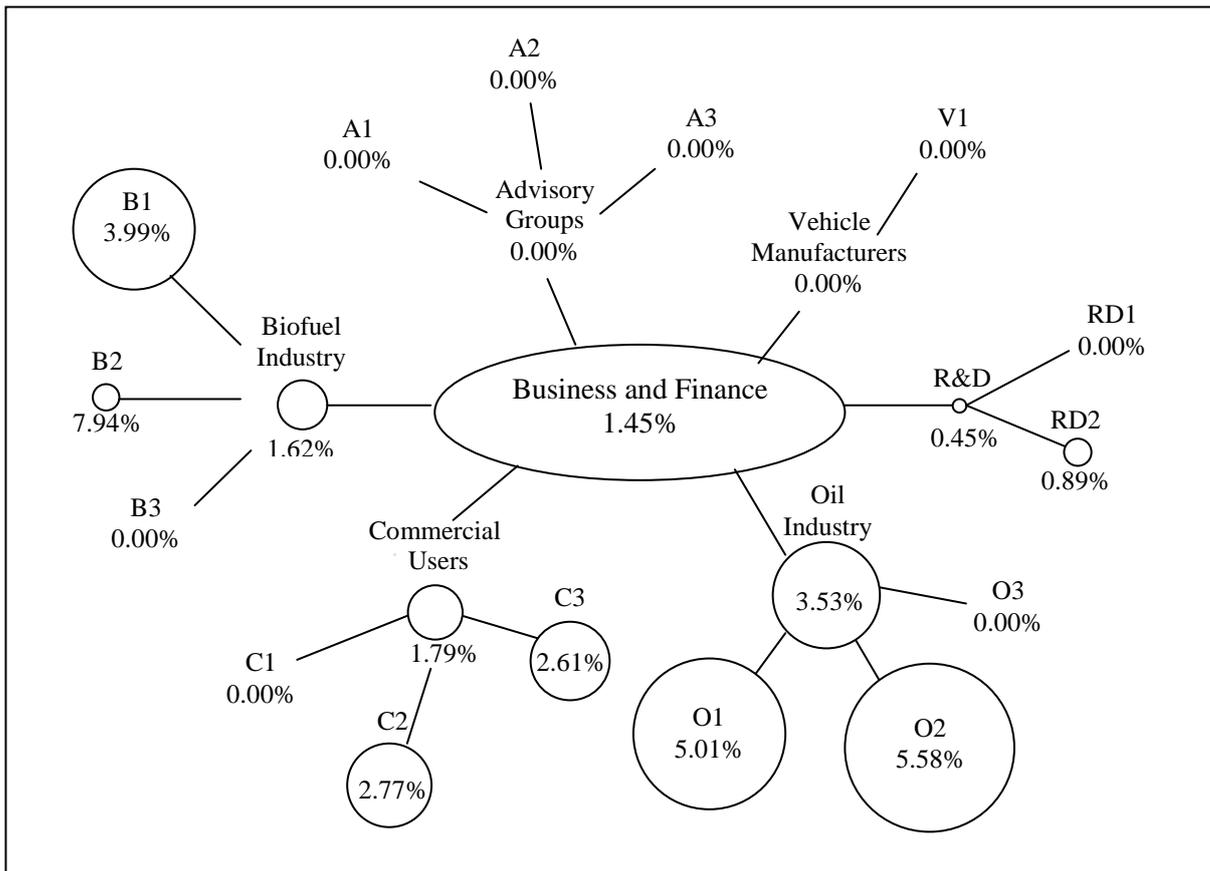
*“So we believe they [biofuels] are a critical enabler to reducing the carbon footprint of, uh, the use of vehicles by the consumer” – V1*

In only three of the six groups (Advisory Groups, Research and Development and Vehicle Manufacturers) did all representatives discuss Carbon Reduction and one of these groups consisted of just one interview. However, at least one representative of each group did discuss Carbon Reduction to some extent.

#### **b) Business and Financial Opportunities**

The business opportunities presented by biofuels was the second most discussed positive/motivating factor in terms of average percentage coverage across all fifteen interviews. Seven of the fifteen interviewees discussed the factor.

The reasons for perception of potential Business and Financial Opportunities presented by biofuels as a positive/motivating factor are quite straight-forward. The prospect of new business opportunities and ways of increasing profits or decreasing costs through producing or using biofuels would always be appealing, particularly during a time of economic difficulties.



**Fig 15. Graphical representation of the percentage coverage of discussion of Business and Finance as a positive/motivating factor for involvement in or support for biofuels, by group and individual interviewee**

As can be seen in Fig 15, the majority of the discussion about Business and Finance opportunities as a reason for supporting or being involved in biofuels was concentrated in the Biofuel Industry, Commercial Users and Oil Industry groups. However, no group had universal discussion of the factor.

*“In terms of business ethics and his [the company director] aim in life originally was to try and demonstrate that biofuels can be proved sustainable and more importantly economically viable” – B1*

*“We recognise that er, the opportunity for making biofuels is, remains a very significant market opportunity” – B2*

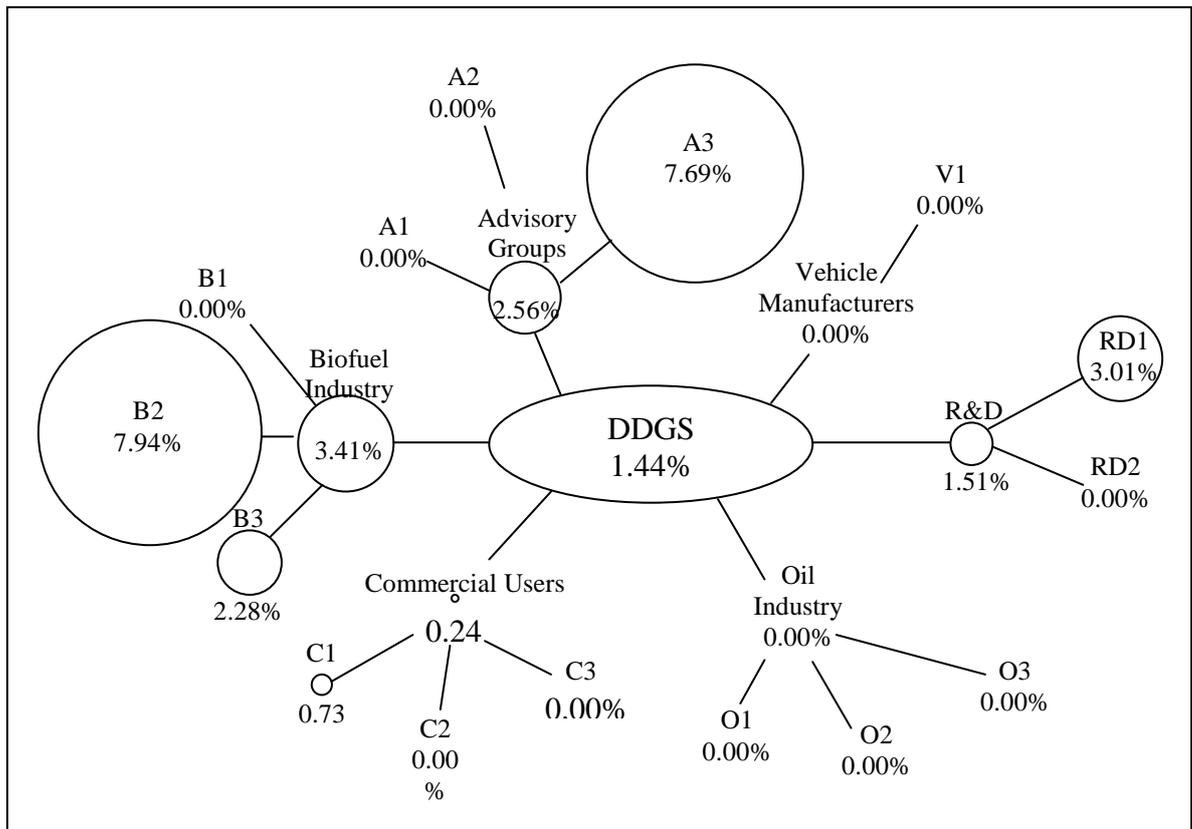
*“There’s also a financial element to that, because if I use less fuel then obviously it costs me less to run the business and I can make more profit or I can pass that saving on to the passengers” – C2*

*“For reasons that they give a low cost, or should I say affordable solution, to give the low carbon results that one would like” – O1*

**c) DDGS (Dried Distillers Grains and Solubles)**

Dried Distillers Grains and Solubles, a high protein animal feed generated as a co-product of ethanol production, was the second most discussed positive/motivating factor in terms of average percentage coverage. However, it should be noted that DDGS was only actually discussed by five of the fifteen interviewees (Fig 16).

The generation of DDGS as a co-product of ethanol production was considered to be a positive/motivating factor for support or involvement in biofuels for a number of reasons. As a high protein animal feed, DDGS can be used to supplement livestock diets in place of soy meal which is currently the most commonly used protein source for animal feed. A large quantity of the soy meal fed to animals in the UK is imported, as such, if DDGS produced in UK based ethanol facilities could be used instead it would help support British industry and agriculture as well as reducing the overall carbon footprint of livestock production. In addition, creation of a valuable co-product from ethanol production increases both the cost and energy efficiency of the production process – reducing overall carbon dioxide emissions associated with the final fuel and making the fuel product less costly to produce.



**Fig 16. Graphical representation of the percentage coverage of discussion of DDGS as a positive/motivating factor for involvement in or support for biofuels, by group and individual interviewee**

As can be seen in Fig 16, the majority of the discussion about DDGS as a positive/motivating factor for support or involvement in biofuels was focussed in the Advisory Groups, Biofuel Industry and Research and Development groups. Specifically, interviewees A3, B2 and R1 made the greatest contributions to their group and overall average percentage coverage.

*“It’s also a stability for the livestock industry through the production of DDGS increasing the availability of sort of high protein animal feed” – A3*

*“We use a million tonnes per annum animal feed wheat. We produce roughly in equal proportions a third of bioethanol, a third of CO<sub>2</sub>, which is captured and goes in to horticulture and industrial use, and a third of animal feed. So the the concept is very much one of a biorefinery. In future*

*that suite of products that we make is likely to grow as we get more refined” – B2*

*“Some of our suppliers have been interested in looking at erm, the distillers product out of bioethanol plants” – C1*

None of the Commercial Users, Oil Industry or Vehicle Manufacturer interviewees made any reference to DDGS or animal feed co-products. No group had discussion of DDGS by all representatives.

### **5.3.2 Improving Communication to increase awareness**

**RA2: To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels awareness and knowledge of biofuels effectively**

Eleven of the fifteen interviewees (A1, A2, A3, B2, B3, C1, C2, O1, O3, R2 and V1) discussed the lack of general public interest, awareness and understanding of biofuels. In addition, seven of the fifteen interviewees (A1, A3, B1, B3, O3, R1 and R2) discussed the importance of public opinion for the future of biofuels.

*“Well I think that that, you know, the, I mean, the public are great ones for ignorance” – A2*

*“The general public is sort of, to various degrees, either ignorant or uncaring about those issues as long as there’s a price difference” – B2*

*“It’s not an issue which preys on the mind of customers and at the present moment in time, frankly, they’re more concerned if they can get hold of petrol not where the petrol’s come from” – C1*

*“Yeah it, as far as the general public is concerned, I think their level of awareness, if you compare it to GM, is quite low” – R&D 2*

Five interviewees (A1, A2, O1, O2 and O3) highlighted the role of the media in public (mis)understanding, providing mixed, inaccurate, biased and misleading information on biofuels. There was also discussion that the generally complex

nature of the issues associated with biofuels also contributes to public confusion, by four interviewees (A1, A2, O3 and R1). There was some feeling that such complexity may also affect media coverage as journalists may also struggle in understanding the issues. On the other hand, it was mentioned by one interviewee that the media were not 'the man on the street' and had a responsibility to understand and accurately report issues.

*"I would love to think there'd be some public, um, public sort of understanding and support out there, but with the media equally more interested in selling their wares I don't know where we're going to get it from" – A2*

*"Other than they [the public] may have read in the newspapers, some of the negative publicity around biofuels" – O1*

*"It's very easy for people to scapegoat the new, ie blame biofuels. So, so there was quite a big debate around that and it was very easy there was a huge amount of lazy journalism around which was, I know let's point the finger at something new, ah here are biofuels, let's point the finger there" – O2*

Despite this perception, only five interviewees (B1, B2, C1, C3 and O3) discussed any measures they took to engage or communicate with the public themselves. Interviewee O3 discussed engagement/outreach work in schools they had undertaken, C1 discussed how they try to be open with the general public and B1, B2 and C3 discussed how they made information available on their websites. In addition to this, two interviewees (C3 and V1) discussed how they did not like to over publicise biofuels and a further two (O1 and B3) explicitly discussed their lack of engagement and communication.

*"I mean, you've seen our website, we do have quite a broad variety of information and prospectus on biofuels on our website which is available to the public" – B1*

*"We have, if you've had a look at our website, we have a certain amount of information which is accessible, um, which also refers to published*

*scientific papers that we and other people have, um, had peer reviewed in in respected high impact factor journals” – B2*

*“I speak to schools, for example, are biofuels good or bad? Put your hands up if you think their good, put your hands up if you think their bad. Of course half and half, then you get the discussion” – O3*

*“We think it’s really important to engage with the, with the public and as a company we we tend to do that via, um, special interest groups” – O3*

However, there was some doubt cast over the effectiveness of the communication strategies that were employed. It was felt that the impact of information made available on company websites would be limited due to the reliance on the public seeking the information out, which was felt to be unlikely by two interviewees (C3 and V1).

*“It’s no good saying here’s the website, go and have a look. No one ever will” – C3*

Interviewees B1 and V1 both expressed a belief that information provided at the fuel pump would be the most effective way of disseminating biofuel knowledge to the general public. They both also discussed how this was the responsibility of the oil industry.

*“It’s more a question of the oil companies getting their, um, er information on the forecourt right so people aren’t, you know, they don’t have a warning bell in their heads going off about whether they’re going to blow their car up by putting a different fuel in it” – B2*

*“There’s a lot of misinformation around what cars could use what fuel, and not helped by the fuel industry either, they weren’t providing any information at the pumps” – V1*

### **5.3.3 Management of Barriers**

#### **RA4: Investigate possible management options for the major identified barriers, from the full range of stakeholders**

##### **i) Government**

Government were considered to be the greatest barrier to the development of biofuels, there was also much discussion of management actions requiring greater support and involvement from government. The details of these options will be discussed in detail under RA6, which specifically addresses the role of government.

##### **ii) Food versus fuel**

Government aside, the biggest perceived barrier was Fuel versus food. From the expert interviews a number of possible steps for management could be drawn.

While eleven interviewees discussed the issue of Food versus Fuel as a potential barrier to development of biofuels, six individuals expressed the view that the problem had been overstated. As such, the Food versus Fuel issue was seen as more of an opinion issue than a practical issue. Based on this perspective, managing Food versus Fuel would mainly require decision makers and stakeholders being better informed about the realities of the situation to reduce unnecessary concern that could impede the future use and development of biofuels.

A number of possible practical management options were discussed for Food versus Fuel. The most discussed management option for tackling Food versus Fuel was improved agricultural practices. Three interviewees (A3, C3 and V1) discussed how continuation and expansion of modern western farming practices to other regions (Eastern Europe and Africa) could benefit global agricultural production and lessen the overall impact of biofuel crop production on food supplies. In addition, interviewee A2 discussed how biofuel production and development could be a means for encouraging more investment in

agriculture and help improve practices, as had been witnessed in the United States.

The second most discussed option was changing feedstocks used for biofuel production. Interviewees A1 and C3 both discussed changing the feedstocks used to reduce the impact of Food versus Fuel. Whilst C3 only discussed moving away from using food crops to produce biofuel, A1 gave more detail, specifically discussing a move towards second generation biofuels and producing biofuel from wastes.

Other options, each discussed by only one interviewee, included: sustainability auditing of biofuel feedstocks and producers (B1) as well as better and more comprehensive land use planning (O3).

### **iii) Indirect Land Use Change (ILUC)**

For Indirect Land Use Change (ILUC), discussions of steps for management were quite limited. For four of the six interviewees who discussed ILUC, it was the political stalling and inaction as a result of ILUC that was more of a barrier than the issue itself. This perspective would suggest that management of ILUC would require better dissemination of facts and advice to both the EU and UK governments to encourage them to act on biofuel development. Two of the interviewees (A1 and A3) made specific reference to the need for government action to move biofuels forward despite the ILUC issue. Beyond this, no interviewee made any suggestions of measures to take to address ILUC, merely that it was an issue that needed addressing.

*“They can’t hide behind, um, hide behind issues such as ILUC, and essentially at the moment they’re saying that they’re not going to act on targets and adhere to targets because the European Parliament haven’t come to a decision on ILUC. Well this has been a decision that we’ve been waiting on, as I’ve already said, for quite some time now and it’s about time someone bit the bullet. Um, we don’t necessarily need a decision on on ILUC in the European Parliament we just need our government to realise that these targets are something that need to be achieved” – A3*

#### **iv) Increased Costs and Need for Investment**

In the case of Increased Costs and Need for Investment, management requirements discussed by interviewees largely focussed on two main areas; increased certainty about the future of the market from government and the provision of incentives or subsidies by government. Three interviewees (A3, B2 and R2) discussed the need for clearer and/or stronger signals and support from government to create certainty and confidence in the biofuel industry that would encourage investors to put money into biofuel development.

*“At the moment the signals are not clear as to what the, what the future energy er mix is going to be” – R&D 2*

As well as government signals, interviewee A3 felt it was important that the media took more responsibility over the messages they sent about biofuels to improve market confidence.

*“The media aren’t the men on the street. The media are the people that have a responsibility to consider, to consider all the sides of the argument and I certainly feel sometimes some of the arguments are lost” – A3*

A further three interviewees (B1, B2 and C3) discussed the importance of financial support from government to support the biofuel industry, either by investing in research and development to improve processes or by reducing overall costs and making the fuels produced more cost competitive with fossil fuels.

*“I think the level of support that they’re [The Government] providing, particularly from a sort of economic perspective, um, is not going to be sufficient to persuade industry to meet the governments targets” – B1*

In addition to these two main issues, other management issues derived from discussion included: maximising the use of wastes as a cheaper feedstock (A1), greater focus on and investment in the development of second generation fuels (O3), better planning of the support and incentive system for biofuels (R1), prioritising the development of economically viable enzymes for second generation fuel production (R1) and general efficiency improvements in the

biofuel production process (V1). Some of these issues, particularly those looking for specific developments such as enzymes and greater efficiency, come back to the issue of generating investment in the industry to fund the development.

**v) Food Prices**

For Food Prices, discussions of management steps were largely negated by the fact that six of the eight interviewees did not consider it to be a biofuel issue (A2, A3, O2, O3, R1 and V1). Whilst it was acknowledged that there had been extreme food price rises witnessed in recent years, the general feeling was that biofuels had been unfairly blamed.

**vi) Fuel Duty and Tax**

Management actions for the perceived barrier of Increased Fuel Duty and Tax on biofuels focussed on government action. Interviewees B2, C3 and V1 all discussed the need for fuel duty and taxation on biofuels to reflect the lower energy content of the fuels compared to petrol and diesel, as well as ensuring that biofuels can be cost competitive with fossil fuels. Interviewee C3 also stated that government would need to provide guarantees for how long fuel duty and tax rates would apply to prevent sudden changes, as have been seen in the past, that have damaged the industry.

*“Because we have a tax regime which charges tax on the litres you buy rather than the energy the energy utility carrier, um, the the UK government will actually benefit from reducing the energy density on fuels a bit, but, not withstanding that, the um the UK government remains pretty staunchly opposed to doing anything which could be seen to advocate or facilitate E10 for the time being” – B2*

*“One thing that could completely kill this over night is if the duty suddenly rockets on biomethane use as a vehicle fuel. So we’re doing quite a bit of lobbying on that, um, DfT starting on treasury, um, and basically saying to anyone that will listen, look you know thi,s this is potentially great for industry” – C3*

## **vii) Engine Damage**

Of the three interviewees who discussed Engine Damage as a potential barrier to biofuel use and development, two discussed specific steps for management based on their own experiences. Interviewee C2 discussed the measures they put in place to overcome early difficulties with biodiesel, including: introducing a tank cleaning regime to prevent bacterial build-up in stored fuels and engine filters as well as using higher quality fuels with fewer contaminants that can damage engine components, and different blends for summer and winter to avoid cold starting issues in cold weather. It was acknowledged by the interviewee that each of these measures had contributed to increased costs associated with using biodiesel.

*“Now we have better blending, we have better quality. All our fuel is certified, we don’t go to backstreet garages for our biodiesel. So we’ve moved past that issue. I clean all my tanks but the cost of that has been considerable. We’ve had to use improved filters which are more expensive, we’ve had to improve, we’ve had to introduce a tank cleaning system which I never had to do with diesel because diesel’s diesel. Um, but because this is hydroscopic, um, it loves absorbing water and, um, and therefore we have to clean our tanks, which is expensive. I mean, I’ve got a hundred depots, so if you’re looking at a two or three thousand pound contract per depot we’re talking quite a lot of money. So, so biodiesel is beginning to cost money” – C2*

Interviewee V1 had concerns about maintaining particle filters in biodiesel vehicles, to the extent that they only produce one biodiesel vehicle. In addition, interviewee V1 had also had to redesign certain engine components for use with bioethanol, due to its corrosive properties.

*“Where we do have concerns is on biodiesel, and we have, as you’re probably aware, diesel particle filters. These have to be regenerated to get the soot out and basically overfuel the engine and that creates an exotherm that drives the carbon out. Whilst you’re doing that you end up building up fuel in the engine oil and the more biodiesel content in the fuel the greater the likelihood of that happening” – V1*

### **viii) NGOs**

Of the six interviewees who discussed NGOs, only one went beyond discussing how they are a barrier to contemplate management options (A2). Suggestions for managing NGOs involvement in biofuels included; trying to engage NGOs in solution planning rather than just highlighting the problems with biofuels, NGOs reducing the hyperbole in their campaigning against biofuels and the Government paying less attention to the messages of NGOs.

*“So the NGOs were pointing up problems but really not willing to engage in solutions cos this was too good an opportunity to get membership up” – A2*

*“Since this has been a sort of naked and opportunistic campaigning subject, um, I would I would hope that that can be dispelled” – A2*

### **ix) Uncertainty**

As a barrier primarily caused by government, discussions of management actions for Uncertainty focussed on government action. Four of the nine interviewees who discussed Uncertainty (A1, B1, C3 and B3) specifically discussed the need for government to take action on biofuels to increase certainty in the market. Specific actions for government to take included: plans for the period between the end of the RTFO (2014) and the beginning of the RED (2020), a clearer indication of preferred technologies and required production as well as what the consequences of not meeting usage targets may be. In addition, interviewee B3 suggested that government needed to improve their understanding of what constitutes a good and a bad biofuel.

*“Our immediate priorities are to encourage the DfT to take leadership in the introduction of E10 into the UK and to agree a solution at the European level for ILUC that allows the development of trajectory to meet the 10% target” – B3*

*“Successive transport ministers have failed to understand the differences between good and bad biofuels and apply policy to support the good accordingly, and have not established a regulatory framework that supports investment” – B3*

*“But we need a kind of rolling ten year guarantee of the difference between diesel duty and biomethane or gas duty” – C3*

**x) Infrastructure**

For the perceived barrier of Infrastructure, discussions of steps for management were quite simple. For the four interviewees who discussed the issue of Infrastructure (C3, O3, R2 and V1), it was generally accepted that to prevent infrastructure from being a barrier, existing infrastructure needs to be capable of handling biofuels and that assurances and changes should happen before any expansion of use. For interviewee C3, the issue was slightly more complex, requiring an expansion of the refuelling infrastructure due to their interest in and use of gaseous biofuels. In discussion with interviewee V1, it was suggested that the government should be involved in management of Infrastructure, providing financial support and setting clear plans for level of use and timescales to allow infrastructure owners to know when upgrades would be required.

