Constructing ‘the ethical’ in the development of biofuels

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Abstract

In the past fifty years, calls to address the ethical and social dimensions in the biosciences have become pervasive. To this end, notions of bioethics, and an associated range of methodologies have been institutionalised throughout the UK biosciences; talk of research ethics, public engagement, various forms of technology assessment, and recently notions of responsible innovation in technoscientific worlds is increasingly commonplace. A desire to unpack discourse and action surrounding these practices sits at the heart of this thesis. Of particular interest are the ways that different groups construct the ethical dimensions of biofuel development and deployment and then distribute responsibility for addressing them. To achieve this, I find analytic power by deploying theory from the interpretative social sciences, namely the sociology of bioethics and science and technology studies. Empirically, I use controversy about the development and deployment of biofuels as a means to analyse, primarily through documentary analysis and qualitative interview, how three prominent groups (non-governmental organisations, public research funders and scientists) construct understandings of ethics and then distribute responsibility for addressing those issues. This approach makes it possible to see that the constitution of ethical issues (their 'form') and the ways that they are addressed (the 'task' of ethics) are both tightly coupled to the situations from which they arise. They are thus fundamentally multiple, locally contingent and often unpredictable. Using a range of discursive strategies and actions, actors are able to negotiate, blurring in and out of focus, what counts as an appropriate issue of concern, who should be addressing it and how. Dominant traditions of theory and practice have a tendency to standardise the form and task of ethics, such as in terms of issue types (e.g. 'Playing God') and the methods for addressing them (e.g. public engagement). I argue that situated nature of ethical dimensions should be acknowledged rather than ignored and that doing so is fundamental to making research more 'socially robust'. However, this tension between dominant institutionalised forms and lived experiences is not easily resolved because it forces an engagement with the roles of those who are tasked with steering knowledge production. Hope is, however, offered by new approaches that have explicitly sought to deal with such tensions in new forms of knowledge production and new models of collaboration.

Acknowledgements

> What her big brain certainly wasn't going to tell her, was that, if she came up with an idea for a novel experiment which had a chance of working, her big brain would make her life a hell until she had actually performed that experiment. That, in my opinion, was the most diabolical aspect of those old-time big brains: They would tell their owners, in effect, "Here is a crazy thing we could actually do, probably, but we would never do it, of course. It's just fun to think about." And then, as though in trances, the people would really do it […] Somewhere […] there should have been, but was not, a warning to this effect: "In this era of big brains, anything which can be done will be done – so hunker down." (Vonnegut, 1985, p. 266)

Kurt Vonnegut quotes are a bit of a cliché but that's probably because they make good quotes. I suspect that they have found their way into lots of theses. I also suspect that, when in theses of this orientation, the quote above is most often used as a comment on scientific and technological progress with a plea for humility. Here I use it self-referentially. Over the past five years I have come up with many big-brained ideas. A few too many of them have probably made it into the next few hundred pages. One of the more stupid ones was to try and thank everyone that has had an impact on my thoughts by name. Instead, I want to ignore my brain and just say thank you to everyone who has provided space, guidance and money to make this happen, not least all who gave up time to participate, my supervisory and examination team, everyone at the Centre for Applied Bioethics and the Institute for Science and Society, the administrative staff, my friends, family, Meg, and all the other animals.

RDJS, Nottingham, June 2015

Declarations

Supplementary work

Chapter six represents a significant expansion of work that has been reported elsewhere, in the form of a report delivered to the Biotechnology and Biological Sciences Research Council (BBSRC) Bioscience for Society Strategy Panel in December 2013. A summary of this report is contained within Appendix Four. My thinking, particularly for chapter three, and around notions of responsible innovation has been supplemented by work conducted as part of the Integrated EST Framework (EST-Frame) project (http://estframe.net) funded by the EC's 7th Framework Programme GA No. 288981.

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Examination team

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Chapter 1

Introduction

The images on the facing page both appear in historian Robert Bud's history of biotechnology, *the uses of life* (Bud, 1994). Both were published within a year of each other, in 1979 and 1980 respectively. The image on the left appeared in the British popular science publication *New Scientist*, whilst the image on the right appeared in *The National Enquirer*, a sensationalist North American tabloid newspaper. Presented together, these two images present starkly contrasting visions of what biotechnology might do. Taken together, they are both prescient and symbolic of the ways that concerns about biotechnology would be articulated in the coming thirty years.

The first image was published as biotechnology was actively moved from a field of professional enquiry to national policy category capable of securing 'public good', making it worthy of national support around the globe. To this end it positions 'biotechnology' as the missing piece of a pipeline, joining the fundamental sciences of engineering, genetics, agriculture, biochemistry, electronics and microbiology to the production of a wealth of societally-useable products such as food additives, methane, antibiotics, ethanol, amino acids, flavouring and vitamins (Bull and Bu'Lock, 1979). *The National Enquirer* in contrast, transformed the tree of untold benefit into an ominous, and surprisingly well-conditioned sentient being able to refuel a car with the produce of its own metabolism, whilst the mechanic is transformed into a pen-pushing clerical assistant. What can be taken from them? Is one simply a crass piece of self-invested propaganda and the other an over-sensationalised cartoon designed to stir up controversy?

The political capital that these images embed should not be ignored; each acts as a significant piece of propaganda able to stir up or neutralise conversation and push it in particular dimensions. And yet, the two images can act as anchors to a range of pervasive characterisations of discussions about science and technology and their place within society. On the one hand novel and future (bio)technologies might offer

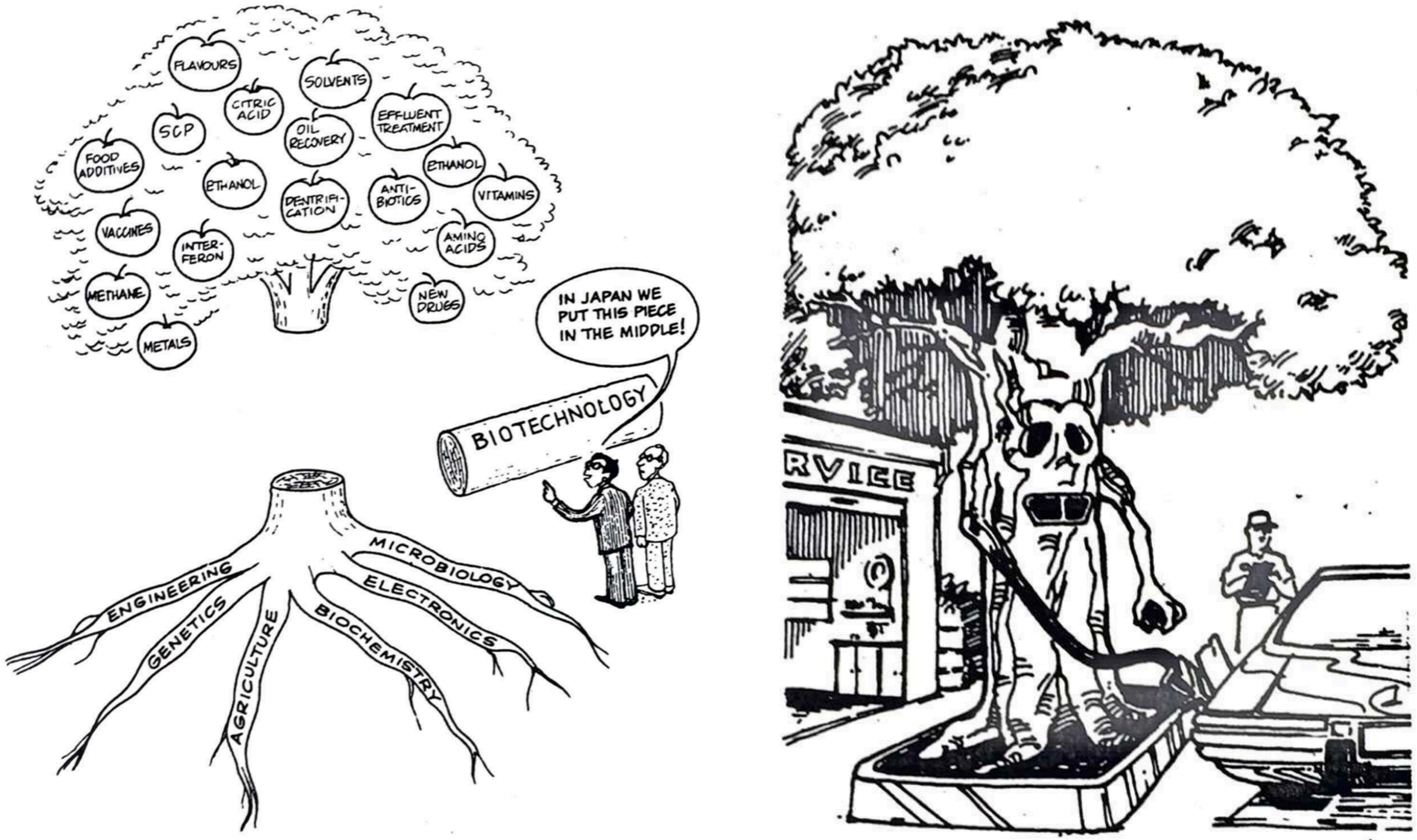

Figure 1.1: *Two visions for biotechnology. The first, appeared in a 1979 edition of New Scientist while the latter appeared in a 1980 edition of National Enquirer (Bud 1994, p159, 173)*

unparalleled promise - in this case access to better, green, more benign or efficient production processes. On the other, an equally evangelistic counterbalancing discourse seeks to emphasise a dark dystopian future where present, wholesome values have been shrugged aside. A more provocative reading might choose to take them in a broader context and emphasise their ability to symbolise a luddite public with obdurate values and naïve concerns that stands in the way of technological progress, facilitated by scientists, and enabling economic growth (Marris, 2014). Others, some scientists included, would read them as symbolic of previously thick and unruly ethico-political debate that has been thinned to be dominated by the four ethical principles of autonomy, beneficence, non-maleficence and justice (J. Evans, 2002) and that repurposes a broad conception of biotechnology that stemmed from the culturing of enzymes and use of fermentation technologies as a narrow suite of genetic modification techniques stemming from recombinant DNA approaches (Bud, 1994, pp. 163-188). Finally, an environmental reading might draw on notions of planetary boundaries to emphasise that many of the promises embedded within biotechnology simply seek to act as technological fixes that increase our control of the natural world, often to its detriment, simply to maintain an unsustainable lifestyle to which we are accustomed.

Scrutiny from forty years of social, ethical, scientific and political scholarship has demonstrated that with a little pressure many of these binaries seem to break down. Humans are frequently presented not as detached and separable from the environment but as one, albeit powerful, constituent of 'nature' (Macnaghten, 2006). Moreover, 'nature' can be cut in many ways, as stock of economic goods (or more recently 'ecosystems services' (Funtowicz and Ravetz, 1994)), as endangered ecosystem, as source of intrinsic good or as social category (Winner, 1986a, pp. 121-137). It is not simply a case of 'the public' or 'non-governmental organisations' on one side, with the holistic whole of 'science' on the other, as evidenced by the many years of calls for scientific responsibility from scientists themselves (Luria, 1972). The notion that 'science' is the bedrock of economic development becomes problematic at best, and the result of a misguided 'fudge' at worst (Mirowski, 2011). Our world then, might usefully be understood as one which is the result of continuing and multifaceted shades of co-production with emergent and varying ways of knowing – conceptions of 'society', 'science', or 'nature' for instance – that, ultimately, are not only inseparable from one another but also from the multiple (sociotechnical) futures that they serve to create (Jasanoff, 2004a). As new knowledge, predominantly titled as 'science' (and its artefactual compatriot, 'technology') provides a lens through which we understand the world, it also embeds and enacts manifest value-laden and politically-significant judgements about what that world will look like (Latour, 2002; 1992; Winner, 1986b). This alone renders 'science', whatever we come to mean by the term, deserving of critical attention (Wynne, 2014; 2008).

To address questions of the intermingling of social and scientific worlds, a bioethics discourse and structural regime has been constructed to accompany developments in the biosciences. This institution, which I understand as any number of a series of phenomena that have normative, ordering or cognitive characteristics that give meaning to social behaviour (Scott, 2013), fully permeates research practice, science policy and public discourse relating to the biosciences (J. Evans, 2012). It has been formally institutionalised as a form of 'soft governance' (e.g. see Tallacchini, 2009) in a range of public advisory committees, within research funding procedures and within hospitals. Scientists are therefore frequently asked to 'reflect' on the social and ethical 'consequences' or 'implications' of the work that they do. Whilst there have been many calls for public engagement and participation, renewed senses of social responsibility amongst scientists, better forms of research ethics, there are relatively few studies that provide empirical understandings of the ways that these calls are institutionalised and the way that they shape scientific practice, the knowledge that it generates and, together, the futures they help to create (see Hedgecoe, 2010; Pickersgill, 2012). Although there are studies of scientists within laboratories, there are few that consider the way that scientists construct ethical issues and responsibility. And there are far fewer still that have extended this focus to different actors across a single case study.

Now of course 'bioethics', in its varying forms, has been the subject of a series of longstanding critiques (e.g. see Petersen, 2013), most famously of serving to separate 'science' from 'ethics', thereby enabling concealment of the fundamentally value-laden and inherently social nature of scientific knowledge generation and assessment (Levidow and Carr, 1997; Wickson and Wynne, 2012; Wynne, 2001). In spite of such insights many of the boundary-enforcing binaries identified above persist in common usage, within science governance, and amongst those seeking to develop new analytical and interventionist approaches. The contemporary concept of 'responsible innovation' is a case in point. One formulation *has* repurposed the seminal work of David Collingridge (1980) and consciously made attempts to preference and embed a language laden with notions of 'resilience', 'care for the future' and 'responsiveness in the face of uncertainty' (Owen et al., 2012; Stilgoe et al., 2013). More often than not however, residual but countervailing discourses remain in the wake of such evolutionary efforts (cf. Owen and Goldberg, 2010; Pidgeon et al., 2013; Schomberg, 2013; Stahl, 2012). Although such methods often have broad, inclusive and reflexive, rather than technocratic, desires at their heart, they still tend to maintain that impacts are identifiable, able to be mitigated or if not can be prepared for. If anything then, recent examples of work from within communities of technology assessment, science and technology studies (STS) and bioethics serve to highlight the obduracy of impact-oriented and consequentialist-focused language, and the difficulties associated with moving beyond it.

Whilst sensitive to such challenges, this thesis represents an attempt to help move beyond dichotomous framings of the relationship between 'science' and 'society' that exist within research governance, of 'ethics' as a 'barrier' to the 'untold wealth' that biotechnological 'progress' will bring, and of 'good' and 'bad' impacts. To do so, it provides an empirical exploration of the ways that ethical questions and reflection upon them occur within one area of bioscience research, biofuels. It takes the following two questions as points of departure and I outline its approach to addressing them in the following section:

1. In what ways does each of the three groups of actors (scientists, BBSRC and NGOs) construct 'the ethical' within biofuels research?
2. How does each group negotiate and distribute responsibility in the development of biofuels?

My analytic desires can be characterised as instrumental, interpretative, and normative (Jasanoff, 2011). That is, I seek not only to mobilise analytic resources to make sense of the ethical dimensions of biofuel development and deployment but also ultimately seek to ask how, if one preferences knowledges, technologies and societies that are sensitive to the kinds of futures being created and the trade-offs that are made in the process, one might develop methods and interactions to meet these desires, finding ways to embed and evaluate them as (for instance) part of science policy. For many with similar intentions, the notion of fostering 'socially robust knowledge' (Nowotny et al., 2001) in the face of uncertainty has become a central concern to aim for. This is knowledge which is rendered "valid not only inside but also outside the laboratory" by involving broad groups of actors in its generation (Gibbons, 1999 C81). While commonly mobilised as an end in itself, 'socially robust knowledge' is rarely unpacked (Hessels and van Lente, 2008). Therefore, my normative intentions, when coupled with a desire to investigate the interfaces between local- and broad-ranging contexts, are guided by a concern with the ways in which interactions between actors might help, hinder and be modulated to foster socially robust knowledge. I shall return to this in the concluding chapter.

1.1 The thesis

This thesis takes bioethics as its object of analysis. Specifically, it considers the way in which a bioethical discussion has played out in a controversial sociotechnical practice – the development and production of liquid fuels from biological material, biofuels – in order to examine the ways in which different actors construct, relate to and ultimately mobilise such a category of practice and discourse. In doing so, it aims to provide insight into the ways in which people come to define 'the ethical' dimensions of research in the biosciences and the ways in which those categorisations shape practice.

The manuscript is structured with two main components. Chapters two, three and four are primarily literature-based and provide contextual details on the case, an unpacking of ethical issues in the biosciences, and lay out my methodological approach. Chapters five, six and seven comprise the bulk of the empirical work, which centres on the ways that NGO representatives, the Biotechnology and Biological Sciences Research Council (BBSRC), and scientists construct ethical issues and distribute responsibility for addressing them. These actor-ordered chapters are then brought together with the contextual aspects of earlier chapters in the concluding chapter eight. To provide an introduction to my approach, I lay out the forthcoming chapters below.

I use chapter two (*Bioenergy research, technology, controversy and policy in Britain*) to develop a recent chronology of biofuel development and deployment in the United Kingdom, with a particular focus on policy-relevant discussions and the biosciences. Here, my aims are threefold: To understand why the development and deployment of liquid fuels derived directly from biological material (biofuels) makes an appropriate arena to explore the ethical dimensions of research; to provide contextual information that will allow a dedicated reader or other willing party to make comparisons; and to begin to address the first research question of the thesis. We see that biofuels have historically spent a large amount of time in a policy hinterland and that recent deployment has been coloured by technical, and occasionally, public controversy. Unpacking biofuels' genealogy helps to draw attention to the way particular concerns about biofuel development and deployment were framed and addressed by prominent actors. This provides a macro-level structuring dynamic that not only shapes the way that ethical concerns come to be constituted but also how they should be engaged with. By pointing to such 'regimes of normativity' (Pickersgill, 2012) it becomes possible to make some initial steps to interrogate the interfaces between wide-ranging and local discourses of concern, which ultimately shape knowledge and action.

Chapter three (*On ethics and responsibility in the biosciences*) considers a second macro-level dynamic, this time from the perspective of traditions of ethical reflection and articulation within the biosciences, namely bioethics. To do so, it unpacks several notions of the term bioethics, from traditions in moral philosophy and the social sciences. In doing so, it aims to show how the ethical dimensions of the biosciences can be shifted to an object of interrogation in their own right by mobilizing theory from within science and technology studies. The chapter closes by briefly considering how responsibility for addressing bioethical issues is institutionalised within bioscience research at the present time.

Chapter four (*Considering method(ology)*) presents a somewhat unconventional methodological reflection that responds to calls for reflexivity and an awareness of the 'mess' (Law, 2004) of research by providing an account of research that is truer to the realities of researching. To do so, it reflects on the use of case studies as a method choice, the ways in which data can be produced and 'rendered analysable' and reflects on the relationship between 'data' and 'theory'. It is not wholly subversive, however, ultimately advocating increased transparency, and also comes attached to a research protocol that details the steps of the project.

The 'data-lead' portion of the thesis explores the way that three groups construct 'the ethical' in documents, interviews and participative work. First is chapter five (*Non-governmental organisations, values and the role of research*). It mobilises data from interviews with a sample of NGO representatives active in the biofuels field to explore (i) the way that they constructed and framed ethical issues, and (ii) the way that the individuals relate scientific knowledge to such issues. Doing so is important for at least two reasons. First, these groups have played fundamental, but underexplored roles within the governance of technoscientific developments. Second, if 'the ethical' is viewed as a task to be done (as introduced in chapter three), then there are important questions regarding the role of NGOs. Do they, for example, compete with those traditionally responsible for the task of ethics, and if so, in what ways? My analysis makes initial steps to show how individuals react in relation to broader normative debates, how they distribute responsibility, drawing attention to the heterogeneity, malleability, and ultimately strategic utility of ethical issues. It ends on a brief discussion of different ascriptions for the place of 'the ethical' within the governance of research, which I return to within the conclusion.

I use chapter six (*BBSRC: Managing a controversial priority*) to explore the way that the BBSRC operated in the bioenergy arena between 2003 and 2014. Building on insights introduced in chapter three that demand we pay attention to not just the actions that are explicitly demarcated as part of the 'task of ethics', I consider both activities (e.g. public engagement), organisational discourse (e.g. meeting minutes) and implicit normative judgements such as the visions embedded within funding priorities. To do so, I mobilise theory introduced within chapter three in the form of 'rationales' (Stirling, 2008) and parts of the sociology of expectations literature (e.g. Hedgecoe and Martin, 2008). I show that the underpinning rationales for particular kinds of engagement within the BBSRC are heterogeneous: fluctuating over time, across the organisation and depending on the audience that is being engaged. Whilst externally facing discussions embed substantive and normative rationales for inclusion, internal documents often point to instrumental rationales that position engagement as a means of securing the economic benefits that technological progress can bring.

The penultimate chapter, seven, (*Scientists' constructions of the ethical: issue types and strategies*) develops some of the themes introduced in chapter six to examine the way that the ethical dimensions of research were discursively constructed during interviews between scientists working in the biofuels field and myself. Siting my analysis in a body of literature that provides examples of the ways that scientist talk about ethical dimensions in complex, diverse and nuanced ways (Burchell, 2007a; e.g. Kerr et al., 1997; Michael and Birke, 1994; Pickersgill, 2012; Wainwright et al., 2006), I make a tentative suggestion that researchers develop a concept of ethics alongside their own research. This concept is therefore malleable; shaped by research experiences and adeptly deployed in different circumstances by individuals for both strategic and pragmatic purposes – that is to get work done. It is therefore inseparable from research, co-evolving with practice, policy and everyday life. Such a malleable concept of the ethical has implications for research policy, particularly concerning individual and collective responsibility. It also raises issues regarding the current points at which ethical dimensions might be considered in the research process.

Finally, in the concluding chapter (*Rethinking the ethical?*), I draw out the key argument of the thesis; that what comes to be demarcated as 'the ethical' is inseparable from the context in which it is produced and it is therefore often unpredictable. Here, I suggest that it is possible to identify at least two dynamics that emphasise this point. Chapters two and three point to macro-level structuring traits that structure and frame in broad terms, debates about what is or is not 'ethical'. A second operates at more tailored, individual, levels that emphasises the very tangible, personal and tightly grounded contexts of research life. Chapters five, six and seven demonstrate this second, local, level, emphasising the need to pay attention to the diverse ways that the ethical dimensions of research can be constructed, the ways that responsibility for addressing them can be distributed and the discursive and practical strategies that are involved in achieving this. I conclude by considering the possibility of achieving this within research governance.

Away we go.

Chapter 2

Bioenergy research, technology, controversy and policy in Britain

2.1 The height of a controversy

Liquid fuels derived directly from biological material, biofuels, have had a mottled history of development and deployment. In January 2009, the Biotechnology and Biological Sciences Research Council (BBSRC) established the BBSRC Sustainable Bioenergy Centre (BSBEC), a national research programme involving seven universities and research institutes as well as a number of industrial partners. This was a much-vaunted single largest UK public investment in 'second-generation' bioenergy research (BBSRC 2009). Six months earlier, in June 2008, the now defunct Renewable Fuels Agency (RFA) published the *Gallagher Review of the Indirect Effects of Biofuel Production* (The Gallagher Review; RFA 2008). Each of these activities came at the height of a controversy that emerged around the development and deployment of biofuels in the mid-2000s, bringing questions about the widespread and government-mandated development of biofuels to the forefront of societal debate.

In different ways, both activities responded to this controversy. The Gallagher Review was a key report to the British Government that came as a response to one of the key shifts in the biofuels controversy: Following concerns about biofuels' direct competition with food production, the need to attempt to account for impacts caused by Indirect Land Use Change (ILUC) emerged, stoked by the publication of two prominent articles in *Science* by Fargione et al. (2008) and Searchinger et al. (2008). The Gallagher review was fairly nuanced in its conclusions. Despite acknowledging the positive greenhouse gas (GHG) savings from 'advanced biofuels' (that made use of lignocellulosic material, for example), it suggested that it might be best to avoid technologically prescriptive policies, as advanced biofuel production methods did not automatically circumvent the displacement of other agricultural activities. Even the use of wastes and residues had the potential to compete with biomass resource demands from other sectors (e.g. heat and power generation) (RFA 2008, p.41). The

BSBEC programme was notable for its focus on 'second-generation' biofuels, which despite the above problems acknowledged in the Gallagher review, were positioned by many as being a solution to issues that had been raised by more traditional biofuel production methods. BSBEC also responded to trends in research funding for ethically controversial (bio)technologies by incorporating social science, agricultural economics, life cycle assessment and bioethical disciplines into the programme with a proportion of the funding being directed towards studies into sustainability, social and ethical aspects of bioenergy.

Like many studies of a similar ilk, this thesis employs controversies as a methodological resource to bring several oft-obscured dimensions of science and technology to the fore (Pinch, 2001). Indeed, this brief vignette tells us a lot about what debates about biofuels might offer. We can see that on the surface, significant debate hinged on the environmental credentials of biofuels and the ability to account for a range of greenhouse gas emissions. The heart of the controversy, which emerged in the mid 2000s, appears to be about epistemic issues; about what we can know and how we can know it. As controversies require, we can see that different groups might have different responses to these questions. If we read between the lines, it is possible to detect a nascent techno-optimism; that emerging technologies – 'second-generation biofuels' – might solve many of the problems of their now centenarian forerunners. It shows us that at least two actors, one governmental and one at arms length from government, were present within debates about biofuels and that the outcomes and responses to controversy were constrained by macro political structures, such as biofuel support policies. Of course, the vignette does not tell us everything. It does not, for instance, draw attention to the range of other parties involved. It also takes for granted the fact that debates were happening in technical terms, obscuring how this came to be, what this particular framing does, and what other concerns might be circulating. Finally, it doesn't explain why, despite the uncertainty about biofuels' credentials, research funders saw it fit to demonstrate that they were responsive to the sensitive nature of the field. It is these less-visible dimensions that the remainder of the chapter will seek to elucidate.

2.1.1 Motivations and structure

This chapter has three motivations. The first is *functional*, to show the value of the case for the project in hand, which examines the way that different groups construct the ethical dimensions of research and distribute responsibility for addressing them. The second is *methodological*; providing a significant amount of contextual detail helps to render the case comparable with others (Hammersley, 1992). As insinuated above, the third, *inquisitional*, motivation is to begin to generate insight for the first research question by examining the way that 'the ethical' is constructed within a specific technoscientific arena. To achieve these aims, the chapter traces the trajectory of biofuel research, development and deployment in the UK, grounding modern day incarnations in the late 1960s onwards. Its key argument, which I will return to at the chapter's close is that it is possible to delineate the emergence of a 'normative regime' (Pickersgill, 2012) within the field. This regime acts to structure the ways that concerns can be discussed, the actors that are able to discuss them, and ultimately the kinds of concerns that can be considered. To make this argument, I seek to demonstrate how particular ways of evaluating and making value-judgements about biofuels were prioritised (i.e. through varying forms of assessment), how different motivations pushed for their use, and how scientific, policy, and public actors have operated and intermingled within the field. It is structured as follows.

In the following section (*Section 2.2*), I provide information about the sociotechnical nature of biofuels and their production. Here, I emphasise the complexity in biofuel production, research and policy that makes them an excellent route to studying the implicit normativity embedded within particular and varying sociotechnical configurations. The remainder of the chapter unfolds in a broadly chronological order. To provide structure, I draw out four roughly distinct time periods. First, in the period 1971-2000 (*Section 2.3*), biofuels existed in a state of dormancy within the UK policy landscape. The British government began to develop a renewable energy programme during this first period but key policy makers and scientists helped to ensure that biofuels remained marginal within this agenda. Nevertheless, a nascent research community was emerging and systemic changes to the structure of research funding set the ground for a later programme when policy did eventually begin to change in the new millennium.

Next comes a brief transitional period between 2002 and 2003 (*Section 2.4*). During this time, the rise of a climate change agenda and a perceived need to lower emissions from transport were key in prompting a reassessment of biofuels as a technological option. The European Commission began to press for production targets. A range of key government reports and assessments were produced that recast biofuels' credentials in a more positive light. It is important to note that during this period no new major technological developments had occurred. Hopes were however placed on the capabilities of so-called 'second-generation' technologies, anticipated to be deployable in the near future. These narratives were vital in providing institutional space for the development of a publicly funded research programme.

Shared genealogical accounts commonly emerge amongst those working in fields of study and biofuels are a case in point; authors working with biofuels typically present standardised sequences of historical events that it is important to try to unpack. For example, examinations of biofuel development and deployment commonly adopt gazes that take the European promotion of biofuels, embodied in European Directive 2003/30/EC (European Commission, 2003), as the point of departure for analysis. They adopt a narrative which begins in 1900 with Rudolf Diesel exhibiting a combustion engine powered by peanut oil in Paris (Canakci and Sanli, 2008; Lewis, 1981), and which then draws attention to a period of extended senescence for bio-based liquid transport fuels because of a glut of readily available and cheap fossil fuel. Post-millennium biofuel developments are viewed as progressing along an initial trajectory of hope in which they were positioned as solutions to rural economic development, energy security and rising greenhouse gas emissions (Gamborg et al., 2011; Swinbank, 2009), before falling to become the centre of a controversy characterised by a 'food', 'energy' and 'environmental' trilemma (Mol, 2007; Tilman et al., 2009). The broad strokes of such a narrative are correct and the work that accompanies it important. Nevertheless, recent biofuel developments are perhaps best viewed as resulting from intricate interactions of ideas, discursive demarcations and political interests which are constructed and interpreted within particular institutional contexts (Palmer, 2010). These kinds of interactions matter. Thus, whilst the extended gaze here results in a lengthy text, such a historical grounding is important because it begins to make visible the kinds of negotiations, assessments and concerns that were being made and which serve to frame the present sedimented narratives, complementing recent work by Raman and Mohr (2013).

Following this grounding I explore the major UK biofuel- and biomass-related policies in the UK between 2003 and 2007 (*Section 2.5*). This period was both formative and turbulent; the silhouette of a debate began to be visible, policy drivers were strengthened from Europe and these fed into the agenda setting of research funders. By 2007 however (*Section 2.6*) a controversy had emerged and taken hold of biofuel development and deployment. Scientists, NGOs and policies were all embroiled and a range of claims about biofuels' various credentials circulated. The debate, policy and research were all fluid during this period, making it difficult to tease out causal links between interactions. This chapter therefore makes a significant effort to make key points discernable. I leave the narrative in the year 2012, which is when much of the empirical work was conducted. Of course, developments have continued. Perhaps most important is the rise of the notion of a bioeconomy and an increasing emphasis on the integration of biofuel production with forms of industrial biotechnology. The impact for the thesis will be considered in the final chapter as I take forward the findings from my analysis.

2.2 Sociotechnical configurations of biofuel production

The currently dominant definition of biofuels is as liquid fuel deriving directly from biological material. Here, the term biofuels is adopted as a form of bioenergy, energy derived directly from biological material. While first generation biofuels commonly depend on conversion of traditional agricultural crops, second-generation (or advanced) biofuels tend to make use of lignocellulosic (woody) components of these crops or non-traditional sources of biomass. Biofuels have occupied many niches in a wandering trajectory; they have seen extensive use as a lamp fuel in the US as

'Camphene', as biodiesel in China, and other countries with traditionally large crop surpluses (Kovarik, 1998). They have, however, been most visible as alternatives for petrochemicals, often coming to prominence in times of supply crisis or as means to support agricultural sectors. Most recently, Government policies have positioned biofuels as a solution to reducing carbon dioxide emissions from the transport sector (e.g. DECC et al., 2012). This latter use has attracted significant attention from academics, policy makers and a range of other actors. Below, I briefly overview biofuel production processes.

2.2.1 Introducing biofuel technology

Biofuels most commonly take the form of bioethanol or biodiesel although others, such as biobutanol are considered as potentially attractive fuels (Gressel, 2008). These fuels are not chemically identical to petroleum-based fuels that are standardly used in vehicles: they often have much higher oxygen content (between 10 and 44% versus nil for petroleum based fuels), a lower energy density, but may be higher octane than standard forecourt fuels (Canakci and Sanli, 2008; Demirbas, 2009). For simplicity, biofuels are differentiated by two major fuel types — ethanol and biodiesel — and by first and second-generation production pathways.

The different generations of biofuel have differing feedstocks, production pathways and co-products. First generation biofuels are produced by growing a generally sugary, starchy or oily crop to produce ethanol or biodiesel (S. C. de Vries et al., 2010). Waste streams or co-products can also be used. In the UK for example, a major source of biodiesel production is waste cooking oil and processes making use of coffee grounds are also being commercialised in densely populated areas (Smedley, 2014). The specific production pathway depends on the end-fuel type that is desired. First generation ethanol fuels can generally be produced in a two-stage process. First the starchy components of crops such as maize, wheat or sugarcane must be broken down, often through an enzymatic process. Second, the resulting sugar-rich mixture is fermented and distilled to produce ethanol (IEA, 2007). The complexity of production depends on the feedstock of choice, for example sugarcane requires only mechanical breakdown – i.e. crushing. First generation biodiesel is based on the transesterification of plant oils. This process involves extracting oil from the feedstock (e.g. oil seed rape) mixing the oil, a triglyceride, with a catalyst (generally a liquid base or acid) to produce glycerol and methyl esters (biodiesel) (Naik et al., 2010).

Second-generation (advanced biofuels) production routes seek to utilise non-starchy biomass, either from otherwise traditional crops, from waste streams or co-products or from dedicated plants. These production pathways insert additional steps into a first-generation route and again, are end product-specific. Two major pathways are distinguishable: a biochemical route and a thermochemical route. Lignocellulosic components of plants are structural, are largely indigestible, and resist catalysis; they are recalcitrant (Rubin, 2008). Therefore, biochemical pathways first physically (e.g. steam explosion), chemically (e.g. acid) or biologically (e.g. enzymes) pre-treat the biomass feedstock to expose cellulose & hemicellulose for a process of enzymatic hydrolysis that converts cellulose and hemicellulose components of the feedstocks to sugars (Zhu et al., 2010). Enzymatic hydrolysis currently commonly relies on enzymes derived from wood rotting microorganisms, such as *Trichoderma, Penicillium, and Aspergillus* which have high production costs (Sims et al., 2010). The resultant sugars can then be fermented to produce ethanol. Thermochemical routes (also known as biomass-to-liquids, BTL) use pyrolysis and / or gasification technologies to produce a synthesis gas (CO + H2) from which a wide range of long carbon chain biofuels can be produced using Fischer-Tropsch conversion, a well-established series of reactions commonly used to produce a range of petrochemical products (Sims et al., 2010).

Finally, two emerging configurations of biofuel production are important to acknowledge. First is the possibility of using liquid-based algae either as a source of biomass or as a means to produce liquid fuel directly (Singh et al., 2011). This approach can mobilise both macro- (e.g. seaweeds) and micro-algae (i.e. unicellular species). Second is the idea of the 'biorefinery' which, in a vision strikingly similar to that of the 1979 cartoon in chapter 1, intends to fractionate a range of biomass to produce high-value and bulk products (Menon and Rao, 2012; Taylor, 2008). Both approaches are in their nascent stages of development, but despite this a range of highly cited reviews of the field have positioned their development as both pressing and necessary to address a range of issues, including the land take of existing biofuel production chains, the development of a 'sustainable bio-based economy', as well as offering the existing promises of rural development, climate change mitigation and energy security (Demirbas, 2009; Mata et al., 2010; Menon and Rao, 2012; Zhang, 2008), essentially offering a panacea for the problems of "debatable land-based fuels" (Singh et al., 2011). Others, such as Taylor (2008; 2007) in a study commissioned by the UK Government, are somewhat less hyperbolic, outlining a range of production and sustainability challenges through to 2050. Although only one researcher in my study worked on algal biofuels, as we will see in later chapters, they are increasingly significant, particularly as they are seen to offer a route through which approaches from synthetic biology will be able to produce fuels (Georgianna and Mayfield, 2012; Lee et al., 2008).

2.2.2 Complexity in production, research and policy

The wide range of production pathways mean that biofuels are a varied and complex suite of processes, the details of which are now explored in more depth. Gallagher et al. (2006) define energy technologies as "the means of locating, assessing, harvesting, transporting, processing, and transforming the *primary energy forms* found in nature (e.g. sunlight, biomass, crude petroleum, coal, uranium-bearing rocks) to yield either *direct energy services*" (e.g. heat from biomass) or *secondary energy forms* (e.g. biofuels) (Gallagher et al., 2006, p. 194). All technological systems are necessarily engendered by complex sets of social interactions. Similarly, social interactions, norms and values are produced through and modulated by technologies (Pinch and Bijker, 1984). In this way technology and society can be said to mutually construct each other.

Each step in the biofuel supply chain is dependent on multiple and often spatially distinct sociotechnical configurations. For instance, between each step in production, transport and distribution networks must be developed. For most renewable energy technologies, the supply chain of usable energy from a primary energy source necessarily exists within a relatively narrow spatial and temporal context. This is not necessarily the case for bioenergy supply chains (both for electricity and fuel). To produce a given batch of biofuel, the primary energy source (light) must be converted by a biological feedstock. After harvesting, the resulting biomass may be stored or transported before being converted into fuel or electricity. For biofuels, additional steps are inserted, which are likely to further distance supply from end use. For the production of lignocellulosic biofuels for example, a range of different biological, chemical and physical processes are available for pre-treatment and conversion (Kumar et al., 2009; Menon and Rao, 2012; Sánchez and Cardona, 2008). Finally, recall that biofuels differ in composition to petroleum-based fuels. Modern engines are not fuel-indiscriminate and therefore cannot run on pure ethanol. Instead, bioethanol must be refined and blended with existing petrochemicals, usually to a maximum of 5-10% ethanol.

Each of the production steps draws on a range of technical knowledge bases, involving (for example) various groups of engineers, chemists, bioscientists, and environmental scientists. Research from the UK bioscience base most obviously fits into the biofuel supply chain at the points of feedstock production (e.g. breeding / optimisation) and catalysis (e.g. through pre-treatment and fermentation). These points of integration for bioscience research serve to highlight a second key aspect of biofuel production: Despite the fact that work into feedstock catalysis is likely to be biofuel-specific, there are a range of competing uses for biomass. The most obvious example of competition comes from other forms of bioenergy such as heat and electricity production, but other sectors, including the paper and agricultural industries make extensive use of biomass. Presently, bioscience research is often framed by visions of developing more 'advanced' biofuels but this potential should be viewed as but one use amongst a range of alternatives for biomass. For this reason, competition for feedstock has been and will likely continue to be a key point of contention in realising the potential of biofuels (BIS, 2009).

Finally, British governmental policy for biofuel (and bioenergy) production is also turbulent, complex and spans several departmental remits: renewable electricity generation; transport policy; pollution prevention; and control agricultural policy and; planning (Slade et al., 2009). Although biofuels and other forms of bioenergy converge around the point of feedstock, relevant policy instruments in these areas have traditionally been distinct and sometimes conflicting in their goals (Foxon et al., 2005). Regulatory regimes are overseen by a diverse range of authorities and bodies. The most prominent authorities to make a contribution to the bioenergy policy process are Government departments (Department for Environment, Food and Rural Affairs (DEFRA), Department for Business, Innovation and Skills (BIS)[1], and Department for Energy and Climate Change (DECC) and HM Revenue and Customs); non-departmental public bodies (Environment Agency, Research Councils); and quasi-autonomous Government agencies (Carbon Trust, Energy Saving Trust, Ofgem) (Slade et al., 2009). Further, as we shall see, over the years many parties external to government have helped to shape biofuel technology, policy and research.

Biofuels' fundamentally multiple nature has implications for a study sensitive to the ethical dimensions embedded within their development. Early assessments of biofuels' potential in the UK viewed them as complex and dependent upon many components that were subject to, for example, price and availability fluctuations, helping to make them an unfavourable option. Modern assessments, however, shifted, positioning biofuels as an easy intermediate option, that was able to utilise existing petroleum infrastructures, on the transition to a hydrogen or electricity based transport system (e.g. IEA, 2004). In doing so, however, such assessments often neglected the wide range of biomass production infrastructures that are required (Adams et al., 2011). Indeed, some have suggested that the especially complex nature of supply and production means that conventional support mechanisms for renewable energy are unlikely to be successful for biomass-based energy (Thornley and Cooper, 2008).

Different technological configurations embed differing requirements for control, distribute costs and benefits varyingly (Winner, 1986a), and engender different kinds and level of risk (Perrow, 1999). Both Winner and Perrow intentionally mobilise nuclear energy as a most extreme case in point; that always demands high levels of

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[1] Government departments in the UK have a turbulent genealogy. Energy policy and public research oversight has for the majority of this discussion been overseen by Department for Trade and Industry (DTI), aside from a stint of time from 1974 and 1992 when it was the remit of the Department of Energy. In 2007 DTI was divided into the Department for Business, Enterprise and Regulatory Reform (DBERR; responsible for energy policy), and the Department for Innovation, Universities and Skills (DIUS; oversight of the science budget). These were later re-merged into a unified department, the current Department for Business, Innovation and Skills (BIS) but responsibility for energy policy became the role of the Department for Energy and Climate Change (DECC).

authority and always embeds complex and tightly coupled interactions that produce unknowable risks. The majority of technologies however are not so clear-cut. Biofuels may for example, be more or less spatially distributed, deployed at larger or smaller scales, make use of different conversion processes and different types of land. They might involve transgenic techniques and novel crops or they might make use of wastes, such as used cooking oil, coffee grounds or forestry residues. Add to this that they might be assessed in one of many understandings of sustainability. Furthermore, research has shown that various scientific cultures can be very different (Knorr-Cetina, 1999), with different standards of measurement, different margins of error and different modes of social interaction, and different forms of legitimacy (C. A. Miller, 2001). When these two points are taken together, it is clear that different modes of knowledge production and envisaged sociotechnical configurations are very tightly coupled to a range of value-judgements and visions and ways of distributing responsibility that underpin debates about said technology. All systems make trade-offs. Finally, the biofuels' heterogeneity means that whilst differences may be mobilised in debates about biofuels, producing conflicts, few parties appear to be wholly opposed to *all* production systems (Boucher, 2012; Raman and Mohr, 2013). Consequently, when departing on empirical research in the field it is important to interrogate the relationship between different ways of knowing and different value-judgements, and the variety of production system that actors advocate and oppose.

My focus in the following sections centres on the dominant policy discussions in the UK. As such, I largely discount alternative forms of bioenergy and international developments. Two exceptions come in the form of discussions about feedstock, which also tie into alternative uses of biomass, and in relation to post-2000 developments in the European Commission, whose decision making has fundamentally driven the more recent UK policies, although not always with commensurate goals to those established at national level. This narrative is inevitably complex and is comprised of many policies and actors. To help guide the discussion, I present a diagram of the main policy instruments and policy-relevant reports that feeds into the discussion on the previous page (*Figure 2.1*). My advice would be to fold the corner of the page over or bookmark it for reference in future sections.

2.3 Biofuels' slow rise (1971 – 2001)

In a number of other situations, most notably in Brazil since the 1970s, biofuels have seen significant use, but in the UK the first significant production and consumption of biofuels since the 1940s occurred in 2002 (Bomb et al., 2007). Up until this point, biofuels had been held in a position of 'relative obscurity' as a suite of largely marginal and niche technologies (Boucher, 2010). This section describes the

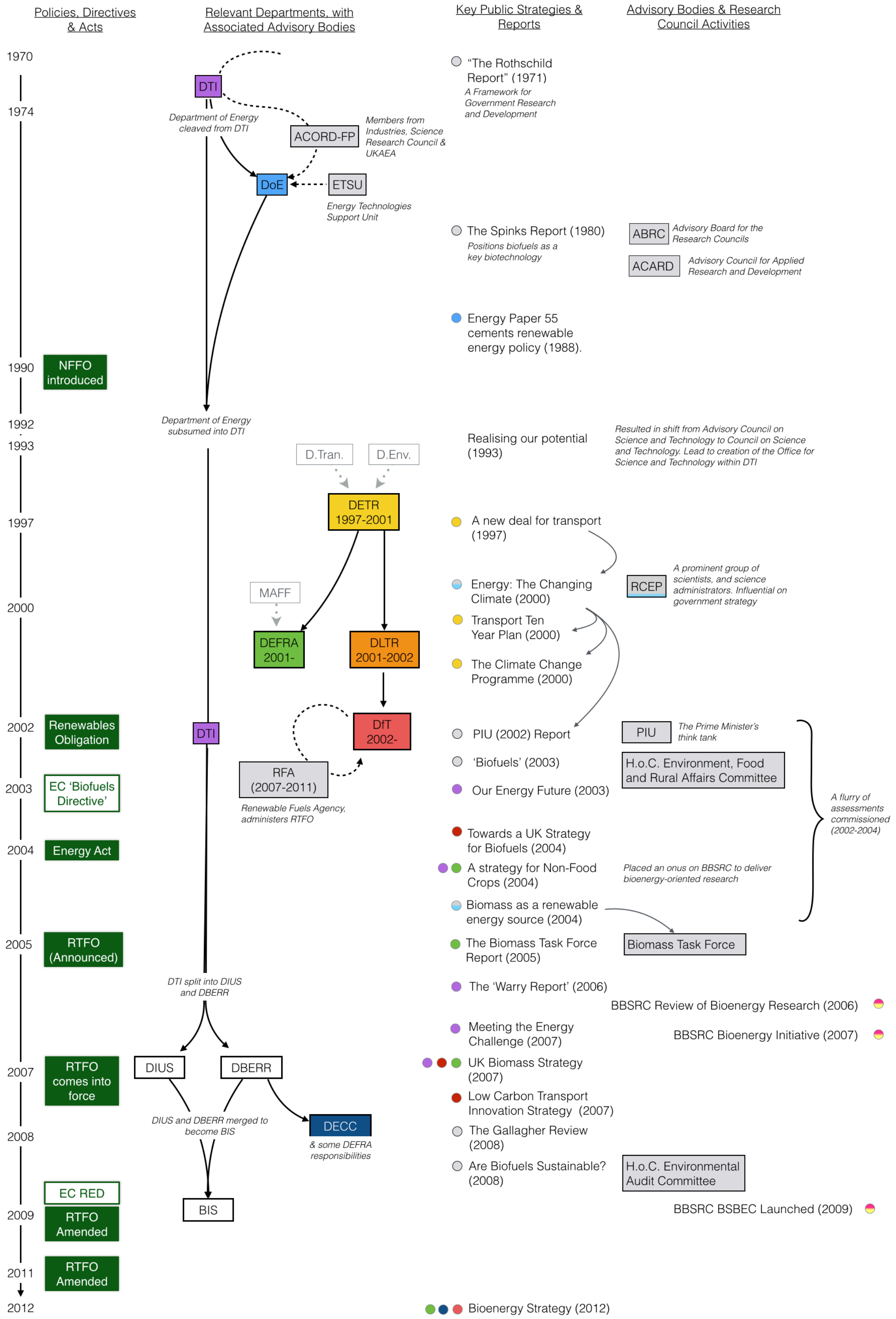

Figure 2.1: *Overview of key biofuel-related developments, parties and policies discussed within the chapter (1971-2012). Relevant abbreviations are provided in the prose. Colours within circles correspond to the authoring department / committee (pink/yellow represents research councils; sky blue represents a report lead by academics)*

discussions and decisions that initially side-lined the deployment of biofuels in the UK and that then eventually facilitated their rise up the policy agenda. Two central goals of this discussion aim to highlight the extent to which technological development and deployment in renewable energy has been explicitly tied to and shaped by political decisions and the ways in which the actors within the research community are implicated in the political discourse. To achieve this, it seeks to emphasise three key points.

First, the present heterogeneity of policy, technology and values, did not emerge until production of biofuels became a concerted policy goal. Instead, regulation of biofuels was most closely tied to renewable energy policy: since biofuels were not encouraged there were no relevant transport, waste or land use policies to consider. Second, it is important to see British renewable energy policy as part of a techno-scientific-industrial complex: In 1972-73 the Department of Energy oversaw research budgets (largely directed towards the nationalised energy industries) of over £103m (£1.3bn in 2014 prices) (Fishlock, 1974) with prominent scientists such as Walter Marshall acting in powerful policy advisory roles, such as Chief Scientific Advisor (Fishlock, 1975). These parties assessed other energy technologies, such as geothermal energy, wind turbines and landfill gas capture, as being less complex, more promising, more suited to national needs and more economically viable. Thus they commanded the lion's share of public research funding and public policy attention. Finally, despite their marginal status in the period 1971-2000, a biofuel research community was emerging, drawing partly out of the development of biotechnology in the middle of the century, and fermented by changes to the rationale for research funding which would formally place visible returns on investment as part of the contract for obtaining public money.

2.3.1 Early renewable energy policy and assessments of technologies

The British renewable energy programme has its roots in the 1973 oil price spikes that shot energy policy up the agenda and prompted the cleaving of responsibility of this area from the Department of Trade and Industry into the newly formed Department of Energy. Coupling this global crisis with a rising environmental movement stimulated a general debate around energy and also refocused attention to the need to seek alternative forms of energy as 'failsafe' options in times of uncertainty (Wilson, 2012) by instigating a renewable energy programme, with preference going to those technologies with the potential to become economically competitive (i.e. those closest to market).

Two groups are of notable significance in the history of both UK renewable energy policy, and research and development. The first of these was the Advisory Council on Research and Development in Fuel and Power (ACORD-FP), which predated both the Department of Energy and Department of Trade and Industry that the former was cleaved from. Established in 1960 to advise the secretary of state for power, its membership comprised representatives from nationalised coal, gas, steel and electricity industries, as well as from the public research bodies such as the Science Research Council (SRC) and the UK Atomic Energy Authority (UKAEA) (Wilson, 2012, p. 78). Its role however, was largely viewed as one of a rubber stamping agency for the nationalised industries until powers were renegotiated following the creation of the second key group, the Energy Technology Support Unit (ETSU), in 1974 (Wilson, 2012, p. 79). Under this renegotiation, ACORD-FP was to act as an oversight and coordination committee for ETSU (Wilson, 2012, p. 93). Those laying the foundations for ETSU envisioned it as an 'advanced energy technology institute' but when finally established, its terms of reference and annual budget (ETSU's £200,000 vs. a UKAEA 1972-73 research expenditure of £64,000,000) made it clear that it was primarily to advise the Department of Energy, by producing research-focused reviews with a view to making decisions about which technological trajectories to publicly pursue (Wilson, 2012, p. 87).

During the 1970s, research into wave power dominated publicly-funded renewable energy research. A key point, however, came in a March 1982 meeting when ACORD-FP determined where best to direct limited resources towards renewable energy development. In doing so they covered a list of 12 existing programmes: Passive solar design; solar water heating; active solar space heating; geothermal aquifers; geothermal hot dry rocks; a range of bioenergy options (combustion, anaerobic digestion for animal waste, anaerobic digesters for vegetable materials, thermal processing); onshore wind power; offshore wind; and concluded with a discussion of wave power (Wilson, 2012, p. 122). Each technology group was ranked in terms of economic competitiveness and a decision "to abandon further development work on off-shore wave and wind power, active solar and biofuel thermal processing" was taken (National Audit Office, 1994, p. 13).

The flagship research support mechanism - the renewable energy research, development and demonstration programme - was 95% administered by the Department of Trade and Industry through the Energy Technology Support Unit (ETSU), and by 1994 had cost £232m (National Audit Office, 1994). Although some bioenergy development was supported in this period, funds were predominantly channelled towards landfill gas collection: £4,012,000 between 1979 and 1993 (National Audit Office, 1994, p. 16). Over a third of the remaining development support funding was allocated to just three technologies: 'hot dry rocks', the Severn and Mersey barrages and 'vertical axis' wind turbines. By 1993, the only major research support from DTI towards biofuels had come in the form of two reports on bioethanol (in 1987 and 1990) and one on biodiesel (in 1993) from ETSU, despite recognition of their potential to make use of set-aside land, to large economic benefit (Healy, 1994; POST, 1993). Essentially, decision makers viewed biofuels as economically expensive, as well as technically and environmentally uncertain. This position was reiterated by the Parliamentary Office of Science and Technology

(POST) in their 1993 Biofuels POSTnote, which specifically drew attention to uncertainties about their energy balance, environmental impacts and the economic case, and further emphasizing that "future trends in the UK will be influenced by DTI support for research and development".

The UK's renewable energy programme was cemented by Energy Paper 55 (Department of Energy, 1988) and by 1991 Government policies for renewable energy began to be framed by the now familiar triad of desires to achieve "diverse, secure and sustainable energy supplies [energy security]; reductions in the emission of pollutants [environmental benefits]; and encouragement of internationally competitive renewable industries [economic development]" (National Audit Office, 1994, p. 5). In 1990 the Non-Fossil Fuel Obligation (NFFO) order was introduced. Although originally intended to support the publicly-owned nuclear industry following privatisation of the rest of the electricity sector, the NFFO also provided limited support to renewable electricity generation. The NFFO worked by redistributing a levy paid by electricity generators to renewable electricity suppliers. The price paid was technology-specific, following a competitive bidding process (Thornley and Cooper, 2008).

The role of the transport sector in addressing climate change

During the 1990s, both climate change and transport rose up the policy agenda. In 1997 the European Union adopted the Kyoto Protocol and the Department of the Environment, Transport and the Regions (DETR) produced the first transport white paper in twenty years (DETR, 1997). During the 1990s, climate change was framed largely as an energy issue meaning that to a large extent its mitigation was seen to depend on reform of energy production and consumption, thus the two policy agendas converged (Lovell et al., 2009). Additionally, the trend of positioning government support for science as necessary for the successful development of technology continued throughout this period – something that has now been well documented. In 2000, the influential (but now defunct) Royal Commission on Environment Pollution published their report 'Energy - The Changing Climate' (2000 RCEP). The report was produced by a committee of prominent scientists, and chaired by Sir Thomas Blundell, then Chairman of the Agriculture and Food Research Council and subsequently chief executive of BBSRC. It is somewhat unsurprising then that the report was concerned about declining public funding for energy research between 1974 and 1997 and recommended that government rectify this by using research funding to support and stimulate the development and environmental refinement of new technologies, including into energy crops.

Following Kyoto, the headline recommendation of RCEP's report was that the government should pursue a 60% cut in CO_2 relative to 1990 levels by 2050. The report considered the role of biomass in achieving this reduction. One of its core recommendations was that growing crops for energy purposes should be regarded as a primary use of agricultural land (i.e. on a par with food production) and that policies and support measures should be orientated towards achieving that. Significantly, the committee questioned the ability of efficiency improvements and congestion reduction to meet the government's aims of reducing CO_2 emissions by 2.7 million tonnes of carbon (MtC) per year that had been set out in the previous Transport White Paper (DETR, 1997). Even if efficiency reductions were successful, RCEP predicted that there would still be an extremely large demand for a "readily portable energy source with a high energy density and power density suitable for propelling personal vehicles" (RCEP, 2000, p. 157). This would be technically-challenging to replace. Despite these gaps, and if one were sceptical, perhaps to justify their perceived need for research, the committee continued the trend of failing to see biofuels as a viable solution, instead arguing that reducing the particulate emissions from diesel would make it an increasingly environmentally-favourable option over petrol:

> "[Biofuels] can be polluting, and in some cases have a high energy requirement (7 .77). To produce biofuels on a large scale a large area of land is needed to grow the crops. It is unlikely that sufficient land could be found for this purpose in the UK, especially if (as seems a more promising approach) large areas of land are to be devoted to growing crops to provide energy in the form of heat. We do not therefore regard biologically produced fuels as a valid option for large-scale use in transport in the UK in the foreseeable future" (RCEP, 2000, p. 157).

Later, and stemming from a Labour manifesto commitment, the White Paper, 'A New Deal for Transport' therefore acknowledged the role of the transport sector in addressing climate change and followed RCEP's recommendations: Overall emissions reductions were intended to be achieved by reducing tailpipe sulphur emissions, European-mandated efficiency savings and increasing fuel duty to discourage driving and stimulate the use of public transport. In short, biofuels were to play no role; efficiency and reduced use were seen as sufficient. Similar commitments were later made in direct response to the Kyoto Protocol when announcing the *Climate Change Programme* (DETR, 2000a) and when outlining the *Transport Ten Year Plan* (DETR, 2000b). Let us now look at the research funding landscape.

2.3.2 Realignments in research funding

In order for biofuel research to make it onto the agenda of the research councils, a change in the rationale for research public research funding first needed to occur. Therefore, the move towards funding large-scale and 'strategic' research programmes, of which biofuels and bioenergy are one, should in part be seen in light of increasing pressure to demonstrate value for money and a socio-economic return on public investment. The UK public research funding arena is known for two characteristic features. The first of these is the often vaunted, but likely spurious (Edgerton, 2009), 'Haldane Principle' whereby academics independently set their own research agendas. The second is the presence of a dual-support funding mechanism of core funding from Higher Education Funding Councils and project-based funding from non-departmental public bodies, the research councils. However these cornerstones, presented to shield research from political influence, have not prevented tensions regarding government returns on investment occasionally being aired with often controversial outcomes (Morris, 2000).