*“There’s a shortage of refilling infrastructure, so again we’re doing quite a bit on that. We’re in a consortium that’s looking at where we can best place gas fuelling infrastructure” – C3*

*“You need to have the infrastructure in place to distribute these things and therefore, uh, if the biofuels are, but with biofuels really need to be compatible with the existing products, so that automatically narrows it down” – O3*

*“They [Oil companies] have infrastructure issues. Their, their pumps have been designed to be capable of running pretty much what we would expect, E10 and B7 kind of thing, so they then, they laid down their infrastructure a long time ago and they, to adopt that the higher levels of biofuels can be a challenge of them. But they do go through a renewal process, so as long as they knew the targets and they knew when people were going to change them, they’re able to refurbish for a large part. But things like ethanol represent a challenge for things like infrastructure associated with their pipeline, er because it, it basically likes water, whereas gasoline doesn’t like water, so some of the things they may not*

*have worried about in the past may come back to haunt them because they now need to care about water ingress into their pipelines and into fuel stations” – V1*

**xi) Engine Manufacturers**

For the perceived barrier of Engine Manufacturers, whilst management steps were not explicitly discussed, based on issues discussed it would seem that government (UK and EU) and industry standards body intervention may play a key role in encouraging greater cooperation of engine manufacturers (B1). In addition, as it seems that engine manufacturers based their opposition to biofuels on technical concerns, investment into technical developments may also help improve engine manufacturer support for biofuels (B1).

*“It’s been fought by the motor manufacturers, but on a much more limited sort of argument. It was basically around, um, technical issues on hot and cold starting. That’s all to do with the vapour pressure of the fuel, um, and ethanol has a big influence on that. But you know cars, cars, there are flex fuel cars on the market that run on up to 85 percent ethanol so that technology’s there it’s, um, it’s perfectly possible to do. It’s just the manufacturers having the will to get it into the mainstream” – B1*

**xii) Blend Limits**

Based on discussion about the perceived barrier of Blend Limits, means for reducing the impact of blend limits on the future of biofuels would seem to include greater government support and the introduction of mandates to increase blend levels (B2) and changes in engine design to be more robust and better able to handle higher blends (O2 and V1).

*“Second obstruction is to do with fuel blends. So the UK government is at present very reticent about, um, its support for mandating or enabling what’s called E10, ten percent ethanol, ninety percent gasoline. Uh, which is a fuel blend that you need to have if you’re going to come anywhere close to achieving the two thousand twenty target” – B2*

*“When you start blending more ethanol in, and that’s, you’re going to have to make a more robust, um, internal combustion engine I mean it’s not a matter of massive redesign, but it’s the car parts” – O2*

### **5.3.4 Comparison with other energy generation options**

#### **RA5: Compare acceptability of and concerns about biofuels with those related to other energy generation options**

From the expert stakeholder interviews, most of the discussions on the relative acceptability of biofuels compared to other energy generation options focussed on alternative options for transport; largely electric vehicles with some mention of hydrogen and the benefits of different generations of biofuel.

#### **i) Biofuels and Electric Vehicles**

Eleven of the fifteen interviewees discussed the potential of electric vehicles as an alternative to biofuels. Of these, four (A1, A3, B2 and R2) discussed the negatives of electric vehicles at greater length while five (B1, C2, C3, O2 and O3) discussed the positives of electric at greater length. The remaining two interviewees showed no difference in their discussion of the positives and negatives of electric vehicles.

Whilst a range of positive attributes of electric vehicles were identified by interviewees, analysis of conversations revealed that only one interviewee expressed a definite preference for electric vehicles over biofuel (C2).

Overall, the preference of the expert interviewees was for biofuels (favoured by seven interviewees; A2, A3, B2, B3, O1, O2 and V1) with a further four showing no preference but seeing both biofuel and electric as part of the future of transport (B1, C3, O3 and R1). The views of the remaining three interviewees (A1, C1 and R2) were unclear and it was not possible to discern any preference from their discussions.

In the cases of those who expressed a preference for biofuels and those who envisioned a mixture of biofuels and electric vehicles, support for biofuels was

not without qualification. In general, it was recognised that current biofuels are not perfect, but that that is not a reason to give up on the technology completely. It was felt that current biofuels needed to be supported in order to encourage investment that would allow developments in the industry to improve biofuels – mostly in terms of increased feedstock yields, more efficient processing and advancement of second generation fuels.

Positive aspects of electric vehicles that were discussed included: improved local air quality, discussed by five interviewees, being well suited to urban transport needs and reduced carbon dioxide emissions, both discussed by three interviewees.

*“If you are travelling, um, you know two miles between, from point to point in a dense urban environment where, um, which is peppered with recharging points, um, electric vehicles do have a very significant advantage” – B2*

*“In the long term we think all electric is probably going to be the way to go, um, which is no pollution, then the pollution is at the point of electricity generation, which is probably easier to control than pollution at point of of use” – C2*

*“Electric is good for local air quality, it’s not great for CO<sub>2</sub> at the moment” – C3*

*“I think they’re a good idea, particularly in urban areas, particularly when journeys are short and particularly where there’s a good quality charging infrastructure. So I think EV’s will kind of have a place and have an important place. I think they may, they may play quite an importantly into the area of air quality so not just CO<sub>2</sub> emissions but also air quality, particularly in very congested and crowded growing third world developing country cities, um, so, so they, they will have a place” – O2*

The low level of preference for electric vehicles over biofuels, despite the positives discussed, can be explained by the fact that most interviewees who discussed the potential positives went on to acknowledge a number of practical difficulties in delivering electric vehicles and the discussed potential benefits.

Such practical difficulties included: lack of existing infrastructure, the need to secure renewable electricity sources to guarantee carbon benefits from electric cars, expense and sustainability issues around battery production and the need for significant behavioural changes.

*“I know people do talk about electrification and I’m all for it, uh, if it’s low carbon electricity. Coming from where I come from I would say it has to be renewable um and we can barely muster enough renewable power to meet our own power targets never mind our heat and transport targets as well” – A2*

*“There also needs to be something of a realisation within government that electric cars aren’t necessarily going to work in the next twenty years, in terms of the infrastructure sort of investment that would be required in order to get electric cars” – A3*

*“I’m, as you’ve probably guessed, sceptical of the broad applicability of that model because it’s very inefficient from the capital perspective. It requires too much stuff, there’s not enough lithium and copper and magnets in the world to make it happen” – B2*

*“There are two kind of significant factors, um, in the near term, which need to be managed. One which is battery costs, we need to see battery costs come down probably to a, to a third to a quarter of their current cost” – O2*

Another issue related to electric vehicles that was widely discussed was the extent of government interest and support. Five of the fifteen interviewees discussed how the UK government are very supportive, possible overly so, of a move towards using more electric vehicles in the UK. It was also suggested that such government interest in electric vehicles may be partly to blame for the reduction in interest in biofuels.

*“There also needs to be something of a realisation within government that electric cars aren’t necessarily going to work in the next twenty years” – A3*

*“I think for a variety of reasons the, the current rush towards er electric vehicle, or rush to promote electric vehicle technology, is wrong headed*

*and the, the government hasn't quite twigged that yet. People at DfT and DECC still talk very much as if electric vehicles are just on the cusp of happening" – B2*

## **ii) Biofuels and Hydrogen**

Only four of the fifteen interviewees discussed hydrogen as an option for fuelling transport. These interviewees were spread across a range of stakeholder groups – A3, C3, O3 and V1.

Of the interviewees who discussed hydrogen, only one seemed to believe that hydrogen would have an important role in the future of transport (O3). The remaining three felt it would be unlikely that hydrogen would emerge as a commercial technology. This was largely due to the lack of development of the technology to date and the substantial financial investment that would be required to bring hydrogen to the necessary level.

*"For hydrogen cells the technology isn't there" – A3*

*"Hydrogen, personal view is that it'll never ever happen because the infrastructure is just too expensive. Um, the cost to compress it is just far too high, the energy density is so low" – C3*

*"Things like hydrogen will be important. We have a a small hydrogen business for example, hydrogen fuel cell vehicles" – O3*

This final comment serves as an example of how commercial interests may have influenced topics of conversation and level of interest in certain issues.

### **5.3.5 The role of Government**

**RA6: Determine awareness of different stakeholder groups and their position on government action on biofuels, including recommendations for improvements or more appropriate actions**

As the government were revealed to be the greatest perceived barrier to the development and expansion of biofuels by the expert stakeholders, there has

been some discussion of the expert position of government action under RA4. Thirteen of the fifteen interviewees considered the government to be a barrier to the further development and expansion of use of biofuels. The only two interviewees who did not consider the government to be a barrier were O1 and O2, both representatives of the oil industry.

Within the discussions of government as a barrier, a total of twenty specific factors were raised (Table 22).

<b>Issue with Government</b>	<b>Number of Interviewees</b>
There is too much uncertainty over the future of biofuels from government	9
Biofuel Policy is poor	8
There is a lack of action from government	6
There is a lack of commitment to plans from government	4
Government don't plan long term	3
There is a lack of support for biofuels in government	3
There is a lack of Engineers in government	2
Government have a poor track record on support for new fuels	2
There are no plans for biofuels for the time between the RTFO ending in 2014 and the RED commencing in 2020	2
Government attitude towards biofuels has become very negative	1
Government are better on theory than practice when it comes to biofuels	1
Government struggle to act on complex issues	1
Government don't see biofuels as long term option	1
Government seem to lack interest in biofuels	1
Government are not a force for change	1
Government action and planning is not joined up	1
There are problems with government strategy for biofuels and transport	1
Government have lost interest in biofuels	1

Government have set opinions that are difficult to change	1
Government are actively obstructive on the issue of biofuels	1

**Table 22. Specific ways in which the government were perceived to be a barrier to the development and further use of biofuels in the UK, by the expert stakeholders**

**i) Uncertainty**

As can be seen in Table 22, the biggest concern was the degree of uncertainty about the future of the biofuels market in the UK created by a lack of clear signals about future support from government. Lack of certainty created by the government was considered to be a barrier as it makes securing investment for developments and new projects more difficult. There were fears expressed by some interviewees that the government could dramatically change or even completely withdraw existing policies, incentives and other support measures rendering the industry unviable.

*“It’s the uncertainty that is also brought about by the conversations that are had within the media, um, no-one knows as to whether or not it is going to be a market in which you can invest” – A3*

*“Whilst there is uncertainty in the market about what return you will get for large scale investment” – R&D 2*

**ii) Inadequacies of existing policies**

The second most discussed way in which the government were perceived to be a barrier to development of biofuels was related to the inadequacies of existing policy. This issue is somewhat related to the previous issue of uncertainty, as three of the eight interviewees who discussed poor policy as a barrier made reference to the lack of certainty created by inadequate policies. The other main concern about poor policy as a barrier was that the biofuel and wider energy policy, both within the UK and at the EU level, were chaotic and not fit to deliver any substantial progress or change.

*“The role of policy is to provide greater certainty and reduce volatility of returns during a transition period and hence the answer to the second*

*question, what's the most significant risk, in the short term is policy risk for the reality is policy does not do what it said it would do" – B2*

*"I think some of it is a challenge because we're not being given the right type of policy frameworks" – C1*

### **iii) Lack of Action**

Lack of action from the government was the third most discussed way in which government were perceived to be a barrier to development of biofuels. Four of the six interviewees who discussed government lack of action as a barrier felt that it was due to the government not knowing what to do in the face of certain problems, specifically ILUC, and stalling on having to make a decision.

*"The lack of a political or scientific solution to ILUC is causing the UK not to set a trajectory for biofuels from 2014 to 2020 beyond the 5% by volume target for 2013 2014" – B3*

*"As we look out we haven't got a clear view of where it's [biofuels in the UK] going to go" – V1*

In general, the perception of government support for biofuels was very negative, with the notable exceptions of interviewees O1 and O2.

Interviewee O1 made no specific reference to any positive or negative perception of the UK government in relation to biofuel. They did discuss the differences in the policy approaches of different nations, specifically the different drivers. They also suggested that the strong and supportive position of the US government and its policies on the subject of biofuels "*puts many other jurisdictions to shame*". It is possible that this statement could be interpreted as an indirect criticism of UK government policy on biofuels.

Interviewee O2 made specific points about how well they felt the UK government was doing in supporting biofuels. They discussed how the UK's greenhouse gas reduction targets and the RTFO and RED legislations were very ambitious and would stretch industry in striving to comply with them. In addition, from their own experiences of setting up a biofuel facility in the UK,

they felt the government were playing their part and remained committed to the further development of a UK biofuel industry.

*“I think the UK government is actually playing its part. Certainly we’ve had a, we’ve had a, we’re hoping to commission our first big biofuels plant in the UK at the end of this year early next which is up in up in [place name removed] we’ve not seen anything to concern us that the UK government isn’t remaining committed to this at the moment” – O2*

The perspective of interviewee O2 is particularly interesting as it is so divergent from the views expressed by all the other interviewees.

Whilst the discussions of the majority of interviewees were dominated by the negative perceptions of government on the subject of biofuels, there were a range of other issues discussed.

#### **iv) Incentives and Subsidies**

The subject of incentives and subsidies from government was discussed by six interviewees (A1, A3, B1, C2, O1 and R1).

Of these, four (A1, B1, C3 and R1) were of the opinion that the government should be providing more in the way of financial incentives to support the industry and encourage development and take-up of biofuels. Three interviewees (A1, B1 and R1) focussed on subsidies to support the biofuels industry and make biofuel production more financially viable whilst the fourth interviewee (C3) was more concerned with incentives for the general public to encourage the use of biofuels, as well as other ‘green behaviours’.

*“I think the level of support that they’re providing, particularly from a sort of economic perspective, um, is not going to be sufficient to persuade industry to meet the government’s targets in terms of achieving ten percent inclusion in fuel” – B1*

*“If this is important to the government then the government need to incentivise it” – C2*

Of the remaining two interviewees; one (A3) did not feel that government subsidies would be helpful for the industry, due to the scepticism it may foster, and one (R1) felt any decision to subsidise should be very carefully considered and implemented with caution due to problems experienced by the implementation and removal of other subsidies.

*“I don’t think incentivising production needs to be, um, necessarily, sort of, I mean public scepticism about anything that is propped up is, certainly speaking from the agricultural side of things, it’s something we know about and people don’t like to think that something’s propped up and you immediately open yourself up to attack if an industry is supported or as I say propped up by the government” – A3*

*“I think governments have to think very carefully when they’re encouraging industrial development of that sort that you, you do the thinking up front so that once you’ve done that you don’t then say right we’re encouraging investment in this area, when people put their money in, or companies put their money in, you then say no we didn’t really mean that so we won’t give you the subsidies” – R&D 1*

A number of other government related issues were discussed, although each issue was only covered by a few interviewees. These included: the potential problems caused by missing targets (discussed by 3), the existence of the targets (2), how ambitious existing targets were (2), the impact of lobbyists on government opinions (2), the Renewable Energy Directive (2), the Renewable Transport Fuel Obligation (2), the challenge that public opinion presents for the government (1), how energy security is likely to motivate more action than environmental benefits (1), how the government used to be supportive of biofuels (1) and the differences between the US and UK in terms of support for biofuels (1).

Thirteen of the fifteen interviewees also discussed things they felt the government could change or do better in relation to biofuels (Table 23).

<b>Things the government could do to improve the situation for biofuels</b>	<b>Number of interviewees that discussed each item</b>
The government need to do more for biofuels	5
Biofuel policy needs to be improved	4
Targets need to be taken more seriously	3
Benefits of biofuels need to be recognised	3
Government need to provide or support greater investment in biofuels	3
Government need to lead the way	2
Government need to be more consistent	2
CO <sub>2</sub> reduction needs to be made a priority	1
Guarantees are needed to provide security for the industry	1
Government need to be realistic	1
A level playing field is needed for all energy options	1

**Table 23. Ways in which government can improve the biofuel situation, by number of interviewees that discussed each issue**

As can be seen in Table 23, the most discussed way in which experts felt the government could improve the prospects of biofuels was simply by doing more. Whilst this comment in itself is quite general, the additional comments provide further detail – with improved policy and legislation, more serious action on targets and greater recognition of the benefits that biofuels can deliver being key.

## **5.4 Discussion**

The interviews with expert stakeholders yielded a vast quantity of information related to the past, current and future situation for biofuels in the UK. Major themes identified included: the perception that the government were a significant barrier to the further development and use of biofuels, the need for greater investment in the industry to allow it to develop and progress, the differences in the expert and public perception of barriers and the need for better provision of information.

### **5.4.1 RA1 – Awareness and Knowledge**

By virtue of being expert stakeholders highly involved in biofuels on a day-to-day basis it was assumed that all participants had high level of awareness of biofuels. The stakeholders demonstrated a range and depth of biofuel knowledge that suggested they also had a high level of knowledge of biofuels. However, this does not mean that specific knowledge was consistent across all interviewees.

While all experts demonstrated high knowledge, there were variations in the specific topics raised and the extent to which they were discussed. This suggests that knowledge was not consistent across all interviewees on all issues. In certain cases, some interviewees demonstrated knowledge of issues that others did not – for a large part it is likely this is due to the particular background and area of expertise of the individual interviewees. For example, knowledge of the benefits of DDGS was higher amongst interviewees working more closely with farmers and ethanol facilities producing the co-product. It is clear therefore, that it would be important to have biofuels experts, and most likely a range of biofuels experts, involved in any exercise undertaken to improve provision of accurate knowledge to increase understanding of biofuels in other stakeholder groups.

This variation in specific areas of knowledge should not be interpreted to mean that the contributions of experts were of unequal value to the overall

examination of issues relevant to stakeholders. Rather, it is my opinion that the difference in specific interests and knowledge of experts contributed to the overall quality of the project – representing a wide range of views and demonstrating the complexities of the issues as well as the existence of cross-stakeholder barriers.

In some cases, the extent and relevance of known issues was disputed by certain expert stakeholders. Most notably, there was much discussion about how much of a problem Food versus Fuel, ILUC and Deforestation actually were.

Whilst the majority of experts demonstrated knowledge of Food versus Fuel as an issue, more than half of those interviewees felt that the production of biofuels was not a major cause of global food problems and that it was not fair to limit the development of biofuels based on Food versus Fuel concerns. From this perspective, the experts did not consider Food versus Fuel to be a genuine barrier to the expansion and development of biofuels. However, it was recognised that government concern about food issues could be a barrier.

There is evidence to support both perspectives in the literature. There is still a large amount of literature being published that discusses biofuels as a cause of food problems, which is contributing to current concern about food issues in government and other groups (Demirbas, 2011, Banerjee, 2011, Tirado et al., 2010).

However, there are an increasing number of publications that support the view that biofuels have not been a significant cause of global food problems (Wetzstein and Wetzstein, 2011, Gilbert, 2010, Timilsina and Shrestha, 2011, Baier et al., 2009, Huang et al., 2012, Timilsina et al., 2012, Mueller et al., 2011, Lam et al., 2009, Ajanovic, 2011b). Much of this research uncovered other factors that made a much greater contribution to global food supplies and prices, including many market and economic factors such as speculative investments and market volatility (Mueller et al., 2011, Gilbert, 2010, Ajanovic, 2011b). In addition, increased demands and adverse weather conditions

impacting supply have also been identified as contributing factors (Lam et al., 2009, Ajanovic, 2011b).

Expert opinion of ILUC as a potential barrier was also not straight-forward. Of those who demonstrated knowledge of the issue, not all considered it to be a barrier to the expansion and development of biofuels, but did feel that political fear surrounding the issue may be. Several experts took the view that ILUC was too complex to overcome but that this was not sufficient reason to prevent development of the biofuel industry. As such, their opinion was more that ILUC should not be allowed to be a barrier to the development of biofuels due to the long-term delays involved in reaching any solution.

Whilst the majority of literature on the subject of ILUC remains dominated by reviews of the impacts of ILUC (Djomo and Ceulemans, 2012), there is some literature available that discusses the political difficulties presented by uncertainties surrounding ILUC, which goes some way to reflecting expert concerns about ILUC as a political barrier (Di Lucia et al., 2012, Palmer, 2012). In particular the publication by Palmer (2012), which highlights deficiencies in the way EU governments have approached and tackled the ILUC issue that have led to increased difficulties in reaching any possible solution, comes close to capturing the expert opinion revealed here.

In addition, whilst no literature was found discussing criticisms of ILUC models and scenarios, industry criticisms similar to those recorded in this study were acknowledged in the Working Paper “Indirect Land Use Change in Europe – considering the policy options” (Malins, 2011).

Due to differences in the methods of data collection, it is difficult to compare the discussions of the expert stakeholders with those of the general public. Whilst, in the case of the public they were considered to either have knowledge of an issue or not, expert discussions provided more detail that included personal/professional interpretations of information.

In total, the general public raised 121 separate negative issues related to biofuels. Deforestation was also the most known potential impact for questionnaire respondents, as well as being the issue of most concern. Land use was the fourth most known issue and came sixth in issues of most concern. The very negative public perception observed may cause problems in any move to expand the production and use of biofuels in the UK. Negative public perception was also identified as a significant barrier to the development of biofuels in a study by Hammond et al. (2012) and Roberts and Upham (2012). Similarly, negative public perception as a barrier to technological development has also been reported and discussed in relation to other areas, including nuclear energy (Goodfellow et al., 2011), hydrogen vehicles (Hickson et al., 2007) and building-integrated photovoltaics (Taleb and Pitts, 2009).

The expert stakeholders raised 73 separate negative issues/barriers, and of these there was not universal agreement that they were barriers, with some being openly rejected as barriers by some experts. It is particularly important to note that included in the issues disputed by experts were the extent of ILUC and land use change as well as deforestation

#### **5.4.2 RA2 - To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels awareness and knowledge of biofuels effectively**

Results suggest that the experts considered positive public opinion to be an important factor for supporting the future of biofuels in the UK. However, it was considered that the public currently lack understanding and awareness of, as well as interest in, biofuels and that this may be problematic. The idea that lack of public knowledge of scientific issues may be a source of contention and generate negative feelings towards science is not new, and was reported on by The Royal Society in 1985 (The Royal Society, 1985).

Despite this, there was a notable lack of engagement and communication activities undertaken by the biofuel experts. The few actions that were taken

were limited in scale and scope, with the effectiveness of information on individual company websites being questioned by some interviewees. Whilst this may be attributable to lack of time or money to put into communication efforts, there was some evidence to suggest lack of communication may be due to reluctance to communicate on the subject of biofuels. This is based on both the lack of communication undertaken combined with certain statements about not overly publicising biofuels or companies taking a different focus in which biofuels were less central. Such reluctance for experts (particularly scientists) to communicate on scientific issues has been documented elsewhere (Mikulak, 2011). As such, results presented by this study may suggest that expert stakeholders are reluctant to communicate with the public on the subject of biofuels. It could be assumed that this is related to the perceived negative public opinion of biofuels and concerns that open involvement in biofuels would result in similarly negative public opinion of the experts and their organisations.

There have been numerous recommendations and calls by the UK government to increase communication between scientists and the public (Kim, 2007), however, this focus on scientists does not address the information communication potential of other stakeholders. As is evident in this study, there are a great many experts in the field of biofuels who have their own information, experience and perspectives that could be communicated but do not fall under the remit of encouraging communication between scientists and the public. As such, it may be necessary for future initiatives in communicating science to take other expert groups into account as well as scientists. There is a lack of literature that discusses the potential to include other expert stakeholder groups in such communication, with a strong focus on the role of scientists, although there is some recognition of NGOs as antagonistic alternative science communicators (Shafer, 2012). This further highlights the need for broader consideration in science communication.

Although I have discussed the lack of communication activities undertaken by the experts as a potential underlying cause of lacking public knowledge, the experts highlighted the general complexity of biofuel issues along with

misinformation and exaggeration perpetuated by the media as reasons for the low level of public knowledge and opinion.

The contributions of inaccurate media coverage of scientific issues to poor public understanding of science is also well documented (Mikulak, 2011, Evans, 2010, Hivon et al., 2010).

There was not a great deal of discussion of ways to improve communication with the general public. Having information about biofuels available at the fuel pump was advocated by two interviewees who also felt this was the responsibility of the oil industry, although neither interviewee was a member of the oil industry. The results would suggest that, while communicating with the public is perceived to be important, the experts in biofuels seem to lack knowledge of how best to communicate with them.

#### **5.4.3 RA3 – Perceived Barriers**

Overall, results of the discussions of problems, barriers and challenges with the expert stakeholders present a somewhat mixed picture. Whilst no one issue was discussed by all interviewees, by far the greatest perceived barrier was the government, based on the fact that the government as a barrier was discussed by thirteen of the fifteen interviewees and assessment of general categories of discussion showed political issues to be, by far, the most prevalent.

This marks a notable difference in perceptions of barriers in comparison with the general public, who were much more concerned about the environmental impacts of biofuels. Whilst a number of environmental issues were discussed by the expert stakeholders, demonstrating their awareness of the issues, discussions were limited. In addition, many experts explicitly discussed how a large number of these environmental issues were not as significant as some people and groups portrayed them. This highlights the need for provision of more accurate information

regarding the positives and negatives of biofuels and a significant area in which public knowledge can be improved.

Whilst the government were generally perceived to be the greatest barrier by the experts, the issues the experts had with government were multiple and varied, although focussed on a few key issues.

Uncertainty about the future of biofuels, caused by government, was the biggest single issue with government, as well as being related to a number of the other concerns raised. Many experts felt strongly that the uncertainty created by (lack of) government action was to blame for current low levels of interest and investment in the UK biofuels industry that were limiting the potential for development and expansion.

Other factors that contributed to the perception of Government as a barrier were criticisms of the poor policy relating to biofuels and the general lack of action by government to support or assist biofuels in the UK. Both of these issues were also felt to be underlying factors in the main concern of uncertainty, as both poor existing policies and lack of action result in lack of certainty about the future of biofuels in the UK.

It is also interesting to note that the two experts who did not seem to perceive the government as a significant barrier were both representatives of the oil industry. Whilst there is no specific evidence to suggest why this was the case, it is possible that long-standing relationships between the oil industry and the government have influenced both the nature of their relationship on the biofuel issue and the general perception of government amongst the oil industry. The oil industry has historically been supported by government through preferential taxes and subsidisation (OECD, 2012) However, it is also possible that members of the oil industry representatives were simply reluctant to express criticism of government.

The finding that the government were perceived to be the single greatest barrier is similar to results of a study by Rogelj et al. (2013), whose investigation into uncertainties related to climate change mitigation found

political factors leading to delays in action to have the greatest effect on the balance of risks and costs. Rogelj et al. (2013) conducted the investigation into which of four areas of uncertainty (geophysical, technological, social and political) had the greatest effect on the probability and associated cost of limiting temperature rise associated with climate change to 2°C. Results suggested political factors were most significant in delaying action and increasing costs associated with limiting the impacts of climate change (Rogelj et al., 2013). This is certainly similar to the results presented here which suggest that politics is the most significant factor in delaying the development and expansion of biofuels, which have the potential to contribute to climate change limitation/mitigation strategies.

It is interesting to note that Technological issues were highlighted as the second most discussed General Category, yet no single technical issue featured higher than seventh in the most discussed individual topics. This may be due to the fact that a large number of individually small technical issues were perceived to be potential barriers across the range of interviewees, but not at great length or by a large number of interviewees – possibly due to the issues being industry or experience specific or not properly understood. As such, the possibility of a broad range of seemingly small individual technical issues presenting a barrier to biofuel development when taken as a whole should be carefully considered.

Beyond this there were no clear trends either within interviewee groups or across the groups. Instead a large number of issues were discussed as barriers, with little clear pattern in relation to the different groups involved. This may suggest that perceived barriers to further development and expansion of biofuels in the UK are numerous and pervasive but perception of their significance is more likely to be dependent on the experience and position of individual stakeholders rather than any broader stakeholder category. This may be due to the fact that, while certain interviewees came from the same general group, they still had different specialties and interests that could impact their perception of barriers. It seems more likely that perceived barriers are affected by the specific

background, experience and area of expertise of the individual interviewee – this may have been more evident if a greater number of interviews had been possible.

Results presented here highlight the specific biofuel issues that seem to be of greatest concern, both to individual stakeholders and to those involved in biofuels more generally. Identifying the key issues in this way allows for action to improve the situation for developing and expanding the use of biofuels to be more focussed and effective. There is a large amount of literature that explicitly assesses and states the value of expert opinions in risk decision making (Fields et al., 2013, McBride et al., 2012b, McBride et al., 2012a, Hoelzer et al., 2012) as well as publications that imply value through the use of expert opinion in decision making (Zubaryeva et al., 2012, Jensen et al., 2012, Keune et al., 2012). As such, the ability to produce a list of most discussed barriers from the perspectives of multiple expert stakeholders is still interesting and helpful for decision making, despite the lack of broad trends.

Management options for the identified barriers will be discussed later, under RA5.

#### **5.4.4 RA4 - Investigate aspects of biofuels in need of development and improvement (environmental or technical), how these aspects are prioritised by different stakeholders and what management goals/options are preferred**

Discussion of actions believed to be necessary to improve the situation for biofuels in the UK was much more extensive among the experts than among the general public. This is unsurprising based on the known differences between lay-person and expert assessments of risk (Fiorino, 1985, United States Environmental Protection Agency, 2007). However, beyond this comparison, the extent and detail of the discussions by experts were still limited. This, combined with the lack of existing engagement and communication activities undertaken by the groups and companies involved, was taken as an indication that the biofuel experts

were not especially knowledgeable in methods of information communication. It may also be that, on a day-to-day basis, when not being interviewed on the subject, public engagement and information provision is not a priority for the experts.

From analysis of discussions surrounding perceived barriers, a list of five key required actions could be identified:

- a) Greater support and action from government,
- b) Investment in the industry,
- c) Better provision of information between all stakeholders,
- d) Improved perception of biofuels
- e) Certain technical improvements.

These actions are not mutually exclusive and are not management options in their own right, they are strongly inter-related and require management options to be brought about and then, hopefully, elicit change for the future of biofuels.

**i) Greater support and action from government** was the most discussed required action, being raised in the case of eight of the eleven barriers.

Desired actions discussed by the experts included: making their support of biofuels clearer, improved policies to support the development of the industry and market, incentives and other financial support and long-term guarantees of such action and support.

If the further development and expansion of biofuels is deemed to be the desirable course of action for the UK, a number of management steps need to be taken to encourage such actions and increase government interest in and alter government perception of biofuels. It is likely such steps would include greater provision of accurate information advocating the benefits of biofuels to both the UK and EU governments from reliable and, preferably, impartial sources, improving public opinion of biofuels, and instituting necessary technical advances in biofuel production and engine capabilities.

The need for government intervention to improve biofuels and their situation is discussed in the literature, including some recommended actions similar to those highlighted in this study, such as: improved decision making and better

policies (Amigun et al., 2011, Endres, 2011, Wiesenthal et al., 2009), provision of subsidies (Amigun et al., 2011, Wiesenthal et al., 2009) and other active involvement in promoting use and developing the market for biofuels (Perdiguero and Jiménez, 2011).

The potential benefits of greater support, action and involvement on the part of government should be clear from observations of other nations that have successfully developed their biofuel industry on the back of government support – most specifically Brazil but also the USA. Indeed, the level of support from the UK government prior to 2008 has been credited as the main reason for the strong growth in the UK biofuels market at the time (Perry and Rosillo-Calle, 2008).

**ii) Generating investment in the biofuel industry** was also widely discussed and leads on from discussion of subsidies.

Desired actions included increasing confidence and long-term certainty in the biofuels market to encourage investments that would allow for further research and development, technical advances and improvements in production that could lead to greater, more efficient production, improved environmental benefits and decreased costs. In order to deliver the increased confidence necessary to encourage investment a number of steps can be taken, the potentially most significant being the delivery of greater support and action from government discussed previously.

In addition, the possibility of government providing financial support themselves was discussed by the experts. The literature does discuss the benefits of the provision of subsidies, which have been reported to be the most successful means for supporting the development of biofuels markets (Wiesenthal et al., 2009). It is unfortunate that the current recession and government cuts mean any provision of financial assistance from government is unlikely for the foreseeable future.

**iii) Better provision of information** and **iv) Improved perception of biofuels** as required actions go hand-in-hand, as the improved provision of accurate information should precipitate improved perceptions of biofuels. The correlation between improved knowledge and improved perception has been

demonstrated in other studies (Ibrahim et al., 2013, Knight et al., 1990, Abdul-Mutalib et al., 2012, Al Bathi et al., 2012).

The potential for better provision of more accurate information to government and the anticipated improved perception of biofuels has already been discussed. There is also scope for improving the accuracy and extent of provision of information to the general public to benefit the situation for biofuels, with the potential capacity to influence government opinion and also increase the likelihood of the public choosing to use biofuels, helping develop the market. Discussions of how to improve the accuracy and extent of information to the general public were limited, with the main practical suggestion being the provision of information at fuel pumps. It is possible that this may go some way to increase awareness and knowledge, as all those who drive and use liquid transport fuel need to visit fuel pumps and are a captive audience for the time they are filling up. Messages would have to be simple and presented clearly. The source of the information would also have to be considered, as results from the research into public opinion suggest that information presented by oil companies may not be the most trusted. It is likely that messages clearly from government or a scientific body may be more likely to influence public awareness and knowledge, with knock-on benefits to their perception of biofuels.

v) **Technical improvements** as a required action for enabling the development and greater use of biofuels were raised in discussions of three of the key barriers. In relation to the key barriers, the technical developments discussed were mostly focussed on improved engines better able to handle higher biofuel blends, as well as some discussion of higher quality fuels. It is likely that in order to encourage and enable the desired technical improvements the aforementioned increased government support and action as well as increased investment may need to be delivered first.

The limited discussion of necessary actions and communication efforts is an issue for concern as – although there was wide-spread recognition that improved public opinion of biofuels could be improved by better public knowledge of biofuels (Clark and Hellwig, 2012) – those with the knowledge of

biofuels also lack the necessary knowledge, skills and potentially will to effectively communicate that essential information. This is compounded by the fact that those with a much better grasp of public communication, specifically NGOs and the media, are perceived to be barriers in themselves due to the biased and inaccurate nature of the information they purvey.

#### **5.4.5 RA5 - Compare acceptability of and concerns about biofuels with those related to other energy generation options**

Results suggest that electric vehicles are perceived to be the main alternative to biofuels for fuelling the transport sector. Whilst there was some discussion of hydrogen, this was very limited both in terms of the number of interviewees and the extent of discussion. This is in keeping with discussions of alternative transport fuels in the literature which consider biofuels, electric vehicles, hybrids and sometimes hydrogen, to be the main competitors (Browne et al., 2012, Streimikiene et al., 2013, Tsita and Pilavachi, 2012, Murphy and Thamsiroj, 2011, Contestabile et al., 2011).

While there was recognition of the potential benefits of electric vehicles, particularly for local air quality, these were felt to be outweighed by the disadvantages including problems associated with battery production and disposal and the lack of charging infrastructure. The majority of interviewees preferred the use of biofuels to the use of electric, with the second most common position being a preference for using a mixture of both electric vehicles and biofuels. Only one interviewee expressed a clear preference for electric vehicles over biofuels.

Results suggest that the majority of experts favoured current and expanded future use of biofuels in the transport sector. Many benefits of using biofuels were recognised, including reduced carbon emissions from transport, improving energy security, supporting agriculture and providing a boost to industry and the economy. Preference was not based on ignorance of the potential problems associated with biofuels, as issues including ILUC, Food versus Fuel and Food Prices were acknowledged and discussed by all those who preferred biofuels

and those who preferred a mix of electric vehicles and biofuels. In general, it appeared that experts either felt that the common problems that are generally associated with biofuels are either not as significant as they are portrayed to be by groups such as NGOs and the media, or that they can be overcome as part of the development of the biofuel industry and the generation of investment and government interest. For those who preferred biofuels, there seemed to be a strong feeling that support for biofuels was important despite any current problems, in order to encourage investment and the development and improvement of the fuels going forward.

In discussions of electric vehicles there were concerns about the level of government interest in electric vehicles over and above biofuels. For several interviewees this was felt to be misguided and not based on a full assessment of the facts – particularly the lack of consideration for generating sufficient renewable electricity to ensure electric vehicles can deliver environmental benefits. It is likely that preference for electric vehicles may increase if sufficient renewable electricity could be generated, but the general feeling was that this would not occur in the near future or without significantly increased action and investment.

Views similar to those expressed by the experts in this study have been reported by Andress et al. (2012). In addition, there is also literature that discusses benefits based on the differing time scales on which each technology will be of most use, with biofuels being seen as a short to medium term option with electric vehicles being a longer term option and the benefits of making use of a range of low carbon transport options (Contestabile et al., 2011, Thomas, 2009). These views are also in-keeping with the opinions expressed by experts in this study.

Conclusions of other investigations into the relative merits of biofuels and electric vehicles have produced mixed results dependent upon the focus of the study. A number of publications focus on specific benefits of electric vehicles, which make them seemingly more preferable, such as GHG reduction potential (Pasaoglu et al., 2012). However, these studies do not seem to consider many

of the practical aspects raised by experts here, including sourcing sufficient renewable electricity, producing batteries and providing the necessary recharging infrastructure. These issues are however considered in other publications (Lutsey and Sperling, 2012)

#### **5.4.6 RA6 - Determine awareness of different stakeholder groups and their position on government action on biofuels, including recommendations for improvements or more appropriate actions**

As previously, by virtue of being expert stakeholders, it was assumed that the interviewees would all have good knowledge and awareness of the government position and action on biofuels.

Overall, the majority of interviewees expressed a very negative opinion of current government action on and support for biofuels. The issue of greatest concern was the uncertain atmosphere that poor regulation, lack of government action and changing subsidy regimes created. It was felt that such lack of certainty had negative effects on investment in the development of new facilities and research into new feedstocks and processes that could help the industry improve. As such, the government were perceived to be a major barrier to the development, improvement and expansion of biofuels in the UK. This finding is similar to those of other investigations into the future of biofuels which have also highlighted uncertainty and lack of decisive policies and support as a concern (Tyner, 2012, Adams et al., 2011, Slade et al., 2009, Jagger, 2008). In a publication from 2007, Bomb et al., go so far as to say clear signals and commitment from national governments are essential as a foundation for the development of a biofuels industry (Bomb et al., 2007).

Only two of the fifteen interviewees were not explicitly negative in their discussions of the government. One of the two had clearly positive opinions of existing government actions. For the second it is possible that, whilst not feeling as negatively as some, they felt the UK government could do better, based on their assessment of the high standard of US government action compared to other nations. It is interesting that both of these interviewees were

representatives of the oil industry, with no member of any other group expressing positive opinions of government. Analysis in the literature suggests that existing oil industry investment in biofuels is driven largely by government legislation (Oberling et al., 2012); as such they may see increased government intervention as a greater problem than lack of legislation, as it would require them to invest more in biofuels. Furthermore, in the scale of oil industry finances, investments in biofuels are comparatively small (Oberling et al., 2012) which may make generating investment for biofuels seem less challenging and the multinational nature of the oil industry may also lessen the extent of the impact of UK government on their activities.

However, as those who felt positively about current government action on biofuels were in the minority, it would seem that improvements in the way government support and act on biofuels would be desirable. As government action that creates uncertainty was the most discussed negative aspect of government, it could be assumed that any steps taken to increase certainty about the future of the industry would be beneficial. Based on the discussions of the expert stakeholders I would suggest that, as a starting point, seeing any movement or action on biofuels from government would be welcome.

There is a large body of literature that discusses the importance of, and need for, government support for a number of technologies and innovations (Voytenko and Peck, 2011, Tarr, 2011, Anadon et al., 2012). Government support for new technologies has been associated with increased success of those technologies, for example the growth of GM crops in some African countries (Okeno et al., 2013). In addition, government intervention, mostly in the form of financial assistance, has been successful at encouraging uptake of new technologies, including solar photovoltaics in Australia (Higgins and Foliente, 2013) and mobile phones in India (Gupta and Jain, 2012) and has been recommended for other areas (Veugelers, 2012) including the improvement of public services such as the health system (Nichols, 2012).

There was some discussion of incentives and subsidies; whilst the majority of those who discussed them were supportive of the idea; it was fewer than half the interviewees (6) that raised the issue at all. As has been previously mentioned, there is discussion of the provision of subsidies in the literature which generally advocates the benefits of subsidisation for supporting a developing biofuel industry (Wiesenthal et al., 2009, Amigun et al., 2011, Bomb et al., 2007). However, in the current financial climate and with the extent of government cuts, it is unlikely that any financial assistance for biofuels would be feasible in the near future. Still, it is likely that there are measures that the government could take to increase certainty about the future of biofuels that do not require financial investment. It is possible that a restatement of interest in the potential of biofuels and a recognition that the industry and technology has moved on and improved since 2008 may go some way to increase confidence in the industry and be a first step in 'doing more'. To go further in 'doing more' and to help address some of the financial concerns of the industry, assurances on the longevity of the existing incentive and tax regimes would also likely be well received and beneficial.

## **6. General Discussion – Informing a Risk Analysis**

### **6.1 Introduction**

In this chapter I will focus on the discussion and assimilation of data from the previous chapters in order to draw conclusions and inform the risk analysis. I will present an overview of the main findings and compare and contrast the views of the different stakeholder groups. This will be followed by addressing the identification of information to inform the three main stages of the risk analysis: Risk Characterisation, Risk Management and Risk Communication.

### **6.2 Summary of Findings**

The summary of findings from all research activities and stakeholder groups will be presented according to the research aims.

**6.2.1 RA1.** Contribute to the understanding of awareness and knowledge of biofuels in different stakeholder groups to identify areas where information is lacking or misinformation is prevalent

- Expert stakeholders demonstrated high awareness and knowledge of biofuels. Their knowledge and awareness of specific biofuel issues was also high, however, certain individuals demonstrated greater awareness and knowledge of specific issues according to their different experiences and perspectives.
- Public awareness of biofuels was lower than for many other energy generation options and technologies.

While public awareness was comparatively low, the majority of participants had heard the term biofuels before. Low public awareness of scientific and environmental issues has been reported in other studies (Fletcher et al., 2009, Bostrom and Lofstedt, 2010, Read, 1999).

- Reported awareness from questionnaires was lower than from the focus groups, likely due to the differences in the samples and potential group pressure in focus groups.

- Public stakeholders awareness of specific biofuel issues was limited and varied by issue – whilst they were aware of some issues, their knowledge was often lacking or incorrect. However, there did appear to be a relationship between level of education and accurate knowledge of the issues. This is an important observation which suggests that there is potential to increase knowledge of biofuels through communication and increased exposure.

- Public knowledge of biofuels was dominated by negative issues, not all of which were accurate. The prevalence of misconceptions is a real threat to biofuels and it is important that these misconceptions are remedied if there is to be significant progress.

Other high profile scientific issues, such as GMOs and the MMR vaccination, have also suffered from widespread public scepticism and negativity as a result of media coverage (Burke, 2004, Mikulak, 2011). It is a matter of concern that, without changes in the general discourse surrounding biofuels, they may suffer a similar fate in terms of public opinion and that this may prove to be a significant barrier to expanded use of biofuels, if this is considered to be a desirable course of action.

- The public stakeholders were highly reliant on widely available and easily accessible media sources which do not always provide the most accurate or balanced information. Public reliance on mainstream media for information is well documented in the literature (Gould et al., 2009, Conesa et al., 2004, Greenberg and Truelove, 2010).

- It is certainly my opinion, and seemingly that of many experts, that it is the poor quality of the sources of information used by the public that has led to their current state of knowledge on biofuels (as well as other scientific and environmental issues).

Similar relationships between poor and inaccurate information in the media and poor and inaccurate public knowledge have been observed by other studies, particularly in relation to health conditions (Scheuner et al., 1998, Bomlitz and Brezis, 2008, Cluckie et al., 2012, Sherratt, 2011). Scheuner et al. (1998) reported that reduced knowledge of Irritable Bowel Syndrome was associated with greater concern and antipathy towards the condition. Cluckie et al. (2012) also reported that inaccurate information in the media regarding treatment for stroke could lead to patients having misguided expectations.

**6.2.2 RA2.** To recommend means for improving communication between stakeholders on biofuel issues in a hope to increase levels of awareness and knowledge of biofuels effectively

- Experts were concerned about the potential problems arising as a result of low public knowledge of biofuels. It is a concern that the expert view of the public is more in-line with the outdated deficit model where the public are considered to be ignorant and not relevant stakeholders with valuable knowledge and experience of their own.
- Efforts made by expert stakeholders to engage or communicate with the general public were lacking. The use of websites to disseminate information was most common, but was still only employed by a minority of those interviewed. Additionally, there was scepticism about the effectiveness of such a passive method of communication.
- Experts lacked knowledge of how to effectively communicate and share information with the general public, as suggestions for improving the provision of information to the general public were not widespread. The only notable suggestion was to make information available at the point of fuel purchase.
- There was some evidence to suggest some experts may have been reluctant to communicate on the issue due to concerns about how making their biofuel interest's public knowledge would negatively impact on their public image.
- Disparity between the perceived need for communication of information and the provision of, and willingness to provide, the information needs to be addressed if the potential for biofuel expansion and development in the UK is to improve.
- Results of the public survey suggest that the biggest issue for communicating biofuel information to the public is related to access. The public relied on the widely available mainstream media sources, such as television and newspapers, for their information on issues such as biofuels, despite awareness that these sources were not the most trustworthy (Stromberg, 2001, Meissner et al., 1992).

Whilst scientists were found to be the most trusted, scientific journals were not widely used, likely due to problems with access. Difficulties experienced by

non-experts in information seeking have been examined in the literature (Kuhlthau, 1991, Arora et al., 2008)

- It would seem that there needs to be a step change in how information on biofuels (and likely other scientific issues) is communicated to the general public. It is my opinion that more active and decisive efforts need to be made to ensure good quality; accurate and up-to-date information is actively expressed to the public through engagement – likely in a collaborative effort between multiple stakeholders in an attempt to overcome trust issues associated with certain groups (Weingart, 1998, Lewenstein, 2001, Čada and Ptáčková, 2012). This collaborative view of communicating science has been referred to as the ‘Knowledge Co-production’ Model, in opposition to the Deficit model, which is now largely considered to be outdated (Čada and Ptáčková, 2012). Unfortunately it seems as though those biofuel stakeholders that are not the general public still subscribe to a more deficit model type view of communication, an issue that needs to be addressed.

### **6.2.3 RA3.** Highlight the key concerns of the different stakeholders

- The concerns of the public and the experts differed notably, the public being showing more interested in the environmental issues and the experts being seemingly more interested in the political and technical issues, despite some apparent overlap in the top concerns.

Such divergence in the concerns of the experts and public were not surprising, as the fact that experts and lay-people assess risks differently is well established (Strachan et al., 2011, Fiorino, 1985, DEFRA, 2000, United States Environmental Protection Agency, 2007).

- The general public were most concerned about deforestation of the rainforest, increased fuel prices, increased food prices, loss of species and reduced food supplies.

- For the experts, the issues of greatest concern were the government, food versus fuel, ILUC, Increased Costs and Need for Investment and Food Prices.

- While food related issues were raised as top concerns of both the public and experts, there were underlying differences in the reasons for the concern. Public concern with food issues centred on concerns about personal finance

and the ability to feed themselves and their families. For the experts, concern about food versus fuel was in part a humanitarian issue, with the potential for reduced food supplies and increased food prices to push poor families below the bread line, but was also about the political fear and stalling created by discussion of food versus fuel. Overall assessment of discussions in fact suggests that most of the experts did not consider biofuels to be a cause of food issues, hence their lower level of concern about social and humanitarian impacts.

- Taking the view of the co-production of knowledge model, the disparities in issues known by and of concern to both the public and expert stakeholders suggests that both groups currently suffer from limited understanding of the full range of issues. Again, this serves to confirm the need for the wide ranging issue identification exercise undertaken by this thesis.

**6.2.4 RA4.** Investigate aspects of biofuels in need of development and improvement (environmental/technical/political etc), how these aspects are prioritised by different stakeholders and what management goals/options are preferred

- Public participants did not seem to have sufficient knowledge of biofuels to properly discuss the developments and improvements that would be necessary to address their concerns.

As such, suggestions for necessary developments and improvements could only be inferred from public concerns. In my opinion, this should not be taken as an indication that the public are incapable of understanding the issues but as further confirmation of how current communication on biofuels has failed the general public.

Just as poor and inaccurate media portrayal of an issue can result in poor and inaccurate public knowledge, as previously discussed, high-quality, accurate information presented by the media can positively influence public knowledge. Results to this effect have been presented in numerous studies and discussed in section 6.2.2 (Scheuner et al., 1998, Bomlitz and Brezis, 2008, Cluckie et al., 2012, Sherratt, 2011).

- Addressing the top public concerns would require developments and improvements to include: improve the environmental practices used in biofuel production, a move away from feedstocks that compete with food production to second generation fuels from wastes and lignocellulosics, improved production processes that reduce costs.
- From the expert's perspective, the key areas in need of development and improvement were more clearly defined and included: increased government support, greater certainty about the future of biofuels in the UK and more investment in biofuels in the UK.
- Increased government interest in and support for biofuels was seen as a necessary starting point to increase the certainty for the future of the industry and create the necessary confidence for investments to be made. The need for increased government action and intervention on biofuels and other issues is widely discussed in the literature (Tyner, 2012, Adams et al., 2011, Wiesenthal et al., 2009). Although certain other changes were discussed, particularly technical issues and other aspects requiring further research and development, this was seen as a secondary issue that would be resolved by securing further investments.
- Responsibility for the situation is not solely that of government. As with communicating with the public, I believe that the expert stakeholders should take a more active role in discussing their needs with government and working towards developing a mutually agreeable solution. Collaborations between government and industry for the purpose of problem are recommended in the literature for the resolution of a range of problems, including the expansion of electric vehicles and reforestation projects (van der Vooren and Alkemade, 2012, Leibowitz, 2012).