One such 'controversial outcome' is an at least perceived increasing focus on 'prioritised', 'strategic' or 'applied' research. Much has been written on this but there has been a palpable and particular furore within academic communities regarding changes to the research evaluation mechanisms that help to determine core funding allocations in universities (e.g. See Demeritt, 2010). A singular object of scorn is the notion of 'impact' – whereby academics are encouraged to emphasise the social, economic or policy benefits that their research might bring. These contemporary developments have a long lineage, and one could arguably trace them back beyond the Twentieth century (e.g. See Gibbons and Gummett, 1976; McLachlan, 1978) but commentators more readily emphasise the importance of two recent reports Realising our Potential of the 90s (HM Government, 1993) and the 'Warry Report' of 2006 (DTI, 2006a). A more modest undertaking, but relevant here, grounds the start of the narrative in a number of fundamental changes that occurred during the 1970s and 80s when OECD governments started to reduce public funding and "re-think the rationale for public support of research, [with the consequence that] universities have reformulated their missions and management to demonstrate economic and social benefits, to comply with tougher notions of accountability, and to interact more closely with sponsors and users" (Morris, 2000, p. 425).

In the 1971 report, 'A Framework for Government Research and Development', Lord Rothschild, head of the Prime Minister's 'think-tank', alleged that concepts of scientific independence advocated in the Haldane Report were no longer relevant to a contemporary discussion of government research (Lord Rothschild, 1971). Instead he expounded that the customer-contractor principle be expanded from departments such as the Ministry of Defence to public research funding. This principle positioned the research base (largely the Research Councils and Universities) as contractors to supply research for government representatives (i.e. Departments or chief scientists). Although a later White Paper accepted that the research councils should be preserved, the Rothschild report helped to cement discussions about the accountability of the research community in receipt of public financing (de Chadarevian, 2002, p. 339).

The 1980s saw a number of further changes. Firstly the public sector as a whole began to be reformed to incorporate management structures which at the time were more commonly seen in the private sector (Morris, 2000). Secondly, questions about research prioritisation came to light once more and research councils began to produce corporate plans. Somewhat unsurprisingly, the application-oriented Agriculture and Food Research Council (AFRC, later BBSRC), was first across the line (AFRC, 1983). Thirdly, research funding shifted from one which was based on an "agreed volume of research" to one which applied strict cash limits. As such, by the late 1980s the government had established that it wanted more specific returns from publicly-funded scientific research. To achieve this, it established powers for universities to make use of research by encouraging entrepreneurial activity and improve links with industry (ACARD and ABRC, 1983).

Now 'Realising our potential', published in 1993, was significant in that it resulted in the explicit insertion of a commitment to economic development into the charter of all research councils (Demeritt, 2010) and expanded government's ability to manage research agendas by creating the Office for Science and Technology, bringing semi-autonomous regulatory capacity into government departments (Morris, 2000). However many of these changes had previously been set in motion and by the time of its publication were well-established realities of a more economically liberal government: "governments had [already] identified a policy for science to confirm their focus upon national economic benefits, to set the boundaries within which research councils would operate, and to take closer control of the machinery through which public funds are distributed" and the research councils had largely accepted this (Morris, 2000, p. 427). Crucially for the current narrative, the emphasis that was placed on contributing to economic development meant that science had to be more closely linked to technology, making university links to industry increasingly important (Calvert and Patel, 2003) and tying research agendas more closely to technologically-based public policy goals; trends that would continue to intensify into the Twenty-first Century as research councils began to search for ways to increase productivity, accountability and demonstrate returns on investment. This meant that when renewable energy policy shifted at the turn of the century, the research councils would be required to mobilise a research community that was beginning to develop during the latter half of the Twentieth Century, which I shall now introduce.

The structural and motivational renegotiation of public research funding during the 1970s and 80s sit in parallel with attempts to establish biotechnology as a formal policy category. Although government favoured alternative forms of renewable energy technology during this first period in question (1971-2001), not all were so sceptical and an embryonic domestic research community was beginning to grow. The rise of biotechnology during the 20th century had provided space within the mind-sets of western societies for a vision of technology that might make better use of existing environmental resources than could be achieved simply burning or combusting them. The production of energy was a key part of this vision (Bud, 1994, pp. 141-162). To this end, the Advisory Board for the Research Councils (ABRC), The Royal Society and the Advisory Council for Applied Research and Development (ACARD) published a key report during autumn 1979 (the Spinks report; 1980). It placed the production of biofuels as one of the key areas for biotechnology research amongst the development of a number of others, including general applications for genetic engineering, monoclonal antibodies and immunoglobulins and waste treatment. The Government response was dismissive of the majority of the recommendations of the Spinks report (Sharp et al., 1989), and as a whole, the Science and Engineering Research Council (SERC) and the Medical Research Council's (MRC) focus towards bioenergy was comparatively limited. Where funding was given, it was generally to forms of bioenergy other than liquid biofuels. Nevertheless, in 1981, the UK's first dedicated biomass research journal, *Biomass* (now *Bioresource Technology*), was established with a first issue editorial that was cautiously optimistic about biomass,

> "Limitless although the possibilities are, reality must be kept in sight. Biomass will compete with other energy sources and other feedstocks, some fossil, some conventional and some yet to be developed. The nature and extent of the role of biomass will vary from region to region and from case to case. At all times emphasis must be laid on economic realities, energy balances and socio-political implications, all of which we hope in due course will be dealt with in the pages of this journal." (J. Coombs and Hall, 1981, p. 2)

Along with the flagship journal Energy Policy (established in 1973), Biomass provided an outlet for researchers working with a focus towards bioenergy. Within, articles questioned and debated the assumptions in methods for determining the energy balances of biofuels (Chambers et al., 1979) and the role of fundamental biological research in developing future biomass technologies (Rabson and Rogers, 1981). In years following the Spinks report, these and a number of other journals provided an outlet for a number of research centres that were beginning to develop, notably at the University of Strathclyde, the University of Birmingham, Aston University and Kings College London. This nascent community also found a surprising ally in the form of parts of the Alternative Technology movement, which had emerged in the 1960s. Although perhaps ideologically unaligned with many of the ideals embedded within the biotechnology trajectory, they too appeared to foresee a role for biofuels in future transport systems. For example, a 1977 Centre for Alternative Technology report, co-authored by David Hall and with a preface by the Astronomer Royal, argued that "new means of utilising present-day photosynthesis" were required and suggested that by 2025, liquid biofuels and synthetic fuels might account for approximately 40% of all road transport propulsion (Todd et al., 1977, p. 13).

Prior to 2003 then, the primary vision for biomass use in the UK was for heat and electricity generation. Government incentives during the 1980s and 90s focused on the development of biogas from landfill and municipal solid waste. Towards the end of this period, policy makers began to envisage an increasing role for dedicated bioenergy crop systems, but with the explicit purpose of supplying electricity production (e.g. DTI, 1999). The possibility of using biofuels as a transport fuel had been raised in policy-relevant discussions throughout the 1970s, 80s and 90s but assessments, often produced by the scientific community, had tended to view their potential as limited because of problems with domestic land availability in the UK (especially if electricity generation were to be encouraged), problems with pollution release during processing and production, uncertainties about energy balances and apparently more enticing alternatives for transport. Significantly, many of the questions and possibilities surrounding biofuels' credentials about energy balance, environmental impacts, public concerns and land availability were raised during this period (Chambers et al., 1979; POST, 1993; Walker, 1995), with the methodologies for considering them also being established.

The assessments and political decisions of the 1970s, 80s and 90s therefore helped to keep biofuel technology in a marginal position. However, changes that occurred in relation to the public funding of research, and pushes from advocates of biotechnology during this period helped to ferment a nascent research community. It was the fostering of this small community of researchers that significantly shaped the later constitution of the biofuels research field in the UK, forming the 'core-set' (Collins and R. Evans, 2002) expertise to be mobilised[2], and supplemented with a range of interloping plant scientists, by research funders as they sought to develop a coherent bioenergy research programme in later years. Furthermore, and as we will repeatedly see later in the thesis, the boundaries of this 'core-set' were less stable than is traditionally conceived; various scientists blurred the roles of policy makers, advocates and knowledge producers. In the first years of the new millennium, biofuels as a liquid fuel for transport would rise up the policy agenda. Significantly, no new major technological developments emerged to alter assessments. Instead, what began to change was the scientific, geopolitical and economic context that lead to more emphasis being placed on greenhouse gas reductions and biofuels being compared more favourably to petrochemicals (Boucher, 2012; Carolan, 2010; Gee and McMeekin, 2011).

2.4 Biomass use expands and biofuels become a viable option (2002-2003)

In this transitional period between 2002 and 2003, reticence about the utility of biofuel production system began to ebb. This was in no small part a result of

[2] For example, Aston University would be awarded the EPSRC Supergen Bioenergy Hub

developments at the level of the European Union (*section 2.4.2*) but projections about the continued growth in emissions from the transport sector and the inability of efficiency savings to curtail that brought biofuels onto the agenda. A flurry of assessments and reports were produced, employing evolutions of the methodologies developed in the previous period. In particular, Life Cycle Analysis (LCA) began to take hold as the dominant model of evaluating biofuels' environmental credentials, defined in terms of energy and greenhouse gas balances. Once again, academics, both elite and mainstream, were central to these assessments. As we will see (*section 2.4.1*), technical assessments often produced divergent conclusions, but rather than using this to provide insight into the assumptions and underpinning theories that went into them, they were used in varying capacities to support policy positions. The final important dimension to highlight the increasing binding of knowledge, policy and research comes in the observation that a number of prominent assessments caveated their projections for biofuel penetration and credentials on the development of technological advances. A significant shift was that instead of this coming from departmental budgets, 'fundamental' but directed research was claimed necessary. Many of the developments within this brief period set the tone for what was to come.

In 2002, the Renewables Obligation (RO; 2002) and the associated capital grants scheme built on the NFFO to expand the support given to bioenergy deployment in the electricity sector. Despite the value of storable generation capacity that biomass energy as a whole might offer, these policy instruments were largely unsuccessful in promoting the growth of biomass crops: By 2005, only 7 of the 22 proposed biomass energy projects under the NFFO were operational (van der Horst, 2005). This backdrop — of failure and a perceived need to act on climate change — meant that policy makers in Europe and the UK were beginning to view the use of biomass to produce transport fuel as an increasingly saccharine option. At the time, transport accounted for around 25% of the UK's total carbon emissions and was the only sector whose emissions were predicted to continue rising into the 21st century. As such, by 2002, DTI, DEFRA and the newly re-established Department for Transport (DfT) had each begun commissioning studies on the potential for biofuels to help meet carbon-reduction targets in the transport sector. DfT was especially active, commissioning a range of analyses, mainly focusing on biomass resource availability, energy balances, greenhouse gas balances and cost. Although a hydrogen-based system was envisioned as the long-term 'dream ticket', previously aired concerns about the limits of efficiency savings had begun to be taken seriously and an intermediate option was needed.

Two notable government-produced reports were published in this period. The first was produced by the Performance Innovation Unit (PIU), which operated as the Prime Minister's strategy unit. Its 2002 report framed energy policy in terms of energy security and emissions reductions in tandem with the protection of economic development (Performance and Innovation Unit, 2002). PIU adopted RCEP's recommendation for a 60% cut in emissions and noted that transport would need to contribute to this. This was one of the first times that biofuels were talked about substantially and more favourably than bioenergy for the electricity sector in government policy discussions. The report, however, placed a limited, niche role on them, primarily as transitional fuels and highlighted problems with land availability in the UK meaning that there would be a dependence on imports. The second, published in 2003 was the White Paper 'Our Energy Future - Creating a Low Carbon Economy'. Although also cautious about land availability and environmental impacts, it was generally positive about the use of biofuels as part of the transport fuel mix. It suggested that biofuels might offer "a potential route for achieving the goal of zero-carbon transport, creating new opportunities for agriculture" (DTI, 2003, p. 69). To support deployment, the White Paper acknowledged the 20p per litre reduction in excise duty for biodiesel that Gordon Brown, then Chancellor of the Exchequer, had announced in his Autumn 2002 pre-budget report (HM Government, 2002). It recommended that this tax cut also be applied to bioethanol production (enacted in 2005). Continuing previous trends, the PIU report again placed research and development as central to a reduction in carbon emissions. Based on the recommendations of a review lead by the Government Chief Scientific Advisor, Sir David King, it proposed establishing a research centre for energy, drawing parallels to discussions in the early 1970s for an 'advanced energy technologies institute' that eventually became ETSU.

2.4.1 Technical assessments and second-generation hopes

Strategies and policy announcements were underpinned by a range of commissioned assessments. These were often conducted by academics operating as members of teams internal to government or on a consultancy basis. Unsurprisingly, they often continued to recommend an increase in research funding with a view to produce novel or lower impact renewable energy technologies. The PIU report's recommendation that research and development were central to a reduction in carbon emissions and that the government might establish a research centre for energy were underpinned by a review lead by the Government Chief Scientific Advisor, Sir David King (Chief Scientific Advisor, 2002). His report recognised the steps that the government "was already taking to encourage innovation and the transition to a low-carbon economy" but placed "particular emphasis on the importance of building a strong base of fundamental research activity", including socio-economic work (Chief Scientific Advisor, 2002, p. 1). Such reports helped to provide a mandate for a more government-directed basic research programme into energy.

The November 2002 pre-budget report referred to various assessments of the greenhouse gas, energy balances and emissions performance of biofuels (A. P. Armstrong et al., 2002; L-B-Systemtechnik GmbH, 2002; Reading et al., 2002). One

DfT-commissioned Life Cycle Analysis (LCA) positioned biofuels as a favourable intermediate option (Eyre et al., 2002). Contradicting previous analyses, this report produced the headline figure that 25% of UK agricultural land could satisfy the country's transport fuel demands. Other assessments were less certain. The previously mentioned consortium, led by General Motors (L-B-Systemtechnik GmbH, 2002), produced an LCA using a range of proprietary models for analysis. Although broadly hopeful about the prospects of biofuels, the report was tempered in its conclusions noting that biomass-derived fuels showed "the highest complexity, and the widest range of results depending on the applicable cultivation method, fertiliser use, soil and climate conditions. The selection of appropriate pathways for widespread implementation [would] require careful selection of the suitable farming practice, climatic condition and soil property" (L-B-Systemtechnik GmbH, 2002, p. 25). Furthermore, of the eighty-eight fuel-drivetrain combinations that they examined, only hydrogen-based fuels had a significant GHG reduction. AEA Technology (2002) concluded that the lowest-cost routes for the UK would be to import refined biofuels from abroad rather than to import feedstocks and various intermediate products for refining. Under this 'lowest cost scenario', the minimum biofuel price would still be 40% higher than petrochemical equivalents, and this price was recognised as being subject to a wide range of sensitivities and uncertainties. In line with the General Motors consortium, the report went on to question a range of other environmental impacts that may be associated with biofuels, including water intensive production, nutrient requirement, land requirement, other environmental impacts associated with biofuel production such as N_2O emissions from fertiliser use, impacts on soil and groundwater quality, eutrophication or toxification of ecosystems through pesticide use, and reduction of biodiversity (AEA Technology, 2002, p. 36).

LCAs produced externally to government departments became cornerstones in the evaluation of biofuels. Taken together however, these assessments often produced conflicting and sometimes directly contradictory recommendations because of implicitly varying normative commitments, and different methodological assumptions. The AEA report drew attention to the variation in experts' assessments, comparing commissioned analyses produced by academics at Imperial College London (Woods and Bauen, 2003) and Sheffield Hallam University (Elsayed et al., 2003). The former concluded that because biofuel production routes were generally energy intensive, it would only be possible to achieve significantly favourable energy balances if production was extremely efficient, utilising biomass residues to produce energy, and if calculations recouped energy by allocating it to co-products of biofuel production (AEA Technology, 2002). The latter assessment, however, concluded that in general the CO_2 and energy balances of biofuels were highly favourable. Similar assumptions underpinning such knowledge claims would become perennial features of disagreements about competing knowledge claims in the years to come.

During this period groups also began to pin their hopes on novel, 'second-generation' technologies. Recall that these approaches aim to make use of inedible plants or the inedible parts of crops by converting their lignocellulosic (woody) components. The technologies were, and largely remain, commercially unproven and uncompetitive with first generation production as a result of a range of economic, technical and infrastructural barriers (Sims et al., 2010). Nevertheless, analysts took seriously the suggestion that a wider range of feedstocks would be available for production chains, quelling some of the previous concerns about biofuels' sensitivities to feedstock price fluctuations, their competition with food production and their debatable greenhouse gas savings (Boucher, 2012). Unproven second-generation technology was therefore built into forecasts. The Eyre (2002) analysis caveated it's claims about land availability on the ability to make use of the woody plants and woody components of existing crops. Similarly, the PIU (2002) report limited its vision for the role that biofuels could play without the development of lignocellulosic biofuels: PIU's scenarios envisioned a major role for hydrogen post-2020, noting that biofuels would only be widely available if a significant proportion could be developed from woody biomass. Even then, there would necessarily be a large reliance on imports:

> "The use of ethanol from biomass in advanced hybrid engines is one of the few configurations which could come close to the low carbon potential of fuel cells. In the short term, the use of biofuels in transport is constrained by the availability of suitable agricultural land, crop yield and the demand for biomass for other uses. From UK production, biofuels could provide niche markets and contribute to wider markets, but are unlikely to supply most UK road transport fuel. In the longer-term, new technologies that widen the range of crops suitable for liquid fuels production could change this. [i.e. production from waste and woody crops.] Wider adoption would depend on the development of these options and/or expansion of the international market." (Performance and Innovation Unit, 2002, pp. 86-87)

These two trends of scientisation of policy (Weingart, 1999) and techno-optimism (Weinberg, 1990) continued throughout the 2000s to shape the format of future disagreements. During the controversy, opposing sides often produced their own assessments and energy and transport scenarios. Equally when Jean Ziegler - who was at the time UN special rapporteur on the right to food - later claimed in 2007 that biofuels were "a crime against humanity", his five year moratorium was based on the hope of scientific progress: "in five years it will be possible to make biofuel and biodiesel from agricultural waste", an estimation now clearly visible as grossly optimistic (Lederer, 2007).

2.4.2 Interlude: European policy at the turn of the century

To conclude this section, I now briefly turn to developments within the European Commission. As stated at the outset of the chapter, UK policy making discourse needs to be situated in relation to European developments since it is these that are largely seen as providing a mandate for biofuels use across the continent. As discussions about biofuels' place in the renewable energy mix were emerging in the UK, the European Commission was also formulating policy. The UK would be bound to the outcomes of these discussions, whether or not national regulatory frameworks were aligned (Slade et al., 2009). A number of continental European nations have historically pursued biofuel development much more ambitiously than the UK and although a draft European Directive to provide a 10% excise duty rate to biofuels was discussed in 1993 (POST, 1993), current European policies stem from discussions at the turn of the century. In 2000, a European Commission Green Paper recommended that alternative energy sources, including biofuels, should be developed by 2010 (European Commission, 2000). Alongside recommendations from the European Climate Change Programme (ECCP), this paper helped to pave the way for subsequent renewable electricity and biofuel directives which would later be introduced in 2003 (Afionis and Stringer, 2012).

The European Directive on the promotion of the use of biofuels and renewable fuels for the transportation sector ((2003/30/EC); European Commission, 2003) was framed by a triad of reducing GHG emissions, improving energy security and promoting rural development. It committed individual Member States to targets for biofuels as part of the fuel mix from a possible ten types: bioethanol, biodiesel, biogas, biomethanol, biodimetyleter, bio-ETBE, bio-MTBE, synthetic biofuels, biohydrogen and pure plant oil. Non-legally binding, but indicative, targets were set at 2.5% by 2005 and 5.75% by 2010 and individual States were free to achieve them as they wished. By 2004 however, progress was considered to be lacking; in 2005 overall biofuel consumption had only grown by 1%, and was largely limited to biodiesel and bioethanol produced from standard agricultural commodities (Afionis and Stringer, 2012; Ryan et al., 2006). In the UK, production had actually decreased from 0.26% when the directive was announced to 0.18% in 2005 (European Commission, 2007). These findings lead to the announcement of a Biomass Action Plan (European Commission, 2005) and an accompanying EU Strategy for Biofuels (European Commission, 2006).

2.5 Deploying modern biofuels and emerging controversy (2003-2007)

In the years that followed the 2002 pre-budget announcement, 'Our Energy Future' and the European Biofuels Directive, UK government departments began to consider how to promote the use of biofuels. However, bringing biofuels onto the policy agenda brought scrutiny and debate. There was a flurry of reviews and strategies, and a number of vocal stakeholder groups emerged. Government publications increasingly framed their policy using European developments. A number of parliamentary committees were critical of both government policy goals and the means by which it intended to achieve them. Academics analysed renewable transport policy mechanisms, some concluding that the GHG emissions would be economically expensive in relation to alternatives (e.g. Ryan et al., 2006). In Europe, an interim report on the status of the biofuels directive (European Commission, 2007 COM(2006)845) highlighted disagreements about the impacts of biofuels, questioned the ability of biofuel production to achieve the European policy goals and indeed whether or not the policy was desirable at all. And all the while, pressure for more structured 'basic' research programmes, to be funded by the research councils, built. This period, then, is perhaps best characterised as one of a shift from cautious optimism to open dissent as biofuels became a political reality. I first cover British policy discussions, then introduce the way that the research councils, particularly BBSRC, built a research agenda in biofuels. Finally, I outline how different kinds of concerns began to be aired and the form that controversy took.

2.5.1 Nascent UK policy

As it was considering how to implement the European Biofuels Directive, the British Department for Transport consulted on a UK Strategy for Biofuels (DfT, 2004), raising the possibility of 'renewable transport fuels obligation' that would function in much the same way as the existing 'renewables obligation' within the electricity sector. The capacity for such an obligation was later provided by the 2004 Energy Act (HM Government, 2004). Similarly between 2003 and 2007, the role of bio*mass,* the feedstock for bio*fuels*, as an energy source was placed under scrutiny. DEFRA and DTI produced a strategy for Non-Food Crops (DEFRA and DTI, 2004). RCEP (the prominent commission of scientists) built on their earlier report from 2000 to examine the potential of biomass-based production methods in renewable energy generation, ignoring biofuels but speaking very positively about the potential for biomass to be used in heat and power production. The publication of the RCEP report (RCEP, 2004) lead to the creation of an independent commission, the Biomass Task Force (BTF), to examine the ways that biomass could optimally meet a range of targets and policy goals. Again, this report was largely focused on biomass for electricity and heat generation but it noted that based on the European biofuel targets and predicted increases in the price of crude oil, there would likely be competition for feedstock from biofuels (Biomass Task Force, 2005). A range of other reports and reviews also sought to influence policy. Later that year, the government responded to the BTF, committing to the development of a long term biomass strategy.

The year 2007 saw the publication of several British strategy documents. Three are of importance here. First, 'Meeting the Energy Challenge' - the second energy White Paper in three years - acknowledged the EU biofuels targets and introduced the RTFO as the primary mechanism for delivering them (DTI, 2007). It delegated decisions regarding bioenergy to the second (aforementioned) strategy on UK Biomass (DEFRA et al., 2007). The UK Biomass Strategy was published alongside a third Low Carbon Transport Innovation Strategy (DfT, 2007) in May. Discussions about the RTFO were now well underway and the Biomass Strategy considered biofuels for transport alongside electricity and heat generation. It spoke very favourably about biofuels for transport and the potential of second-generation technologies. Despite being ranked lowest in a hierarchy of cost per tonne of carbon saved, it noted that factors other than cost would be important in determining decisions. In the transport sector, the Government had few alternatives – efficiency savings and reduced use had been side-lined – to reduce carbon emissions. The strategy predicted that 2.5% of the 5% target would be obtainable from indigenous sources of biomass but noted that the EU had recently agreed to a 10% biofuels target for all member states by 2020. This target was to be subject to biofuels' ability to meet sustainability criteria but importantly for this narrative, the Biomass Strategy also placed significant hopes on the promise of second-generation biofuel technologies:

> "A key element in the development of a sustainable Biomass Strategy will be the development of second-generation biofuels. For this reason longer term targets for the increased penetration of biofuels are contingent on this." (DEFRA et al., 2007, p. 12)

In response to environmental concerns, food supplies and impacts on developing countries the government tied further biofuel blending targets to the successful market penetration of second-generation biofuels. When coupled with the systemic changes to funding rationales in the previous section – changes that meant that they increasingly sought to demonstrate the return on investment – statements like this begin to make it clear how pressure to fund research into bioenergy would build for the research councils. This was to be the case even in the face of the significant controversy that had begun to develop.

2.5.2 Creating a mandate for biofuels research

Now, I have noted that as policy makers began to view biofuels as a viable option, they also began to pin their hopes on novel, second-generation, technologies. This is a perennial trend; future biofuels have been and continue to be stories of hope and promise, positioned as solutions to many of the problems that their ancestors have raised, if only they can be made technically and commercially viable. In 2004, the government consultation on a biofuel strategy, drew directly from the assessments in 2002-03 and positioned lignocellulosic fuels as an increasingly attractive option, adding in the idea that they had the potential to serve as a transitional technology to build infrastructure for a hydrogen-based economy because a biomass-based hydrogen production process was seen as the most cost-effective route (DfT, 2004, p. 13).

Similarly utopian visions for research were being created in relation to non-food crops and biomass more generally. In the foreword to the DEFRA and DTI joint strategy for non-food crops Lord Whitty and Nigel Griffiths, the respective departmental ministers, opened with a vision in which "a significant proportion of demand for energy [including biofuels] and raw materials should be met through the commercial exploitation of science from crops" and talked up the role that bioscience could play in helping to "deliver the actions and turn this vision [...] into a reality" (DEFRA and DTI, 2004, p. 5). The strategy was, of course, very positive about non-food crops and said that government took responsibility for developing the sector. One of its key mechanisms for doing so was to "increase public funding of research on non-food crops and stimulate projects jointly funded with industry, and establish a major programme of demonstration projects" (DEFRA and DTI, 2004, p. 8). For the first time, it also placed an onus on BBSRC to develop a strategy for research in this area.

To sum up this research funding thread so far, I first highlighted the ways in which renewable energy policy was explicitly coupled to research and development in the public sector. As a result biofuel-focused research was initially broad in terms of topic and rather limited in terms of funding but this began to change as biofuels rose up the policy agenda. Further, systemic changes such as the rise in a 'customer-contractor principle' had allowed research funding allocation to be coupled to perceived returns (on, for example technologies). During the 1990s, the privatization of British energy industries also resulted in shrinking departmental research budgets. Taken together with the visions above, these changes meant that the research councils – rather than government departments – were increasingly seen as having an explicit and important role to play in the realisation of governmental energy policy goals, in our case by improving biomass and biofuel production methods. The government response to a recommendation of the Biomass Task Force (2005) was typical in placing both EPSRC- and BBSRC-funded research as fundamental in producing a "focused and well co-ordinated" research and development biomass energy programme, promising holistic coordination through a Bioenergy R&D Funder's Forum and through the Energy Research Partnership (ERP) and a National Institute for Energy Technologies (DTI and DEFRA, 2006, p. 60). During this period BBSRC commissioned strategic reviews into crop science (2004) and bioenergy (2006a), the latter explicitly framed as a response to the 2003 energy white paper. Taken with the above developments, one might be forgiven for seeing their recommendation of bioenergy as a research priority as a *fait accompli*. I will now turn to events surrounding their publication.

BBSRC's Bioenergy Initiative

The BBSRC's funding process, its rationales and activities in the bioenergy arena will be covered extensively in chapter 6. Therefore, the focus here is synoptic, as a means to situate developments in bioenergy and biofuels research within a wider landscape. At the time that the BBSRC bioenergy review was commissioned, bioenergy research was covered by a triad of flagship public research programmes in the form of SUPERGEN (Sustainable Power Generation and Supply), RELU (Rural Economy and Land Use), and TSEC (Towards a Sustainable Energy Economy). These programmes had recently been brought under the coordinating role of the Research Councils Energy Programme (RCEP). Each of these programmes represented significant public investments of around £20m, of which a significant proportion was dedicated to bioenergy research. By 2007 SUPERGEN's Bioenergy Consortium initial investment of £2.9m had risen to £6.4m by 2007 (BBSRC, 2006a). Each was also a large cross-council consortium project, which to varying degrees adopted 'whole system approaches' and aimed to integrate insights from technical, economic and social fields. The mission statement for the bioenergy-focused component of TSEC, for example was to provide "authoritative and independent answers on technical, economic, environmental and social issues related to the development of bioenergy in the UK" (House of Commons Innovation Universities Science and Skills Committee, 2008, p. 222). As such, the BBSRC review (perhaps accurately) considered the bioenergy research field 'crowded', recognised the benefits that such multi-disciplinary projects offered a research vision of unilaterally funded 'underpinning' bioscience research to "strengthen bioenergy options for the future" (BBSRC, 2006a, p. 13). By mobilising the idea of 'bioscience as remit', the BBSRC was able to advocate a vision that excludes the integration of multidisciplinary research, as was made explicit in a later BBSRC response to a parliamentary committee (House of Commons Innovation Universities Science and Skills Committee, 2008, p. 225).