There is certainly a great deal of literature that advocates scientists taking greater responsibility for science communication (Wilcox, 2012, Jergovic, 2005). In relation to the responsibility of the expert stakeholders, again, it would seem that reluctance to be seen openly discussing biofuels due to concerns about public perception are also hampering expert willingness to raise the issue with government. Such reluctance will need to be overcome to prevent the situation becoming a stalemate where government do not act because they are unaware of the needs of the biofuels market/industry due to the market/industry

experts not wanting to make their biofuel position known. In addition, efforts to improve public perception of biofuels would also be beneficial if it removed the concern on the part of the market/industry to be seen discussing and developing biofuels.

**6.2.5 RA5.** Compare acceptability of and concerns about biofuels with those related to other energy generation options

- In the opinion of the general public there was a clear divide in acceptability between renewables, such as solar and wind power, and fossil fuels; with renewables being much more preferable than fossil fuels and biofuels falling between the two (Greenberg, 2009, Poortinga et al., 2006).
- Only two options provided in the general public questionnaire were directly applicable to transport (without a significant move towards electrification) and, of these biofuels, were more preferable than the only other option, oil.
- Experts were much more aware of which options were applicable to transport and focussed their discussions on these.
- Electric vehicles stood out as being the only other main alternative to fossil fuels, alongside biofuels, in the experts' opinions, a view that is echoed in the literature (Browne et al., 2012, Streimikiene et al., 2013, Contestabile et al., 2011). However, overall biofuels still seemed to be preferred over electric vehicles, largely due to their compatibility with existing vehicles and infrastructure. In addition, significant changes that would be needed to generate sufficient renewable electricity to deliver emissions targets through electric vehicles, counted against electric vehicles as an option for transport.
- Government interest in electrification of transport was a concern for the experts who considered government thinking to be misguided.

**6.2.6 RA6.** Determine awareness of different stakeholder groups and their position on government action on biofuels, including recommendations for improvements or more appropriate actions

- Public awareness of the UK government position and action on biofuels was extremely limited. This may be partly explained by the view of the expert that, at

present, the UK government has very little in the way of a position or any action on the matter.

- The public had some awareness of targets for levels of use of biofuels, and some assumptions of government support for biofuels based on the existence of those targets. They seemed to have no awareness of actual reasons why the government had put those targets in place or that all fuel now contains a percentage of biofuel.
- Public scepticism about the government and their motivations was clearly evident in the focus group discussions.
- Expert stakeholders had much more extensive knowledge of the government position and action on biofuels and, on the whole, were highly critical of the government.
- In the opinion of the majority of the experts, the government were the single most significant barrier to the future development and use of biofuels in the UK. It was felt that lack of government interest, discussion, planning and action on the future of biofuels in the UK had created an atmosphere of uncertainty that discouraged investment and, in turn, didn't allow for the industry to develop and improve.
- It is my opinion that active government involvement in biofuels would be essential to enable the industry to develop and to ensure the fuels are taken up by consumers. This is similar to conclusions drawn in work by Stoddart et al, (2012). However, this is not to suggest that increasing government involvement will be simple.

The profile of biofuels needs to be raised in government consciousness and experts need to ensure that government are aware of the balance of risks and benefits biofuels can deliver.

Biofuels are part of the wider energy and environment issue for the government, with a move away from fossil fuels towards renewables needing to be taken much more seriously if any action is to be taken to improve our current situation. It is unfortunate that we are in the midst of a recession and extensive government cut-backs as this will likely reduce the ability of government to assist and can also be used as a reason for ignoring and/or stalling on the issues in the short term at least.

### **6.3 Informing a Risk Analysis**

At the outset of the project, the overarching aim was to compile information that could inform a risk analysis of biofuels – detailing and discussing the risks associated with their expansion and use in the UK from the perspectives of stakeholders. However, the course of the research has revealed that threats to the future of biofuels, combined with the threat of not taking action on our future fuel supply, may be the more pressing issue. As such, the risk analysis information presented here will consider both perspectives.

#### **6.3.1 Risk Characterisation**

As already mentioned, the full course of the research revealed that the ‘risk’ aspect of biofuels in the UK fell into two distinct categories – risks posed by biofuels and risks posed to biofuels.

Risks posed by biofuels, risks to the environment, individuals or society by the production of biofuels, were primarily the concern of the general public and in some academic literature. Risks posed to biofuels, risks and barriers that may prevent or limit the expansion and development of biofuels, were primarily the concern of the experts and also some academic literature. It is suspected that this difference is related to the different way in which experts and lay people perceive risk (The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997, Fiorino, 1985, United States Environmental Protection Agency, 2007).

##### **i) Risks posed by biofuels**

The concept of risks posed to the environment and society by the production and use of biofuels very much dates back to 2008, with the publication of papers by Searchinger et al. (2008), Fargione et al. (2008) and Danielsen et al. (2008) which prompted the commissioning of the Gallagher review (2008) and resulted in the revision of the UK position on biofuels. It is this view of biofuels that seems to have informed the majority of thinking on biofuels in the years since 2008, in particular amongst the media, general public and government.

Whilst the government were not available to contribute to this study, the lack of government discussion of or action on biofuels since 2008 certainly supports

the idea that they are still reluctant to support biofuels further than existing regulations require.

A full review of the media coverage of biofuels was not undertaken by this study; however, the prevailing negative nature of coverage in recent years has been observed and was commented upon by participants across the range of stakeholders.

The attitude of the general public however, has been well documented by this study, and suggests a definite negative leaning in public perception of biofuels (see sections 3.7.2 – 3.7.4 & 4.4.1 – 4.4.4). As has already been discussed, public knowledge of biofuels was dominated by negative environmental impacts and their concerns were a mixture of these environmental impacts and negative financial implications.

## **ii) Risks posed to biofuels**

The concept of concern about the risks posed to the future of the biofuel industry and market in the UK and Europe, that dominated the thinking of expert interviewees, seems to be a much more well informed and up-to-date perspective. Since the criticisms of biofuels from 2008, industry, researchers and other groups have taken steps to improve production of biofuels and reduce the negative impacts that had been brought to light. As such, many of the 2008 criticisms are now less serious issues, if they remain issues at all, and this was reflected in many of the expert interviews. However, it is clear that this newer information has not managed to reach the general public, highlighting deficiencies in communication on the matter.

Expert concerns were focussed on the interaction between lack of government interest and confidence and lack of investor interest and confidence. Almost all expert interviewees that contributed to this study were of the opinion that the current government position and (lack of) action on biofuels was a significant barrier to expansion of the industry, generating uncertainty that prevented investment. Such investment was considered to be essential to fund research and development of feedstocks and process technologies, development of new facilities and upgrading of infrastructure, all of which would help further mitigate the remaining concerns of other stakeholders.

Whilst some of the environmental and social concerns that dominated discussion with the public, such as deforestation and increased food prices, were raised by the experts, the discussions largely focussed on how these issues were not significant concerns associated with the production and use of biofuels.

Whilst a deficit model approach would likely interpret these results to suggest that the public are largely misinformed about biofuels – being aware of issues that are not expert concerns and not being aware of issues that are expert concerns – a co-production of knowledge approach suggests that both groups have limitations to their knowledge from each other's perspectives. As such, the discussion of both sets of views in this thesis is particularly important.

### **6.3.2 Risk Management**

Risk management options need to be considered for both the public concerns about the risks posed by biofuels and the expert concerns about the risks posed to biofuels. While it is felt that many of the public concerns are not necessarily issues relevant to biofuels, as public concern in itself is a risk posed to the future of biofuels, such concerns need to be addressed in order for mitigating steps to be developed.

#### **i) Managing Public Concerns - Risks posed by Biofuels**

It would seem that options for managing public concerns need to focus on improving the environmental credentials of biofuels, reducing the financial impacts of biofuels as well as ensuring the public are adequately informed about biofuels based on accurate, up-to-date knowledge.

Examination of the literature and discussions with the expert stakeholders revealed that many of the concerns of the general public - particularly deforestation of the rainforest and increased food prices/reduced food supplies - may not currently be as serious as the public seem to believe and also may not all be attributable to biofuel production. As such, it would seem that the most logical management option would be to increase the provision of accurate

and up-to-date information to the public in the hope of alleviating their concerns about such issues.

There was also some discussion, amongst both experts and the general public of introducing a sustainability standard to ensure biofuels used in the UK did deliver real environmental benefits. Instituting sustainability standards or certification for biofuels is discussed at length in the literature (Thornley and Gilbert, 2013, Partzsch, 2011, Tait, 2011, Khanna et al., 2011, Scarlat and Dallemand, 2011). Whilst some considered certification to be one of the most effective ways of making significant improvements to the sustainability of biofuels (Thornley and Gilbert, 2013) there is also discussion of the difficulties and limitations (Partzsch, 2011).

Although logical, the implementation of any standard would require significant international, inter-agency and inter-industry co-operation. The full range of stakeholders involved in the production, transport and processing would need to contribute data on inputs too and impacts of their activities to ensure a comprehensive and reliable measure of a fuel's sustainability. In addition, funding for the administration of such a standard would need to be supplied from somewhere, ideally not through increasing prices of fuels or consumers who are already concerned about increased costs. If this were an easy thing to achieve it would likely have been done so already.

Further to this, if a sustainability standard scheme is to have any effect on public opinion, it must be open, well explained and easily understandable.

## **ii) Managing Expert Concerns - Risks posed to Biofuels**

The main focus of managing expert concerns clearly needs to be on improving the political and financial/investment situation for biofuel in the UK.

From the perspective of the expert stakeholders, the most significant step that could be taken to address the risks posed to the future of biofuels is for the government to put biofuels back on the agenda and work to increase the certainty for and confidence in the industry's future.

A number of the experts interviewed discussed specific actions government could take including, revisions to existing biofuel policy and long-term planning for the use of biofuels, both of which apply to the desire for government to set out plans for biofuels between the expiry of the RTFO in 2014 (at 5% biofuel by volume) and the requirement to deliver 10% of transport fuel from renewable sources by 2020, under the RED.

However, it is likely that management steps need to be taken to encourage government to renew their interest in and support for biofuels before they will implement measures that will benefit the biofuel market and industry. As was the case for the general public, it is likely that better provision of more accurate and up-to-date information on biofuels to government may go some way to restore their confidence in the potential of the technology and hopefully encourage renewed interest. Improved public perception of biofuels would also likely reduce government reluctance to be seen supporting biofuels.

### **6.3.3 Risk Communication**

Communication of science is a subject that is discussed at length in the literature (The Office for Science and Technology and Wellcome Trust, 2000, Kim, 2007, Hart and Nisbet, 2012). The subject of science communication has been undergoing a paradigm shift, where the old 'deficit model' of communication is being replaced by an 'engagement model' (The Office for Science and Technology and Wellcome Trust, 2000, Kim, 2007).

Under the deficit model, it is the role of scientists/experts to send information to the public, for the public to listen to and learn from with an assumed result of improved public opinion of the issue concerned (Hart and Nisbet, 2012, Ahteensuu, 2012). Increasingly, evidence is suggesting that this approach is misinformed, particularly in the field of biotechnology (The Office for Science and Technology and Wellcome Trust, 2000, Ahteensuu, 2012, Marris, 2001, Marris et al., 2001, INRA (Europe) - ECOSA, 2000). Research conducted into public opinions of GMOs by Marris et al, (2001) suggests that opposition of or uncertainty about GMOs was not associated with lack of knowledge that could

be addressed by improved communication of information. This runs against the central principle of the deficit model.

Evidence from this research certainly seems to be more in-keeping with engagement models than the deficit model. Results from the public have shown that the public are aware of a great many issues relating to biofuels and that their concerns are based on these facts rather than a complete lack of understanding of the technology and science underlying biofuels.

What may be of concern is that findings related to public opinion of GMOs suggest that increasing public knowledge is more likely to harden existing positions rather than convince people of the virtues of the technology (DTI, 2003). As such, increased communication efforts are not a guarantee of improved public opinion. It is again relevant to reference the differences between the deficit and engagement models and suggest that the understanding of 'risk communication' include the holistic view of 'communication' as a two way, or engaging, process. Therefore risk communication must involve discussion rather than simple provision of information if the intention is to alter public perception of biofuels.

The 'engagement model' is based on a more collaborative effort between scientists/experts and the general public (or other stakeholders), where information flows in both directions and the general public are much more involved (engaged) in the process (The Office for Science and Technology and Wellcome Trust, 2000). It is felt that this project is in keeping with the principles of the engagement model of science communication.

Both the Risk Characterisation and discussion of Risk Management conducted above highlight the critical importance, and current lack, of effective communication between stakeholder groups on the subject of biofuels.

It is clear that any communication strategy will need to be very carefully considered to avoid being a waste of time and resources. It is also likely that such a strategy will need to be wide ranging and cannot rely on a single message or approach.

In order to improve the effectiveness of efforts to increase the provision of information to the general public, a range of other stakeholders and information sources/providers will need to be involved, including science, industry and market experts, the government and the media. Whilst research suggests the majority of the general public have an interest in scientific developments, it has also been suggested that science communication needs to highlight specific links between research and people's lives to encourage interest and engagement (The Office for Science and Technology and Wellcome Trust, 2000). In the case of biofuels this should not be difficult, as the majority if not all people in the UK will rely on some form of transportation at some point in their lives. Whilst the environmental aspects of biofuels that have been the focus of discussion to date are important, the conversation should be expanded to incorporate the potential financial, economic and energy security aspects as well, as these also hold relevance for people's lives.

Clearly, based on the theory of the engagement model of science communication, it is not sufficient to just make information available to the general public and expect them to find it, absorb it and change their opinions in relation to the information presented. Unfortunately, this still seems to be the approach taken by many of the experts interviewed for this study. If the provision of information is to be effective in increasing public awareness and knowledge of biofuels, as well as improving opinion and perception, an engagement based approach is necessary. However, as involvement activities such as the focus groups conducted by this study are lengthy and limited in the number of people they can access, it seems likely that engagement for communication purposes would need to take another form.

The attraction of passive means of information communication, such as websites and the media are clear – requiring little effort on the part of the scientists/experts, who may also have little experience of public communication, yet reaching a potentially huge audience. As such, an approach that can incorporate similar means for making information available alongside a method allowing for public feedback and engagement may be preferable. The use of the internet as a tool does not have to be inherently

passive and online engagement and participation approaches have been utilised in other fields (Richardson et al., 2013).

However, it would have to be ensured that information conveyed through third parties was accurate and balanced, which the media does not have the best track record of doing. The poor quality of reporting of scientific issues in the media has been discussed in the literature (Bruno and Verzellesi, 2002, Lewenstein, 2001, Weingart, 1998). With this in mind, it may be desirable to increase the number of scientifically literate journalists involved in the provision of information on biofuels, as well as other scientific issues. This was also a recommendation of Bruno and Verzellesi (2002).

Improving public knowledge and perception of biofuels could also be benefitted by greater involvement of government. Whilst the government were not the most trusted source of information, according to results of this and other studies (Grimmelikhuisen, 2012, Hunt and Frewer, 2011, Hunt and Frewer, 2001, Frewer et al., 1996, Lang and Hallman, 2005), a more noticeable and positive government position on biofuels is unlikely to be detrimental to public knowledge and perception. However, prior to government being able to take any steps to change their position and communication on biofuels it will be necessary to ensure the government are receiving the best information on which to base their renewed position. As government were unable to contribute to this study it is not possible for any informed comments to be made on where government currently obtains biofuel information or identify how and why this may be lacking.

Improving the communication of biofuel information to the public (with possible implications for communication of other scientific and environmental information) could be taken forward in two main ways;

- a) A definitive decision made by an expert on the best means of communication to pursue
- b) An experimental approach testing various communication methods.

My personal preference would be to pursue the experimental approach, utilising randomised control trials to test the effectiveness of different approaches to communication in terms of;

- The reach of the information (number of people accessed),
- The penetration of the information (number of those accessed who read/otherwise took in the information)
- Overall impact on knowledge and opinions (of both biofuels and the agencies involved in delivering the information).

Based on results presented by this study combined with knowledge of communicating with the general public, I suggest a number of approaches be tested under the criteria listed above;

#### • **Provision of information at petrol stations**

This approach was advocated by some of the experts interviewed. It would likely involve clear and prominent signs, and possibly additional leaflets, made available at petrol stations to capitalise on the captive audience of vehicles users.

How the information is purveyed, and by whom, would be matters for testing. Likely variables would include the nature of the information (statements by different experts, facts and figures etc) as well as who was seen to be presenting the information (government, scientists, oil industry etc).

#### • **Advertising Campaign**

Such an approach could involve the production of billboard signs, magazine and newspapers adverts and television adverts.

As with information at petrol stations, the specific messages and source of the information would be additional factors to be tested.

#### • **Public Information Leaflets**

The UK Government has employed Public Information Leaflets before, for the dissemination of information on what to do in the event of an emergency in response to an increased terrorist threat (HM Government, 2004). In addition,

information leaflets have been utilised for increasing awareness and knowledge of topics particularly in relation to medical conditions (Sustersic et al., 2013, Espin et al., 2012, Korb-Savoldelli et al., 2012). As such, it may be possible for a similar publication to be produced on the matter of biofuels, or energy and the environment more widely but ensuring inclusion of biofuels.

As there does not seem to have been any investigation into the effectiveness of the emergency response leaflet, such information would also be generally interesting and beneficial for the future of public information communication.

• **A national web-based resource for biofuel (and wider scientific) communication and engagement**

A website (with associated social media connectivity) could be established, by government (or other well-trusted, national organisation with an interest in accurate and effective communication of science) to provide up-to-date information on biofuel research and development and news in a way that is easy to access and understand for a general audience.

In addition to the provision of information, the resource could incorporate means for feedback and engagement of the public through forums, surveys and advertisements of public meetings or discussions.

There is research to suggest that the full potential of the internet in engagement and participation is not currently being fulfilled (Chiabai et al., 2013). Literature on the subject of 'e-participation' is growing (Chiabai et al., 2013, Medaglia, 2012, Åström et al., 2012, Royo et al., 2012), although examples of resources similar to that described here are not easy to find. One example of a resource similar to that described here, incorporating information, guidance and the opportunity for engagement was found to have been used for encouraging and supporting people to quit smoking (Richardson et al., 2013).

#### **6.4 The Future for Biofuels in the UK**

Based on the results and finding of this research it seems that the future for biofuels in the UK is currently uncertain and dependent on a number of factors. Key amongst these factors are future government positioning, legislation and

action on biofuels as well as public opinion of biofuels and communication on the issue.

If the situation continues on its current course, with low government interest and support, lack of confidence amongst investors and uncertain public opinion, it seems that the UK biofuel industry and market will be more likely to shrink than develop and expand. This is a fear shared by those involved in the production, sale and use of biofuels in the UK that was highlighted in this study.

The production and use of biofuel in Europe has been required by EU legislation since 2003, and has been incorporated into UK policy since 2008 with the introduction of the RTFO. During the life-span of this policy, targets for use of biofuels have already been revised down due to concerns about environmental impacts (Boucher, 2012). The RTFO is now approaching the end of its remit in 2014, with no current replacement policy governing use of biofuels in the UK in place or proposed; despite the EU target of delivering 20% of energy and 10% of transport fuel from renewable sources remaining in place. Furthermore, in October 2012 the EU announced that use of biofuels produced from food crops would be limited to 5% of transport fuel, requiring much greater production of currently under-developed, second generation biofuels if any greater percentage of biofuel in transport fuel is to be achieved.

As such, an already weakened UK biofuel industry and market face a potentially indefinite period without any government position, interest or policy based support/guidance. In addition, during this period significant advancements need to be made (and funded) in the production of second generation fuels from Lignocellulosic biomass, wastes and algae.

It is my opinion that the EU and UK government position on biofuels is in need of updating and should be informed by the latest knowledge from the full range of stakeholders – including the general public, scientists and industry experts. A case should be presented that demonstrates the *current* issues that have been highlighted in this study;

- There is a need for alternative and renewable transport fuels which biofuels may be well-positioned to meet in the short term. Electric vehicles running on renewable energy are also likely to have a role but this requires more development of renewable electricity generation capacity and charging infrastructure.

The costs and benefits of biofuels should also be presented in comparison to the costs and benefits of fossil fuels. Governments should not allow the prospect of some hoped-for perfect solution to prevent them from developing a known and available good solution.

- An up-to-date assessment of the issues of concern, with particular reference to advancement made and new knowledge related to the environmental and land use issues that have dominated government and public thinking in recent years.

In addition, it seems the governments would benefit from being reminded of the additional, non-environment related benefits, such as improved energy security and rural, and potentially general, economic development.

- Governments have an important role in helping to secure investment that will fund further improvements and developments in the biofuel industry (Higgins and Foliente, 2013, Zeeshan Shirazi and Zeeshan Shirazi, 2012, Yin and Powers, 2010). The current EU and UK government position creates an environment in which investors do not have the confidence in any future for the industry to provide investment. The suggestion that lack of strong government action and support creates a lack of confidence in investments is supported by the literature (Bomb et al., 2007, Tyner, 2012, Adams et al., 2011).

As stakeholder experts in this study have highlighted, clearer and stronger government support for biofuels that would ensure a long term future would help encourage investors to put money in.

- It is economically important to foster the development of biofuels in the EU rather than forcing the companies and individuals with the knowledge and skills to move elsewhere (Brazil, USA, and China).

At present, based on these experiences with biofuels as well as past experience with GMOs, the EU risks being seen as anti-technology and anti-development, potentially driving more than just biofuel related development

away. This is an accusation that has been levelled against Europe previously in the literature (Davison, 2010, Dale, 1999).

If such a case was made to government, it would be my hope that they would be encouraged to develop a new plan of action in relation to biofuels in the EU and UK.

Such action could include a renewed, public commitment to the development of biofuels as part of their strategy to achieve the RED targets. In addition, there would also need to be consideration of the future of usage targets beyond 2014 and any specifications to be placed on biofuels such as minimum emission reductions and types of feedstock or land that may be used. If the 5% cap on food crop based biofuels is to remain in place it would be wise to fund the further development of second generation fuels to enable them to meet future demand.

Of course, while government action was highlighted by expert stakeholders as the single most important factor in improving the situation for biofuels in the UK, there are others who can also take steps to improve the future for biofuels and the environment, including, but not limited to individuals, NGOs businesses, industry and the media (Stoddart et al., 2012, Wadham and Warren, 2012, Trapp, 2012, Lyytimaki, 2011). In a culture where each of these stakeholders often tries to shift blame onto another (Pidgeon, 2012), working collaboratively to solve problems such as these is of great importance.

## **6.5 Further Work**

There are, potentially, a great many questions that could be asked and actions that could be taken by any work to continue this study. My primary interests for expansion of this work fall into three main categories - Extension of Engagement and Involvement Activities, Investigation into Methods for Science Communication and Inter-Stakeholder Risk Management Efforts.

- Extension of Engagement and Involvement Activities

Whilst the results presented in this study are felt to be robust and valid, I would be interested to address some additional questions through engagement activities.

a) Do the general public in other areas of the country feel similarly about biofuels? Whilst efforts were made to engage a representative sample in this research, additional work to corroborate this would be beneficial.

b) Does proximity to a biofuel or biomass power production facility affect knowledge and attitudes? If so, how?

c) Would public opinion change if a series of focus groups were undertaken where participants were provided with information on biofuels either prior to or during sessions, and how?

d) Does being better informed lead to more positive opinions about biofuels? If presented with conflicting information from different sources, what affects how people assess the information and decide who to believe?

Additional results would either support existing findings or present new issues for consideration as well as helping to better inform any strategy for communication and publicising biofuels.

#### • Investigation into Methods of Science Communication

The issues regarding science communication that have been raised by this study are fascinating and I feel hold potential for further investigation.

a) What kinds of communication are most effective for communicating on scientific issues with the public?

b) What reasons do the general public give for not accessing scientific information? Is it related to ability to access sources, complexity of the information, style of scientific interest, lack of personal interest or other reason?

c) If more information was provided directly by scientists (rather than via the media) would the public make use of this?

#### • Inter-Stakeholder Risk Management Efforts

Initial plans for this project involved a further stage of engagement with expert stakeholders, bringing together multiple stakeholders in a group workshop(s) to discuss management options and discuss, debate and, hopefully, work to

resolve issues that arise. Unfortunately this was not possible within the time, but is still something that could generate interesting outputs.

- a) What are the reasons for many identified stakeholders choosing not to participate in the study? Is this related to interest in biofuels and concern about public image or another factor?
- b) How successful would efforts to bring multiple expert stakeholders together for a planning workshop for the future of biofuels be?
- c) Will a collaborative effort between stakeholders generate a greater number of management options or more creative management options? Will the group setting hinder the full participation of certain stakeholders, particularly those with concerns about commercial sensitivity?

I believe there is still great scope for investigation into the issue of acceptability and risk analysis for biofuels in the UK. In addition, research into communication methods and collaborative risk management efforts may be able to have impact in other fields, such as renewable energy more broadly, environmental and climate change issues, technological developments and medical developments.

## Appendix 1

### Focus Group Question Guide

#### Introduction

Who I am and What I am doing

Purpose of the session

Participants role

#### Participant Introductions

**1. What ways of generating energy can you think of? Different technologies or fuels?**

(Oil, Gas, Coal, Nuclear, Wind, Solar, Hydro, Bioenergy, Biofuels, Wave, Geothermal)

**2. Who has heard the term “Bioenergy” before today?**

**Who has heard the term “Biofuels” before today?**

- What do you know about biofuels?
- Are biofuels and bioenergy different things?
- Which of these facts are positive/negative?
- Overall, are you in favour of or against the use of biofuels?
- Which of the negative issues do you feel are most serious/ are you most concerned about?

**3. How do you think biofuels can/should be improved?**

- Are any of the negative impacts acceptable/more acceptable/less concerning to you? Why do you consider these to be negative impacts?
- Do the possible benefits make any level of risk acceptable?

**4. In relation to the impacts of other ways of generating energy, What do you think of these energy options?**

(Oil, Gas, Coal, Nuclear, Wind, Solar, Hydro, Bioenergy, Biofuels, Wave, Geothermal)

- Which of these options do you think are better/worse than biofuels? How and why?
- What are your concerns/what do you like?
- Which options would you prefer to see in the UK?

**5. Where have you/do you find out about biofuels from?**

- What sources of information do you think are reliable/trustworthy?  
(Media, Government, NGOs, Scientists, Industry, Independent groups)

**6. Do you feel well informed/that you know a lot about biofuels? Would you like to be better informed about biofuels in general (or other options) and what the government is doing about them?**

- Where would you like that information to come from?  
(Media, Government, Industry, NGOs Independent body, Scientists)
- What sort of information would you want? How would it be delivered?

**7. Do you know if the government support biofuels and how?**

- Do you think they should be?
- What reasons do you think the government have for supporting biofuels?  
(Reduced emissions, Improved energy security, Rural development)
- What do you think of these goals?
- Should there be more or less government support for biofuels?

**8. Can you suggest any alternative measures for reducing emissions from transport?**

- What do think of the following possible options for reducing emissions from transport?  
(Improved public transport, Higher car tax/fuel duty, Biofuels, Money off more efficient vehicles, Electric vehicles, 'Smart' driving courses, Road pricing, Low emission zones and charges,

Hydrogen vehicles, Reduced air travel, Greater regulation of air travel)

**9. Do you think there should be guarantees/certification to ensure that biofuels deliver environmental benefits/help people choose greener fuels?**

- Who should be in charge of setting up and monitoring such a scheme?  
(Government, Industry, NGOs, Independent body, Scientists)
- Who would you trust to report and manage biofuels in the UK?  
(Government, Industry, NGOs, Independent body, Scientists)

**10. Would you be willing to pay more for biofuel or bioenergy?**

- How much more (in p per litre or £ per year)?  
(Extra 5p/10p/20p/50p/£1 + per litre or £10/20/50/100/200 + per year)

**11. Do you know if biofuels are easily available anywhere?**

- If they were readily available, would you use biofuels?
- Were you aware that biofuels are already found in all petrol sold in the UK?

**12. Have you ever been involved in a discussion or other form of consultation on an issue of government policy?**

- What? How? Why?
- Would you like to have more opportunities to do so?
- Do you think other people would make use of opportunities to contribute to similar debates?

## Appendix 2

### Chi Squared Tests for Biofuel Comments

ES1:  $X^2= 7.137$ , d.f.= 2,  $p<0.05$

ES2:  $X^2= 1.226$ , d.f.= 2,  $p>0.05$

S1:  $X^2= 7.914$ , d.f.= 2,  $p<0.05$

S2:  $X^2=7.001$ , d.f.= 2,  $p<0.05$

OS1:  $X^2= 12.601$ , d.f.= 2,  $p<0.01$

OS2:  $X^2= 3.587$ , d.f.= 2,  $p>0.05$

### Appendix 3

#### Coded topics of conversation for Focus Groups

##### Negatives

All problems equal
Aviation - Difficult
Bad Smell
Biodiversity Impacts
Blending
Can't buy at pump (rare)
Can't Produce Enough
Car damage
Car modification
Changed to negative image
Chip Oil - Negative
Climate Change
Cons outweigh Pros
Controversial
Countryside Aesthetics
Deforestation
Don't know where to buy
Don't know who to believe
Drive more
Economically based concerns
Ecosystem Problems
Environmentally based concerns
Extensive Land Use
Food supplies and prices
GM
Harmful emissions
High atmosphere carbon
Humanitarian Concerns
Increase dependency of poor nations
Indirect effects
Inefficient process
Inputs
Loss of Carbon Sink
Maize
Monoculture
More expensive
More policy driven than environment driven
Native people losing land
Need new car
Not a general solution
Not Carbon Neutral
Not clean
Not clear if biofuels are good or not
Not everyone can use them
Not had enough investment
Not if more expensive

Not the best option
Only slowing fossil fuel use
Over work land
Palm Oil
Personal Threat
Poor energy balance
Problems Interlinked
Processing costs
Produce CO2
Reduced carbon sequestration
Some problems can't be solved
Species loss
Subsidies
Too much would be unsustainable

### Positives

100% biofuel car
AD
Algae
Alternative Income
Blending
Brazil
Carbon Neutral
Cheaper
Chip Oil
Clean(er)
Crop Breeding
Economic Benefits
Economies of Scale
Energy Security - Self dependent
Fewer Particulates
Formerly positive image
From waste
GM
Good Concept
Good for transition
Good investment
Good selling point in aviation
Have a place
Higher Octane
Job creation
Less polluting than nuclear
Maintain Rural Landscape
Microgeneration
No other option for transport
Not a Fossil Fuel
Ok at small scale
Only small engine changes
Palm Oil - Positive

People would get used to it
Potential
Renewable
Second Generation
Small use ok
Will become cheaper than oil
Would pay more

Other

AD
Algae
An option but not ideal
Aviation - Not a major source of emissions
Brazil
Brazil - Don't know
Can buy from farmers
Can get at some petrol stations
Carbon cycle
Carbon Neutral
Changes need to be cheap
Changes need to be simple
Chip Oil
Depends on crop
Depends what land is converted from
Depends where it comes from
Don't know enough
Driving is bad anyway
From Crops and Plants
Germany - Choice of fuel
Hard to know what is good or bad
Haven't thought much about it
Human lifetime
Maize
Make your own
Market not developed
Methane
Miscanthus
More sustainable dieta
Natural Sources
Need better distribution of resources
Need for Blending
Need full LCA
Need more research
Need sustainable solution
Need to be done Carefully
Need to find information for yourself
Need to imptove public image
Need to reduce petrol use
Needs of farmers

Oilseed rape
Palm Oil
People would use at comparable price
Power of human ingenuity
Prolong oil reserves
Pros and Cons
Recession
Reduce resource use
Reduced dependence on oil
Remove choice - Make biofuels compulsory
Short term or Long Term
Short term, not long term
Sugar cane
Unleaded fuel - Large conversion costs
Would be popular if cheaper than petrol
Would consider using

## Appendix 4

### Question 6 Results Tables

#### **We can't produce enough biofuel to meet current fuel demand or increased future demands**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	180	23.0	23.5	23.5
	Strongly Disagree	5	.6	.7	24.2
	Disagree	36	4.6	4.7	28.9
	Neither Agree not Disagree	99	12.6	12.9	41.8
	Agree	310	39.6	40.5	82.2
	Strongly Agree	136	17.4	17.8	100.0
	Total	766	97.8	100.0	
Missing	System	17	2.2		
Total		783	100.0		

#### **It is not possible to buy biofuels in the UK at present**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	293	37.4	38.3	38.3
	Strongly Disagree	61	7.8	8.0	46.2
	Disagree	216	27.6	28.2	74.4
	Neither Agree not Disagree	90	11.5	11.7	86.2
	Agree	88	11.2	11.5	97.7
	Strongly Agree	18	2.3	2.3	100.0
	Total	766	97.8	100.0	
Missing	System	17	2.2		
Total		783	100.0		

**Biofuels are worse for the environment than fossil fuels**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	242	30.9	31.6	31.6
	Strongly Disagree	48	6.1	6.3	37.9
	Disagree	256	32.7	33.5	71.4
	Neither Agree nor Disagree	165	21.1	21.6	92.9
	Agree	43	5.5	5.6	98.6
	Strongly Agree	11	1.4	1.4	100.0
	Total	765	97.7	100.0	
Missing	System	18	2.3		
Total		783	100.0		

**Biofuels are generally cheaper than petrol or diesel**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	311	39.7	40.7	40.7
	Strongly Disagree	26	3.3	3.4	44.1
	Disagree	100	12.8	13.1	57.1
	Neither Agree nor Disagree	121	15.5	15.8	72.9
	Agree	183	23.4	23.9	96.9
	Strongly Agree	24	3.1	3.1	100.0
	Total	765	97.7	100.0	
Missing	System	18	2.3		
Total		783	100.0		

**Using biofuels will reduce greenhouse gas emissions from transport**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	224	28.6	29.3	29.3
	Strongly Disagree	17	2.2	2.2	31.5
	Disagree	81	10.3	10.6	42.1
	Neither Agree not Disagree	106	13.5	13.9	55.9
	Agree	284	36.3	37.1	93.1
	Strongly Agree	53	6.8	6.9	100.0
	Total	765	97.7	100.0	
Missing	System	18	2.3		
Total		783	100.0		

**Biofuels can only be used in cars if they have specially modified engines**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	205	26.2	26.8	26.8
	Strongly Disagree	20	2.6	2.6	29.4
	Disagree	101	12.9	13.2	42.6
	Neither Agree not Disagree	61	7.8	8.0	50.6
	Agree	308	39.3	40.3	90.8
	Strongly Agree	70	8.9	9.2	100.0
	Total	765	97.7	100.0	
Missing	System	18	2.3		
Total		783	100.0		

**Biofuels are carbon neutral**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	364	46.5	47.6	47.6
	Strongly Disagree	30	3.8	3.9	51.6
	Disagree	137	17.5	17.9	69.5
	Neither Agree nor Disagree	106	13.5	13.9	83.4
	Agree	113	14.4	14.8	98.2
	Strongly Agree	14	1.8	1.8	100.0
	Total	764	97.6	100.0	
Missing	System	19	2.4		
Total		783	100.0		

**Biofuels are the only available alternative for use in transport**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	218	27.8	28.5	28.5
	Strongly Disagree	153	19.5	20.0	48.5
	Disagree	289	36.9	37.8	86.3
	Neither Agree nor Disagree	63	8.0	8.2	94.5
	Agree	38	4.9	5.0	99.5
	Strongly Agree	4	.5	.5	100.0
	Total	765	97.7	100.0	
Missing	System	18	2.3		
Total		783	100.0		

**Biofuels will help reduce our dependence on fossil fuels**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	154	19.7	20.2	20.2
	Strongly Disagree	13	1.7	1.7	21.9
	Disagree	59	7.5	7.7	29.6
	Neither Agree not Disagree	80	10.2	10.5	40.1
	Agree	371	47.4	48.6	88.7
	Strongly Agree	86	11.0	11.3	100.0
	Total	763	97.4	100.0	
Missing	System	20	2.6		
Total		783	100.0		

**Growing biofuels in the UK will reduce the natural beauty of the countryside**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	196	25.0	25.6	25.6
	Strongly Disagree	18	2.3	2.3	27.9
	Disagree	154	19.7	20.1	48.0
	Neither Agree not Disagree	148	18.9	19.3	67.4
	Agree	206	26.3	26.9	94.3
	Strongly Agree	44	5.6	5.7	100.0
	Total	766	97.8	100.0	
Missing	System	17	2.2		
Total		783	100.0		

**Biofuel production is contributing to destruction of the rainforest**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	276	35.2	36.1	36.1
	Strongly Disagree	16	2.0	2.1	38.2
	Disagree	67	8.6	8.8	47.0
	Neither Agree nor Disagree	99	12.6	13.0	59.9
	Agree	208	26.6	27.2	87.2
	Strongly Agree	98	12.5	12.8	100.0
	Total	764	97.6	100.0	
Missing	System	19	2.4		
Total		783	100.0		

**Biofuel production is responsible for reduced food supplies and increased food prices**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	309	39.5	40.3	40.3
	Strongly Disagree	11	1.4	1.4	41.8
	Disagree	91	11.6	11.9	53.7
	Neither Agree nor Disagree	138	17.6	18.0	71.7
	Agree	168	21.5	21.9	93.6
	Strongly Agree	49	6.3	6.4	100.0
	Total	766	97.8	100.0	
Missing	System	17	2.2		
Total		783	100.0		

### I support the use of Biofuels in the UK

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	192	24.5	25.0	25.0
	Strongly Disagree	32	4.1	4.2	29.2
	Disagree	48	6.1	6.3	35.5
	Neither Agree nor Disagree	204	26.1	26.6	62.1
	Agree	230	29.4	30.0	92.0
	Strongly Agree	61	7.8	8.0	100.0
	Total	767	98.0	100.0	
Missing	System	16	2.0		
Total		783	100.0		

## Appendix 5

### Public Questionnaire

(formatting differs from the version sent to the public due to constraints of the thesis margins)

1. The following terms relate to energy generation and transport. Please tick each of the terms which you have heard of previously.
  - Nuclear Energy
  - Wind Power
  - Biofuels
  - Solar Power
  - Hydroelectricity
  - Bioenergy
  - Geothermal Energy
  - Fossil Fuels
  - Greenhouse Gases
  - Hybrid Cars
  - Electric Cars
  - Carbon Capture and Storage
  
2. How would you rate your knowledge of biofuels? (please tick one answer)
  - Very High
  - High
  - Neither High nor Low
  - Low
  - Very Low
  - Don't Know
  
3. How concerned are you about the environment and environmental issues? (please tick one answer)
  - Very Concerned
  - Concerned
  - Neither Concerned nor Unconcerned
  - Unconcerned
  - Very Unconcerned
  - Don't Know
  
4. Which of the following potential impacts of biofuel production and use have you heard of previously? (please tick all that apply)
  - Cutting down Rainforests
  - Increased Greenhouse Gases
  - Reduced Food Supplies
  - Use of a large amount of land
  - More Expensive Fuel
  - Human Rights Abuses

- Improved Energy Security
  - Use of Genetically Modified crops
  - Increased Food Prices
  - Loss of Plant and Animal species
  - Changes to the appearance of the Countryside
  - Less investment in other renewable transport technologies
  - Reduced Carbon emissions from transport
  - Other (please state)
5. Of the following potential impacts of biofuels, please number the 5 that are of most concern to you (with 1 being the issue of highest concern)
- Cutting down Rainforests
  - Increased Greenhouse Gases
  - Reduced Food Supplies
  - Use of a large amount of land
  - More Expensive Fuel
  - Human Rights Abuses
  - Improved Energy Security
  - Use of Genetically Modified crops
  - Increased Food Prices
  - Loss of Plant and Animal species
  - Changes to the appearance of the Countryside
  - Less investment in other renewable transport technologies
  - Reduced Carbon emissions from transport
  - Other (please state)
6. For each of the following statements, please indicate how much you agree or disagree (1=strongly agree, 5=strongly disagree)
- We can't produce enough biofuel to meet current fuel demands or increased future demands
  - It is not possible to buy biofuels in the UK at present
  - Using biofuels will reduce greenhouse gas emissions from transport
  - Biofuels can only be used in existing cars if they have specially modified engines
  - Biofuels are carbon neutral
  - Biofuels are generally cheaper than petrol/diesel
  - Biofuels are the only available alternative fuel for use in transport
  - Biofuels will help reduce our dependence on fossil fuels
  - Growing biofuels in the UK will reduce the natural beauty of the countryside
  - Biofuel production is contributing to destruction of the rainforest
  - Biofuel production is responsible for reduced food supplies and increased food prices
  - I support the use of biofuels in the UK

7. For the following energy generation options, please state whether you think they are More Preferable, Equally Preferable or Less Preferable than biofuels in terms of environmental impact
- Oil/Petrol
  - Nuclear Energy
  - Coal
  - Hydroelectricity
  - Solar Power
  - Wind Power
  - Gas
  - Tidal/Wave
  - Geothermal Energy
  - Hydrogen
8. For each of the following statements, please indicate how much you agree or disagree. (1=strongly agree, 5=strongly disagree)
- The use of fossil fuels (coal, gas, oil) is contributing to climate change
  - Transport is a major source of greenhouse gases
  - Transport change is a serious threat that requires rapid action to reduce its impacts
  - Fossil Fuels are running out so we need to develop new ways to fuel transport
  - The recession is a more important issue than climate change
  - We should be reducing our energy use not looking for alternative fuels
  - I don't know who to believe when it comes to biofuel information
  - Subsidies for growing biofuel crops are a good idea
9. Where do you get information about biofuels from? (please tick all that apply)
- Broadsheet Newspapers
  - Television/Radio News
  - Television Programmes/Documentaries
  - News Websites
  - Relatives/Friends
  - Other Websites
  - Work/School/University
  - Scientific Journals
  - Magazines
  - Government Reports
  - Oil/Biofuel Industry
  - Tabloid Newspapers
  - Other (please state)

10. For each of the following statements , please indicate how much you agree or disagree (1=strongly disagree, 5=strongly agree)

- I would trust the information I see/hear on Television News
- I would trust the information I read in Broadsheet Newspapers
- I would trust the information I read in Tabloid Newspapers
- I would trust the information published by Government
- I would trust information published by Scientists
- I would trust information in Television Documentaries

#### Personal Information

The information provided in this section will be used to help analyse the answers you have provided in the questionnaire. All questionnaires are anonymous and confidential; information collected will only be used for the purposes of this project and will not be passed on to any other party. The questions below are not compulsory and you do not have to provide the requested information if you do not wish to.

Many Thanks again for taking the time to participate in my research.

- **Age**

- 19 or Under
- 20 – 29
- 30 – 39
- 40 – 49
- 50 – 59
- 60 – 69
- 70 or Over

- **Gender**

- Male
- Female

- **First four characters of your postcode (ie. SO19)**

- **Highest level of educational achievement**

- No Qualifications
- GCSEs D – G, NVQ level 1, Foundation level GNVQ
- GCSEs A\* - C, NVQ level 2, Intermediate GNVQ
- A levels, NVQ level 3, Advanced GNVQ
- Diploma of Higher or Further Education, Foundation Degree, HND
- Bachelors Degree, Graduate Certificate/Diploma
- Masters Degree, Postgraduate Certificate/Diploma
- Doctorate
- Other (please state)

- **What do you consider your ethnic group to be?**

- White**

- British

- Other White background (please state)

- Mixed**

- White and Black Caribbean

- White and Black African

- White and Asian

- Other Mixed background (please state)

- Asian or Asian British**

- Indian

- Pakistani

- Bangladeshi

- Other Asian background (please state)

- Black or Black British**

- Caribbean

- African

- Other Black background (please state)

- Chinese or Other ethnic group**

- Chinese

- Other background (please state)

## Appendix 6

Liz Shepherd  
School of Biological Sciences  
Building 85  
Highfield Campus  
University of Southampton  
Southampton  
SO17 1BJ

es1204@soton.ac.uk

Dear Sir/Madam,

My name is Liz Shepherd and I am a research student at the University of Southampton. My research is concerned with public knowledge and opinions of biofuels as an alternative to fossil fuels in transport, in order to help assess how appropriate biofuels are for use in the UK. As part of the project I am sending out 3000 questionnaires to Southampton residents to find out what they know and think about biofuels. You have received this letter as your name has been selected at random from the Southampton electoral roll to be included in this survey.

Included with this letter is a copy of my questionnaire which consists of 10 questions, plus a short section for some personal details and a freepost addressed return envelope to send your completed questionnaire back. However, it is also possible to complete the questionnaire online at [www.surveymonkey.com/s/sotonphd](http://www.surveymonkey.com/s/sotonphd). Each question includes instructions on how to answer. Don't worry about getting the answer 'right', the purpose of my project is to find out what you think and how you feel about biofuels.

The questionnaire is very straight forward and should not take more than 10 minutes of your time to complete. Don't worry if you feel you know nothing about biofuels or don't particularly care about environmental issues, everyone's opinion matters and your answers are still important for my project.

The personal information questions have been included to help me analyse the information I receive and will be held in strictest confidence and not passed on. All questionnaires will remain anonymous.

Your involvement and assistance is greatly important to my project and I hope you can spare a few minutes to complete this questionnaire. The information collected will be invaluable to my project and your assistance is greatly appreciated.

If you have any questions or additional comments, please feel free to contact me or include an additional sheet in your response envelope.

Many Thanks for your time,

Liz Shepherd

## Appendix 7

### **Deforestation of the Rainforest**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=20.658$ , d.f.=6,  $p=0.002$ ) and Knowledge of Biofuels ( $H(2)=14.421$ , d.f.=5,  $p=0.013$ ).

### **Reduced Carbon Emissions from Transport**

Statistical testing revealed significant differences in awareness of the impact by Knowledge of Biofuels ( $H(2)=24.522$ , d.f.=5,  $p=0.000$ ).

### **Changes to the Appearance of the Countryside**

Statistical testing revealed significant differences in awareness of the impact by Environmental Concern ( $H(2)=13.856$ , d.f.=5,  $p=0.017$ ) and Knowledge of Biofuels ( $H(2)=23.546$ , d.f.=5,  $p=0.000$ ).

### **Use of Large Amounts of Land**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=14.002$ , d.f.=1,  $p=0.000$ ), Level of Education ( $H(2)=31.677$ , d.f.=8,  $p=0.000$ ), Environmental Concern ( $H(2)=48.204$ , d.f.=5,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=80.535$ , d.f.=5,  $p=0.000$ ) and ACORN group ( $H(2)=34.619$ , d.f.=13,  $p=0.001$ ).

### **Loss of Plant and Animal Species**

Statistical testing revealed significant differences in awareness of the impact by Environmental Concern ( $H(2)=16.456$ , d.f.=5,  $p=0.006$ ) and Knowledge of Biofuels ( $H(2)=28.483$ , d.f.=5,  $p=0.000$ ).

### **Use of Genetically Modified Crops**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=14.829$ , d.f.=6,  $p=0.022$ ), Gender ( $H(2)=7.348$ , d.f.=1,  $p=0.007$ ), Level of Education ( $H(2)=24.079$ , d.f.=8,  $p=0.002$ ) and Knowledge of Biofuels ( $H(2)=26.583$ , d.f.=5,  $p=0.000$ ).

### **Increased Food Prices**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=9.601$ , d.f.=1,  $p=0.002$ ), Level of Education ( $H(2)=21.696$ , d.f.=8,  $p=0.006$ ), Environmental Concern ( $H(2)=17.960$ , d.f.=5,  $p=0.003$ ), Knowledge of Biofuels ( $H(2)=39.828$ , d.f.=5,  $p=0.000$ )

### **More Expensive Fuel**

Statistical testing revealed no significant differences in awareness of the impact by the demographic factors recorded.

### **Reduced Food Supplies**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=22.112$ , d.f.=1,  $p=0.000$ ), Level of Education ( $H(2)=35.240$ , d.f.=8,  $p=0.000$ ), Env Concern ( $H(2)=39.944$ , d.f.=5,  $p=0.000$ ), knowledge ( $H(2)=98.992$ , d.f.=5,  $p=0.000$ ).