The BBSRC chose the start of science and engineering week in March 2007 to announce the launch of its 'bioenergy initiative'. Here, it committed up to £20m to "more than double" public funding in the area (BBSRC, 2007a). This commitment was later emphasised in their subsequent delivery plan for 2008-2011, which placed bioenergy research as one of three priority areas (BBSRC, 2008a). Manifest in early discussions about bioenergy was the need to take note of 'societal issues' (BBSRC, 2006a, p. 37). Thus, in spite of the earlier unilateral desires, this need eventually resulted in the integration of social and ethical research into its flagship bioenergy programme, the BBSRC Centre for Sustainable Bioenergy (BSBEC), as well as a string of 'engagement' activities such as a large-scale public dialogue that ran between 2009 and 2014. Of course, in ramping up of funding activity the BBSRC enacted particular visions of suitable research structures, appropriate end goals, systems of bioenergy production and the place and role of ethics within the programme, which are the focus of the later chapter *BBSRC: Funding a controversial priority*.

2.5.3 Emergent debate and the making of controversy

Biofuels initially enjoyed support from the agricultural sector and the fuel industry. During the formative years of debate, the most frequent charge was that the Government's strategy for promoting biofuel deployment (and other uses of biomass) was muddled, both in terms of motivation and support mechanisms (e.g. House of Commons Environment Food and Rural Affairs Committee, 2003; House of Commons Environmental Audit Committee, 2003). Major environmental NGOs within the UK (e.g. Greenpeace, Friends of the Earth, and the Royal Society for the Protection of Birds (RSPB)) were also initially supportive, especially as a means to address climate change (Bomb et al., 2007; G. Thompson et al., 2004). Such recommendations, however, came with an emphasis on biofuels as part of a package of mitigation measures, with a cautious approach and the need to ensure 'true' sustainability (e.g. see Friends of the Earth, 2006a; 2006b). To this end, WWF had highlighted problems with the enforcement and certification of environmental regulation in producing countries: Despite it being illegal, Indonesian rainforest was being removed to grow oil palm for biofuels (WWF, 2002). The position of these NGOs would subsequently shift dramatically, with many of them becoming both powerful lobbying forces and knowledge generating centres against the development of biofuels.

Issues around the potential environmental, land use and social implications had long been raised within assessments from researchers and the UK Government (Goldemberg et al., 1987; Hall, 1991; Hall et al., 1992; e.g. Lewis, 1981; Ramsay, 1985; Rosillo-Calle and Hall, 1992). For instance, one particular report from the Office of Technology Assessment in the US pointed to biofuels' potential to exacerbate reductions in soil quality and erosion, increase run-off and sedimentation in water bodies, cause ecosystem destruction, present occupational hazards for biofuel producers and to increase food commodity prices, which would unduly affect the poorest demographic groups (OTA, 1980). And in striking prescience with WWF's documentations, it suggested that the heterogeneity of production pathways and sites would make it extremely challenging to protect against such problems. Some of these issues had been explicitly referred to when explaining the UK's reticence towards biofuels. Unsurprisingly then, as the policy tide began to shift in favour of biofuels between 2003 and 2007, attention also increasingly focused on their long-known impacts[3].

Between 2003 and 2007 then, the major focus of controversy was quickly framed by three issues which had previously been raised in research and policy discussions: the credibility of GHG emission reductions; biofuels' direct competition with food production, leading to price increases ('food versus fuel') and; the speed of technical development versus scientific knowledge about impacts (Boucher, 2012). It was, for

[3] The word 'impacts' is notable here in that it demonstrates that discussion was centred around the specific consequences of biofuel development and deployment rather than, for example, different visions of what agricultural systems might be preferable (P. B. Thompson, 2012) or how different production systems might deployed in ways that were responsive to their contexts (Raman et al., 2015).

example, commonly argued that the GHG benefits of biofuels could be negated by emissions from the production process, which was compounded by large tracts of environmentally productive forest being cleared and replaced with industrial scale monocultures. Despite many other potentially damaging impacts having been previously and extensively covered in the literature (S. C. de Vries et al., 2010; e.g. Gomiero et al., 2009; Mol, 2007; Naik et al., 2010; P. B. Thompson, 2008), particular attention was directed towards the potential for biofuels to increase demand for agricultural commodities and inflate the price of food products, pushing already vulnerable people further into food poverty (IFPRI, 2006; Stein, 2007).

It is important to emphasise that in general the debate about biofuels played out amongst organised stakeholder groups and many varying assessments were produced in the grey literature; in 2013 my own work identified 618 such assessments in the public domain, with a spike in publication during 2008 (Boucher et al., 2014). As seen in subsection 6.2.1, technical assessments often produced conflicting results, which was only exacerbated when causal relationships were attempted to be distilled from multi-factorial and context-specific analyses (Eklof and Mager, 2013; van der Horst and Vermeylen, 2011). The controversy did eventually achieve some public salience in 2007, notably when biofuels were viewed as the dominant cause of the global food price spikes and media reporting peaked (Boucher, 2012). Indicative of the growth in attention is the difference in the DfT's consultation responses - 2004 had 129 and 2007 had over 6335 (Dunlop, 2009). By the controversy's peak, major international organisations had begun to comment and produce assessments. For instance, the Food and Agriculture Organisation of the United Nations (FAO) dedicated their 2008 'State of Food and Agriculture' report to the topic of biofuels (FAO, 2008). As we shall see, this technical framing of policy discussions emphasised as the controversy progressed.

2.6 Controversy, policy and research (2007-2012)

Before moving to discuss the implications of biofuels' sociotechnical trajectory for a study of the place of 'the ethical' within research in this field, a little elaboration on the period that precedes this project's empirical work is necessary. Although much of the story has already been told, three key developments remain, relating to the nature of controversy, European and UK policy and, interwoven within this, the place of researchers.

2.6.1 Continued scientisation of controversy

The initial shape of the biofuel controversy has been traced; concerns were often quite technically-framed, and focused largely on both biofuels' competition with food production and their environmental credentials. This was at least partly as a result of the modern European and British mandate for biofuel production being coupled to their potential to achieve emissions reductions. Policy discussions during this period increasingly focused on the ways that these reductions could be secured in the face of direct land use change, arguably contributing to the neglect of other important impacts, or indeed broader framings such as seeing biofuel controversy as part of questions about agriculture or land use.

In 2008, however, concerns about the impacts that might arise as a result of indirect land use change (ILUC) began to be voiced. Two academic studies published in the journal *Science* were central to this shift. Searchinger et al (2008) and Fargione et al (2008) showed that restricting biofuels to those produced on land previously used for agriculture was not enough to stop land-use change, because the activity that took place before biofuel production, which is not subject to land restrictions, would be displaced and result in net land-use change. If biofuel production leads to an increase in the total demand for land, land-use change will prevail. The authors argued that it did not matter whether land-use change makes way for biofuel production directly or for some other agricultural activities displaced by biofuels production. If these changes were accounted for in LCA then biofuel production would be seen to increase rather than reduce GHG emissions, contradicting a central motive for biofuel development. In the years that have followed the publication of these studies, both controversy and policy has increasingly focused on and attempted to respond to concerns about the highly technical nature of ILUC, which has now effectively become the major proxy for environmental sustainability (Palmer, 2014), despite persistent and broader concerns being voiced.

2.6.2 European policy responses to controversy

At the European level, for example, policy has fluctuated rapidly in response to the ensuing controversy. The aforementioned Biomass Action Plan (European Commission, 2005) and accompanying EU Strategy for Biofuels (European Commission, 2006) proposed coordinated, legally binding targets for both the Community and individual Member States, as well as the adoption of sustainability assessment schemes which were proposed in response to criticism of biofuels' environmental credentials. Latterly, following extensive negotiation, the Renewable Energy Directive (RED, 2009/28/EC) was adopted in April 2009, making the previous Biofuels Directive obsolete. Together with the Fuel Quality Directive (FQD, 2009/30/EC), its stated policy objectives were to: 1) improve energy security by reducing dependence on petrochemical-based transport fuel; 2) foster agricultural productivity and rural development, and; 3) to reduce GHG emissions through sustainably produced biofuels. The RED required all Member States to develop action plans to meet biofuels consumption targets (10% penetration by 2020) and report regularly on their progress. Responding to the initial stages of controversy, it drew an explicit link between consumption of biofuels and their sustainable production. In order for biofuels to contribute to meeting targets set out in the RED, they would have to comply with a set of sustainability criteria which prohibited the use of feedstocks from primary forest, lands with high biodiversity value, protected territories and carbon rich areas. In addition, biofuels needed to offer a 35% GHG reduction versus their fossil fuel counterparts and second-generation biofuels were encouraged by doubling the certificates awarded to them. Further, biofuels from food-producing crops could only contribute to 5% of targets.

The European Commission also recognised the importance of addressing ILUC and promised an investigation into its mechanisms and management. Late in 2012 the Commission therefore proposed an amendment (2012/0288) to the RED and FQD to take account of the issue. The amendment would set and apply factors to specific biofuels to account for variances in GHG emissions attributable to ILUC. Biofuels that already accounted for *direct* LUC or that were derived from waste or oceanic feedstocks (e.g. algae) would be exempt from the ILUC factors. If accepted, member states would be required to implement the amendment within a year. There was significant debate about the weight that these factors would be given: In a draft of the proposed amendment (leaked before the official publication), ILUC factors would be directly incorporated into the calculation of GHG emissions associated with biofuels. European biofuel consumption targets require a minimum level of emissions savings in relation to fossil fuels (35%, rising to 60% in 2017), meaning that the amendment would remove the incentive to produce biofuels with large amounts of associated of ILUC. Industry lobbying eventually meant that the ILUC factors were reduced to reportage status, which seriously weakened the proposed amendment because the mandatory targets could still be met by biofuels with the highest ILUC factors (Kretschmer and Baldock, 2013). Ultimately, the final proposal to the RED and FQD brought forward the rise in minimum emissions reductions (of 60%) to 2014 and maintained that biofuels from edible crops could only contribute to 5% of targets. The proposal suggests that both the ILUC factors and the methodology for their calculation should be reviewed and updated on the basis of the latest scientific evidence. As it stands, it is unclear whether the EC would propose that ILUC factors are strengthened beyond the 'reporting status' in future, given the evidence that they accepted for the need to manage ILUC (Boucher et al., 2014).

2.6.3 UK Policy: The RTFO and beyond

In the United Kingdom biofuels policy was also draped in discord. The RTFO had a long lead-in time, being announced in 2005 but not coming into force until April 2008 when it would gradually replace the excise duty rebate which was intended to be phased out by 2010 (HM Government, 2007). The RTFO worked by requiring any transport fuel supplier that provided an annual amount of fossil fuel to the UK market that was greater than 450,000l to ensure that 5% of total fuel sales were from renewable sources by 2010. To encourage this, it put in place a mechanism similar to the renewables obligation (the primary renewable electricity policy) which was in principle technology blind and market-based (Slade et al., 2009). Suppliers would receive certificates (Renewable Transport Fuel Certificates) for compliance and a market-trading scheme would be developed for these certificates. Administration of the RTFO was to be carried out by the newly established Renewable Fuels Agency (RFA).

However, as we have seen, during this long incubation period both European policy and the broader debate shifted significantly. By 2008, a range of issues had been well-documented, and any policy that encouraged the widespread deployment of biofuels would be viewed as controversial. Pressure therefore fell on the Department for Transport (DfT) to develop a carbon and sustainability certification scheme that would be implemented alongside the RTFO. Under the DfT scheme, any obligated suppliers also had to submit carbon savings emissions using a standardised LCA approach. Sustainability criteria focused on the farm or plantation level and adopted a 'meta-standard' which borrowed from a range of pre-existing voluntary certification schemes. Because there was to be no exclusion of specific supply-chains, the RTFO relied on stakeholder pressure to encourage use of the most sustainable types of biofuel (Upham et al., 2009). Despite these additional requirements, by the time the RTFO came into force, several groups, both internal and external to parliament had called for the abandonment of any biofuel target encouraged by the RTFO (Palmer, 2010). The House of Commons Environmental Audit Committee (e.g. 2008a), for example recommended a moratorium on supply targets and proposed increase focus be devoted to sourcing biofuels from waste feedstocks, such as used cooking oil.

The UK Government also responded to shifts in concern about ILUC by commissioning a review from the Chairman of the Renewable Fuels Agency to examine the indirect effects of biofuel production (The Gallagher Review; RFA, 2008). The report, published in 2008, highlighted the scale and problem of ILUC and questioned the potential for second-generation technologies to meet the problems raised by the 1st generation. However, it also maintained that given predicted increases in global transport emissions, the UK could not afford to abandon the use of biofuels as part of a 'low carbon future'. Following publication of the review, the UK government amended the RTFO (in 2009) to slow the rate of increase in its supply targets (Secretary of State for Transport, 2009). The target for 2010 was now set at 3.63% of total supplied transport fuel with a maximum target of 5.26%. In December 2011 the RTFO was amended once more to implement the mandatory sustainability criteria required in the RED (Secretary of State for Transport, 2011). Under the new terms, biofuels that did not meet the sustainability criteria would be regarded as fossil fuels for the purposes of the order, thereby accruing an obligation to supply sustainable biofuels alongside them. In order to accrue RTFCs, suppliers would also be obligated to have the performance of their fuels independently verified.

Additionally, the amendment also favoured specific production pathways by introducing double counting for feedstocks, such as used cooking oil.

Like policy at the European level however, UK discussions continued to fluctuate. The above amendments may have softened targets and made sustainability reporting mandatory but the RTFO as a whole was still considered a support mechanism for biofuel supply. By 2011, the discussion of biofuels had begun to be more consistently placed in terms of bioenergy as a whole. The Committee on Climate Change was established by the Climate Change Act (2008) to set carbon budgets mandated under the Act and advise on how to meet those budgets. In 2011 it produced a detailed analysis of the role that bioenergy could play in meeting the UK's carbon budgets and targets (Committee on Climate Change, 2011a). Although biofuels continued to be driven by EC directives, this report and the accompanying technical papers (Committee on Climate Change, 2011b) were to feed into the forthcoming Bioenergy Strategy (DECC et al., 2012). The report made a range of recommendations, including ranking biofuels for automotive transport as the least desirable form of bioenergy in a hierarchy of use to 2050, instead recommending that their use should be reserved for aviation and shipping. It also recommended that current European regulations should be strengthened to take account of emissions from ILUC. The 2012 Bioenergy Strategy made no new policy commitments but agreed with many of the recommendations of the Committee on Climate Change, especially regarding ILUC for bioenergy. Finally, the strategy continued to broaden the way in which biofuels were framed, more explicitly within the topic of the bioeconomy. These discussions of "bioenergy and the wider bioeconomy" (DECC et al., 2012, p. 36) for example, had begun to emerge from within DEFRA and DTI in 2004 (DEFRA and DTI, 2004, p. 5). Such a reframing of biofuels will be discussed in later chapters.

2.7 Conclusion: Producing and structuring particular concerns

This chapter has provided a lens through which to examine the development of biofuels in the United Kingdom since the 1970s. Whilst a comprehensive history would be impossible to achieve, it has sought to redress some of the balance commonly present in contemporary studies of biofuels (e.g. Gamborg et al., 2011; Swinbank, 2009; Tilman et al., 2009), their impacts and indeed the controversy. First, I showed how biofuels emerged in British renewable energy policy as a relatively unfavourable technological option. Scientific assessments were key to this positioning. Many of the issues that were raised during this time have also dominated recent debates and helped to maintain biofuels' marginal position. It then demonstrated how at the turn of the century, a flurry of policy and assessments were produced that began to encourage biofuel production. This was despite no new technological breakthroughs occurring, and despite many of the earlier concerns and uncertainties still being raised. As policies began to be designed to encourage biofuel development and deployment, a controversy ensued. A range of parties took up varying positions within this controversy; it was not solely NGOs on one side and science on the other. During this period policy was in flux and both scientific knowledge and actors played prominent roles. Furthermore, these actors were sometimes able to strategically respond to both policy and controversy to bolster the need for research funding in the area, which, by 2009 had resulted in the funding of a flagship BBSRC bioenergy programme.

At the outset I pointed to three motivations for this chapter. The first was *functional*, to show the value of the case for a study of the way that different groups construct the ethical dimensions of research and distribute responsibility for addressing them. The second was *methodological*, in that by providing a significant amount of contextual detail, making key facets clear, it becomes possible to render the case comparable (Beaulieu et al., 2007). The third was *inquisitional*, aiming to shed light on the first research question by generating insight into the way that 'the ethical' is constructed within technoscientific arenas. I take the first two goals in tandem and then expand on the latter.

If technologies are considered to progress along a broad set of trajectories then controversial periods can be seen to play important technology assessment functions in those trajectories (Cambrosio and Limoges, 1991; Rip, 1986). Controversies often bring underlying normative commitments to the fore. Occasionally they can provide spaces for them to be constructively discussed and they will almost always shape technological pathways in unexpected ways. Overall, then, this study is perhaps best viewed as one in an extensive lineage of Science and Technology Studies (STS) that employs controversies as a methodological tool to garner insights that would otherwise be unavailable (Pinch, 2001). The biofuels field is densely populated and complex, cutting across a range of sociotechnical 'regimes' (Caniëls, 2011). Further, many of the issues raised in the debate around biofuel use are also relevant to other regimes, such as agricultural technologies more generally, industrial refining and energy. For example, some view the biofuel controversy as a means to provide space to begin more general discussions about land use (Karp and Richter, 2011). These features make the case challenging to work with but they are also its major strength: The fact that the complexity spills out of the laboratory makes it possible to interrogate a range of perspectives beyond the scientific; The fact that actors are not wholly specific to the case makes it possible, if one were inclined, to examine how they differ in alternative arenas; And the fact that biofuels clearly show the coalescing of certain groups which then move on to other arenas makes it possible to develop a lineage of ethical concern and to examine how different arenas relate to one another. Detail increases granularity, making it possible — although I do not do so within this thesis — to approach comparative questions about the reasons that some terms ('sustainability', 'ethics', 'responsibility' etc.) dominate in particular fields and not in others. Finally, broader questions, for instance about trends in governance, the importance of global networks, and the role of scientific knowledge within society become answerable.

Finally, the work within this chapter allows me to make tentative steps towards my *inquisitional* goal, by making it possible to begin to highlight the ways that ethical dimensions come to be demarcated within a given sociotechnical arena. Although the political capital of many of the positions taken within the grey literature reviewed here requires a much more in-depth analysis mobilising, for example the approach introduced by Boucher (2013), in a cartographic exercise, I am able to sketch out some key features and flows stemming from particular reports, institutions and actors that work to structure the ethical dimensions of biofuel development and deployment. These features include the initial framing of debates, biofuels broader motivational positioning, and previous controversies and emergent issues.

When biofuels re-emerged in the 1970s as a potential renewable energy option, we saw that they were coupled to small-scale scientific controversies about their impacts (for example on the environment, and on GHG emissions) or in terms of their technical characteristics (e.g. net energy balance). As the questions were technically-framed, scientific knowledge was seen as key to resolving these debates. In different geographical deployments, such as North America and Brazil, rationalities such as ensuring a secure domestic energy supply and rural development are considered to be primary drivers. In Europe, at the turn of the century, biofuels were positioned as being driven primarily by a climate change mitigation motivation. This had two consequences. The first was that they were bound to a 'global climate change regime', that again predominantly seeks to mobilise scientific expertise in support of policy making (C. A. Miller, 2001). And, coupled to this is the fact that an environmental framing carves out space for NGOs to partake in governance as 'sources of moral authority in environmental controversies' (Mol, 2010). These trends then, established in the 1980s and 90s, continued into the mid-2000s as controversy and attempts to quantify sustainability emerged.

Emergent issues such as biofuels' ability to impact on food production, and their contribution to ILUC resulted from a messy arena of interactions, making it difficult to identify causal relationships. With that said, some have sought to emphasise the importance of media staging in such controversies (Eklof and Mager, 2013), which others have suggested was strategically mobilised by a range of NGOs to intervene and significantly shape politically-instituted markets (Pilgrim and M. Harvey, 2010). Nevertheless, both technical assessments (Kretschmer and Baldock, 2013; Ostwald and Henders, 2014) and ex-post economic evaluations and explanations (e.g. HM Government, 2010a) continue to be sought, demonstrating the pervasiveness of the approaches in what are intractable and potentially empirically unresolvable 'wicked' situations (Palmer, 2012). Despite their inherent messiness, what is clear is that such prominent contestations become key points in a landscape that structure the kinds of concerns that are most important to consider. The chapter has, for example, shown how they have shaped both policy and the structure of research programmes.

If such landmarks in discussions about the development and deployment of biofuels act to structure and prioritise particular concerns, they also act to conceal others. Recall in *section 2.2.2* that I emphasised the fundamentally diverse and multiple nature of biofuel production chains. Drawing on Winner (1986a) and Perrow (1999), it became possible to see that different configurations engender a wide range of social, political, and ethical judgements, as well as technical and economic ones, "thus, the key choices involved in energy transitions are not so much between different fuels but between different forms of social, economic, and political arrangements built in combination with new energy technologies" (C. A. Miller et al., 2013, p. 139). A technicalised and impact-oriented debate has, for the most part silenced such discussions, to the extent that the majority of campaigning NGOs seek to express their concerns in such discourse, even if they embed implicit alternative judgements (e.g. see BirdLife Europe, 2011; WWF, 2011). Nevertheless, recent work has sought to show that different implicit judgements are being made within national biofuel policies, for example by prioritising international resource-trading based configurations over domestic models of production (Raman and Mohr, 2013), by implicitly prioritising security of supply over environmental drivers (van der Horst and Vermeylen, 2011), or by implicitly favouring large-scale vertically integrated forms of production over local, distributed and small-scale configurations (Levidow et al., 2013).

To conclude, the detailed narrative that I have presented in this chapter has served a number of different goals. Most simply, it has acted as a contextual plunge pool, immersing us in the complexity of the case at hand, and drawing out some of the most important interactions of the key actors within the field. It also serves to introduce the first step in my overall argument within the thesis: the ethical dimensions of the field emerge alongside particular visions of technological systems, and from a complex and messy set of interactions between a range of actors. This high-level 'regime of normativity' (Pickersgill, 2012) serves to structure particular concerns and particular ways of addressing those concerns. In this context, concerns about biofuels' potential to compete with food production, their sustainability, their net GHG emissions, and later GHG emissions resulting from indirect land use change became high-level matters of concern for anyone operating in the field. All of these concerns were 'scientised', meaning that they became contestable in technical terms, but this also served to silence other ways of articulating around the sociotechnical practice. In making these points, I do not wish to suggest that alternative, subversive discourses do not exist within the biofuels case – to be sure, some of the later chapters will emphasise precisely the opposite – but rather that they are not visible the level of granularity that I have provided here (that is, dominant policy debates).

A secondary concern, that continues as a sub-tone throughout the remainder of the thesis, is with the place of scientific knowledge and culture in society. Thus, in this chapter, we saw (*section 2.3.2*) that a crucial piece of groundwork was laid in the form of the renegotiations between research funders and the government that occurred in the 1970s — the forerunners to 'impact'. Without this renegotiation, it is unlikely that the development of biofuels, as a desired ends of research, would become a priority area for the largest British public funder of bioscience and biotechnology in 2006. In the next chapter, I turn to a second dimension of the regime of normativity by examining the way that ethical concerns have traditionally been addressed within the biosciences.

Chapter 3

On ethics and responsibility in the biosciences

In the previous chapter, I outlined how biofuels became a controversial sociotechnical practice to pursue. The controversy that surrounded them was framed in predominantly technical terms and occurred amongst a number of key parties in policy and scientific arenas that were able to engage on such terms. Scientific actors and technical models of knowledge were prominent constituents in framing and shaping debate but they were also structured in relation to a perception of biofuels' controversial nature. But despite such a technical crust, often what was (and continues to remain) below the surface were particular and varying judgements about systems of biofuel production, impacts on communities, notions of fair trade, acceptable agricultural practices and land use applications; As is commonly the case, there was and is more at stake than technical issues.

Now of course, the biosciences are well acquainted with controversy; a persistent mantra is that the knowledge offered by the biosciences presents both promise and peril. Both bombastically and in subtle ways, this knowledge transforms (for example) the way we inhabit and relate to our external world and the ways in which we understand ourselves and other humans. Particularly prominent is a discourse emphasising the need to address such 'bioethical' aspects that has evolved to become part of biotechnology governance so that, in an albeit piecemeal way, consideration of the 'social', 'ethical', 'political', 'risky', or 'public' nature of bioscience has been embedded within research practice and funding (Moore, 2010). But how should one understand such claims of a need for 'bioethics'? And how might it be possible to begin to analyse the ways in which bioethical issues are produced and shape research?

The notion of bioethical issues and a need to address them is perhaps the most pervasive framing of ethics in the biosciences. A wide range of communities of theory and practice have developed that each aim to address, in various and often vaguely differentiated ways, bioethical concerns. But whilst on the surface bioethics seems to permeate technoscientific worlds, there are far fewer ways of analysing how these issues come to be defined, and the kinds of judgements that are made about how they should be addressed and by whom. In short, there have been few attempts to make 'bioethics' a phenomenon for study in its own right. My aim in this chapter is to outline how this might be possible by drawing together perspectives from the interpretative social sciences, specifically the sociology of bioethics and science and technology studies (STS).

To this end, I depart by considering how one might begin to define the term 'bioethics', briefly unpacking some prominent definitions from academic and public realms (*Section 3.1*). Although useful as a point of departure, such definitions tend to stifle rather than facilitate an analysis of the way that different groups define the ethical dimensions of biofuel development and deployment, and distribute responsibility for addressing them. In the final subsection, I turn to some sociological interpretations of bioethics, which leads to conceptualising bioethics as a 'task' (introduced in *Section 3.2*). This is indebted to the work of John Evans (2012), amongst others. This definition acts as a foundation to collect and amalgamate a set of particular analytic intrigues that will guide the analysis within the thesis (*Section 3.3*). To pre-empt some methodological tensions that will be introduced within the next chapter (*Considering method(ology)*), I propose this as a fundamentally integrative and 'mid-range' (Wyatt and B. Balmer, 2007), rather than esoteric, approach that combines well-established orientations from the social construction of technology (Bijker et al., 1987), co-production (Jasanoff, 2004a), boundary work (Gieryn, 1983) and is underpinned by a small number of previous studies of bioethics that do exist (e.g. J. Evans, 2002; Hedgecoe, 2004). Although applicable in this context of biofuels, my gambit is to pitch such an approach at a level that makes it suitably adaptable to other scenarios, if desired.

3.1 Defining bioethics

How might we begin to consider engaging with ethical issues in the biosciences? There are, inevitably, many answers to this simple question, each with their own ontological commitments, political affiliations, methodological dispositions and preferred issues of concern. Amongst them however is a steadfast notion of 'bioethics'. Emerging in the 1970s alongside the development of biotechnology, the term has become deeply institutionalised within medical practice and bioscience research. It has developed cultural (J. Evans, 2012) and political capital (M. B. Brown, 2009; Salter and Jones, 2005). There are many ways in which bioethics can be cut: by theoretical traditions (e.g. principlism, deontology, casuistry, feminist ethics), by sites of practice (e.g. the clinic, the lab, the office) or by areas of legitimacy (e.g. in policy, in research funding). This, then, is a term which presents its own site of contestations as well as being 'an elusive empirical subject' (Rosenberg, 1999).

As phenomena and object of interest then, 'bioethics' represents an analytic challenge. To address the term completely would be a significant undertaking that would require the negotiation of many theoretically- and professionally- invested actors, each having a stake in pushing for their version of bioethics, and is not the goal of this work. And yet, if one is to study the ways in which different actors construct and respond to ethical issues in the biosciences – to study their ethical lived-experiences – then delineating the nature of the 'ethical' and the means by which it could be considered is a crucial step. Without attempting to resolve perennial problems that exist within this field, to move forward I take an actor-, issue- and task- oriented approach to demarcating ethics. This approach amalgamates those previously adopted by Daniel Callahan (1999), Charles Rosenburg (1999), Sheila Jasanoff (2005a) and by John Evans (2012; 2006) in their own studies of bioethics. Although indebted to these forerunners, my approach departs from them in the sense that it is less tied to a study of bioethics as 'enterprise', 'profession' or 'activity' and more to a study of the 'task' of ethical consideration, reflection and management.

In what follows I review the most prominent positions about the nature of bioethics, paying attention to: i) what each account sees as being of ethical concern; ii) who they suggest should be doing the ethical work; iii) how they position themselves in relation to other accounts of ethics, and; iv) what aspects of the biosciences they are concerned with. As will be shown in the later sections of the chapter, these dominant accounts contrast with a number of other perspectives, which are introduced towards the section's end. Whilst not intended to be comprehensive, my claim is that these accounts represent the key variances from prominent actors within the British public-, policy- and research- oriented arenas.