### **Increased Greenhouse Gases**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=36.796$ , d.f.=6,  $p=0.000$ ), Level of Education ( $H(2)=56.484$ , d.f.=8,  $p=0.000$ ), Knowledge of biofuels ( $H(2)=24.811$ , d.f.=5,  $p=0.000$ )

### **Improved Energy Security**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=7.148$ , d.f.=1,  $p=0.008$ ), Level of Education ( $H(2)=47.439$ , d.f.=8,  $p=0.000$ ), Environmental Concern ( $H(2)=30.390$ , d.f.=5,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=93.159$ , d.f.=5,  $p=0.000$ )

### **Less Investment in Other Renewable Transport Options**

Statistical testing revealed significant differences in awareness of the impact by Level of Education ( $H(2)=17.755$ , d.f.=8,  $p=0.023$ ), Environmental Concern ( $H(2)=22.867$ , d.f.=5,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=47.358$ , d.f.=5,  $p=0.000$ ).

## **Human Rights Abuses**

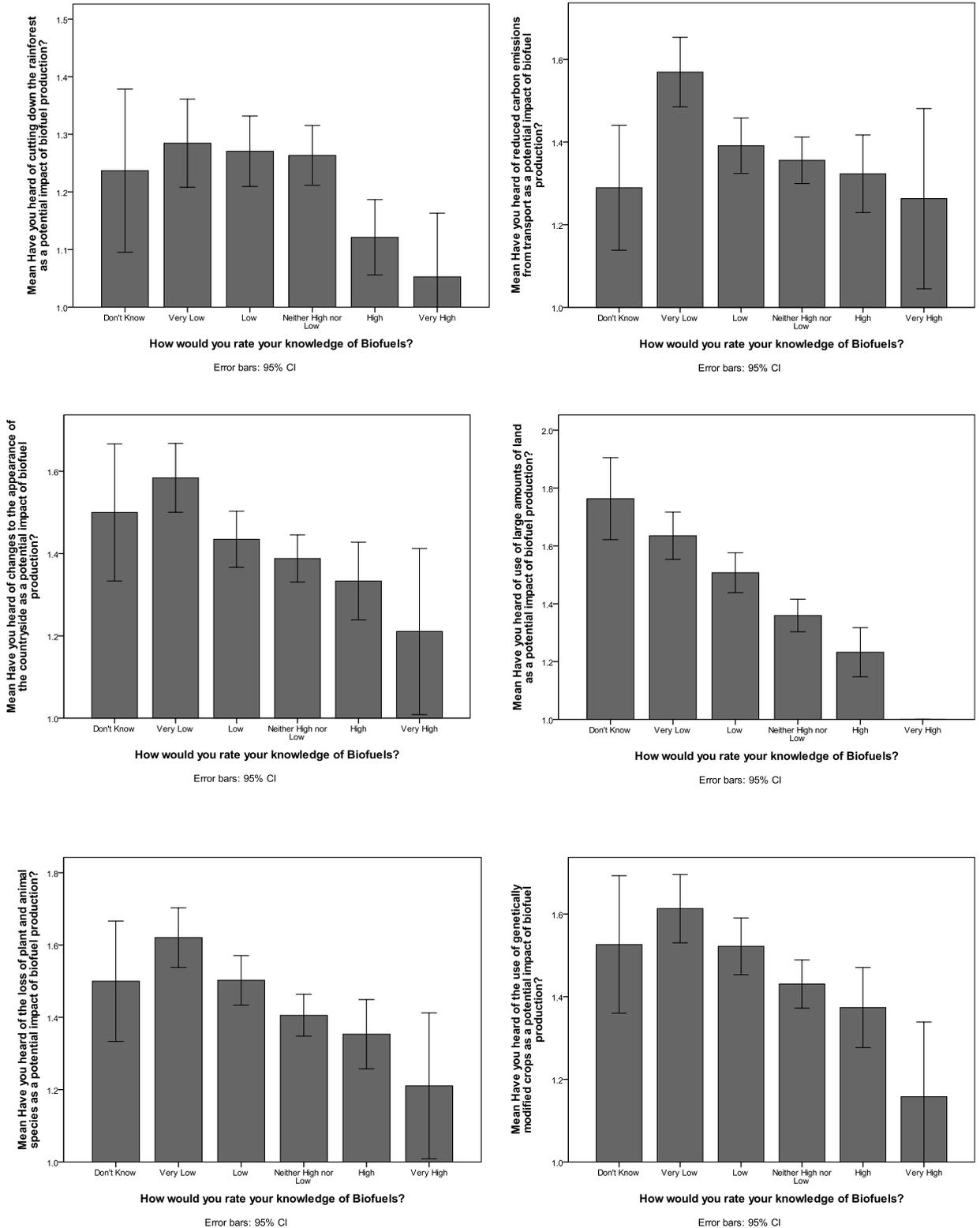
Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=15.782$ ,  $d.f.=6$ ,  $p=0.015$ ), Environmental Concern ( $H(2)=19.373$ ,  $d.f.=5$ ,  $p=0.002$ ), Knowledge of Biofuels ( $H(2)=16.511$ ,  $d.f.=5$ ,  $p=0.006$ )

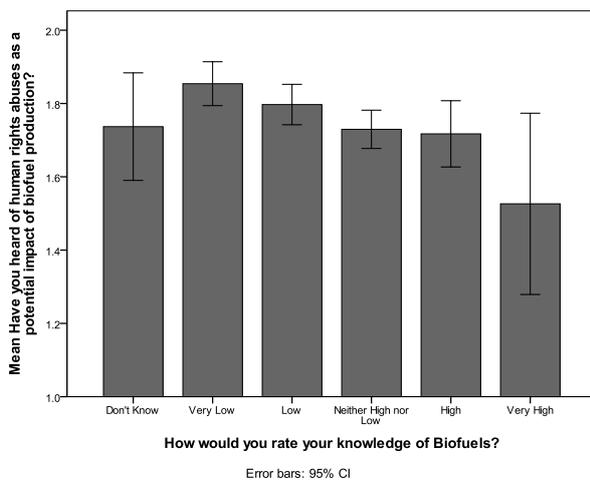
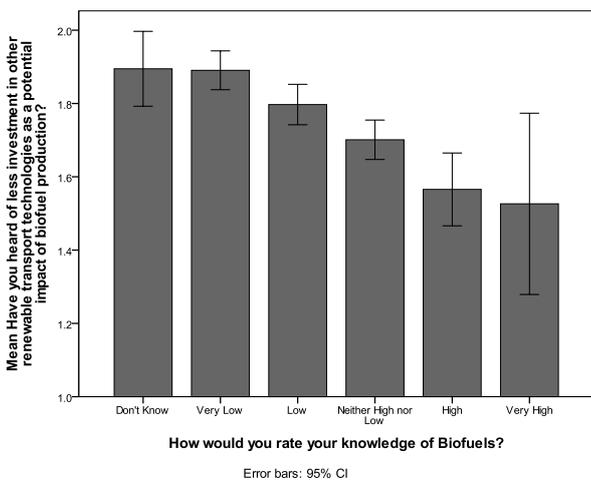
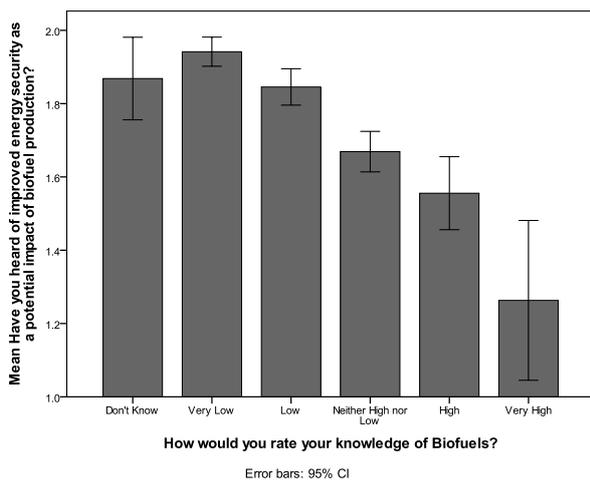
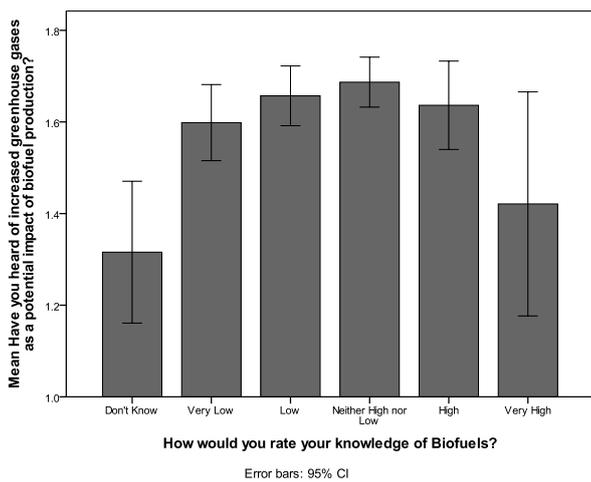
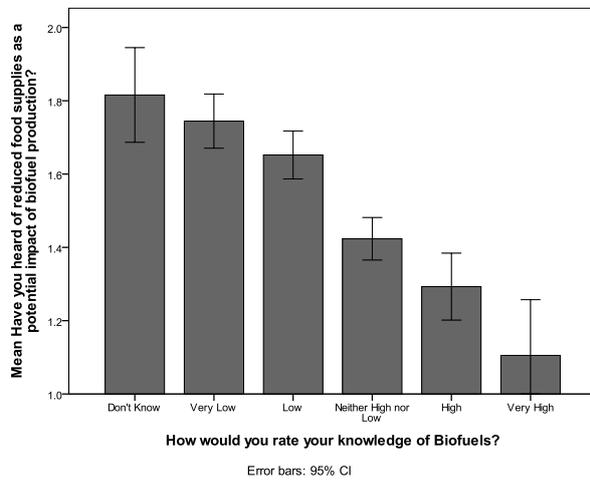
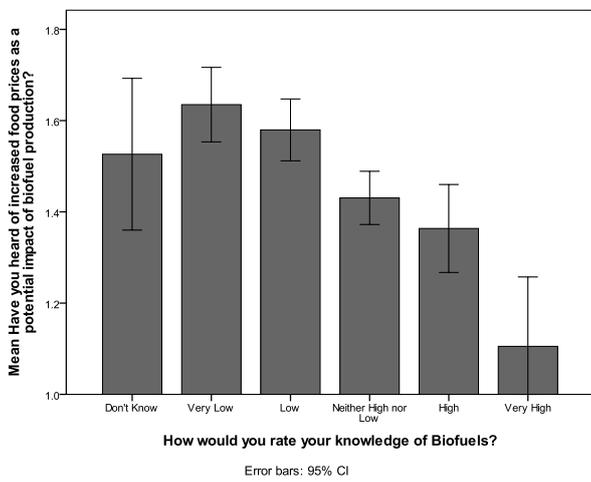
## Appendix 8

### Significant differences in awareness of potential impacts of biofuel use and production by demographic factors

#### Level of Biofuel Knowledge

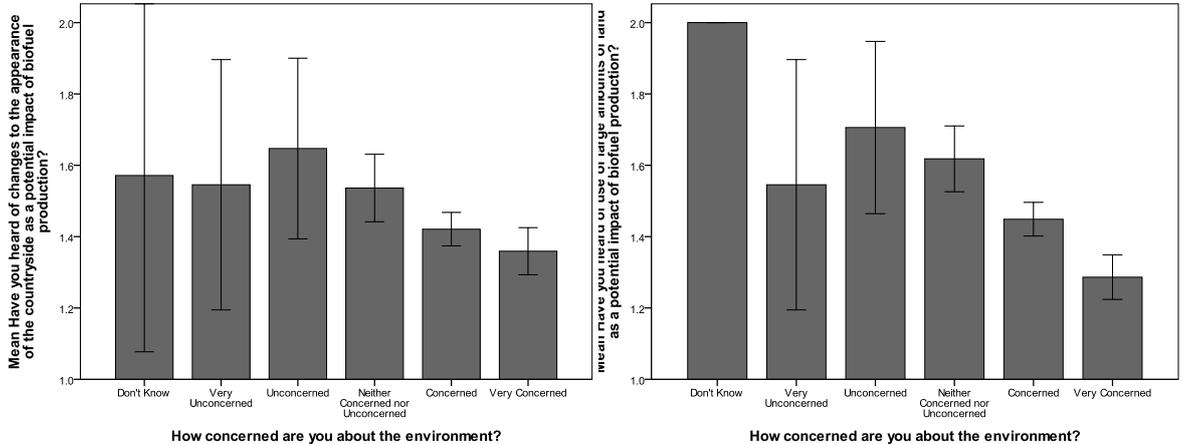
Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by Level of Knowledge of Biofuels (1=Yes, 2=No)





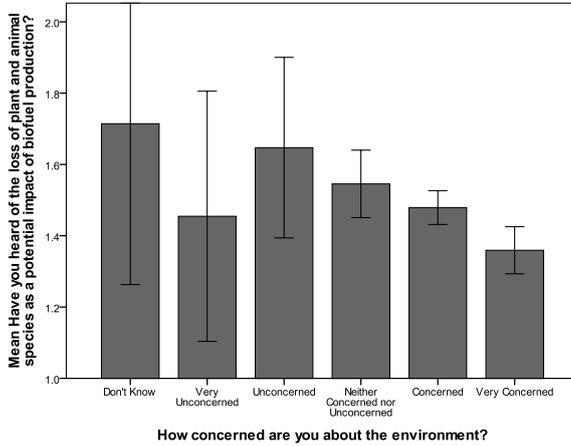
## Level of Environmental Concern

Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by Level of Environmental Concern (1=Yes, 2=No)

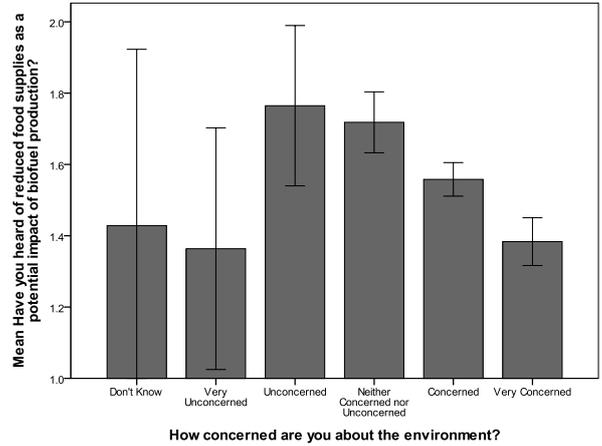


Error bars: 95% CI

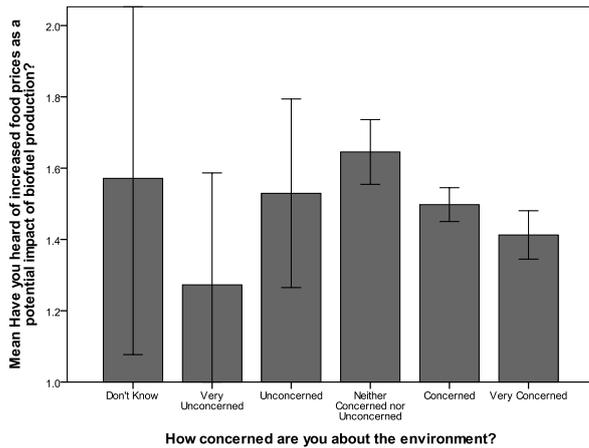
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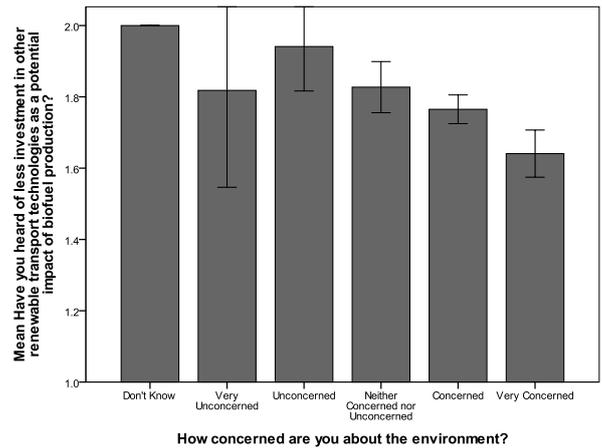
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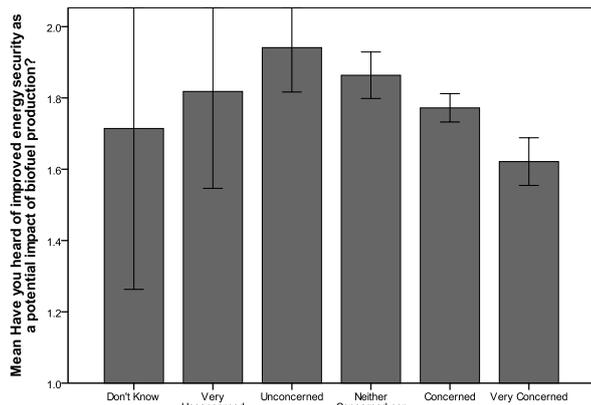
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Error bars: 95% CI

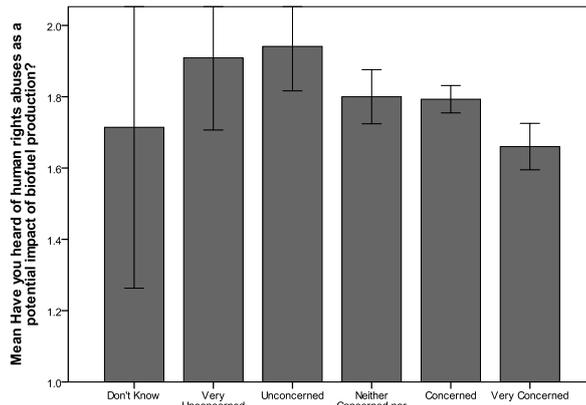


Error bars: 95% CI



How concerned are you about the environment?

Error bars: 95% CI

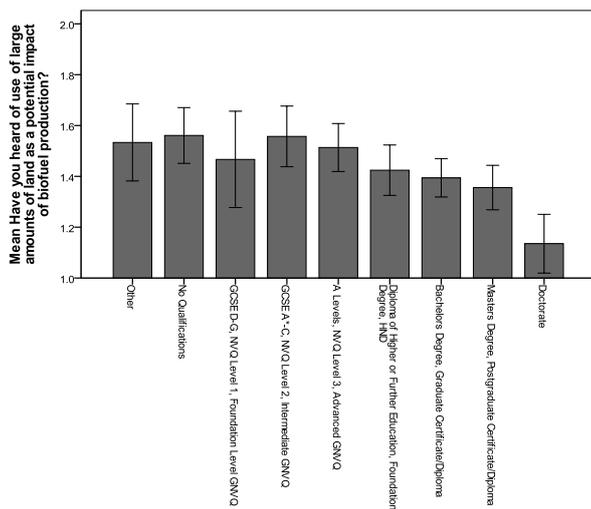


How concerned are you about the environment?

Error bars: 95% CI

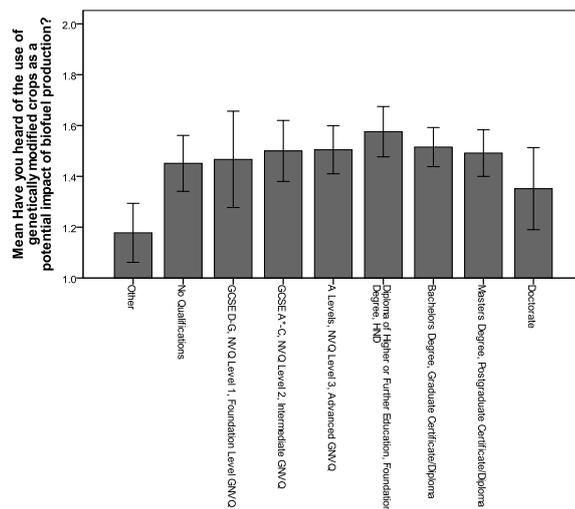
### Level of Education

Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by Level of Education (1=Yes, 2=No)



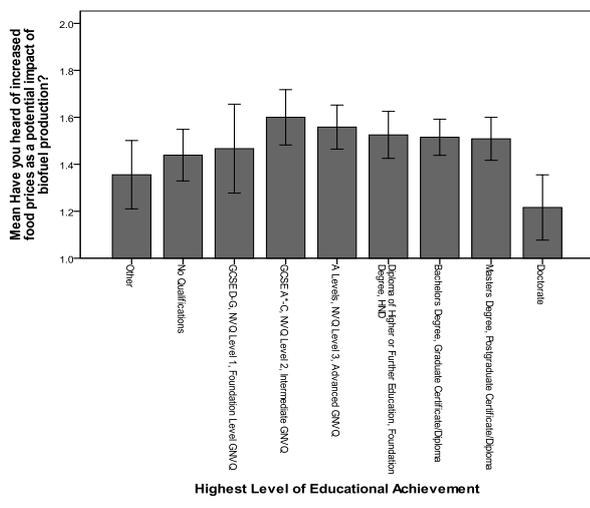
Highest Level of Educational Achievement

Error bars: 95% CI



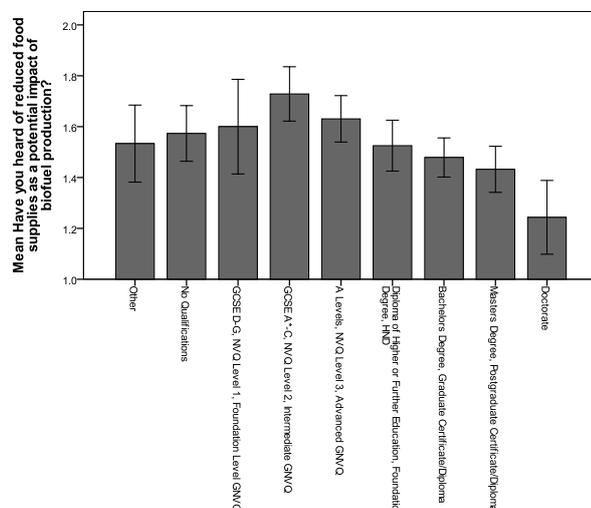
Highest Level of Educational Achievement

Error bars: 95% CI



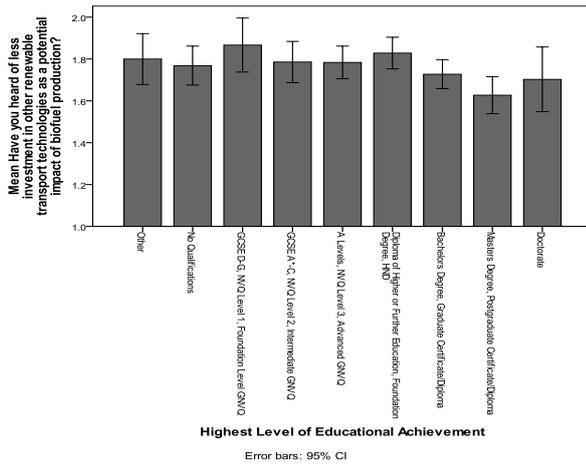
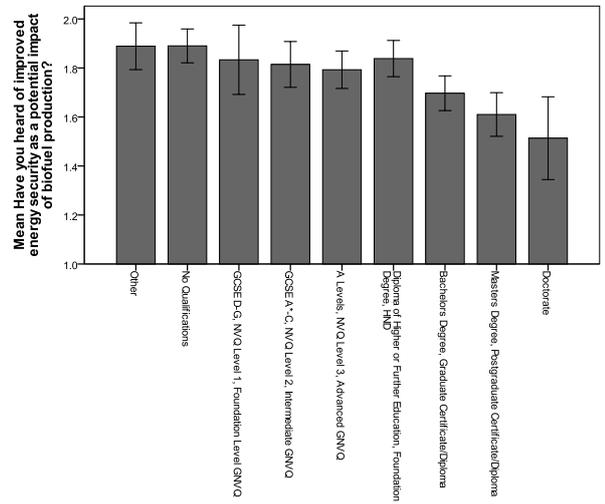
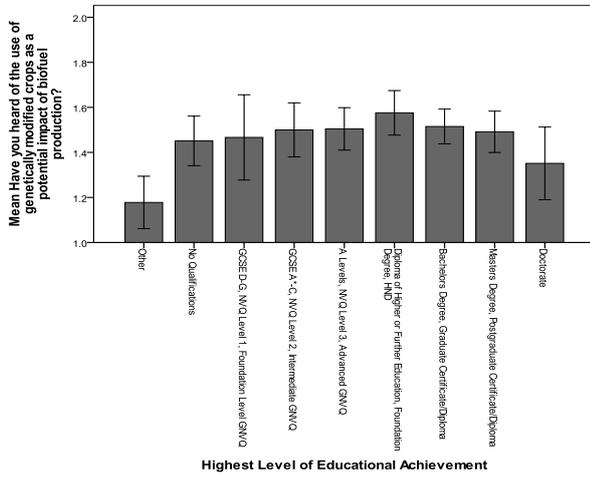
Highest Level of Educational Achievement