3.1.1 Moral philosophical underpinnings

When biofuels attracted significant attention in the UK, one of the most prominent public reports came from the Nuffield Council on Bioethics' (NCB; the council) in its 2011 offering, *Biofuels: Ethical Issues* (Nuffield Council on Bioethics, 2011). This intervention was typical of the NCB, who commonly produce glossy reports on emerging controversial issues in bioscience and the medical sciences. The reports are produced by a working group comprised mostly of 'lay' experts consisting of a mixture of non-scientists and scientists. More often than not, their analyses fall back on a utilitarian consequentialist analysis, which some have attributed to organisational practices, such as their committee selection procedures, which contribute "to an underrepresentation of deviating opinions and fundamental criticism […] beyond the utilitarian mainstream" (Bogner and Menz, 2010). In this instance, the report did in fact produce a series of 'ethical principles' for biofuel production, with a controversial sixth principle of 'if you can meet the other five criteria for production, then there is an obligation to produce biofuels'.

Formed whilst the dissolution of the Soviet Union was making geopolitical waves, the spawning of the NCB in December 1991 created comparatively gentle national ripples. The council was funded independently, but with the endorsement of the British Government, was intended to fulfil the role of a national bioethics committee – similar in kind to those that were becoming prevalent across the Channel on the European continent – and was at least in part intended to protect the British Bioscience research space (Jasanoff, 2005a). Unlike its continental counterparts, the council had no statutory basis; its political legitimacy and longevity were largely to rest on the perceived quality of its outputs. Twenty-four years later, in 2015, one might be tempted to declare it a notable success in the building and maintaining of these traits. One might also conclude that the instigating scientists, science administrators and trustees of the Nuffield Foundation were ahead of their time, preceding (and outlasting) Government-mandated advisory committees on ethically-relevant topics in the biosciences by eight years. Indeed, the NCB's permanence attests to the presence of a niche in the UK for the kind of structured and high profile bioethical reflection that it provides. A more critical analyst might add that at least part of the NCB's success story lies in its ability to produce comprehensive, sometimes agenda-setting, reports on controversial topics without significantly challenging the status quo or ruffling any vested feathers; the council could be viewed as a model for 'playing it safe', maintaining the legitimating and protective capacity that it was initially set up to provide (Bogner and Menz, 2010; Jasanoff, 2005a). Noting their profile, it seems sensible to turn to this centrepiece of British public bioethical discourse for a departing definition of the term 'bioethics', which can be compared with other similar perspectives.

Falling back on a common encyclopaedic definition, the NCB presents bioethics as being, "about what we ought or ought not to do" (Nuffield Council on BioethicsBioethics, 1999, p. 6) in relation to ethical issues arising from the biological and medical sciences. It claims bioethics as a sub-branch of ethics (moral philosophy). Furthermore,

> "According to the Encyclopedia of Bioethics (1995. p. 250) it encompasses: "the broad terrain of the moral problems of the life sciences, ordinarily taken to encompass medicine, biology, and some important aspects of the environmental, population and social sciences. The traditional domain of medical ethics would be included within this array, accompanied now by many other topics and problems."
>
> It is sometimes said that science moves so quickly that ethics has difficulty in keeping up. Just because something is technically possible does not mean that should be done. It is crucial that ethical, legal and social issues raised by the introduction of a new technology are considered from an early stage. By bringing together ethical analysis and scientific understanding, society can evaluate policies and regulate developments.
>
> The Nuffield Council on Bioethics aims to anticipate developments in medicine and biology before problems arise, providing independent and timely advice to

> assist policy makers and stimulate debate in bioethics." ("Bioethics FAQs - Nuffield Bioethics," 2015)

General definitions such as these are common. In the introduction to the same volume quoted by the NCB, Thomas W. Reich specifies bioethics as, "the systematic study of the moral dimensions – including moral vision, decisions, conduct and policies – of the life sciences and health care, employing a variety of ethical methodologies in an interdisciplinary setting" (Reich, 1995a). Similarly Tom Beauchamp and James Childress, two wardens of the ubiquitous 'principled' approach to bioethics, speak of ethics as "a generic term for several ways of examining the moral life". For them, bioethics is a sub-field of applied ethics that aims to provide "ethical theory and methods of analysis to examine moral problems in the professions, technology, public policy and the like" and to develop 'action-guides' in medicine, healthcare and the biological sciences (Beauchamp and Childress, 1989, p. 9). Originally published in 1979 and now in its seventh edition, this book and its enclosed approach has been hugely influential but also significantly critiqued, not least for its use of a notion of the 'common morality' that "refers to norms about right and wrong human conduct that are so widely shared that they form a stable social compact" (Beauchamp and Childress, 2012, p. 3). Despite these criticisms, this definition has changed little to date, maintaining a distinction between studies of "normative" [read ought] and "descriptive" [read is] ethics that was introduced in the first edition (Beauchamp and Childress, 1979, p. 8), demonstrating at least a level of consistency.

The three perspectives above offer complementary but specific claims for the term bioethics. All share an underpinning in moral philosophical thought and an understanding of what should be analysed - ethical issues resulting from a particular scientific field - but differ in terms of the broadness of focus and in terms of who should be doing the analysis. Whilst Reich and Beauchamp and Childress focus predominantly on the life and medical sciences, the NCB sets its net much more widely, with bioethics concerning the life, medical, environmental, population and some social sciences. This at least partially resulted from a government desire for the council to consider food, agricultural and environmental biotechnologies in addition to medical innovations when it was established (Jasanoff, 2005a). Another artefact of its remit is the Council's quite pragmatic goals. Rather than being concerned with 'systematic' or logical studies of moral questions, the NCB frames bioethics as being concerned with making assessments of real-world uses of technologies to support policy making. In this respect a key notion is 'anticipation', in part to raise awareness of issues and attempt to address problems before they arise. To this end, bioethics should occur within the public domain but like the two academic definitions, it is largely to be conducted in an expert-driven and technocratic manner. One exception to this is Beauchamp and Childress' concern with clinical decision makers. Despite their theoretical focus, many of their case studies are concerned with bioethics in the context of clinical ethics committees which although comprised of 'bioethicists' are people who are unlikely to self-identify as moral philosophers (House of Commons Science and Technology Committee, 2005 Ev.86; Whitehead et al., 2009). Further, Beauchamp and Childress make a distinction between 'moral' and 'descriptive' ethics — the former to be conducted by moral philosophers and the latter to be conducted by 'social scientists'. And superficially at least, Reich leaves space for different disciplinary approaches, claiming that bioethics exists within 'an interdisciplinary setting'.

3.1.2 Personal notions of bioethics

One might interpret Reich's claim of bioethics as an interdisciplinary field as a form of disciplinary diplomacy; attending to the divergences within moral philosophers in the panoptic and ultimately gatekeeping *Encyclopaedia of Bioethics*. But this perception is at least partially guided by some personal remorse about the political struggles between the moral philosophers and theologians at Georgetown University and Van Rensselaer Potter, the individual who claims to have coined the term in 1971 (V. R. Potter, 1971); what Reich (1995b) describes as bioethics 'bilocated birth'. An oncologist by training, Potter's (admittedly esoterically articulated) notion was more concerned with 'long range environmental concerns' which required a 'general normative ethic' rather than the specific and tightly argued 'concrete medical dilemmas' of the Georgetown scholars (Reich, 1995b, p. 21). As was the case with a number of other prominent scientists (e.g. see Luria, 1972) throughout the twentieth century, Potter's calls for 'bioethics' "grew out of the frustrations, commitments, and responsibilities he experienced as an oncologist, coupled with his refusal to isolate those issues and responsibilities in separate, atomistic fields of inquiry" (Reich, 1995b, p. 26).

Equally individualised accounts of bioethics have been offered by a number of moral philosophers[4]. In his highly personalised accounts of bioethics (what he describes as ethics in science), Rollin recounts how as a student he "chafed under science and teaching that ignored ethical and conceptual issues raised by biological science" (Rollin, 2006 p.xi). Later he talks of his,

> "full abandonment of scientific ideology [in realising] how value-driven, culturally radish, and political was science funding and even scientific methodology, as when only males were studied in clinical studies, or when IQ

[4] Some scholars refrain from using the term bioethics in their texts to describe their fields of study, often seemingly to distance themselves from the American biomedical traditions. Rollin, despite his American roots, talks about ethics more generally; the book this quote is taken from is entitled science and ethics, despite being wholly about the biosciences. Others, such as Irena Pollard (quoted in Ross, 2010) refer to bioscience ethics. In this chapter I use the term bioethics for consistency.

> was banished for reasons of political correctness, or when my biomedical scientist colleagues had to spin their research programs every few years to make them relevant to AIDS or whatever happened to be trendy" (Rollin, 2006, p. 248).

For Rollin, acknowledging the value-laden nature of science is key to the practice of science. Bioethics provides a way of reasoning through this, and Rollin offers a differentiation between 'Ethics1' and 'Ethics2'. Ethics1 is analogous to morality: "the set of beliefs that society, individuals, or subgroups of society hold about good and bad, right and wrong, justice and injustice, fairness and unfairness. Ethics2, he defines as "the logical examination, critique, and study of Ethics1" (Rollin, 2006, p. 248). Although still grounded in approaches that aim to examine 'morality', such personalised accounts begin to open up space for individual agency and responsibility within scientific practice. Like some of the earlier scientists within chapter two (*Biofuels research, technology, controversy and policy in the UK*), Potter blurred the boundary between professional and personal responsibility (V. R. Potter, 1975). Similarly Rollin's definition of bioethics and Reich's admission of bioethics' birth begin to make room for the political and socially contingent nature of much scientific practice, as well as within bioethics itself.

The range of definitions that these extracts offer begins to hint at the multifaceted nature of 'bioethics' as: context-sensitive; a discipline; a set of activities; a discourse or way of reasoning; as well as being highly personalised. In reality, bioethics is perhaps best constituted by action, making its underpinning agenda, be that technocratic or democratic, expert led or deliberative and open, important to question. And yet, despite the prolific definitions and the many years of institutionalisation, there has been a relative scarcity of accounts of 'ethics in practice' which build on these academic and generalised definitions to explore the realities and meanings of ethics in scientific life. As Sheila Jasanoff (2005a, p. 174) recounts, in attempting to define ethics "people usually stress its indeterminacy". Further, in a recent study of the Human Genetics Committee, the Human Fertilisation and Embryology Authority and the Nuffield Council on Bioethics, each a prominent bioethics committee in the United Kingdom, the sociologist Alfred Moore notes that many members of these committees had trouble in defining what an 'ethical issue' was. This is despite the committees in principle being rich holding pools of bioethical expertise. Ultimately, the only cohesive characteristic in interviewees' responses was that 'ethical issues' were distinct from commercial and scientific considerations (Moore, 2010).

3.1.3 Accounts of bioethics from the social sciences

So, despite the term's multivalence, the dominant form of bioethical analysis would apply 'moral theory' to 'ethical problems' in order to suggest reasons for action. However, sociological analyses of bioethics have not been limited to Beauchamp &

Childress' notion of 'descriptive ethics'. Such studies place the practice of bioethics itself as an object of analysis[5].

Early on in the bioethical project, Renée Fox challenged the emergence of a bioethics discipline which although interdisciplinary, had a notable 'moral-philosophical' skew in terms its publications (Fox, 1976). Fox did not draw a boundary around bioethics as the purview of particular theoretical orientations, but instead defined it by its focus of analysis – as being concerned with "the social, ethical, theological and legal implications of developments in biomedical research and technology" (Fox, 1976, p. 231), which is clearly an appropriate target for sociological study. Appell reiterated Fox's observance of the scarcity of sociological research that placed bioethics as a site of enquiry (Appell, 1980) (what de Vries (1995) later termed the sociology *of* bioethics). Framing ethics as "a code of behaviour, a set of rules, to regulate competition for resources and power" (Appell, 1980, p. 351), he argued that consequently, it was important to pay attention to what the discursive positioning of things as 'ethical' or 'moral' does, suggesting that the terms could be used to 'cleanse' certain behaviours.

These and subsequent studies claim to varying strengths that: i) bioethics is an appropriate target for the social sciences; ii) bioethics is at least in part best thought of as a complex social actions; and iii) that unless bioethical study incorporates empirical insights it will remain problematic. At the strong end, Hoffmeister (1992, p. 1421) bombastically questions whether "ethnography can save the life of medical ethics", ultimately claiming that unless anthropological approaches are incorporated into the model of bioethical scholarship and practice it will fade into obscurity. Others tend towards a more moderate re-framing of bioethics away from a particular Anglo-American analytic-philosophical canon (Kleinman et al., 1999), suggesting that philosophical and sociological approaches to ethics are to a large extent complimentary (Zussman, 2000). Contributions might be made at theoretical and empirical levels which show the ways in which bioethics is socially constituted and situated as a field of analysis and debate (Haimes, 2002). Moreover, whilst such studies might be seen as being of little direct utility by moral philosophers, there is hope that they may begin to embed a level of reflexivity into bioethics (R. de Vries, 2003).

To greater or lesser extents then, these scholars define bioethics as a value-laden and socially constituted theoretical and practical action that is primarily concerned with

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[5] The intention here is not to produce a comprehensive overview of this critique, which has been reviewed elsewhere (e.g. Turner, 2008a). Rather, my aim is to quite cursorily indicate some key articulations of why the philosophical positions of bioethics introduced so far might be problematic, and offer some alternatives that might be fruitful for the study in hand.

dilemmas raised by modern bioscience and (bio)medicine. Such definitions leave space for perspectives that are broader than moral-philosophy and allow alternative insights to become more than mere 'hand maidens' to the incumbent approaches within bioethics (R. de Vries, 1995). One goal of this positioning is to imbue both studies and practice with notions of an empirical rooting, of theory challenging, reflexivity and polite scepticism, what Hedgecoe (2004) terms 'critical bioethics'. With these perspectives in mind, I now turn to one particular way in which bioethics might become an object of study.

3.2 Some heuristics for analysing 'the ethical'

Within sociological studies of bioethics (e.g. Bosk, 1999; J. Evans, 2002; 2000; Salter and A. Harvey, 2014; Taylor-Alexander, 2014), one of the most pervasive articulations of bioethics is as a 'task'. This approach has been taken by Daniel Callahan (1999), Charles Rosenberg (1999) and has been subsequently expanded on by John Evans (2012; 2006). Conceiving of bioethics as a task opens up space for negotiation and work regarding who should be doing bioethics, when and how they should do it, and what is or isn't 'of concern'. It makes it possible to look beyond formal demarcations to the way that ethics is constituted in practice (Jasanoff, 2005a). Furthermore, it is amenable to the 'idiom of co-production' (Jasanoff, 2004a) which suggests that knowledge, its technological artefacts and society are mutually shaped to the point that they are constitutive of each other. Work within STS has examined the embedded political, normative and social prescriptions within scientific practice (Latour and Woolgar, 1986); the production of technological artefacts (Pinch and Bijker, 1984; Winner, 1986a); and the science-policy interface (Guston, 2000; Jasanoff, 1990; Wynne, 1993). As with co-production, these approaches suggest that both scientific knowledge and technologies are dependent upon social actions and therefore cannot pre-exist them. As the field has developed, scholars have become more disposed to examining the explicitly normative dimensions and implications of such observations. This is an important and rich corpus, containing notions of 'ethical boundary work' (Wainwright et al., 2006), 'the co-production of ethics' (Pickersgill, 2012), 'soft impacts' (van der Burg, 2009) and 'embedded visions' that demonstrate the performative power of bioethics in constituting emerging technoscientific fields (Hedgecoe, 2003).

Below (*subsection 3.2.1*), I introduce Evans' approach and offer some modifications that I believe are necessary to make use of it in this study. I then draw from the STS corpus (*subsection 3.2.2*) to add colour to the ways in which ethical concerns come to be demarcated and responsibility for addressing them is distributed. In particular, this facilitates an analysis of the discursive and structural negotiations of actors, and draws attention to a number of ways that 'the ethical dimensions' of research can be implicitly embedded within these negotiations. My claim is that Evans' modified approach coupled with STS's analytic work provides a heuristic framework that will allow an analysis of the bioethical domain in the UK biosciences.

3.2.1 Bioethics as a task

In his 2012 book (J. Evans, 2012), the sociologist and seasoned bioethicist watcher John Evans teases out a common theme from a number of his previous talks and writings (J. Evans, 2002; e.g. 2000). Whilst his notion of both bioethics and bioethicists is decidedly US- and medically- oriented, his analytic gaze is useful. This gaze draws from Callahan (1999) to introduce the notion of bioethics as a 'task'. At its simplest, this notion suggests that there are: (i) tasks; (ii) actors responsible for doing those tasks; (iii) preferred ways of going about doing those tasks; and (iv) a space for all this to occur within (*figure 3.1*). These are what Evans correspondingly terms (i) 'tasks', (ii) 'professions' with 'jurisdictions', (iii) 'systems of abstract knowledge' and (iv) 'task-spaces' (*figure 3.2*) (J. Evans, 2012 p.xvii). Whilst some of these conceptual keystones are self-explanatory, others are more opaque and potentially more problematic. Below, I add detail to this outline and offer some refinements for the purposes of this study by asking: (i) *What is the task*?; (ii) *How do tasks get done and by whom?*; and (iii) *Where do tasks happen and who decides who does what?* The schematic representation of these refinements is presented in *figure 3.3*.

For Evans, the 'task of bioethics' is "making ethical claims about medical and scientific technologies and practices" (J. Evans, 2012 p.xvii). Whilst this is sufficient, making claims about issues is not all that happens; they must also be acted on. Therefore, attention towards a number of associated tasks is also warranted. Of immediate concern is the addition of a second associated task of, 'acting on the ethical claims made about developments within the biosciences'. Although these two tasks are related, they may or may not be completed by the same groups of actors.

To explain how the task gets done and by whom, Evans relies on a notion of 'professions', drawn from Andrew Abbott (1988). Under this framework, professions' systems of abstract knowledge are both used to gain control ('jurisdiction') of tasks and also to dictate how that task should be done. Put another way, "their 'jurisdiction' [is] the link that professionals make between themselves and a series of tasks, or their 'work'" (J. Evans, 2012 p.xix). Whilst appealing, two problems remain with Evans' proposition. First is the wedding to professions. As this chapter has shown, claiming bioethics as a profession is but one way that the term can be cut. One might therefore be sceptical of a predilection for bioethics' professional status over alternatives. Evans knows this, acknowledging that "what constitutes 'bioethics' is becoming increasingly murky" (Turner, 2008b, p. 778). He consequently spends a significant amount of time defending this position, using criteria such as the ability to mediate public debate, requests for expertise from actors external to the community, the presence of centres, journals and professional publications to defend his framing of bioethics as a profession (J. Evans, 2012 p.xxi). Whilst these markers are all helpful, there remains a

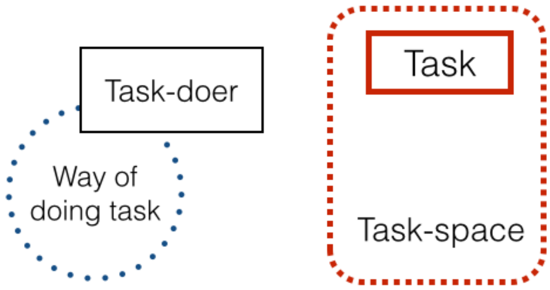

Figure 3.1: *Approach to the study of bioethics distilled from Evans' (2012) text.*

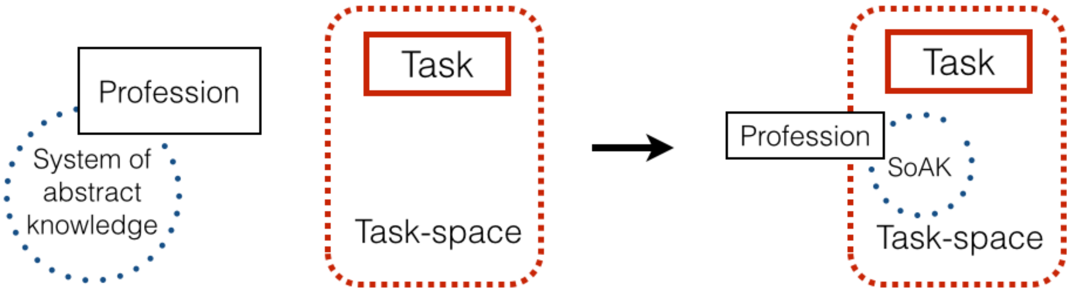

Figure 3.2: *Schematic of Evans' conceptualisation of professions, systems of abstract knowledge, and task-spaces. A task exists within society (e.g. making ethical claims about developments in the biosciences). A profession (e.g. bioethics) uses its system of abstract knowledge to claim authority for doing that task (i.e. gain jurisdiction). This happens within a particular regulatory, political and social context (the task-space) such as within clinical practice or research.*

Figure 3.3: *Summary of the changes made to Evans' framework. Multiple tasks are present; professions become 'theory-practice communities' who are able to mobilise multiple resources, including systems of abstract knowledge, to distribute responsibility for tasks; and task-spaces are considered 'forms of life' which operate at varying scales.*

reliance on a singular, dominant and identifiable 'system of abstract knowledge'. He identifies bioethics' system of abstract knowledge as being,

> "wherein ethical recommendations are not based on their own personal values or the values of a particular group in society, but based on the values of either the individuals involved with an ethical decision or the values of a subgroup of the public" (J. Evans, 2012 p.xxi)

So Evans could be suggesting that bioethics is a profession primarily of moral philosophers. However, a broader understanding of bioethics must be predicated on these being not the only actors who are qualified to make bioethical claims. To unify moral philosophical approaches within bioethics seems to be slightly disingenuous, but to unify other fields of actors such as STS and Technology Assessment becomes problematic (Cruz-Castro and Sanz-Menéndez, 2005; Fuller, 1999). Fields, professions and disciplines are only unified from a distance; even the most monolithic entities might be better viewed as a self-produced account, which effaces the subtle heterogeneities and "mixed genealogies" (Schaffer, 2013, p. 64). This then is a matter of scale and performativity of language. Ultimately the use of professions attempts to allow the examination of i) the kinds of knowledges that are being used to make claims about ethics and ii) the groups of actors making those claims. To do this, the notion of professions is not needed here, seeming a little too cut and dried. Instead I conceive of groups of actors that share at varying levels histories, epistemologies, ontologies, methodological preferences, and areas of concern, present here as *theory-practice communities*.

Second, Evans suggests that it is the 'systems of abstract knowledge' that allow groups to make strong claims about ethical developments in the biosciences and then to argue that *they* should be the ones, using their body of theory, to address those ethical aspects. This has credence, but actors act to distribute tasks to other groups as well as gain control of it themselves. Similarly, there are powerful resources that can be deployed in addition to knowledge-systems to achieve this. Evans' simplification therefore risks missing the manifest motivations of actors and the more systemic and political interactions that might be occurring during a given period. The complexity of the biofuels case demonstrates that the arrival of 'ethical aspects' within the biosciences and the distribution of responsibility for addressing them stems from complex interactions between different actors that involve more than just the use of particular forms of knowledge and more than just groups competing to claim 'jurisdiction' for themselves. There are numerous factors that shaped how biofuels became 'of concern' in the way that they did, and they were positioned as being of particular concern for researchers at least in part as a defensive strategy to justify research in the area. Whilst bioethicists argued that these matters of concern should be framed as 'ethical' questions (e.g. Gamborg et al., 2011; P. B. Thompson, 2008), they could also be framed and disputed in terms of sustainability, political problems or technical questions. Such designations are performative (Appell, 1980) and can serve to legitimate an issue and mark it as an appropriate area of work for particular disciplines and particular methods (Hedgecoe, 2001). Likewise, the designating of an issue as technical need not belie its value-laden nature. So, issues may or may not be couched in ethical terms and different groups are likely to approach the subject through different lenses and with varying agendas. Many actors thus do the first task, of making claims about ethical issues. However some, with their traditions of theory and practice, have more authority than others in making such claims and the desirability of particular framings depends on the actors involved, their agendas and negotiations beyond epistemic contestations. It is therefore important to dig a little deeper into the discursive strategies, assumptions, and motivations, which I outline in *subsection 3.2.2*.

What contexts do bioethical tasks inhabit and how is responsibility for their completion distributed? Evans locates tasks within a methodological, conceptual and institutional 'task-space'. Drawing on Callahan (1999), he suggests four distinct task-spaces: healthcare; research; public policy; and human culture more broadly. Whilst conceptual space can be provided by a robust system of abstract knowledge, gaining *institutional* legitimacy is most important. This can be catalysed by a range of processes, including enrolling support from actors, for example by negotiating between competing professions such as bioethics and medicine (J. Evans, 2002, pp. 11-44). Ultimately however, legitimacy is protected by processes like formal regulation that mandates particular ways of approaching the task of ethics, and professional accreditation that identifies individuals as having the appropriate expertise to conduct the task. So, whilst tasks are being institutionalised a wide range of voices are able to shape the task of ethics, but they are ultimately formalised by an ecology of powerful actors such as organisational governing bodies, professional organisations, regulatory agencies, and governments (J. Evans, 2012 p.xix). Changes to this ecology will produce new configurations of actors, sources of authority and discourses of value which can position different approaches as appropriate ways for addressing tasks.

Here then, Evans is reliant on a predefined categorisation of bioethics 'enterprises' and is primarily concerned with the strength of their institutionalised space. He therefore risks neglecting the importance of space in its geographical and material sense that work from within STS has been at pains to draw attention to; the 'task' of bioethics might happen within a clinic, within a university, within a laboratory or within a broadcasting studio. The characteristics of each of these spaces will help to determine what that process looks like. Such spaces co-evolve with the task and the wider context. Additionally, the focus on rather macro-level dynamics and pre-existing categories runs the risk of over-universalising particular 'clinical', 'research' or 'public policy' task-spaces by suggesting that the actors operating within the task-space will make use of the same knowledges, employ the same tests and measures of credibility, and involve similar groups of actors. But the way that different research projects, for example, are funded will dictate the ways that the tasks of ethics are distributed and will likely employ different acceptable ways of going about that task. And what seem like equivalent ethics committees in the public-policy task-space might upon closer inspection turn out to operate differently, significantly shaped by the specifics of their terms of reference that, for example, might impose or remain silent on the need for consensus (Kelly, 2003), which may also take numerous forms (Horst and Irwin, 2009).

Evans (2002, pp. 42-43) puts some of his choices down to a trade-off between generalisability and specificity that exists within any qualitative work, which I will address in detail in the following chapter (*Considering method(ology)*). For now, I want to turn to the tension between wanting to analyse the task of ethics in different contexts, whilst simultaneously wanting the analysis to not be predicated on pre-defined and neatly demarcated contextual categories. Put another way, one should be hesitant about dividing up such arenas so neatly; Although categories such as science and policy have historically been understood as discrete arenas, empirical investigations into scientific culture and practice make these distinctions and the boundaries between them more fluid. “Viewed up close, science turns out to look a lot like other social institutions, full of norms, beliefs, ideologies, practices, networks, and power and deeply engaged in the production and management of social order” whilst “political institutions rely deeply on the production of matters of fact to acquire and retain legitimacy” (C. A. Miller, 2001, p. 481). To deal with this, I follow Miller (2001) in mobilising Wittgenstein’s ‘forms of life’ to distinguish between different changing and contingent arenas that people operate in (Biletzki and Matar, 2014). Each ‘task space’ therefore contains a different and unique “ordering and amalgamation of human norms, practices, discourses and knowledges” (C. A. Miller, 2001, p. 482). Important here is that each also contains different ways of producing credibility, legitimacy and acceptable forms of expertise for particular tasks or speaking about particular problems.

In closing this subsection, let us recapitulate and review the state of ‘the task of ethics’ so far. Evans’ framework of ‘bioethics as task’ provides a useful tool to orientate a study of the way that ethical issues are produced and responsibilities for addressing them are distributed. My modifications (characterised in *figure 3.3*, above) can be summarised as follows. First, the notion of a ‘task’ was expanded to suggest that if there is a task of making claims, then one should also consider a task of acting on those claims. Second, although robustly defended in Evans’ own study, I found characterising all groups of actors making claims about ethical issues and their engagement as professions unsuitable for this study, hence the jettisoning of professions and the incorporation of ‘theory-practice communities’. These theory-practice communities are able to mobilise multiple resources, including knowledge-systems but also make use of particular methods, rhetorical strategies, political contexts and relationships with other actors to produce and frame issues and claim or delegate responsibility for their management. They need not require a singular or coherent form of each resource. Finally, the notion of task-spaces provides a suitable way of contextualising discourse and action, if such spaces are equated to distinct 'forms of life'. And although institutional and conceptual space is important to be aware of, one should also be cognizant of the potential specifities resulting from material, organisational and project-based characteristics that operate within distinct forms of life, most notably 'scientific' and 'public'.

Perhaps the most significant of these changes is the simplest. Identifying two related tasks, of discourse and action, means that it is possible to see that the constituents of debates about each task may differ. And nor must the group with authority in each situation be the same. Scientists, parliamentary committees, politicians, governments, non-governmental organisations, social scientists, industry representatives, bioethicists and so on make claims about the issues raised by the development and deployment of biofuels. Similarly, the second task of acting on those issues is carried out by many different groups: bioethicists, social scientists, research funders, policy makers, members of committees, scientists, and consultants to name a few. The diversity of actors and the diversity of tasks means that is unlikely for all actors to ascribe to the dominant traditions of theory and practice within each task-space. Nevertheless, to take part in debate they will likely be required to use such terms and to adopt the methodological predispositions. For example, scholars within STS in the UK have been fundamental in advocating public engagement as a means of addressing ethical and social issues within science and technology (Wynne, 2008; cf. 2007a). However, largely, these scholars are not the ones who are responsible for actually conducting the engagement in day-to-day practice; this is generally left to scientists, research funders and an industry of 'engagement practitioners' that has developed. As such there is a potential for reinterpretation of theoretical articulations and therefore a point of conflict and negotiation between those responsible for developing the theoretical basis for the task and those responsible for acting on ethical issues within the biosciences. Asking what these conflicts are, examining the relationships between 'issue', 'action' and different actors, why particular formations hold together and what strategies for subversion are available therefore become important topics of exploration (and are not all within the bounds of this study). Having raised this as a possibility, I now want to drill down into some of the resources and processes that might be visible in the production of bioethical tasks by drawing from the work in STS that I have previously alluded to.

3.2.2 Dynamics of the bioethical

Whilst the notion of bioethics was being made into a field of its own right, a number of other areas of scholarship were also paying heed to the social, ethical and political aspects of scientific knowledge and technology development. During the 1970s, 80s and 90s what proved to be durable insights began to emerge from within the field of STS, its sub-field of the Sociology of Scientific Knowledge (SSK) and from studies in the history, philosophy and sociology of technology. Enlisting a 'wild' form of social constructivism (Sismondo, 1993), such studies took the examination of scientific knowledge as a starting point and began to hold that rather than the truth of scientific statements being solely derived from nature, they were best thought of as inherently social processes. Subsequent work has expanded significantly and finessed the detail of underpinning social processes involved in the making of scientific claims as they move from laboratory out into the world (Latour, 1987; Latour and Woolgar, 1986), the design of technological artefacts (Bijker et al., 1987; MacKenzie and Wajcman, 1985), the assessment of risk and environmental regulation (Wynne, 2002), and the designation of expertise (Collins and R. Evans, 2007; Wynne, 1991).

Within STS, a body of work that examines the social construction of technology is particularly helpful to understand the way that a bioethical task is constituted. Introduced in a 1987 volume edited by Bijker, Hughes and Pinch (Bijker et al., 1987), the broad approaches to the social construction of technology incorporate a wide range of approaches, including the now prominent notion of Actor Network Theory (ANT) adopted by Callon (1986), Latour (1992) and Law (1986). A narrower, programmatic approach, the Social Construction of Technology (SCOT) has also been widely applied (Bijker, 2009). Initiated to bridge social studies of science and technology (Pinch and Bijker, 1984), the SCOT programme has two tenets at its core: the concept of a *relevant social group*, and the notion of *interpretative flexibility*. Relevant social groups are "institutions and organizations (such as the military or some specific industrial company), as well as organized and unorganized groups of individuals" (Pinch and Bijker, 1984, p. 414) that coalesce around a technology. Different actors amongst the relevant social groups attach different meanings to the technology, thus it has 'interpretative flexibility'. As groups consolidate and begin to attach meanings to a technology, a 'technological frame' develops (Bijker, 1995). A technological frame is similar to Kuhn's (1970) notion of paradigm with the exception that it is applicable not just to scientific communities (Bijker, 2009). Therefore, what technologies are is inseparable from the meanings to which they are attached. The SCOT approach is more interested in "understanding the process [by which technologies get made] than in describing the product" (Bijker, 2009, p. 68). Once technologies have associated groups of actors that attach meanings to them, SCOT holds that technologies might begin to gather momentum and become stabilised. Stabilisation might occur over a short or extended period of time but comes at the cost of interpretative flexibility and one particular technological frame becomes dominant. Through stabilisation, technologies gain 'obduracy', meaning that they begin to structure and shape the actions of individuals and societies (Bijker, 2009). These characteristics become visible as one's gaze moves from a level of 'artefact' to 'technological system' to 'sociotechnical ensembles' (Bijker, 2009).

Bijker holds that SCOT employs methodological relativism whilst maintaining political, ethical and ontological agnosticism. Thus, whilst "this implies a specific form of being relativistic with respect to how the working of a machine is explained" (Bijker, 2009, p. 66), it does not mean that one has to adopt a particular normative position of how that machine *should* behave, nor of whether different actors are seeing the same or different machines. By understanding them as inherently socially constituted processes, it is therefore possible to transfer this thinking to many other things that would not normally be understood in such terms (e.g. cities, parents, children, economic markets (Bijker, 2009, p. 73)). The notion of bioethics is also treatable in such ways. Applied to ethics, using a social construction of technology approach means that it becomes possible to understand the processes that go into the first task of 'making bioethical claims' and the second task of 'acting on those ethical claims'. Methodologically, it means that one should commence a study by mapping the different groups involved in the action of bioethics before digging deeper to examine the ways in which the different groups claim that bioethics should occur and the ways in which the object of study, bioethics, becomes institutionalised, perhaps gaining obduracy. Beforehand, there are some further insights regarding the dynamics discourse and action around bioethical tasks that can be gleaned from work within STS.

Bioethics 'in action' / discursive constructions of bioethics

A relatively small number of studies have paid attention to practices and discourses within science and technology that constitute bioethics at the micro-level. Whilst some (e.g. Frith et al., 2011) contend that the majority of studies of bioethical practice examine participants' responses in hypothetical situations, there is a relatively small but tightly interlinked body of work that employs ethnographic and qualitative interviewing methodologies from the interpretative social sciences and anthropology to examine the ways in which individuals and groups construct a sense of ethical research and ethical problems, commonly within controversial areas of practice and medicine.

The core of this body of work seeks to explore the ways in which individuals, commonly scientists and practitioners working in biomedical fields, either construct ethical issues, position themselves in relation to those ethical issues and other sets of actors, or examine the ways in which individuals 'cope' with dilemmatic situations. Here, Gieryn's (1995; 1983) notion of 'boundary work' holds considerable sway. Boundary work refers to, "the discursive attribution of selected qualities to scientists, scientific methods and scientific claims for the purpose of drawing a rhetorical boundary between science and some less authoritative residual 'non-science'" (Gieryn, 1999, p. 4). Although initially developed as an attempt to move beyond what Gieryn saw as analytically problematic demarcations between scientific and other forms of knowledge, the concept has now been widely applied, most commonly as a form of critique of the empiricist – socially contingent divide (Burchell, 2007b; Kerr et al., 1997; e.g. see Michael and Birke, 1994). Such studies demonstrate that, at least in interview, the boundary between 'the social' and 'the scientific' becomes increasingly murky. Empiricist discourses are often mobilized at a 'micro level' to delineate and protect a space for scientific practice within the immediate vicinity of those interviews. In contrast, 'macro' levels of research agenda setting and application are subject to social forces. Kerr, Cunningham-Burley and Amos (1997) suggest such boundary work both provides an interface between social debates and micro-level empirical work, but also allows individuals to construct discursive boundaries around "different levels and types of responsibilities" allowing different aspects of responsibility to be 'embraced or abrogated' (Kerr et al., 1997, p. 290). As such one might hypothesise that 'ethical boundary work' (Wainwright et al., 2006), demarcates 'selves' from 'others', personal from professional responsibility, humans from non-human animals and embryos (Hobson-West, 2012) and regulatory ethics from personal ethics. Each of these facets might be viewed as intrinsic components of individuals' on-going negotiation of individual roles within research and medical practice (Nicholas, 1999), helping them to delineate a 'positive ethical space' (Wainwright et al., 2006) that allows work to be done (Fujimura, 1987).

The aforementioned research provides insight into the way that bioethical issues might be managed within research. A number of recent studies help to provide insight into the way in which 'bioethical tasks' might emerge. At least in part, such studies aim to move beyond formalised and expert-led notions of the task of bioethics to move towards bottom-up conceptualisations. By 'conceiving of the normative broadly' they move to begin to broaden the notion of bioethics, away from solely within the bounds of moral philosophy, towards a conception of bioethics that sits in the middle ground of the social science - moral philosophical divide (Pickersgill, 2012). This does not come without its problems however, including widely held and pervasive notions of the hierarchical differentiation between facts and values, which give scientists a 'head start' in discussions of ethical issues and a tendency to push ethical issues 'downstream' in the innovation process (Felt et al., 2009). Each of these studies draw on the notion of 'co-production' to explore the ways in which researchers and practitioners produce and engage with ethical issues in the biosciences, suggesting that 'concerns for the data' (for example what is known and not known, misinterpretation of data), personal relationships, and 'emotional' aspects of research are all built into the daily practice of science (Brodwin, 2008; K. Fortun and M. Fortun, 2005; Pickersgill, 2012) — all aspects which typically lie outside institutionalised forms of bioethics.

In addition to boundary work, Jasanoff's 'idiom of co-production' is also pertinent. Co-production is taken as "shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiment are at once products of social work and constitutive of forms of social life" (Jasanoff, 2004b, p. 2). This approach allows analyses to "take on the normative concerns of political theory and moral philosophy by revealing unsuspected dimensions of ethics, values, lawfulness and power within the epistemic, material and social formations that constitute science and technology", emphasising the "interconnections between the macro and the micro, between emergence and stabilization, and between knowledge and practice." (Jasanoff, 2004b, p. 4). Such language facilitates the move beyond what are generally considered distinct categories of 'ethical' and 'non-ethical' realms.

This framework has allowed Brodwin, studying community psychiatry practitioners in the US, to suggest that lived ethical experience is best thought of as being co-produced between micro-level day-to-day practice and macro-level regulatory regimes, which often conflict to produce dilemmas of their own (Brodwin, 2008). There is also a temporal element. Past ethical concerns, for example around patient confidentiality, have spurred particular developments within community psychiatric treatments (such as non-disclosure of names and maintaining anonymity of patients), which in turn 'loop back' to shape present day moral discourse and practice. Current moral discourse is therefore shaped and interwoven with present day practice, formal bioethics procedures and past debates. Similarly, in his study of neuroscientists, Pickersgill suggested that 'the normative' and 'scientific' within scientific practice articulate with one another to 'create' ethical issues that demand engagement at specific 'social and historical moments', sometimes requiring significant sociotechnical work (Pickersgill, 2012). By considering bioethics in light of co-production, it might be possible to begin to extend the notion of ethics from traditional forms, to also pay critical attention to, for example the act of scientific claim-making (R. de Vries, 2003). Rather than ethical implications and reflection coming after knowledge-production or the making of technological artefacts, Pickersgill (2012) argues that the '*ethical dimensions*' should be viewed as constitutive of the practice of scientific activities. In the subsection that follows, I suggest two particular characteristics that are important to pay attention to within institutionalised forms of bioethics.

Assumptions within scientific and bioethical practice

By paying attention to the actions and discourses that go into producing scientific knowledge and technologies, approaches within STS have prided themselves on drawing attention to previously unsaid assumptions. Further, by 'opening up' such processes to scrutiny, it is possible to examine the way that current practices both produce and are tied to future worlds. As Brodwin's (2008) community psychiatrists show, if current ethical discourse and practice is shaped by the past, then it seems reasonable to assume that today's processes will shape the future. Present actions are thus grounded in past experience and future imaginations; biotechnology thus inhabits a past and 'future oriented environment' (N. Brown, 2003). These future visions, as well as the underpinning motivations for the task of bioethics and the production of knowledge and artefacts, therefore deserve attention.

Despite the long-recognised normative nature of scientific and technological practice within STS, it is only relatively recently that concerted attention has begun to be placed on studying the temporal aspects of technoscientific practice, placing 'the future' as an object of study in itself. From this position, the future is not a 'neutral temporal space' (N. Brown, 2003). Rather, the forwarding and constituting of expectations, visions, promises and imaginaries are all organised fields of social practices (Jasanoff and Kim, 2009) that seek to shape the trajectories of science and technology, legitimating some whilst disabling others (Michael, 2000). Such a 'sociology of the future' (Selin, 2008) has now become relatively widely deployed within cases of membrane technology (van Lente and Rip, 1998), neural computing (Guice, 1999), gene therapy and pharmacogenomics (R. Coombs et al., 2001; Hedgecoe, 2003), nanotechnology (Selin, 2007) and nuclear energy technologies (Jasanoff and Kim, 2013; 2009). The approach has demonstrated the 'constitutive power of expectations' and their temporal variability through cycles of hype and disappointment (van Lente, 2012). It has suggested that expectations vary in predictable ways according to the socio-spatial position in relation to knowledge production (N. Brown and Michael, 2003), and has examined the different forms and shape of expectations in their material setting (Borup et al., 2006). Imagined futures operate a various scales: whilst often highly personal and individualised they might also become 'collectively imagined forms of social life' (Berkhout, 2006; Jasanoff and Kim, 2009).

The majority of this literature has examined the so-called 'dynamics of expectations', for example by examining the promissory discourses that flow around an emerging technology and there is therefore a relative scarcity of work here that explicitly considers the embedded normative aspects of such visions. Of course, that is not to say that discourse around the need to address the ethical and social issues associated with technologies has been devoid of a notion of the future. Informed by the increasingly ubiquitous 'Collingridge dilemma' (Collingridge, 1980), the premise of moving engagement 'upstream', for example, is to better allow new forms of science and technology to be shaped to become more socially desirable at their malleable stages (i.e. before they becomes ubiquitous, 'socially embedded' and intractable (e.g. see Wilsdon et al., 2005)). Others aim to conduct ethical analyses of technologies that have yet to 'emerge' (Brey, 2012). At a research governance level, 'responsible innovation' aims to instil a 'care for the future' (Stilgoe et al., 2013) whilst notions of 'anticipatory governance' aim to prepare society to effectively govern technologies as they emerge (Barben et al., 2008).

Within the previously described sociology of expectations literature, Petersen (Petersen, 2009) examines "the largely overlooked personal and social implications of expectations, especially where there is a failure to deliver technologies (at least within envisaged timeframes) or where technologies develop in unanticipated ways" (2009, p. 05.1). For Petersen expectations are important because they make claims about the future, which may influence parties both internal and external to technoscientific development. Sufferers of a genetic condition may attach hope to the discipline-building hype claims that often come with novel fields of enquiry or emerging technologies. For others, examinations of expectations may produce moral questions because access to information about a technology may change the relative judgement of its success and this information is not uniformly distributed (N. Brown, 2003).

Operating with a broader focus, Jasanoff and Kim(2009) describe how projections of the future at the level of state policy are normative, being "almost always imbued with implicit understandings of what is good writ society at large – for instance, how science and technology can meet public needs" and in defining relevant publics (Jasanoff and Kim, 2009, p. 122). Sociotechnical imaginaries therefore operate by "encoding visions of the good society" as a cultural resource to mobilise research funding, public support or institutional space (ibid p. 122). In the bioenergy context for instance, Levidow & Papaionnou (2012) identify three UK state imaginaries of the public good – localisation, agri-diversification and oil substitution – different aspects of which can be mobilised in the development of different innovation pathways. Further, although biofuels could in principle allow for decentralised, locally-produced and small-scale production of energy, European imaginaries and their associated policies have been implemented in ways that limit such configurations (Levidow et al., 2012). At the research funding level, Felt et al. (2007) prominently criticised European innovation policy as unreflexively staging science and technology "as the solution to a range of social ills, including the problematic identity of Europe itself. […The social ills from science and technology] are cast solely in the form of mistaken technological choices. There is no question about whose definition of society's problems or needs [science and technology] should address, nor any prior question about who participated in determining what is seen to be a 'worthwhile' […] objective or outcome" (Felt et al., 2007, p. 76).

So attention should be paid to the motivations that underpin technoscientific research. Simple questions such as 'who benefits?', 'who decides?' and 'why?' are useful to ask of processes here. Likewise, attention should also be paid to the motivations for the task of bioethics: These processes should be taken as a fundamental part of science with consequences for the future. Different processes are likely to be suited to different roles in different contexts but the potential roles are tightly matched to the underpinning motivations for the processes in the first place (Fiorino, 1990; Stirling, 2012). Whilst the concepts of visions and imaginaries go some way to begin to ask such questions, further elaboration is possible using the notion of 'rationales'.

Daniel Fiorino, a senior policy advisor at the US Environmental Protection Agency, introduced the notion of rationales for public participation in a series of articles in 1989 and 1990. Fiorino was ultimately concerned with the ways in which democratic institutions and processes might be able to 'keep pace with technological change' (Fiorino, 1989a), suggesting that participatory procedures needed to treat participants as 'citizens rather than subjects', meaning that they should have the capacity to seek information and shape outcomes rather than being repositories of perspectives to be mined. Expanding on this to consider different existing approaches, he later outlined three reasons why existing methods of (largely technocratic) risk assessment could be viewed as 'ethically weak' and lacking in public legitimacy: substantive, normative and instrumental (Fiorino, 1990). An instrumental rationale places engagement as a means to a predefined end. A substantive rationale assumes that engaging a diverse set of perspectives in decision-making can produce better decisions or innovations. A normative perspective is occupied with including diverse voices because it aligns with the ethic of democratic theory.

Whilst referring to motivations in this way could be seen to be normative in itself, aiming to prescribe 'substantive engagement' over 'instrumental' for example — and to be sure, Fiorino was explicit in this aim — this is not the intention here. Rather, I suggest that these rationales first 'make visible' some of the different possible motivations for engagement. Second, such motivations are likely to be more or less aligned to particular methods. Further, the different motivations are concerned more or less with certain aspects of engagement: instrumental and substantive being concerned more about outcomes, whereas a normative rationale would focus concern more towards the process of engagement in its own right (Stirling, 2008).

From individuals to intermediaries and organisations in the task of ethics

Each of the above strategies and characteristics is present within the discourse and action of individuals, and attention has mainly been focused on elucidating this. Far less, but needed, attention has been given to the "architecture and relationships between the intermediary layers of science and policymaking" (Webster, 2007, p. 610), particularly those organisations that operate in the spaces between science and society, such as those whose primary responsibility is research budget administration and the 'steering' of science (Rip, 1998). Of the work that does exist, one maturing perspective stems from the notion of 'boundary organisations' (Guston, 1999), which has gained currency as a way to position such organisations as intermediaries between the intuitively different worlds of 'science' and 'politics' (Kearnes and Wienroth, 2011; van der Meulen, 2003), and increasingly the market (Meyer and Kearnes, 2013). This perspective provides a way of conceiving of the actors operating from powerful, but interstitial, positions.

David Guston introduced the notion of boundary organisations in his (now seminal) study of the US Office for Technology Transfer. This theoretical package ties together two well-trodden positions from STS and from policy studies respectively: the concept of 'boundary work' (Gieryn, 1983) and of 'principal-agent theory' (Braun, 1993; Guston, 1996). As we saw above, boundary work is the practice of rhetorically demarcating intellectual and institutional space by attributing selected characteristics to science and non-science (Gieryn, 1983). In the context of boundary organisations, principle-agent theory seeks to describe the relationship between actors, primarily government (the principal) and the research council (the agent) (Braun, 1993; Guston, 1996). Guston, in applying these concepts to the organisations of science seeks to explore the ways that they employ boundary work to demarcate and negotiate their roles within the scientific enterprise through,

> "The creation of a space for the creation and use of boundary objects or standardised packages, or a combined 'scientific and social order'; the collaborative participation of principals and agents, or scientists and non-scientists; and the mooring to mutual interests and distinct lines of accountability" (Guston, 1999, p. 105).

Thus, both scientists and policy makers have an "opportunity to construct the boundary between their enterprises in a way favourable to their own perspectives" (Guston, 1999, p. 106) as a way of successfully intermediating at the science-politics boundary (Kearnes and Wienroth, 2011).

Accounting for the performativity of organisations begins to highlight that the relationship between 'principal' and 'agent' might be more complex than accounted for by principal-agent theory. Asymmetrical perhaps — research council power relies, for example, on Royal Charter and government mandate that is frequently reviewed and renegotiated (BIS, 2015; e.g. House of Commons Science and Technology Committee, 1997) — but suggesting a unidirectional flow of power is disingenuous. Similarly, the principal-agent conception can be criticised for its limited treatment of multi-actor interactions. Recent models of governance (e.g. see Lyall et al., 2009; Lyall and Tait, 2005) have emphasised the ways in which multiple actors often inhabit shared spaces within decision making process, often pulling in different and fluxing directions. When a research council acts, this is increasingly not just with a conception of its sole audience as government but rather with an awareness of multiple audiences, including scientists, companies, media outlets, professional organisations, NGOs and citizens to name a few – what are increasingly termed stakeholders – that it must attempt to manage. As such under distributed models of governance, it often becomes difficult to demarcate "who has authority over whom, who belongs to which side, which functions are distributed, and who is delegating what" (Am, 2013, p. 469).

These observations have led several scholars to begin to refer to boundary organisations and their success in terms of 'hybridity'. This notion of 'hybrids' is indebted to both Latour (1993) and Jasanoff (1990), defining them "as social constructs that contain both scientific and political elements, often sufficiently intertwined to render separation a practical impossibility" (C. A. Miller, 2001, p. 480). Thus, a successful boundary organisation will seek to engage in 'hybrid management' in which it will "put scientific and political elements together, take them apart, establish and maintain boundaries between different forms of life, and coordinate activities taking place in multiple domains" (C. A. Miller, 2001, p. 487). In this understanding, boundary work allows actors to demarcate science from non-science whilst also allowing different actors to interact by creating 'hybrids' of science and non-science' (van Egmond and Bal, 2011, p. 111).

In social studies of science and technology, the default object of interest tends to be the way in which scientific knowledge is produced and what that knowledge production does. Hence, the primary goal of the boundary organisation concept is to seek to explain how organisations and groups construct and mobilise specific kinds of 'hybrid' knowledges that hold together under both political and scientific pressure, despite not being founded on "testable objective truths about nature, as presupposed by the technocratic model of legitimation, nor on the kind of broadly participatory politics envisaged by liberal democratic theory" (Jasanoff, 1990, p. 234). Moreover, the general explanatory motivation for organisations producing such hybrids is that they are required to maintain legitimacy and credibility within specific governance structures or looser social perceptions. Here, conceptualising of the organisations in question as boundary organisations engaged in hybrid management provides a heuristic guide that draws to attention the ways that, and to what ends, their employees and advisors might begin to construct ethics within their research funding processes.

Transposed to the present study, it therefore becomes possible to see that NGOs must mediate between different groups involved governance of their particular arenas of activity, be that in relation to the environment, international development or specific technologies. To do so, they must negotiate not-wholly-detachable scientific, political and public arenas. They must maintain their legitimacy and credibility, whether this is perceived from the political actors that they are seeking to influence, whether this is through the production and interpretation of knowledge, or whether this is through maintaining continued support from membership and donations (Eden et al., 2006). Similarly, the BBSRC has to formally maintain its existence by continuing to meet its terms of reference laid out in its Royal Charter (HM Parliament, 1993). In practice, this means negotiating with and maintaining the support of a wide range of actors pointed to in the paragraphs above. The point here is that there are no solely unidirectional bipartisan relationships. As such, the kinds of boundaries that must be negotiated and the kinds of hybrids that must be created are manifest, existing for example, between scientific and social worlds, scientific knowledge and other knowledges, disciplines, kinds of research, ethical and unethical, experts and lay people.

With care, then, conceptualising the BBSRC, any number of NGOs (and indeed many an entity) as a boundary organisation engaged in hybrid management provides a heuristic guide to a study of the ways in which, and the ends to which, its employees and advisors might begin to construct ethics within their research funding processes. One might hypothesise that requiring and partaking in 'ethical activities' is in part driven by a need to 'manage' different imperatives at the boundaries of scientific, societal and political 'worlds'. Moreover, these practices are likely to both shape and be shaped by negotiations with actors – both real and imagined – internal and external to the BBSRC. I will return to these possibilities in chapters five and six.

3.3 Tasks of bioethics in the United Kingdom

At the chapter's outset I suggested that bioethics is a multifaceted term that resists definition, and that to begin an analysis of the way in which bioethics is given meaning, one should resist an urge to take particular existing dominant classifications at face value. Viewing 'bioethics' through the lens of STS makes several intricacies visible. First, if science and technology development are considered to be inherently social processes, then normative and political choices can be traced through to the discourse, action and the artefacts of these processes (Pinch and Bijker, 1984; Winner, 1986a, pp. 19-39). Technologies, especially biotechnologies, are involved in powerful acts of "world making by kind making" (Hacking 1992, cited by Jasanoff, 2005b, p. 171) and so in a study of the construction of bioethics, attention should be paid not just to impacts but also to the nature of new knowledge and technologies, to the practices and decisions that go into producing them, to their intended purposes and ultimately the kinds of future worlds that they encode, all of which may either be visible or shrouded. Bioethical concerns and the contemplation thereof are now implicated in producing new technological artefacts and fields of inquiry, mediating between different groups and acting, in places, as legitimating tools with the power to shape practice (Brosnan et al., 2013; J. Evans, 2002; Hedgecoe, 2003).

By conceiving of bioethics as tasks to be vied for by different actors with traditions of theory and practice, my chimeric orientation encourages questions about who is making claims about concerns within the biosciences, what kinds of concerns are encoded, which bodies of knowledge and methods are used to do this, how responsibility for addressing concerns is claimed and delegated, and how authority for these tasks is maintained or contested. Helpfully, work from within STS also excels at drawing specific attention to the discursive strategies within actors' accounts of ethics, the assumptions that exist within discourse and practice of ethics as currently demarcated, as well as nurturing a sensitivity to the work that happens within the interstitial spaces between different 'forms of life', particularly with respect to 'boundary organisations'. These are all powerful tools to be employed in the forthcoming analysis.

Now, so far this discussion has been rather nebulous. I therefore want to conclude by grounding my heuristics in the British context that is at hand. My interest is primarily with the non-medical biosciences in public (policy) and research task-spaces. It is important to note that there is a well-rehearsed 'traditional' narrative for the institutionalisation of the consideration of ethical concerns in the medical and non-medical biosciences that I do not wish to recount here (J. Evans, 2002; Jasanoff, 2005b; Lengwiler, 2007; S. Miller, 2001; but see Wright, 1994). Instead, I wish to sketch out the landscape as it currently stands.

We have already seen how some debates about the normative dimensions of developments in the biosciences play out in public (*chapter two*). However, when people speak of bioethics in the public sphere, they usually speak of bioethics committees in their various forms. They thus speak of bioethics as formally mandated. The European Commission employs various forms of committees, such as the European Group on Ethics (EGE) and Science Technology Options Assessment (STOA), operating as part of an 'ethical turn' in an expanding and murky web of governance for science and technology on the European Continent (Bogner and Menz, 2010). Such groups, and their national counterparts often raise problems of democratic legitimacy (J. Evans, 2006; Mohr et al., 2012), operating in what are in general expert-orientated and closed communities amongst a wide web of other policy actors. Some however, such as STOA do tend towards acting as facilitators in deliberative open forums with lower entry barriers for participation (Jasanoff, 2005a). Now, a legally-mandated 'ethics committee' is notably absent in the UK; our old flame, the Nuffield Council on Bioethics, with government support but not legal mandate, is the closest there is. This apparent paucity, however, draws attention to the wide range of other actors making credible normative claims about science and technology within public policy spheres, actors who might not adopt a philosophically-imbued discourse.

Parliamentary committees (e.g. The House of Lords Committee on Science and Technology), national academies (e.g. The Royal Society, The Royal Academy of Engineering), policy-advisory bodies (e.g. The Parliamentary Office for Science and Technology), research funding organisations (e.g. The Research Councils, The Wellcome Trust), formally-mandated governmental and non-governmental bodies (e.g. Technology Foresight within BIS), and a wide range of civil society organisations including think-tanks and NGOs (e.g. Demos, Chatham House, ActionAid) can all be seen to make claims, assessments and analyses about the ethical and social dimensions of science and technology. To be sure, many of these groups will be found within the bibliography of this thesis. Despite undoubted heterogeneity, these actors can be characterised by three dimensions. First, is a notable absence of moral philosophers and moralistic discourse. Second, is a tendency to either make broad claims, (for instance regarding the relative 'health' of science), to conduct specific forms of politically-attuned sociotechnical assessment, or to intervene in specific (bioethical) discussions. And third is their potential to act crucibles for a wide range of agendas, interests and formal terms of reference, meaning that they are unlikely to be formally and/or solely mandated to analyse the ethical and social dimensions of technoscience. Thus, they might all be characterised as intermediaries between different debates and worlds, with the potential for conflict between different communities of theory and practice (e.g. see Wynne, 2014) each demanding their own interrogation.