Error bars: 95% CI



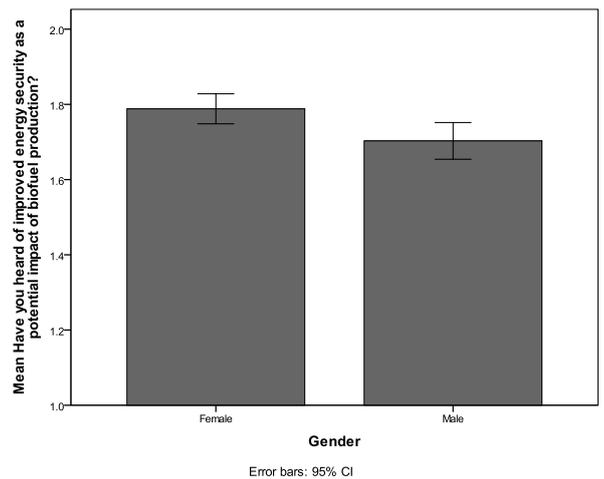
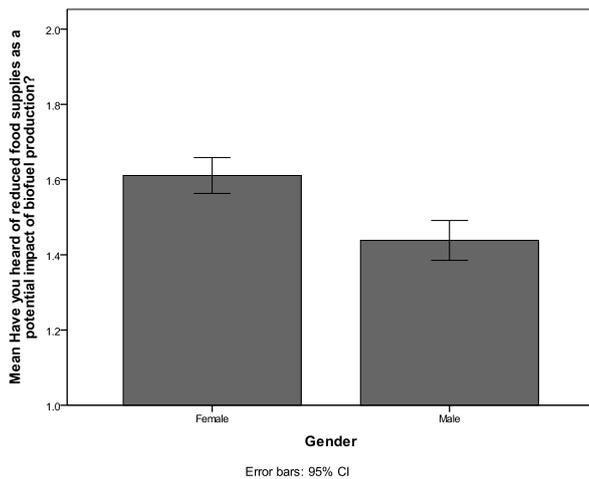
Highest Level of Educational Achievement

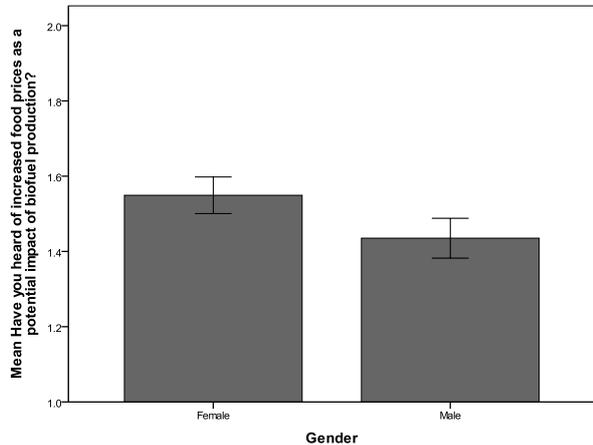
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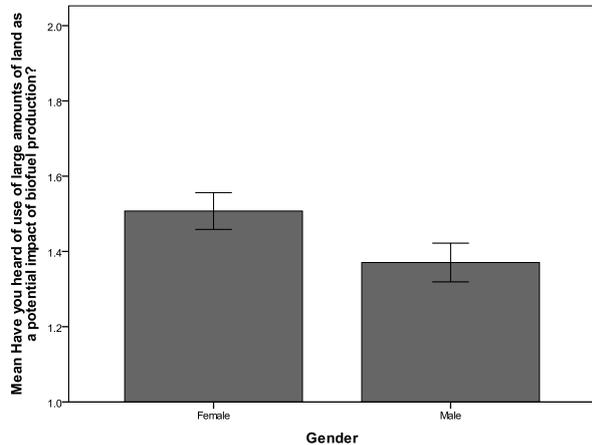
## Gender

Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by Gender (1=Yes, 2=No)

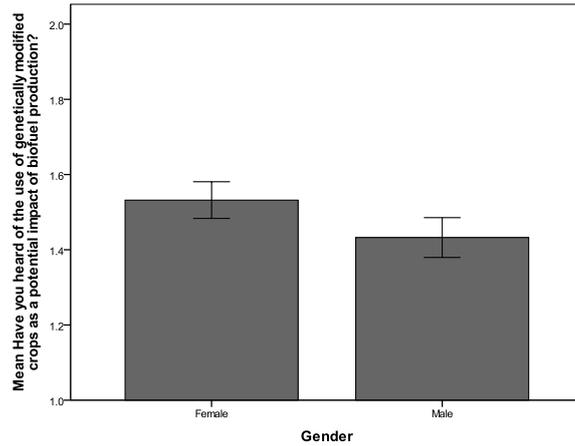




Error bars: 95% CI



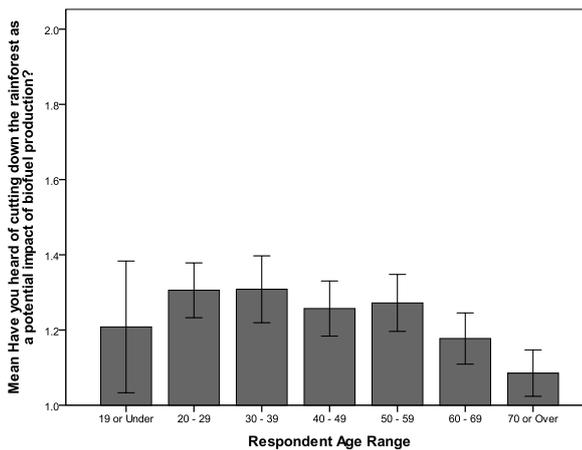
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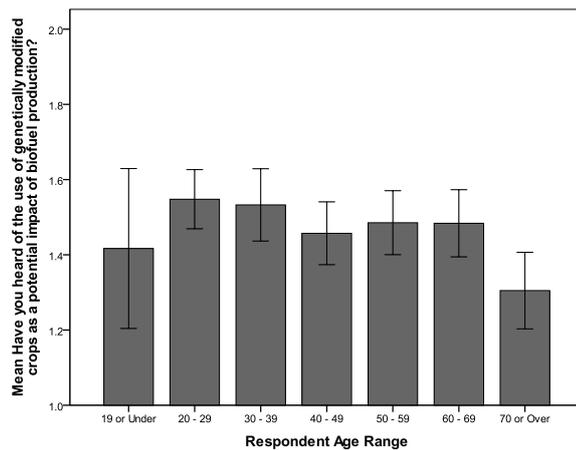
Error bars: 95% CI

### Age

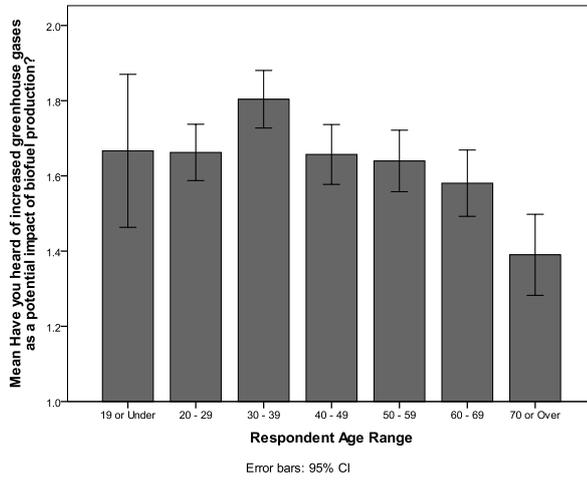
Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by Age (1=Yes, 2=No)



Error bars: 95% CI

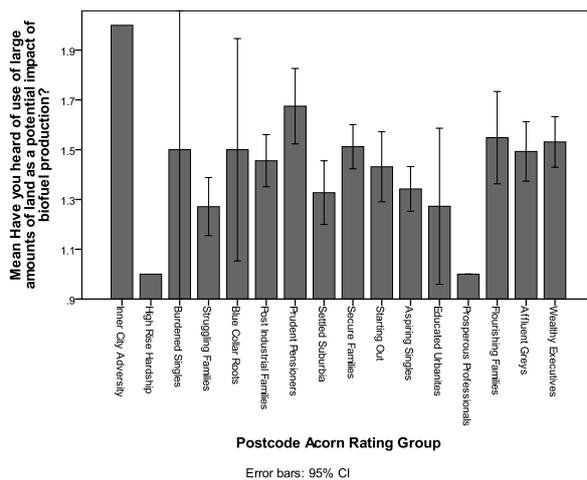
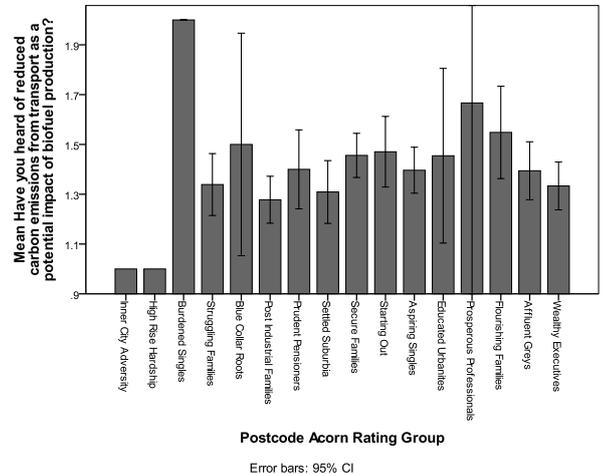
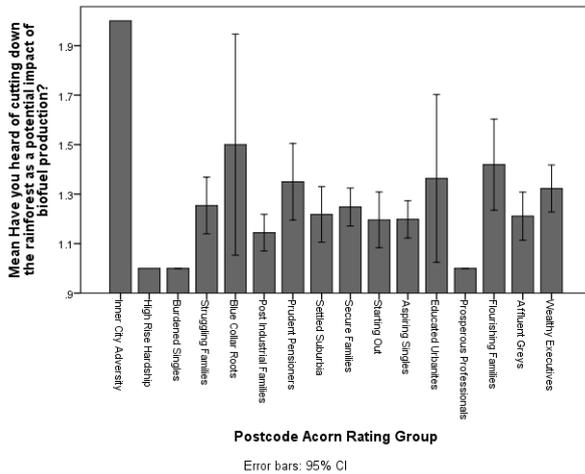


Error bars: 95% CI



### ACORN Group

Mean responses to the question 'Have you heard of the following potential impacts of biofuel production and use?' by ACORN group (1=Yes, 2=No)



## Appendix 9

### **Deforestation of the Rainforest**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=20.658$ , d.f.=6,  $p=0.002$ ) and Knowledge of Biofuels ( $H(2)=14.421$ , d.f.=5,  $p=0.013$ ).

Those aged over 70 reported significantly higher awareness of Deforestation of the Rainforest as an impact of biofuels than those aged between 20 and 59, on average.

Those who rated their knowledge of biofuels as High or Very High reported significantly higher awareness of Deforestation as an impact than those who rated their knowledge as 'Neither High nor Low', 'Low' or 'Very Low', on average.

### **Reduced Carbon Emissions from Transport**

Statistical testing revealed significant differences in awareness of the impact by Knowledge of Biofuels ( $H(2)=24.522$ , d.f.=5,  $p=0.000$ ).

Those who rated their knowledge as 'Very Low' reported significantly lower awareness of Reduced Carbon Emissions from Transport than those who rated their knowledge as 'High', 'Neither High nor Low', 'Low' and 'Don't Know', on average.

### **Changes to the Appearance of the Countryside**

Statistical testing revealed significant differences in awareness of the impact by Environmental Concern ( $H(2)=13.856$ , d.f.=5,  $p=0.017$ ) and Knowledge of Biofuels ( $H(2)=23.546$ , d.f.=5,  $p=0.000$ ).

Those who were 'Very Concerned' about the environment reported significantly higher awareness of Changes to the Countryside than those who were 'Neither Concerned nor Unconcerned', on average.

Those who rated their knowledge of biofuels as 'Very Low' reported significantly lower awareness of the impact than those who rated their knowledge as 'Very High', 'High' or 'Neither High nor Low', on average.

## **Use of Large Amounts of Land**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=14.002$ ,  $d.f.=1$ ,  $p=0.000$ ), Level of Education ( $H(2)=31.677$ ,  $d.f.=8$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=48.204$ ,  $d.f.=5$ ,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=80.535$ ,  $d.f.=5$ ,  $p=0.000$ ) and ACORN group ( $H(2)=34.619$ ,  $d.f.=13$ ,  $p=0.001$ ).

Males reported significantly higher awareness of Use of Large Amounts of Land than females, on average.

Those at education level 8 (Doctorate) reported significantly higher awareness, on average, than those at levels 0 (Other), 1 (No Qualifications) and 3 – 6 (GCSE A\*-C or equivalent – Bachelors Degree or equivalent).

Those who rated their environmental concern as 'Very Concerned' reported significantly higher awareness of the impact than those who were 'Concerned', 'Neither Concerned nor Unconcerned', 'Unconcerned' or did not know how to rate their concern, on average. In addition, those who were 'Concerned' had significantly higher awareness than those who were 'Neither Concerned nor Unconcerned' or did not know how to rate their concern. Those who were 'Neither Concerned nor Unconcerned' also reported significantly higher awareness than those who did not know how to rate their knowledge.

Those who rated their knowledge as 'Very High' reported higher awareness of the impact than those at any other knowledge rating. Those who rated their knowledge as 'High' or 'Neither High nor Low' reported significantly higher awareness than those who rated their knowledge as 'Low' or below. Those who rated their knowledge as 'Low' reported significantly higher knowledge than those who did not know how to rate their knowledge.

Those from groups 1, 2, 3, 7, 8, 9, 11 were significantly more familiar with the impact than those in group 4. Those in groups 6 and 13 were significantly more familiar with the impact than those in groups 4 and 10. Those in group 10 were significantly more familiar with the impact than those in groups 4, 6 and 13. Those in group 4 were significantly less familiar with the impact than those in groups 1, 2, 3, 6, 7, 8, 9, 10, 11 and 13.

### **Loss of Plant and Animal Species**

Statistical testing revealed significant differences in awareness of the impact by Environmental Concern ( $H(2)=16.456$ ,  $d.f.=5$ ,  $p=0.006$ ) and Knowledge of Biofuels ( $H(2)=28.483$ ,  $d.f.=5$ ,  $p=0.000$ )

Those who were 'Very Concerned' about the environment reported significantly higher awareness of the impact than those who were 'Neither Concerned than Unconcerned', on average.

Those who rated their knowledge of biofuels as 'Very Low' reported significantly lower awareness of the impact than those who rated their knowledge as 'Neither High nor Low' or higher.

### **Use of Genetically Modified Crops**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=14.829$ ,  $d.f.=6$ ,  $p=0.022$ ), Gender ( $H(2)=7.348$ ,  $d.f.=1$ ,  $p=0.007$ ), Level of Education ( $H(2)=24.079$ ,  $d.f.=8$ ,  $p=0.002$ ) and Knowledge of Biofuels ( $H(2)=26.583$ ,  $d.f.=5$ ,  $p=0.000$ )

- Those aged 70 or older reported significantly greater awareness of the impact than those aged between 20 and 39, on average.
- Males reported significantly greater awareness than females, on average.
- Those at education level 0 (Other) reported significantly higher awareness, on average, than those at levels 1 (No Qualifications) and 3 – 7 (GCSE A\*-C or equivalent – Masters Degree of equivalent).
- Those who rated their knowledge of biofuels as 'Very High' reported significantly greater awareness, on average, than those who rated their knowledge as 'Low' or below. Those who rated their knowledge as 'Very Low' reported significantly lower awareness than those who rated their knowledge as 'Neither High nor Low' or higher, on average.

### **Increased Food Prices**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=9.601$ ,  $d.f.=1$ ,  $p=0.002$ ), Level of Education ( $H(2)=21.696$ ,  $d.f.=8$ ,

$p=0.006$ ), Environmental Concern ( $H(2)=17.960, d.f.=5, p=0.003$ ), Knowledge of Biofuels ( $H(2)=39.828, d.f.=5, p=0.000$ )

- Males reported significantly greater awareness than females, on average.
- Those at education level 0 (Other) reported significantly lower awareness of the impact, on average, than those at levels 7 (Masters Degree or Equivalent) or 8 (Doctorate). Those at education level 1 (No Qualifications) reported significantly lower awareness than those at levels 6 (Bachelors Degree or equivalent) and above, on average.
- Those who were 'Very Concerned' about the environment reported significantly greater awareness than those who were either 'Concerned', 'Neither Concerned nor Unconcerned' or 'Unconcerned', on average.
- Those who rated their knowledge of biofuels as 'Very High' reported significantly greater awareness than those who rated their knowledge as 'Neither High nor Low' or below. Those who rated their knowledge as 'High' or 'Neither High nor Low' reported significantly greater awareness than those whose rated their knowledge as 'Low' or below.

### **More Expensive Fuel**

Statistical testing revealed no significant differences in awareness of the impact by the demographic factors recorded.

### **Reduced Food Supplies**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=22.112, d.f.=1, p=0.000$ ), Level of Education ( $H(2)=35.240, d.f.=8, p=0.000$ ), Env Concern ( $H(2)=39.944, d.f.=5, p=0.000$ ), knowledge ( $H(2)=98.992, d.f.=5, p=0.000$ ).

Males reported sig higher awareness.

Doctorate sig greater awareness than 4, 3 and 1. 7 and 6 sig higher than 3.

V concerned sig greater than Concerned, neither and Unconcerned.

Concerned sig greater than neither.

DK, V low, low, sig less aware than neither, high and v high. Neither sig less aware than v high.

### **Increased Greenhouse Gases**

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=36.796$ ,  $d.f.=6$ ,  $p=0.000$ ), Level of Education ( $H(2)=56.484$ ,  $d.f.=8$ ,  $p=0.000$ ), Knowledge of biofuels ( $H(2)=24.811$ ,  $d.f.=5$ ,  $p=0.000$ )

Over 70s sig more aware than 20-59. 60s sig more aware than 30s.

Other sig greater awareness than 2 or higher. None sig higher than 5 or higher.

DK sig greater than v low – high.

### **Improved Energy Security**

Statistical testing revealed significant differences in awareness of the impact by Gender ( $H(2)=7.148$ ,  $d.f.=1$ ,  $p=0.008$ ), Level of Education ( $H(2)=47.439$ ,  $d.f.=8$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=30.390$ ,  $d.f.=5$ ,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=93.159$ ,  $d.f.=5$ ,  $p=0.000$ )

Males sig more aware.

Doctorate sig greater than 0, 1, 5. Masters sig greater than 0, 1, 5. Bachelors sig greater than 1.

V concerned sig greater than concerned-unconcerned.

V high sig more aware than neither and below. High and neither sig more aware than low and below. Low sig more aware than v low.

### **Less Investment in Other Renewable Transport Options**

Statistical testing revealed significant differences in awareness of the impact by Level of Education ( $H(2)=17.755$ ,  $d.f.=8$ ,  $p=0.023$ ), Environmental Concern ( $H(2)=22.867$ ,  $d.f.=5$ ,  $p=0.000$ ), Knowledge of Biofuels ( $H(2)=47.358$ ,  $d.f.=5$ ,  $p=0.000$ ).

Maasters sig greater awareness than diploma of he.

Dk sig less aware than neither or higher. Unconcerned, neither and concerned sig less aware than v concerned.

DK, v low sig less aware than neither and high. Low sig less aware than high.

## Human Rights Abuses

Statistical testing revealed significant differences in awareness of the impact by Age ( $H(2)=15.782$ , d.f.=6,  $p=0.015$ ), Environmental Concern ( $H(2)=19.373$ , d.f.=5,  $p=0.002$ ), Knowledge of Biofuels ( $H(2)=16.511$ , d.f.=5,  $p=0.006$ )

Age not sig in post hoc

V concerned sigg more aware than concerned and unconcerned.

Neither high nor low sig more aware than v low.

## Age

Age was shown to significantly influence familiarity with three of the potential impacts: Deforestation ( $H(2)=20.658$ , d.f.=6,  $p=0.0020$ ), Increased Greenhouse Gases ( $H(2)=36.796$ , d.f.=6,  $p=0.000$ ) and Use of GM ( $H(2)=14.829$ , d.f.=6,  $p=0.022$ ).

- In the case of Deforestation, those over the age of 70 were significantly more familiar with the impact than those aged between 20 and 59.
- In the case of Increased Greenhouse Gases, those over the age of 70 were significantly more familiar with the impact than those aged between 20 and 69. Those aged 60-69 were significantly more familiar with the impact than those aged 30-39.
- For Use of GM crops, those over the age of 70 were significantly more familiar with the impact than those aged between 20 and 39.

In all three cases, those aged 70 or over were significantly more familiar with the impacts than younger age groups. This is contrary to previous results, which suggested that older groups were less aware of biofuels and knew less about them than younger age groups.

## Gender

Gender was shown to affect familiarity with 5 potential impacts: Reduced Food Supplies ( $H(2)=22.112$ , d.f.=1,  $p=0.000$ ), Improved Energy Security ( $H(2)=7.148$ ,

d.f.=1, p=0.008), Increased Food Prices ( $H(2)=9.601$ , d.f.=1, p=0.002), Use of Large Areas of Land ( $H(2)=14.002$ , d.f.=1, p=0.000), Use of GM ( $H(2)=7.348$ , d.f.=1, p=0.007).

- In all cases, males were significantly more familiar with the impact than females. This may be a reflection of the fact that males seemed to know significantly more about biofuels than females and are consequently more aware of specific issues than females.

### **Knowledge of Biofuels**

Knowledge of Biofuels was shown to affect familiarity with 12 potential impacts; Deforestation of the Rainforest ( $X^2=12.508$ , d.f.=5, p=0.028), Reduced Food Supplies ( $X^2=98.992$ , d.f.=5, p=0.000), Improved Energy Security ( $X^2=93.195$ , d.f.=5, p=0.000), Increased Food Prices ( $X^2=39.828$ , d.f.=5, p=0.000), Changes to the Appearance of the Countryside ( $X^2=23.546$ , d.f.=5, p=0.000), Reduced Carbon Emissions from Transport ( $X^2=24.522$ , d.f.=5, p=0.000), Increased Greenhouse Gases ( $X^2=24.811$ , d.f.=5, p=0.000), Use of Large Areas of Land ( $X^2=80.535$ , d.f.=5, p=0.000), Human Rights Abuses ( $X^2=16.511$ , d.f.=5, p=0.006), Use of GM ( $X^2=26.583$ , d.f.=5, p=0.000), Loss of Plant and Animal Species ( $X^2=28.483$ , d.f.=5, p=0.000) and Less Investment in Other Renewable Transport Options ( $X^2=47.358$ , d.f.=5, p=0.000).

For Deforestation, those who rated their knowledge of biofuels as High or Very High, were significantly more familiar with the impact than those who rated their knowledge as Neither High nor Low or below.

For Reduced Food Supplied, those who rated their knowledge of biofuels as Very High were significantly more familiar of the impact than those who rated their knowledge as 'Neither High nor Low' or below. Those who rated their knowledge as High were significantly more familiar with the impact than those who rated their knowledge as Low or below.

For Improved Energy Security, those who rated their knowledge of biofuels as Very High were significantly more familiar of the impact than those who rated

their knowledge as Neither High nor Low or below. Those who rated their knowledge as High or Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Low or below. Those who rated their knowledge as Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Increased Food Prices, those who rated their knowledge of biofuels as Very High were significantly more familiar with the impact than those who rated their knowledge as Neither High nor Low or below.

Those who rated their knowledge as High or Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Low or below. Those who rated their knowledge as Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Changes to the Appearance of the Countryside, those who rated their knowledge as Very High, High or Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Reduced Carbon Emissions from Transport, those who rated their knowledge as High, Neither High nor Low, Low or Don't Know were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Increased Greenhouse Gases, those who rated their knowledge as High, Neither High nor Low, Low or Very Low were significantly less familiar with the impact than those who answered Don't Know.

For Use of Large Amounts of Land, those who rated their knowledge as Very High were significantly more familiar with the impact than those at any other knowledge rating. Those who rated their knowledge as High or Neither High nor Low were significantly more aware of the impact than those who rated their knowledge as Low or below. Those who rated their knowledge as Low

were significantly more aware of the impact than those who did not know how to rate their knowledge.