Turning to the research-space, we might conceive of two independently institutionalised but related tasks. The first draws from concern about protecting the 'integrity' of scientific knowledge and the professional norms of scientists, institutionalised in the form of 'research ethics committees' in the 1960s and 70s (Hedgecoe, 2009) and more recently in codes of conduct such as the UK Research Integrity Office's (2009) '*Code of Practice for Researchers*' or the UK Government Office for Science's (2007) '*Universal Ethical Code for Scientists*'. This, coupled with concerns about the use of animals in research are tightly regulated at both the university and research funding level in the UK. More superficially embedded are sets of concerns that emerge, in broad terms, from concerns about the environmental and cultural impacts of technologies, enshrined in stories of Bhopal, Three Mile Island, Recombinant DNA technologies and the BSE crisis, what Simone van der Burg (2009) has articulated as 'soft impacts'. Whereas concerns about 'what scientists do' are largely dominated by moralistic discourse (J. Evans, 2012 p.xxix), 'soft impacts' are open to much broader communities of theory and practice. In the UK, these concerns were famously articulated as a deficit of public knowledge, and later a deficit of trust by scientific organisations (Wynne, 2006), resulting in requirements for public engagement and in some areas, originating from genomics, the incorporation of social and ethical strands into research programmes (Calvert and Martin, 2009). Importantly, in ways similar to the 'public bioethics' arena, these broader concerns are open to a wide number of communities of theory and practice, and responsibility for addressing them is distributed to a wide range of actors, allowing for conflicts and negotiations about what is and should be of concern, as well as how it should be addressed and by whom, questions that are central to this thesis, to be unpacked in the forthcoming chapters.

Chapter 4

Considering method(ology)

4.1 A primer

In the previous chapter I situated the present study as one that questions how different groups produce bioethical concerns, and the ways that those productions shape bioscience. To begin to do this, I drew on bioethical and sociological literature to present a number of articulations of the term 'bioethics', ultimately favouring a sociologically-informed approach that is underpinned by the social construction of technology (Bijker et al., 1987), an understanding of 'ethics as task' (J. Evans, 2012), the notion of boundary work (Gieryn, 1983), approaches that consider the ways that the future is constituted (N. Brown et al., 2000), and a concern with the underpinning rationales for action (Stirling, 2008). In final form, then, I am primarily concerned with the actions and discourse of three groups of key actors: non-governmental organisations (NGOs), the Biotechnology and Biological Sciences Research Council (BBSRC) and scientists. To ground the work in the specifics of a case study, I work with biofuel development and deployment in the United Kingdom within a primary time period of 2006-2014. I mobilise an understanding of 'the ethical' as constructed, malleable and context-specific. Empirical material is primarily provided by 29 interviews (22 with scientists and 7 with NGO representatives) and a large corpus of BBSRC-relevant grey literature. Data was analysed in a theoretically-grounded and iterative process, indebted to discourse analysis techniques. Primarily, it considered the way that different understandings of 'ethics' and responsibility in the field of biofuels were produced between participant and interviewer and the ways that the BBSRC mobilised different understandings of ethics in their discourse and action.

However, if a take home point from a 101 in STS is that the process of science is a much more social, messy and initially flexible process than common accounts let on, the same can be said of *any* research, social science included. To take a recent example, Davies (2012) has demonstrated how particular regulations and reporting allow people, as collective and individuals, to remove affective dimensions of laboratory work with animals. The vocabulary, language and account matters (G. Davies, 2013). Similarly, a thesis presents a final 'artefact' that represents a process of investigation. Although the analytic orientation and theoretical alignment are now fixed, this was arrived at through much discussion, reflection and iteration across the course of the project. During this time I progressed from natural scientist with a perhaps vague, but persistent concern for 'bioethical issues' to a social scientist fundamentally trying to unpack what such issues and reflection upon them means. So whilst the object of analysis within this project has always been a concern with the ways that ethical issues and their consideration play out in research, this is not a fixed, linear or foreclosed process: Questions get set, redefined and refocused and modulated (to take an example, the 'thesis planning' folder on my computer has 57 similar documents explaining my interests and research questions); methods are selected, mobilised and mutated; opportunities are taken advantage of; and theory is picked up, put down, (perhaps) bastardised and tailored to fit the work that is being done. For Law, learning to live with this 'mess' is part of doing research. Accepting this in the accounts of such research is the first step to allow for a "broader or more generous sense of method, as well as one that is different" (Law, 2004, p. 4), but which still produces theoretically robust, defendable and insightful work.

For others, a turn to reflexivity as a central tenet of 'good' research has crystallised (Bryman, 2012; e.g. see Silverman, 2013). In part demonstrating the diversity of its application, Lynch (2000) offers up an atlas of possible reflexive types and goals. Drawing extensively on the work of Ashmore (1989) and Woolgar (e.g. 1988), he problematises traditional notions of reflexivity, ultimately favouring an ethnomethodologically-flavoured account of reflexivity that takes account of everyday language, gestures, expressions, figures and objects and which has no 'unreflexive other'. Whilst such radically reflexive calls are appealing, they are problematic on both a practical and metaphysical level, setting in motion a 'demonic machine' which for many (but not all) is self-defeating, ultimately collapsing into a state of infinite regress (Lynch, 2000). Nevertheless, as Cohen and Manion emphasise, there is a clear danger in qualitative analysis that,

> "the analysis and the findings may say more about the researcher than about the data. For example, it is the researcher who sets the codes and categories for analysis, be they pre-ordinate or responsive (decided in advance of or in response to the data analysis respectively). It is the researcher's agenda that drives the research and the researcher who chooses the methodology." (Cohen et al., 2007a 469)

This chapter then, represents an attempt to deal with such 'mess' in a reflexive manner without setting in place a demonic, consuming, machine. Presenting it in this way is sensitive to the challenges that might otherwise be disavowed and makes the work more robust. To do so, it is structured in two parts. In the first of the two parts (*section 4.2*), I consider some key methodological considerations. In the second part of the chapter (*section 4.3*), taking into account the discussion contained in section 4.2, I present an in-depth protocol of work that details how the work was conducted, focusing on the identification of actors of interest, the production of data, and the method of analysis. I close the chapter with a reflection on the sum of its parts (*section 4.4*). To make these steps is not to advocate that another project should, or indeed could, adopt them. Instead, the aim is to set them out for inspection and discussion in a transparent way.

4.2 Key methodological considerations

Here I present a broad methodological excursion with four key waypoints to unpack some of the major consequences of the decisions that I have taken when researching. Within this section my attention first turns to the definition of case studies and questions of generalisability, which represents perhaps the *de facto* concern in case-based qualitative research (*subsection 4.2.1*). I then turn to the sources of data elicitation that I chose, namely the selection of qualitative interviews and documentary sources over ethnography and the consequences that go with that (*subsection 4.2.2*). This leads to a discussion about the relationship between data and theory (*subsection 4.2.3*). Along the way, I include responses and reflections to each major waypoint for the study in hand, which are summarised in *section 4.2.4*.

4.2.1 Case studies and generalisability

Like many of the key terms within this thesis - bioethics, science, biofuels - case studies are imbued with significant malleability. Some methodologically unify them as employing observational techniques (Cohen et al., 2007b, p. 253). Indeed STS, which provides much of the theory load in this thesis, is known for its seminal expeditions to the search for gravitational waves (Collins, 2004), laboratories (Knorr-Cetina, 1981; Latour and Woolgar, 1986), fallout and farmers (Wynne, 1998), bicycles (Bijker, 1995) and scientific organisations (Jasanoff, 1990), many of which employ such approaches. Simons (1996) builds on this ethnography-oriented definition, introducing six 'paradoxes' of case study research, most prominently suggesting that one should seek to blur the traditional subject-object dichotomy that exists within research. Put another way, in pursuing case study methodologies, one should not treat the object of analysis as cleanly demarcated from the observer. In what reads more like a manifesto than a descriptive list of defining features, Hitchcock and Hughes (1995) define case studies less by method and more in terms of a series of criteria, of: being concerned with 'thick' description (Geertz, 1973) that is rich, embedded and provides detailed descriptions of the events within the case; being chronologically and temporally aware of events within the case; blurring the line between description and analysis; sharpening the focus on specific actors or groups to gain insight into their perspectives; casting specific events and their importance into sharp focus; blurring the boundary between researcher and researched and; attempting to capture such 'richness' in the writing up.

Manion, Cohen and Morrison (2007b, p. 254), contend that a hallmark feature of case studies is the ability to demarcate them within particular geographical, temporal and actor-based points. Yin (2009a) echoes this, using similar criteria to schematically differentiate between 'context' and 'case'. When defined in these terms a key intention, and tension, is of enabling one to point to wider phenomena that are visible within a tightly bounded system (Cohen et al., 2007b, p. 253). Ultimately however, both sets of authors end up conceding that such boundaries are at best seen as porous. STS has long contended that boundary-drawing is best considered a rhetorical device, most commonly deployed for strategic ends (Gieryn, 1999; 1983) – in this case heuristic – rather than as representing fundamentally real, bright, lines. To this end studies in the field have generally striven to transcend and deconstruct — rather than essentialise — a pre-existing boundary, be it between method, kinds or disciplines (Barry et al., 2008; Jasanoff, 2013) leading some to propose that the clunky neologism "reificaphobia", a fear and challenge of anything settling, is endemic within STS (Wyatt and B. Balmer, 2007 624). Importantly, these tensions in definition are represented when considering the *outcomes* of case study research. Ultimately, many tie into deeper questions of generalisability, a perennial topographical feature of all methodological debates.

One common response to problems of generalisation is to demarcate between 'case studies' and 'experiments' and to then claim that what is at stake is less statistical generalisability (i.e. moving from sample to population) and more analytic generalisability (i.e. aiming to mobilise theories to help others make similar analytic points) (e.g. see Cohen et al., 2007b 253; Yin, 2009a). Yin (2009a) for example expresses that in both experiments and cases it is impossible to generalise from one single example to 'all', suggesting that instead one should aim to generalise to 'theoretical propositions' rather than to populations or universes. When doing so, ensuring an analytically robust and iterative development between empirical data, theory and analysis is most commonly suggested as a strategy to ensure both validity and generalisability with other similar cases. But forgoing any right to generalise to other broader populations or situations whilst simultaneously relying on and claiming to generalise to theory which itself is developed and translated from empirical work in specific circumstances to other instances is problematic.

Martyn Hammersley (1992) has harpooned such traditional responses. Hammersley maintains that there is a logical problem for statistical generalisation in the form of 'infinite populations' - the populations in question must necessarily expand to include "all past, present and future instances to which the theory claims apply" (Hammersley, 1992, p. 174). Thus, statistically-based generalisations can only be used in finite populations, e.g. from single features of a case to the whole of the case.

However, Hammersley also makes two other moves. The first is to reject the demarcation between case studies and other forms of inquiry, particularly in terms of a quantitative-qualitative dichotomy, instead locating all studies on a spectrum of breadth-depth. One result of this is to reject the idea that sampling methodologies are not required in case studies; rather, specific questions demand them in all forms of enquiry. Here, in perhaps surprising harmony with John Law (2004), he eschews rigid binaries and instead likens research to a maze, "which means that we need a methodological language that gives us rather more guidance about the range of routes that is available at each point in our journey than the conventional dichotomies" (Hammersley, 1992, p. 184). Hammersley's second move argues that in addition to statistical inference failing to provide a robust base for generalisations beyond a finite population, logical inference also struggles to extrapolate beyond specific case studies. This tension within induction, identified by Popper (1968), leads Hammersley to conclude that, "we cannot extrapolate on logical grounds from the study of a single case, or from the study of a small or a large number of cases, to necessary truths about all cases of a given type" (Hammersley, 1992, p. 180). How might we deal with these concerns about analytic generalisation?

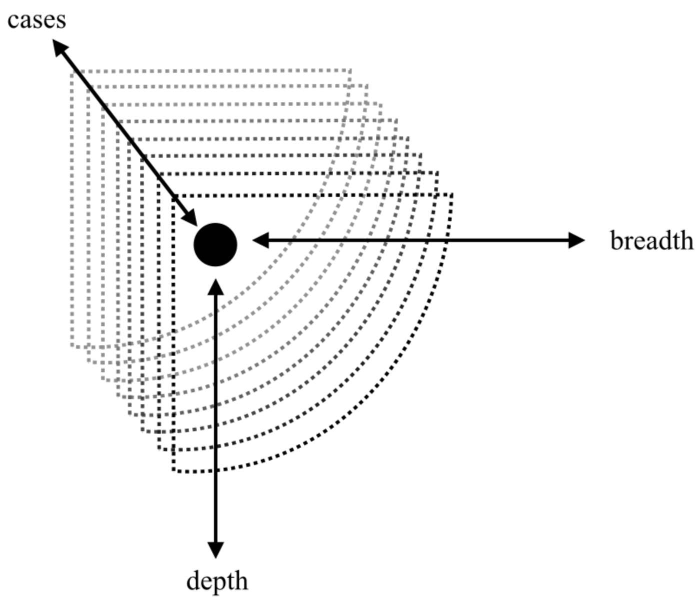

Figure 4.1: *Questions of research design can be envisaged as trade-offs to be made in the face of limited resources and potentially infinite populations, adapted from Hammersley (1992)*

The tensions in generalisability and study design that I pointed to above can be summarised schematically, as in *figure 4.1*, above. Any given project, represented by the black dot, is constrained by a finite amount of resources, most obviously money and time. The X-, Y- and Z-axes represent breadth, depth and case number, respectively. To move along the axes, increasing granularity, requires more resource.

Thus there are clear trade-offs to be made between the three, given finite resource. Decisions about the amount of trade-off should be matched to the research questions in hand. Whilst greater breadth, in temporal-, geographical- or sample- form, might increase the ability to generalise to the whole population, the ability to confidently translate insights to other contexts is dependent on knowledge of the given case, i.e. depth. By moving further along these axes, one is able to increase the resolution of the analysis by, for example pointing to sites of heterogeneity or similarity that will allow one to be sure of the applicability of theory to other examples when developing, or drawing from, theoretical positions. Note the absence of end-points on the axes. This counters the plausible assumption that by maximising resources it would be possible to produce a comprehensive study that covers intense and minute details and covers the entirety of a case. However, this assumption depends on finite end points, which often do not exist (Hammersley, 1992, p. 187).

Considering cases and generalisability

There is clearly some discomfort in drawing boundaries around a situation using terms such as 'biosciences', 'science', 'NGOs', 'the UK' (the list goes on), in a study which seeks to emphasise the heterogeneity and flexibility of other terms, such as ethics. However, doing so is necessary to prevent falling into a state of infinite regress, and to move forward heuristically. Perhaps the most satisfying approach follows the language of Hitchcock and Hughes (1995) in being primarily concerned with 'thick' description that is rich and provides the kind of detailed narrative of events that comes with being thoroughly embedded within a situation. This approach is striking in similarity to perspectives, such as Beaulieu, Schornhorst and Wouters (2007), and almost inevitably teeters on the edge of reducing the approach down to its lowest common denominator of, being "careful examination of a particular episode or object" (2007, p. 672).

In this project therefore, I provide rich, detailed and contrasting accounts of the construction of the ethical dimensions of research through interview and documentary work. This is supplemented by my extensive five-year immersion in the biofuels field. I draw loose boundaries in terms of geography (the United Kingdom), temporality (2006 – 2014), the phenomena of interest (the construction of 'the ethical' dimensions of research), and the arena of interest (the development and deployment of biofuels) that provides a series of populations of interest. These demarcations come with the extensive caveat that 'biofuels', amongst other terms, represent a slippery arena to be operating within and a slippery term to be working with. For instance, they challenge traditional geographical boundaries of production and impact; whilst their consumption and research into their production might be contained within national boundaries, their production and impacts often happen in quite different spatial arenas. Similarly, despite being primarily concerned with events in the twenty-first century, as previous chapters have shown, all of these developments must be viewed as part of a continuing genealogy that extends back into the previous century. Furthermore, by conceiving of 'the ethical' broadly, I sought to eschew narrow and predefined definitions of what an ethical issue is, how it might arise and how it might be managed, by whom and for what ends. Although obviously not adopting a formal ethnographic method, the approach I take is sensitive to Hine's (2007) suggestion that analysts might follow the phenomena of interest around without presupposing any tightly defined arenas, definitions or presumption of the most relevant parties of interest as a means to develop novel insights in qualitative research.

What of generalisability? Clearly, there are different research strategies for addressing this evergreen tension. To take an example from biofuels, one might aim to provide insight into the issues that arise around specific biofuel production chains, or around specific biofuel development and production sites (e.g. Giampietro and Ulgiati, 2005; Upham et al., 2007). Whilst valuable, such approaches trade off breadth with depth in ways that would not allow me to talk confidently to other aspects of the non-medical biosciences. Similarly, a comparative case study approach might help when making generalizable claims when theory building (e.g. see Yin, 2009a), but again the description of cases must be fine-grained enough to be confident about the characteristics of each when beginning to make coherent theoretical linkages. I did not feel that this was possible with the resources available. However, generalisability is not rendered obsolete. I clearly do think my findings tell us something of the way in which actors might construct and deal with the ethical dimensions of the work that they are engaged in. Similarly, I do think that biofuels might be applicable to other contexts. To address this, pointing to sites of heterogeneity and similarity (for example across groups or conceptualisations of 'the ethical') as I do, allows me to ensure a robust set of theoretical insights (Hammersley, 1992). Equally, the case can be 'rendered comparable' by pointing to commonalities and tensions with existing bodies of theory, and mobilising complementary theoretical frameworks to other studies of similar phenomena of interest (Beaulieu et al., 2007), which I have introduced previously and continue to do throughout the thesis. Whilst I cannot hope to settle such debates (indeed they pervade many of the forthcoming discussions), and any response would be unsatisfactory in some respect, reflection emphasises the nature of the trade offs that are made in order to be able to confidently say something about the construction of 'the ethical' in more than just a very specific setting.

4.2.2 The status of data

Within this project, I rely primarily on textual information – transcripts produced from interviews with actors in the field of biofuels and grey literature – as sources of data for analysis. Here, I consider the status of my data sources, something especially important given the apparent disposition towards ethnography within STS. Whilst some have suggested that such a dominance might represent an "implicit commitment to realism" (Wyatt and B. Balmer, 2007, p. 622), others have argued that ethnography represents the 'gold standard' on a scale of qualitative research (Murphy and Dingwall, 2003, p. 54). Either way, sources of data and the methods for eliciting and rendering them analysable should never be a foregone conclusion. These decisions in research design ultimately come with manifest considerations that should not be neglected. Issues of generalisability have already been introduced. Well-trodden questions of interview structure, question formulation, access, anonymity, rapport and interview location are comprehensively reviewed in many well-known methods tomes (Bryman, 2012; Cohen et al., 2007c; Silverman, 2006a), were all taken into account during research design and will be given more time later in the chapter. Here, following Martyn Hammersley (2012) I want to turn my attention to a particularly 'radical' critique of interview methodology, that stems from traditions in conversation analysis and ethnomethodology. Much of this critique relates to the transcription of interviews as a basis for data, but helpfully the most critical of the points raised by such a critique are applicable to all forms of data elicitation, including documentary sources.

One of the most coherent 'radical' critiques comes from Jonathan Potter and Alexa Hepburn (2005) in their article, *Qualitative interviews in psychology: problems and possibilities*. They lay out nine challenges for interview-based investigations, divided into two categories (J. Potter and Hepburn, 2005, p. 281). The first category is typified by being contingent largely on the way that interviews are commonly reported, namely: (i) the deletion of the interviewer; (ii) conventions within transcription that remove interaction between participants in transcription; (iii) a lack of specificity when making analytic observations; (iv) a general failure to account for or detail the specifics of the interview set-up. Ultimately, they claim, these oversights lead to (v) the overarching problem of failing to view the interview as a process of interaction, which needs to be rectified.

The second category is broader in its target but numerically more limited. First, is a problem of *flooding* interviews with social science agendas. They contend participants are often explicitly or subtly 'coached' to respond, leaving "the possibility that a piece of interview research is chasing its own tail, offering up its own agendas and categories, and getting those same agendas and categories back in a refined or filtered or inverted form" (J. Potter and Hepburn, 2005, p. 293). They are equally concerned with the problem of *footing*, which is best characterised as difficulty in identifying *for whom* interviewees speak. Most bluntly this might come in the form of representatives of organisations 'towing the party line', but more subtle forms stem from the knowledge that individuals often carry multiple, simultaneous identities - mother, teacher, scientist for example - and are able to flip between them. A problem of *attuning* can be likened to the idea of 'second guessing' perceptions. When people speak, they often speak with an awareness of the ways that others might perceive what they are saying. In these cases, people often seek to pre-emptively position themselves in relation to how they think others will position them. For Potter and Hepburn, the consequence of this is that one should abandon trying to get to personal thoughts or feelings and instead seek to do nothing more than "document the different 'attitudes' displayed on particular occasions by speakers and seek to understand these displays" (Hammersley 2012: p.72). Finally, *cognitivist trends* within social science methods are problematised. In doing so they provocatively claim that such approaches ask interviewees to act as 'proto-social scientists' (J. Potter and Hepburn, 2005, p. 298) by asking them to reflect on causal relationships for particular feelings or phenomena and then take those ruminations at face value in their analysis.

On the surface, much of Potter and Hepburn's concern is about the way that transcripts are presented and research is reported. However, this leads to two further points that relate to a deeper problematisation of the way that interviews are analysed, and ultimately to subterranean ontological and epistemological questions and affiliations about whether or not one believes there is a truth 'out there' and whether interviews (or any other methodological forms) are able to help get at it. I will address the third point in later sections of this chapter but the first two – relating to transcription and analysis – are worth reflecting on here.

Recall my earlier reference to Gail Davies' (2013; 2012) concern that issues of affect within animal experiments are systematically cleansed from regulatory frameworks and scientific accounts. Complementarily, Donna Haraway (1992) makes a potent analysis of dominant accounts of the African-American abolitionist and women's rights activist, Sojourner Truth's famous 1851 speech *Ain't I a Woman*. The most dominant transcriptions of Truth's speech present it in a grammatically standardised English dialect. Noting that this is the version that adorns the walls of women studies centres, she suggests that such transcriptions at best represents a "white abolitionist imagined idiolect of The Slave" (Haraway, 1992, p. 97). Truth was born in New York and was owned by a Dutchman, meaning that in contrast to standardised accounts that assume an Afro-American English dialect of southern state slaves, she would likely have spoken with an Afro-Dutch dialect. Transcriptions of this kind do exist, which are closer to Truth's likely dialect and Haraway claims that they recast *Ain't I a woman* as *Ar'n't I a woman*, forcing the reader to rethink Truth's story. Going further, Haraway suggests that to read any transcription without a corresponding experience of the situation in which the speech occurred represents an ultimate inability to hear Truth's language, to 'face her specificity' and 'acknowledge her' (p. 98). Instead transcriptions allow Truth to be re-represented and re-cast in one of many "unending chains of non-innocent translation" (p. 87) that remove the specificities of both narrow circumstance and broad political context.

Central to both Potter and Hepburn, and Haraway's concern is that a loss of contextual awareness inevitably occurs through the interpretation and appropriation of situations to make arguments, be they theoretical, political or otherwise; Textual representations matter. Potter and Hepburn suggest that adopting their preferred approach to research can rectify these concerns. The first step here is to adopt the 'Jefferson' transcription system, which includes standardised notation for variations in speech and interaction, such as changes in intonation, speed and points of shared speech. They suggest that adopting such a system, even if the focus of the analysis is not primarily on the interactions between those in the conversation, at least allows such interactions to be taken into account. Their superficially soft conclusion is to pursue an ideal situation whereby interviews would be used less often but in situations where they are best suited to the kinds of questions that one wants to answer. Their second recommendation, regarding analysis, makes it clear that such suggestions are best seen to be as much a call for conversation analysis or ethnomethodology as the *only* acceptable form of analysis, discounting any interpretations of data that go beyond examining the discursive strategies, repertoires and structures that emerge within discourse. Two points: First, these prescriptions are not settled even amongst ethnomethodology and conversation analysis communities (Have, 2002; Lynch, 2002; J. Potter, 2002; Speer, 2002); Second, such conclusions would clearly be unsatisfactory for Haraway, who would ultimately place such tensions as much more recalcitrant than something rectifiable by adopting a particular transcription methodology or approach to analysis that focuses solely on interaction. Instead, as a remedial strategy we might pay attention to the 'differences that matter' (Haraway, 1992, p. 98).

Considering the 'radical' critique

Here I extend the above reflection to the project at hand. Whilst making an insightful contribution, Potter and Hepburn's solutions are not a panacea and will not *a priori* avoid many of the conflicts that they point to. Aside from the fact that many suggestions tap into broader ontological and epistemological debates that exist amongst those in their own field (as noted above), several tensions remain in their suggestions. First, pragmatically, as acknowledged by Potter and Hepburn, the Jefferson transcription standard comes with an extremely large resource burden that either significantly increases the amount of time to produce analyses or significantly reduces the sample from which data can be drawn. To counteract this, the authors suggest that interviews should only partially be transcribed but this opens up the analysis to a charge of selectivity. More fundamentally, and with a little irony, Potter and Hepburn advocate that *all* transcription take this format as if this will unproblematically make interactions visible. But as we have seen part of both sets of authors' unease rests on the fact that transcription makes particular contextual dimensions of a situation visible and hides others. The suggestion that the Jefferson method will simply make 'interactions visible' without shrouding other aspects that might be of interest to analysts is self-defeating.

Issues of *footing* and *flooding* are more tenacious, but again Potter and Hepburn's suggestions are not wholly satisfactory. The authors suggest that to best counteract these problems, 'natural' data, by which they mean that which would exist irrespective of the researcher, be used as a basis for analysis. Here however, the idea that 'natural' data will be free of the biases and tensions that exist with 'artificial' data is unconvincing. Whilst documents or pre-existing interviews, for example, might be free from the flooding of sociological theory, they are no less flooded with political, personal or ideological agendas (e.g. see B. Balmer and Sharp, 1993). All texts are constructed for particular and varying audiences. Rather than trying to remove these characteristics, a more acceptable solution might be to acknowledge their existence and incorporate their effects into the analysis. This can be achieved, for example, as I do, by acknowledging the implicit normative positions embedded within many documents and discursive arguments. For example, in many of their publications (e.g. ActionAid UK, 2010), the development NGO ActionAid adopt an implicit 'pro-poor' agenda which shapes all of their subsequent recommendations (Boucher et al., 2014).

Some previous studies have made attempts to avoid flooding within interviews. For example, following Weiner (2006), when interested in exploring sociality in neuroscientific models of autism, Hollin (2013, p. 60) refrained from asking scientists about 'the social' dimensions of neuroscientific accounts of autism because responses discussing this aspect might be considered an interview artefact. Such approaches are laudable, and moving to general questions within the interview schedule might, to an extent, mitigate the possibility of the 'research chasing its own tail' (Potter and Hepburn 2005, p.293). At the same time however, they contend that whilst sometimes explicit, *flooding* is ultimately a result of more subtle assumptions that arise in ways other than simply asking leading questions, such as the "disciplinary embeddedness of the research enterprise [including…] the various theoretical frames that interview researchers use, the assumptions about what a person can know about her or his own practice and so on" (Potter and Hepburn 2005, p.292). They go on to highlight that all discourse ultimately builds on 'sedimented' theory and concepts (a good example is the pervasive Freudian explanations for behaviour), meaning that avoiding this is likely impossible. Similar insights have lead Lynch (2002) to suggest that *all* data be it documentary, ethnographic or interview-based be considered produced and rendered analysable. The extent to which it undermines the research being considered is again a matter of ontological, epistemological and political affiliation.

With respect to *footing*, I suggest that a sensible strategy is again to acknowledge and incorporate the phenomena into the analysis in hand. As Hedgecoe (2010) has observed, the categories between, for example 'scientist', 'social scientist' or 'ethicist', are far from 'cut and dried'. As an example, Hedgecoe points to Amalia Issa, a pioneering discussant of the ethics of pharmacogenetics, but one who formally identified as a neuroscientist at McGill University. Similarly, although they were approached on behalf of organisations, some NGO representatives interviewed in this study (e.g. participants CS3 and CS7) muddied the categories between 'NGO' and 'scientist'. As noted elsewhere, NGOs have increasingly recruited professional scientists either as campaigners or experts (Eden et al., 2006). To preserve anonymity, consider that Sue Mayer (who was external to my sample) trained as a veterinary surgeon, subsequently sat on the board of Greenpeace, was co-director of the biotechnology monitoring NGO 'GeneWatch', and has subsequently returned to veterinary practice, whilst also publishing in academic circles on the topic of biotechnology and commercialization (e.g. Mayer, 2003). Similarly, as *chapter eight* will demonstrate, during interview, a number of scientists sought to complicate the relationship between 'professional responsibilities' and 'personal responsibility'.