For Human Rights Abuses, those who rated their knowledge as Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Use of Genetically Modified Crops, those who rated their knowledge as Very High were significantly more familiar with the impact than those who rated their knowledge as Low or below. Those who rated their knowledge as High or Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Loss of Plant and Animal Species, those who rated their knowledge as Very High, High or Neither High nor Low were significantly more familiar with the impact than those who rated their knowledge as Very Low.

For Less Investment in Other Renewable Transport Options, those who rated their knowledge as High were significantly more familiar with the impact than those who rated their knowledge as Low or below. Those who rated their knowledge as 'Neither High nor Low' were significantly more familiar with the impact than those who Very Low or below.

In general, across all potential impacts where knowledge of biofuels was shown to be a significant factor, those with higher biofuel knowledge ratings showed greater familiarity with the impacts than those at lower levels of biofuel knowledge. As greater familiarity with the potential impacts should be a defining factor in determining higher levels of knowledge of biofuels, this result may have been largely expected. The results also provide some support for the accuracy of self reported levels of biofuel knowledge, as those who said they knew more, were, largely, more aware of the potential impacts.

## **Environmental Concern**

Concern about the Environment was shown to influence impact awareness, the most notable effects are with familiarity with Reduced Food Supplies ( $H(2)=39.944$ ,  $d.f.=5$ ,  $p=0.000$ ), Improved Energy Security ( $H(2)=30.390$ ,  $d.f.=5$ ,  $p=0.000$ ), Increased Food Prices ( $H(2)=17.960$ ,  $d.f.=5$ ,  $p=0.003$ ), Changes to the Appearance of the Countryside ( $H(2)=13.856$ ,  $d.f.=5$ ,  $p=0.017$ ), Use of Large Areas of Land ( $H(2)=48.204$ ,  $d.f.=5$ ,  $p=0.000$ ), Human Rights Abuses ( $H(2)=19.373$ ,  $d.f.=5$ ,  $p=0.002$ ), Loss of Plant and Animal Species ( $H(2)=16.456$ ,  $d.f.=5$ ,  $p=0.006$ ) and Less Investment in Other Renewable Transport Options ( $H(2)=22.867$ ,  $d.f.=5$ ,  $p=0.000$ ).

- In the case of Reduced Food Supplies, Improved Energy Security, Increased Food Prices, Use of Large Areas of Land and Less Investment in Other Renewable Transport Options, those who were Very Concerned about the environment were significantly more familiar with the impact than those who were Concerned, Neither Concerned nor Unconcerned or Unconcerned. For Reduced Food Supplies, those who were Concerned were also significantly more familiar with the impact than those who were Neither Concerned nor Unconcerned. For Use of Large Areas of Land and Less Investment in Other Renewable Transport Options, those who were Very Concerned were also significantly more familiar with the impact than those who did not know.
- In the case of Changes to the Appearance of the Countryside and Loss of Plant and Animal Species, those who were Very Concerned about the environment were significantly more familiar with the impact than those who were Neither Concerned nor Unconcerned.
- In the case of Human Rights Abuses, those who were Very Concerned about the environment were significantly more familiar with the impact than those who were Concerned or Unconcerned.

## Appendix 10

- **“We can’t produce enough biofuel to meet current fuel demands or increased future demands”**

Statistical testing showed that responses were significantly affected by Age ( $H(2)=23.844$ , d.f.=6,  $p=0.001$ ), Gender ( $H(2)=10.005$ , d.f.=1,  $p=0.002$ ), Level of Education ( $H(2)=17.539$ , d.f.=8,  $p=0.025$ ) and Environmental Concern ( $H(2)=19.494$ , d.f.=5,  $p=0.002$ ).

- **“Biofuels are generally cheaper than petrol/diesel”**

The data show that responses to this statement were only significantly affected by Level of Education ( $H(2)=17.742$ , d.f.=8,  $p=0.023$ )

- **“Biofuels can only be used in existing cars if they have specially modified engines”**

Responses were shown to be significantly affected by Age ( $H(2)=15.273$ , d.f.=6,  $p=0.018$ ), Gender ( $H(2)=17.063$ , d.f.=1,  $p=0.000$ ), Level of Education ( $H(2)=26.721$ , d.f.=8,  $p=0.001$ ), Knowledge of Biofuels ( $H(2)=47.602$ , d.f.=5,  $p=0.000$ ).

- **“Biofuels will be useful to help reduce our dependence on fossil fuels”**

Responses to this statement were not shown to be significantly affected by any of the demographic factors for which data was collected.

- **“Growing biofuels in the UK will reduce the natural beauty of the countryside”**

Responses were shown to be significantly affected by Age ( $H(2)=19.470$ , d.f.=6,  $p=0.003$ ) and Level of Education ( $H(2)=23.744$ , d.f.=8,  $p=0.003$ ).

- **“Biofuel production is contributing to destruction of the rainforest”**

Responses to this statement were shown to be significantly affected by Environmental Concern ( $H(2)=17.443$ ,  $d.f.=5$ ,  $p=0.004$ ).

- **“Biofuel production is responsible for reduced food supplies and increased food prices”**

Responses to this statement were shown to be significantly affected by Gender ( $H(2)=8.144$ ,  $d.f.=1$ ,  $p=0.004$ ) and Environmental Concern ( $H(2)=17.385$ ,  $d.f.=5$ ,  $p=0.004$ ).

## Appendix 11

- **“It is not possible to buy biofuels in the UK at present”**
- Responses to this statement were shown to be significantly affected by Gender ( $H(2)=12.762$ ,  $d.f.=1$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=53.244$ ,  $d.f.=5$ ,  $p=0.000$ ).
- **“Biofuels are worse for the environment than fossil fuels”**
- Responses to this statement were shown to be significantly affected by Environmental Concern ( $H(2)=15.984$ ,  $d.f.=5$ ,  $p=0.007$ ).
- **“Using biofuels will reduce greenhouse gas emissions from transport”**
- Responses to this statement were shown to be significantly affected by Gender ( $H(2)=4.878$ ,  $d.f.=1$ ,  $p=0.027$ ).
- **“Biofuels are carbon neutral”**
- Responses to this statement were shown to be significantly affected by Age ( $H(2)=22.417$ ,  $d.f.=6$ ,  $p=0.001$ ), Level of Education ( $H(2)=32.734$ ,  $d.f.=8$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=11.575$ ,  $d.f.=5$ ,  $p=0.041$ ).
- **“Biofuels are the only available alternative for use in transport”**
- Responses to this statement were shown to be significantly affected by Gender ( $H(2)=26.617$ ,  $d.f.=1$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=33.370$ ,  $d.f.=5$ ,  $p=0.000$ ).

## Appendix 12

### **Television Programmes/Documentaries**

Statistical testing showed significant difference by Age ( $H(2)=26.242$ , d.f.=6,  $p=0.000$ ), Gender ( $H(2)=9.248$ , d.f.=1,  $p=0.002$ ) and Biofuel Knowledge ( $H(2)=38.746$ , d.f.=5,  $p=0.000$ ).

### **Television/Radio News**

Statistical testing showed significant difference by Age ( $H(2)=30.985$ , d.f.=6,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=19.868$ , d.f.=5,  $p=0.001$ ).

### **Broadsheet Newspapers**

Statistical testing showed significant difference by Age ( $H(2)=35.422$ , d.f.=6,  $p=0.000$ ), Gender ( $H(2)=28.192$ , d.f.=1,  $p=0.000$ ), Level of Education ( $H(2)=35.265$ , d.f.=8,  $p=0.000$ ), Biofuel Knowledge ( $H(2)=44.284$ , d.f.=5,  $p=0.000$ ) and ACORN rating ( $H(2)=36.236$ , d.f.=13,  $p=0.001$ ).

### **Relatives/Friends**

Statistical testing showed significant difference by Age ( $H(2)=22.596$ , d.f.=6,  $p=0.001$ ), Level of Education ( $H(2)=19.733$ , d.f.=8,  $p=0.011$ ) and Environmental Concern ( $H(2)=12.157$ , d.f.=5,  $p=0.033$ ).

### **Work/School/University**

Statistical testing showed significant difference by Age ( $H(2)=81.411$ , d.f.=6,  $p=0.000$ ), Level of Education ( $H(2)=42.802$ , d.f.=8,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=101.350$ , d.f.=5,  $p=0.000$ ).

### **Magazines**

Statistical testing showed significant difference by Gender ( $H(2)=17.465$ , d.f.=1,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=19.733$ , d.f.=5,  $p=0.001$ ).

### **Industry**

Statistical testing showed significant difference by Biofuel Knowledge ( $H(2)=63.083$ , d.f.=5,  $p=0.000$ ).

### **News Websites**

Statistical testing showed significant difference by Age ( $H(2)=51.951$ ,  $d.f.=6$ ,  $p=0.000$ ), Gender ( $H(2)=7.992$ ,  $d.f.=1$ ,  $p=0.005$ ), Level of Education ( $H(2)=46.636$ ,  $d.f.=8$ ,  $p=0.000$ )

### **Other Websites**

Statistical testing showed significant difference by Age ( $H(2)=18.547$ ,  $d.f.=6$ ,  $p=0.005$ ), Gender ( $H(2)=4.946$ ,  $d.f.=1$ ,  $p=0.026$ ), Level of Education ( $H(2)=38.681$ ,  $d.f.=8$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=42.211$ ,  $d.f.=5$ ,  $p=0.000$ ).

### **Scientific Journals**

Statistical testing showed significant difference by Gender ( $H(2)=9.546$ ,  $d.f.=1$ ,  $p=0.002$ ), Level of Education ( $H(2)=57.326$ ,  $d.f.=8$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=26.289$ ,  $d.f.=5$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=199.453$ ,  $d.f.=5$ ,  $p=0.000$ ).

### **Government Reports**

Statistical testing showed significant difference by Environmental Concern ( $H(2)=15.996$ ,  $d.f.=5$ ,  $p=0.007$ ) and Biofuel Knowledge ( $H(2)=81.153$ ,  $d.f.=5$ ,  $p=0.000$ ).

### **Tabloid Newspapers**

Statistical testing showed significant difference by Age ( $H(2)=21.896$ ,  $d.f.=6$ ,  $p=0.001$ ), Gender ( $H(2)=5.284$ ,  $d.f.=1$ ,  $p=0.022$ ), Level of Education ( $H(2)=51.926$ ,  $d.f.=8$ ,  $p=0.000$ ).

## Appendix 13

For Television News, statistical testing revealed significant differences by Gender ( $H(2)=4.502$ ,  $d.f.=1$ ,  $p=0.034$ ) and Biofuel Knowledge ( $H(2)=16.474$ ,  $d.f.=5$ ,  $p=0.006$ ).

For Tabloids, statistical testing revealed significant differences by Level of Education ( $H(2)=46.643$ ,  $d.f.=8$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=11.201$ ,  $d.f.=5$ ,  $p=0.048$ ) and Biofuel Knowledge ( $H(2)=30.608$ ,  $d.f.=5$ ,  $p=0.000$ ).

For Government, statistical testing revealed significant differences by Age ( $H(2)=21.245$ ,  $d.f.=6$ ,  $p=0.002$ ) and Gender ( $H(2)=6.722$ ,  $d.f.=1$ ,  $p=0.010$ ).

For Scientists, statistical testing revealed significant differences by Age ( $H(2)=36.084$ ,  $d.f.=6$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=32.087$ ,  $d.f.=5$ ,  $p=0.000$ ) and Biofuel Knowledge ( $H(2)=19.434$ ,  $d.f.=5$ ,  $p=0.002$ ).

For Television Documentaries, statistical testing revealed significant differences by Gender ( $H(2)=5.734$ ,  $d.f.=1$ ,  $p=0.017$ ).

## Appendix 14

For Oil/Petrol, statistical testing revealed significant differences by Level of Education ( $H(2)=37.328$ ,  $d.f.=8$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=40.841$ ,  $d.f.=5$ ,  $p=0.000$ ), Biofuel Knowledge ( $H(2)=25.696$ ,  $d.f.=5$ ,  $p=0.000$ )

For Nuclear, statistical testing revealed significant differences by Gender ( $H(2)=46.876$ ,  $d.f.=1$ ,  $p=0.000$ ), Level of Education ( $H(2)=20.782$ ,  $d.f.=8$ ,  $p=0.008$ ), Biofuel Knowledge ( $H(2)=26.501$ ,  $d.f.=5$ ,  $p=0.000$ )

For Coal, statistical testing revealed significant differences by Level of Education ( $H(2)=36.303$ ,  $d.f.=8$ ,  $p=0.000$ ), Biofuel Knowledge ( $H(2)=26.611$ ,  $d.f.=5$ ,  $p=0.000$ )

For Hydroelectric, statistical testing revealed significant differences by Gender ( $H(2)=21.971$ ,  $d.f.=1$ ,  $p=0.000$ ), Biofuel Knowledge ( $H(2)=13.970$ ,  $d.f.=5$ ,  $p=0.016$ )

For Solar, statistical testing revealed significant differences by Environmental Concern ( $H(2)=27.613$ ,  $d.f.=5$ ,  $p=0.000$ )

For Wind, statistical testing revealed significant differences by Age ( $H(2)=24.351$ ,  $d.f.=6$ ,  $p=0.000$ ), Environmental Concern ( $H(2)=24.375$ ,  $d.f.=5$ ,  $p=0.000$ )

For Gas, statistical testing revealed significant differences by Level of Education ( $H(2)=32.149$ ,  $d.f.=8$ ,  $p=0.000$ ), Biofuel Knowledge ( $H(2)=16.603$ ,  $d.f.=5$ ,  $p=0.005$ )

For Tidal/Wave, statistical testing revealed significant differences by Gender ( $H(2)=5.279$ ,  $d.f.=1$ ,  $p=0.022$ ), Level of Education ( $H(2)=34.965$ ,  $d.f.=8$ ,  $p=0.000$ ).

**Appendix 15**  
Environmental Concern by Level of Education

**Multiple Comparisons**

How concerned are you about the environment?

Tamhane

(I) Highest Level of Educational Achievement	(J) Highest Level of Educational Achievement	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Other	No Qualifications	.227	.157	.997	-.29	.74
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.378	.227	.981	-.40	1.15
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	.306	.134	.592	-.13	.75
	A Levels, NVQ Level 3, Advanced GNVQ	.457*	.134	.031	.02	.89
	Diploma of Higher or Further Education, Foundation Degree, HND	.289	.127	.599	-.13	.71
	Bachelors Degree, Graduate Certificate/Diploma	.069	.113	1.000	-.31	.44
	Masters Degree, Postgraduate Certificate/Diploma	-.093	.114	1.000	-.47	.28
	Doctorate	-.092	.154	1.000	-.60	.42
	No Qualifications	Other	-.227	.157	.997	-.74
GCSE D-G, NVQ Level 1, Foundation Level GNVQ		.151	.240	1.000	-.66	.96
GCSE A*-C, NVQ Level 2, Intermediate GNVQ		.080	.155	1.000	-.42	.58
A Levels, NVQ Level 3, Advanced GNVQ		.230	.155	.995	-.27	.73

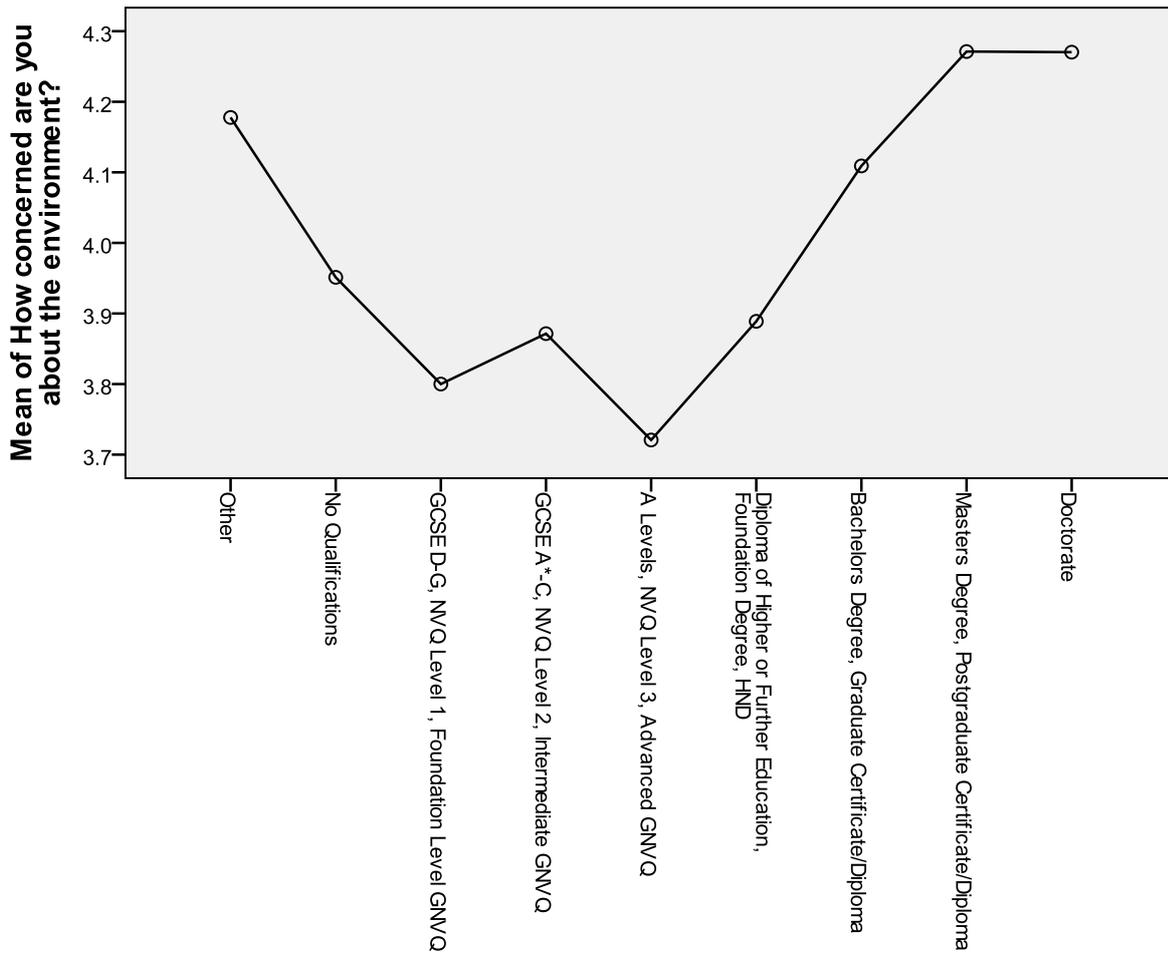
	Diploma of Higher or Further Education, Foundation Degree, HND	.062	.149	1.00 0	-.42	.55
	Bachelors Degree, Graduate Certificate/Diploma	-.158	.137	1.00 0	-.60	.29
	Masters Degree, Postgraduate Certificate/Diploma	-.320	.137	.545	-.77	.13
	Doctorate	-.319	.173	.919	-.89	.25
GCSE D-G, NVQ Level 1, Foundation Level GNVQ	Other	-.378	.227	.981	-1.15	.40
	No Qualifications	-.151	.240	1.00 0	-.96	.66
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	-.071	.226	1.00 0	-.84	.70
	A Levels, NVQ Level 3, Advanced GNVQ	.079	.225	1.00 0	-.69	.85
	Diploma of Higher or Further Education, Foundation Degree, HND	-.089	.222	1.00 0	-.85	.67
	Bachelors Degree, Graduate Certificate/Diploma	-.309	.214	.998	-1.05	.43
	Masters Degree, Postgraduate Certificate/Diploma	-.471	.214	.719	-1.21	.27
	Doctorate	-.470	.238	.866	-1.28	.34
GCSE A*-C, NVQ Level 2, Intermediate GNVQ	Other	-.306	.134	.592	-.75	.13
	No Qualifications	-.080	.155	1.00 0	-.58	.42
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.071	.226	1.00 0	-.70	.84
	A Levels, NVQ Level 3, Advanced GNVQ	.151	.131	1.00 0	-.27	.58
	Diploma of Higher or Further Education, Foundation Degree, HND	-.017	.124	1.00 0	-.42	.39

	Bachelors Degree, Graduate Certificate/Diploma	-.238	.110	.694	-.60	.12
	Masters Degree, Postgraduate Certificate/Diploma	-.400*	.111	.016	-.76	-.04
	Doctorate	-.399	.152	.317	-.90	.10
A Levels, Other		-.457*	.134	.031	-.89	-.02
NVQ Level 3, Advanced GNVQ	No Qualifications	-.230	.155	.995	-.73	.27
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	-.079	.225	1.000	-.85	.69
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	-.151	.131	1.000	-.58	.27
	Diploma of Higher or Further Education, Foundation Degree, HND	-.168	.124	.999	-.57	.23
	Bachelors Degree, Graduate Certificate/Diploma	-.388*	.109	.017	-.74	-.03
	Masters Degree, Postgraduate Certificate/Diploma	-.550*	.110	.000	-.91	-.19
	Doctorate	-.550*	.152	.018	-1.05	-.05
Diploma of Higher or Further Education, Foundation Degree, HND	Other	-.289	.127	.599	-.71	.13
	No Qualifications	-.062	.149	1.000	-.55	.42
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.089	.222	1.000	-.67	.85
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	.017	.124	1.000	-.39	.42
	A Levels, NVQ Level 3, Advanced GNVQ	.168	.124	.999	-.23	.57
	Bachelors Degree, Graduate Certificate/Diploma	-.220	.101	.670	-.55	.11

	Masters Degree, Postgraduate Certificate/Diploma	-.382*	.102	.008	-.71	-.05
	Doctorate	-.381	.146	.325	-.87	.10
Bachelors Degree, Graduate Certificate/D iploma	Other	-.069	.113	1.00 0	-.44	.31
	No Qualifications	.158	.137	1.00 0	-.29	.60
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.309	.214	.998	-.43	1.05
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	.238	.110	.694	-.12	.60
	A Levels, NVQ Level 3, Advanced GNVQ	.388*	.109	.017	.03	.74
	Diploma of Higher or Further Education, Foundation Degree, HND	.220	.101	.670	-.11	.55
	Masters Degree, Postgraduate Certificate/Diploma	-.162	.084	.861	-.43	.11
	Doctorate	-.161	.134	1.00 0	-.61	.29
Masters Degree, Postgraduat e Certificate/D iploma	Other	.093	.114	1.00 0	-.28	.47
	No Qualifications	.320	.137	.545	-.13	.77
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.471	.214	.719	-.27	1.21
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	.400*	.111	.016	.04	.76
	A Levels, NVQ Level 3, Advanced GNVQ	.550*	.110	.000	.19	.91
	Diploma of Higher or Further Education, Foundation Degree, HND	.382*	.102	.008	.05	.71

	Bachelors Degree, Graduate Certificate/Diploma	.162	.084	.861	-.11	.43
	Doctorate	.001	.134	1.00 0	-.45	.45
Doctorate	Other	.092	.154	1.00 0	-.42	.60
	No Qualifications	.319	.173	.919	-.25	.89
	GCSE D-G, NVQ Level 1, Foundation Level GNVQ	.470	.238	.866	-.34	1.28
	GCSE A*-C, NVQ Level 2, Intermediate GNVQ	.399	.152	.317	-.10	.90
	A Levels, NVQ Level 3, Advanced GNVQ	.550*	.152	.018	.05	1.05
	Diploma of Higher or Further Education, Foundation Degree, HND	.381	.146	.325	-.10	.87
	Bachelors Degree, Graduate Certificate/Diploma	.161	.134	1.00 0	-.29	.61
	Masters Degree, Postgraduate Certificate/Diploma	-.001	.134	1.00 0	-.45	.45

\*. The mean difference is significant at the 0.05 level.



## Appendix 16

### Expert Stakeholder Interview Questions

#### Introductory Question

1. Outline your organisations involvement in Biofuels

#### Perception of Biofuels (positives, negatives, development)

2. What are your motivating factors/drivers in developing biofuels?
3. What do you consider to be the most significant risks associated with biofuels? Internally and Externally.
4. Do you think it will be possible to overcome these barriers?
  - a. How?
  - b. What are your priorities for action?
  - c. What else needs to be done? By who?
5. In your opinion what is the future of biofuels? Globally and in the UK
6. What is your opinion of government action on and support for the biofuel industry?
7. In comparison to other options for transport, how preferable are biofuels, in your opinion?

#### Perception of Public Engagement

8. What is your understanding of the public perception of and support for biofuels?
9. Do you consider the public to be an important stakeholder in decision making?
10. Do you undertake any consultation or communication with the public?
  - a. What and How?
11. Do you feel a clearer understanding of public opinion would be beneficial for the industry?
12. Do you think the public trust you?

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