In contrast to Potter and Hepburn, I suggest that to acknowledge these challenges, taking them as analytically interesting and potentially powerful currents to be incorporated into investigations, strengthens rather than flaws research. In the analysis embedded in subsequent chapters, it is observations and challenges to categorisation such as this that have helped me to, for example, move to consider what, if any, the fundamental differences between scientist and NGO, and NGOs and the BBSRC might be when they advocate certain constructions of 'the ethical' and 'ethical research'. To this end, to be aware of such complexities could seen to be complementary to Maria Puig de la Bellacasa's (2011; 2012) suggestion of 'thickening' and 'caring for matters of knowledge production' by thinking with and for the data.

So far, I have shown how one of the major avenues of discussion around case studies can lead to claims of preferring forms of generalisation that build links to bodies of theory over statistical forms of generalisation. I have also shown, drawing on the work of Hammersley (1992), how this is not an unproblematic stance to take; one should be careful when making generalisations of any kind, be it from case to case, sample to population or study to body of theory. I have introduced a radical critique of interview methodology, consideration of which helps to strengthen the project. Contained within this critique is an assumption that qualitative research should focus more on interactions between each conversant and adopt a form of 'natural' data to do so. This prescription, however, suggests that 'natural' data will be free of transformations through analysis and will contain fewer and less significant problems of participant identity and buried agendas, which I have countered. Instead, following the perspective of Lynch, and a notion of care for the data, I have suggested that the categorical challenges to identity and the political nature of data should be acknowledged and brought into the analysis, rather than attempted to be sanitised.

4.2.3 Exploring the relationship between data and theory

The above discussions come with three consequences that make it prudent to consider the relationship between data and theory. First, if one seeks to eschew a differentiation between 'pristine' forms of data and 'applicable theory' then the process of moving between those idealised worlds must be brought into question. Second, whilst pursuing a strategy of caution when making claims of generalisability is wise, one must also pay attention to the (empirical or otherwise) origins of the theory to which a project wishes to mobilise. Finally, whilst restraint is wise, there are often concerns of theoretical stagnation that stem from the cumulative effects of staying close to dominant theoretical canons. To give an example, in a recent editorial of *Social Studies of Science*, Lynch (2012, p. 452) coined the term 'BADANT' (Banal and Derivative Actor Network Theory) concluding "that the volume of BADANT greatly exceeds the well-researched, original, and broadly informative written work that rides under the ANT banner". To be sure, one does not have to look very far to find other theoretical perspectives with similar pleas for originality, care of use and modernisation (e.g. Ravetz, 2007; Star, 2010).

Perhaps the most coherent (and least partisan) reflexive explorations of the potential for theoretical modernisation and consideration of the empirical-conceptual boundary within studies of science and technology come the form of two recent special issues in one of the flagship STS journals, *Science, Technology and Human Values*. The first focuses on 'middle range theory' (Wyatt and B. Balmer, 2007) and the latter explicitly concerns itself with 'the conceptual and the empirical' (Gad and Ribes, 2014). I use these two special issues as a route to consider the relationship between theory and data, and then reflect on their implications for the study in hand. At the outset it is important to note that the debates within these special issues are dense and multi-modal, representing the pinnacle of anxieties within STS, what Wyatt and Balmer (2007, p. 620) characterise as a sense that "something was missing from the middle of STS". In what follows I cannot do justice to the whole range here. Therefore in addition to the two introductory sections from the editors, I focus predominantly on three articles, from Geels (2007), Beaulieu, Scharnhorst and Wouters (2007), and Jensen (2014); Each offers interesting and useful, but different reflections on the relationship between theory and data and the consequences that follow.

The North American sociologist Robert Merton (1968) conceived of 'middle range theory' as a prescriptive call to the social sciences to develop theory that sits between necessary but quotidian observations, musings and hypotheses and unified theories that, as with scientific theories, are able to consistently explain all unified phenomena (Merton, 1968, p. 39). He held that unless the social sciences started to develop unifying theories, they would fail to mature as disciplines, a suggestion treated with careful scepticism in these circles. Geels (2007) takes this conceptualisation of middle range theory at face value to plead for more work that sits between the general and the specific, that aims at explanation of phenomena and that makes an attempt to be analytically integrative. Such an approach, he suggests will avoid four 'problems' with: (i) a lack of policy relevance; (ii) a pervasive use of overly complex language; (iii) what he now views as a banal focus on complexity, local practices and contingency and; (iv) problems with the characteristics of some dominant canons within STS. In contrast, Beaulieu, Scharnhorst and Wouters (2007) employ a conceptualisation of the middle range as reflexive practice. They argue for a use of the middle range not as representing a point between data and theory, or micro and macro. Instead they conceive of it as a fruitful way to reflexively consider the relationships "between methods, concepts and empirical work" (Beaulieu et al., 2007, p. 673).

Whilst Geels' concerns seem much more pragmatic than those of Beaulieu, Scharnhorst and Wouters, they too are concerned with the ability of case studies to make certain kinds of arguments, evident in their identification of a "deep tension around the role case studies can play, whether as ends in themselves, as illustrations, or as building blocks for theory" (Beaulieu et al., 2007, p. 673). Furthermore, the last of these points embeds an implicit concern about the impact of 'verbal pyrotechnics' (Jasanoff, 2012) rather than tight empirical description, that was captured in Hammersley's earlier (1992) warning of the need to carefully consider the empirical basis for existing theoretical corpuses. Rephrased, if case studies are excellent tools for deconstructing 'claims of universality' (i.e. scientific theory), of laying out all the pieces, then how might they be mobilised to reconstruct those pieces in alternative ways without falling into the 'universalising fallacy' that they initially sought to deconstruct (Beaulieu et al., 2007, p. 673)?

The papers in the 2014 special issue are predominantly concerned with a third, nounic construction of 'middle range': the relationship between common-sense notions of the relationship between data and theory, where 'the empirical' belongs to the realm of reality and 'the conceptual' belongs to the realm of ideas. Here, 'the middle' is something which is populated between data and theory but which is in need of interrogation (Wyatt and B. Balmer, 2007). Jensen (2014) explicitly articulates with the 'discontents' (Geels, 2007) of the 2007 special issue. Characterising their existence with a kind of 'blandness' of research symptomatic of a field in the stages of 'normal science' (Kuhn, 1970), he ultimately makes a plea for experimentation and variation in methodology. However, in contrast to claims that studies might simply be realigned in terms of goals, he diagnoses the ultimate cause of 'blandness' as a result of a tension that must be reconfigured at the metaphysical level. Jensen suggests that there remains a vestigial and implicit binary within STS because many of the seminal studies that led to the constitution of STS as a field (Barnes, 1981; e.g. Bloor, 1976; Collins, 1981; Haraway, 1989; Knorr-Cetina, 1981; Latour and Woolgar, 1986) were grounded in an assumption that micro-ethnographic methods would allow "more robust contact points with the real" (C. B. Jensen, 2014, pp. 193-194), hence Latour's (Latour, 1987, p. 258) famous first rule of method, "we *study science in action* and not ready made science or technology; to do so, we either arrive before the facts and machines are black-boxed or we follow the controversies that reopen them."

To interrogate and address common sense delineations between 'the empirical' and 'the conceptual' Jensen draws on Bloor's (1976) conception of symmetry as the 'standard tool' within STS to rid oneself of dichotomies. Pushed further, symmetry's Latourian counterpart works by providing agency to 'every conceivable entity' (Latour, 1993). In coarse terms, this notion can be used to emphasise the performative nature of concepts; that is to say they do not exist in absence of a world, but rather, "are located in the world; […] they operate in and on the empirical (e.g. Pickering and Stephanides, 1992)—although of course not equally in all cases. At the same time, it implies that the empirical is itself conceptual in multiple ways" (C. B. Jensen, 2014, p. 201). When seen in this way, the relationship between the 'conceptual' and the 'empirical', and indeed 'outside of research' and 'inside research' break down to become at best "unstable hybrids" (p. 198) with ontologies that are always shifting, contingent, and 'open for negotiation'. Rather than disavowing this, Jensen suggests that we embrace it: Working with novel and fluid 'conceptual-empirical packages', he suggests, might open up space for experimentation to bring even "more varied conceptual resources into play in STS" (p. 198) from new geographical and institutional arenas, neighbouring disciplines, and by reflexively learning from such experiences.

Jensen's ultimate suggestion is that all research is engaged in 'continuous variations' and the production of 'blended products'. This chimes harmoniously with stances to the data-theory relationship from ethnomethodology (Lynch, 2013; 2002), symbolic interactionism (Clarke and Star, 2008) and ANT (Law, 2012; 2004). Through terms such as 'theory/methods packages' (Clarke and Star 2008) and 'methods assemblage' (Law, 2004, p. 14), each emphasise the performativity of method, theory and a wide range of other factors. As these authors note, "we begin with some combination of previous scholarship, funding opportunities, materials, mentorship, theoretical traditions and their assumptions, as well as a kind of deep inertia at the level of research infrastructure" (Clarke and Star, 2008, p. 116).

The point then is that there is no 'blank slate' with which we approach the world. Rather, prior commitments, be they personal, relational, political, institutional, ontological or methodological all shape the kinds of research that is done. Theory and method become ways of seeing the world, making it analysable and rendering it in particular ways (and not rendering it in other ways). But what, precisely does this mean for method and research? Does it mean, as some have suggested, that STS merely preferences a grounded theory approach to study (Fuller, 2007, pp. 152-156)?

Clarke and Star (2008) *are* prescriptive. Their suggestion of theory/methods packages is not to advocate theoretical or methodological anarchism. Rather, what they claim is that specific theoretical perspectives provide specific insights, which need to be aligned with the methods. Put another way, "method, then, is not the servant of theory: method actually grounds theory" (Clarke and Star, 2008, p. 117). Thus, the method (e.g. grounded theory) is inseparable from the theoretical framework (e.g. symbolic interactionism). Furthermore, within these theory/methods toolboxes are a series of sensitising concepts (Blumer, 1969) that provide an 'analytical entrée' and routes through to 'provisional theorising' (Clarke and Star, 2008, p. 118). Although Clarke and Star locate themselves within a symbolic interactionism branch of STS that mobilises grounded theory (Glaser and Strauss, 1967) as a predominant method of enquiry, it is important to be clear that they are not advocating for monopoly over method; rather they are advocating for ontological, methodological and theoretical coherence, or at least reflection on that coherence. To do so takes work and requires learning, persistence and luck, as eloquently emphasised by Law:

> "I have been saying that theory […] is not best thought of as something separate that is applied to empirical materials. Instead, it is better understood as a set of threads that are densely woven into our fieldwork practice. It informs how we see whatever it is that we are looking it, and it is something, a set of propensities and sensibilities, that shapes what we look at and poses questions, issues, possibilities of whatever it is that we come into contact with. To say this is not to say that these propensities and prejudices are always productive. Clearly it is sometimes the case that our theory-threads block us off, creating dead ends, or leading us to sterile places. Doing good theory and doing good empirical work – articulating them together – is pretty tough going and it takes luck as well as judgement." (Law, 2012, p. 10)

Others arrive at a range of suggestions as to how we might deal with this kind of new reflexed-relationship between method, theory and data but all ultimately want STS to do different kinds of work. These are contrasting but not necessarily contradictory: consolidate and do more middle-range theory building, and try to realign methodology to ask new questions. Geels focuses much more on the former and points to three exemplars of middle-range theories, which he has (conveniently) contributed to: Expectations and promises within technology (Geels and Smit, 2000); Niche theory and emerging technological trajectories (Geels and Raven, 2006) and; Multi-level perspectives on sociotechnical transitions (Geels, 2004). Such approaches, he suggests, successfully trade off between "relatively simple, sensitising conceptual schemes [SCOT] and detailed, complex case descriptions with some empirical generalisations [ANT]" (Geels, 2007, p. 633).

In contrast, Beaulieu, Schornhorst and Wouters' (2007) primary concern is one of supplementing 'deconstruction questions', by reconfiguring the form that case studies take. They come up against three tensions: a need for comparison (and generalisation) within case study work; "an assumed triad between the space of the lab or context of use, the ethnographic account, and the constitution of a proper object of study for STS" (Beaulieu et al., 2007, p. 678) and; the (in)ability for case studies to act as mediating objects in interdisciplinary research because different actors often bring their own disciplinary desires with them to the case. Whilst the need for such a 'comparison engine' is limiting in terms of analysis but fruitful in terms of theory-building, they suggest that they are "confronted with the middle-range issues of what might count as a proper comparison, of what it means for the case to be made comparable, and how we might know this" (Beaulieu et al., 2007, p. 677). In an encouraging turn, they therefore suggest three reconstitutions of case studies: (1) to focus on time rather than place or space (echoing Hine 2007); (2) including attention to the role of researchers and particular infrastructures within fieldwork, and; (3) pleading for diversity in method and reflection on what such diversity might do. Ultimately this translates into two further solid prescriptions: "making the field through mediated interaction" and "interdisciplinarity, interactivity and new representations" (Beaulieu et al., 2007, pp. 680-684). Put another way, by focusing on networks interactions as a whole, questions of organisation or flow become more important than micro-macro scales, which means that questions such as the "functions of stakeholders, rather than about the association of particular epistemologies and national cultures (King, 2002)" become pertinent (Beaulieu et al., 2007, p. 682).

Despite their differences, what each of these calls is doing is to emphasise that rather than being gifted 'natural' data and insights by particular methods, which we then use to either generate or reinforce 'theory', the reality is a murky maze through which one passes, generating insights, testing the applicability of existing theories, and often discarding what can't be made sense of. In this sense, research and its insights are local and the relation between data and theory is blurry at best, hence Jensen's attempt at correction at a philosophical level. What the discussions above ultimately aim to do is to sensitise ourselves to this process and provide metaphysical space to allow for it as an acceptable account, rather than retrofitting 'post-hoc rationalisations' to justify particular findings. For itinerant Law, this means moving beyond method that "is enacted in a set of nineteenth- or even seventeenth-century Euro-American blinkers" (Law, 2004, p. 143). For others, some of the problems might be solved by gently reshuffling the rationales, goals and constitutions of projects. As I have repeatedly noted, many of these prescriptions, (and those presented in prior subsections) embed particular normative, political, ontological and epistemological ideals. I turn briefly to these before drawing together conclusions from the present section and its forerunners.

Interlude: Metaphysical and political commitments

Many of the calls above, from Potter and Hepburn, from Lynch, and from Geels, for example, are built upon underlying preferences for particular ontological and epistemological positions – whether or not there is a singular reality out there and whether interviews (or any other methodological forms) are able to help us get at it. There is more at stake however. Drawing on his 'tastes of research' metaphor Jensen (2014, p. 204) notes that,

> "When Latour, Jasanoff, and Collins carry out 'high-end' STS discussion, we are witness to a competition among some of the most enduring and beloved tastes of research in STS. […] We are witness to a set of well-established and canonical theories battling for turf. When Jasanoff or Collins and Evans offer prescriptions for what the field should be, they focus on imposing order and coherence (Jasanoff) or on adopting just the right kind of theory (Collins and Evans, namely their own)."

These, then, are not solely philosophical debates, relying on disagreements about realism and relativism that need to be settled, but also political battles about institutional affiliations, conceptual and task-based ownership, as well as personal relationships. Ultimately they are about what a field (be it STS or bioethics) is aiming to achieve and which approaches and theories are acceptable ways of achieving it. As we saw in the previous chapter, perhaps the most enduring characterisation of a divide between social science and moral philosophy is in their respective (and claimed) siting on either side of a descriptive – normative binary. Clearly this is outmoded at best. Bioethical studies have increasingly adopted empirical methodologies to the study of ethical dilemmas, symbolised by the launch of the journal *AJOB: Empirical Bioethics* to collect them in. And, despite suggestions to the contrary (Fuller, 2005; Pestre and Pestre, 2004), social studies of science and technology have far from abstained from making political and normative prescriptions. Despite calls at the turn of the century (e.g. Edge and Edge, 2003), STS *has* made policy inroads, particularly in UK research governance (Irwin, 2006; Jasanoff, 2013; Owen and Goldberg, 2010). To this end, calls that studies of science and technology have failed to have a policy impact are perhaps better heard as little impact beyond being a) critical of 'assumptions' within existing policy discourses or b) uniformly prescribe public participation and empowerment in matters of technoscience (Geels, 2007). Put another way, if public engagement has been inherited as *the solution*, it is increasingly viewed as *the problem* as the value of the theoretical solutions that have previously been fought for has to be demonstrated (Delgado et al., 2011). Alternatively, if STS methodologies and philosophies in their current configurations have proved powerful tools for taking apart hegemonic structures then how might it be able to build alternative forms in ways that are coherent with its emphasis on the power of local, situated practices (Beaulieu et al., 2007)?

As a whole, STS employs varying degrees of social constructivist perspectives to critique the production of knowledge and the constitution of objects (Bijker et al., 2009, pp. 23-46). For many of the above authors it is precisely this perspective that has prevented STS from making strong political contributions to matters of science and technology. In 'wild' form, the constructivist claims that dominate within STS make the claim that "the truth of scientific statements and the technical working of machines are not derived from nature but are constituted in social processes" (Bijker, 2009, p. 65). We might conceive of a 'rough continuum' of weak to strong scepticism regarding the pre-existence of realities; social shaping, aggregating, affording, providing for, constructing, apprehending, performing, accomplishing, bringing into being, constituting and enacting (Woolgar et al., 2013 324). Now famously, claims at the radical end of these spectrums have lead to heated debates both within and external to STS (e.g. Callon and Latour, 1992; Edwards et al., 1995), culminating in the 'science wars' of the 1990s (Fuller, 2007, pp. 163-166; Gross et al., 1997). The philosopher Ian Hacking (1999 63-99) has diagnosed such disagreements as 'sticking points'; whereas it is hard to argue that ideas and concepts are socially constructed or indeed that science is 'shaped' by social processes, for many applying this to 'natural phenomena' becomes problematic. It is however, important to note that such a perspective, as employed by many others, and in this thesis, is not anti-realist if taken in a 'primitive or originary sense' (Law, 2004 140-143):

> "There is only one way in which my thesis is contrary to a bundle of metaphysical doctrines loosely labelled 'realist'. Realists commonly suppose that the ultimate aim or ideal of science is 'the one true theory about the universe.' I have never believed that even makes sense." (Hacking, 1992, p. 31)

What Hacking, and Law after him, is saying is that methods produce the ways in which we come to know the world and ultimately form an impossible barrier to move beyond. Furthermore, different methods allow us to see the world in different ways. For Law, this is central to the 'enactment of method' (Law, 2004 141). Thus, even if we were able to bring all the different theory/methods packages together with their insights, they would produce tensions, contradictions and differing realities in addition to their commonalities.

In this project therefore, I employ a constructivist perspective to the ethical dimensions of science that is aligned with the 'idiom of co-production' (Jasanoff, 2004a). Translated, this is to say that science, ethical dimensions, and society co-evolve and co-constitute each other in a process of mutual shaping. The approach follows that of Pickersgill (2012) and of Brodwin (2008). In this way, it becomes impossible to separate one from the other. I have little problem in claiming that 'ideas' of what might be ethical or not and the associated ethical lived experiences of people are shaped, re-constituted and ultimately enacted, in relation to the particular local situations in which they exist. Ultimately, this means eschewing one dominant coherent notion of a 'common morality'. It also means that I am unable to produce a moral analysis of different judgments, as moral philosophers such as Beauchamp and Childress (2012) would have me do. However, this does not prevent me from making normative prescriptions (for example in research policy); the question shifts from making judgments on 'right' and 'wrong', 'acceptable' and 'unacceptable' to one of 'how might policies and practices better accommodate such heterogeneity?' The question also turns to how we might produce investigations that accommodate such prescriptions, which I address in the final subsection below.

4.2.4 Summary of outcomes for the project

I have covered a lot of ground so far, so it is worth summarising the take home points, particularly for the thesis at hand. With respect to case studies, I follow Hitchcock and Hughes (1995) and Beaulieu, Scharnhorst and Wouters (2007) in considering case studies as being primarily concerned with the form of description that they entail rather than being defined by particular, spaces, methods, theoretical commitments or goals. To do so helps to prevent a reification of pre-existing boundaries between scales, groups and terms which was identified by Wyatt and Balmer (2007).

Whilst problems of generalisation are intractable, unsolvable by resource, the trade-offs can be made visible. Cases must be rendered comparable to mitigate problems of generalisation. Two strategies are presented here. The first is to tend towards the 'thick' description discussed above which increases 'granularity' and allows intra- and inter-case points of similarity and heterogeneity. The second is to adopt a strategy which rather than "treating the laboratory as the site *par excellence* for studying scientific controversies", treats "social controversies as laboratories for studying how science and technology work in society" (Jasanoff, 2012, p. 439). Instead of simply following scientists in laboratories, we should use broader arenas to examine and interrogate the status of science and technology. Similarly, by rendering cases in particular ways, it is possible to make comparisons with existing theoretical perspectives (Beaulieu et al., 2007).

Within this thesis I rely primarily on a range of texts to build insights into the construction of the task of ethics and its distribution. I employed Potter and Hepburn (2005) as proxies for a radical critique of interview methodology as a way to generate text for interpretation. Unpacking their critique demonstrates that superficial unease with transcription methodologies corresponds to epistemological claims about what one is able to know and how that knowledge can be accessed. These concerns apply to all forms of data. Potter and Hepburn's predisposition is to make use of 'natural' data and employ 'analysis' that does not look beyond the discursive architecture within it. In contrast, I take a perspective similar to Lynch (2002) in treating all data, whatever its origin (e.g. published documents or interview transcripts), as constructed. This is not to say that the specific contextual factors surrounding their production do not matter; rather *all* texts have histories which should be accounted for rather than removed. For instance, transcripts are produced by participants at particular moments but they also contain sedimented accounts and narratives. Similarly, published documents are constituted by pro- cesses within the BBSRC but they also serve to constitute it as an entity, setting out positions and future practices, for example. Treating data as produced therefore helps to provide comparative power, but it also means that judgements about the extent to which outside accounts are accessible should be made with care and sensitivity to the contexts of production. This also, in part, helps to understand why the analytic presentations in *chapters 5-7* preference slightly varying orientations.

The articles discussed that considered the relationship between theory and data are less critiques of the methodology employed in the present study and more critiques of common conceptualisations of qualitative research and common-sense separations between empirical and conceptual. This is particularly important to ensure the coherence of a study that on the one hand seeks to deconstruct terms and boundaries whilst on the other hand needs to employ categorisations to mitigate problems of generalisability. Instead of clearly demarcated 'conceptual' and 'empirical' worlds, instead we might conceptualise the process of analysis as 'continuous variations' employing theory/methods packages (Clarke and Star 2008) or methods assemblages (Law 2004). In these terms, there is no clear bright line between the production of 'data', the application of 'theory', and the emergence of analysis. Instead, theory, method and analysis are bound together to provide particular views of the world. High-level theory and methodological frameworks, such as ANT, co-production, SCOT, discourse analysis and grounded theory can act to 'sensitise' one to particular ways of treating a phenomena of interest. The form that this process takes will become evident as I outline the process of analysis pursued in this project (*section 4.2*).

Finally, although employing a metaphysical approach that is excellent at deconstructing golems, many within STS have expressed unease about the desire to coherently intervene in various technoscientific arenas. Demonstrating the diversity of meanings and the particular dominance of certain ones is still powerful in new arenas, not least because of Edge's (2003) identification of the incredible staying and structuring power of large-scale and global institutions, but attempts to produce novel analyses should not be neglected. The challenge then becomes finding ways to intervene that will resonate with such institutions. To this end, Geels' (2007) suggestion of speaking to middle-range theories such as boundary work, the sociology of expectations and underpinning rationales for engagement is useful to begin to make theoretical progress. Similarly, Beaulieu, Schornhorst and Wouters' (2007) and Jensen's (2014) suggestion of experimenting with new collaborations, hybrid methodologies and focusing across networks rather than defined spaces might help to make coherent interventions. For Hine (2007), such strategies might offer the "opportunity to develop new notions intervention and explore alternative ways of making contributions to development of theory and practice" (Hine, 2007, p. 652). I will consider the tensions in achieving this in more detail in *chapter 8* as I conclude the thesis. Translated to the project in hand, this is not to say that demonstrating the diversity and contingency of ethics is not important, but rather, it might be possible to move beyond such arguments to ask how different actors produce differing or dominant senses of 'the ethical' and 'ethics' and why certain forms prevail and hold together. In the forthcoming section, I present a protocol that is sensitive to many of the concerns covered above.

4.3 Research Protocol

Here, in light of the above discussion I add colour to some of the major events, decisions and details of the project. It is structured as follows: (i) *focusing the gaze and mapping the field*; (ii) *producing empirical material* and; (iii) *working with data and theory*. For coherence, the section is structured in loose chronological stages but as with any qualitative research, in reality the process was iterative, particularly between stages two and three, and within three itself. They are therefore, perhaps best seen as heuristic and pragmatic structures made to deal with the 'mess' of research.

4.3.1 Focusing the lens and mapping the field

In years one and two three main activities occurred. First, I undertook a series of postgraduate modules on qualitative methods and science, technology and society. Second, I produced comprehensive maps of the 'core concern' of the project, i.e. science and society discussions, which form the basis of chapter three in this thesis. Third, I developed and documented the objectives and research strategy for the project as a whole, resulting in the fateful fifty-seven documents in my planning folder.

The project was initially envisaged in a comparative design to examine the ways that science and society activities played out amongst actors across the biosciences. As is common, case studies were envisaged to provide comparative power and specificity within a biosciences context to help make viable propositions within that context (Yin, 2009b). Potential options were narrowed to a choice of three, each with their respective merits. The use of *animals for experimental purposes* has been a longstanding source of debate within the biosciences. It has been significantly treated by moral analyses (e.g. see S. J. Armstrong and Botzler, 2003; Singer, 2009) and less extensively treated by sociological analyses (R. de Vries, 2006; e.g. Hobson-West, 2012; Michael and Birke, 1994). At the project's inception, regulatory procedures covering animal experimentation were being harmonised by the European Commission in directive 2010/63/EU (Council of the European Union, 2010). It therefore represented an established case, with a contemporary and contested policy context in which it might be possible to ‘follow’ ethics in action. *Synthetic biology* emerged as a site for sociological and ethical scrutiny whilst it was being convened as a field. Birthing in the wake of the human genome project, social scientists and bioethicists were once again mobilised to be incorporated into natural science research programmes[6]. The motivations for such structural requirements were (and remain) quite heavily contested, further complicating any negotiation of what would in any other circumstance likely remain a challenging collaboration. Synthetic biology therefore represented a second timely field of research, where new forms of ‘ethical work’ were being done. At the same time, it seemed to be relatively well-covered within the UK, as demonstrated by the emergence of a synthetic biology-oriented post-ELSI community (e.g. see A. Balmer et al., 2012). *Biofuels* represented a potentially novel option. Relatively uniquely for projects in this area, social scientists were funded as part of the BBSRC-funded BSBEC programme. Furthermore, in terms strikingly similar to interventions in nanotechnology and synthetic biology, one particular strand explicitly aimed to embed real-time technology assessment (Guston and Sarewitz, 2002). Such integration presented an opportunity to consider whether or not they might indicative of a general and increasing trend to fund ‘convergence’ research (Frow, 2009). Alongside the significant funding, the development and deployment of biofuels seemed to be contested on social, political, moral and, indeed, scientific grounds. It was also a field that was relatively sparsely populated with social science research and even more sparsely populated with ethical and social research that provided insights into the way that scientists were negotiating this landscape. As a whole, it represented a complex regulatory and disciplinary arena that was also timely and relatively underexplored.

Although controversial topics and moments are able to ‘open up’ fields to investigation (Pinch, 2001), they demand sensitivity and present access challenges, they allow certain questions to be asked and not others, and they include different sized populations of interest. The final format of the project is thus perhaps best understood in terms of a ‘melding’ of intellectual desires with the specific practical, methodological and theoretical demands of a given case study. Such a process began with the actor mapping activities of years one and two, which are summarised by *figures 4.2 - 4.4.*

The initial project framing expressed a desire to investigate science and society activities within the UK biosciences context (*Figure 4.2*). At the time ‘engagement activities’ were taken as the current manifestation of attempts to address ethical and social issues in research funding policy and management. Later, this was abstracted to consider ‘the ethical dimensions of research’, which was seen as valuable because it

[6] For example, four UK research councils co-funded ‘networks in synthetic biology’ that mandated collaboration between social and natural sciences (Calvert and Martin, 2009)

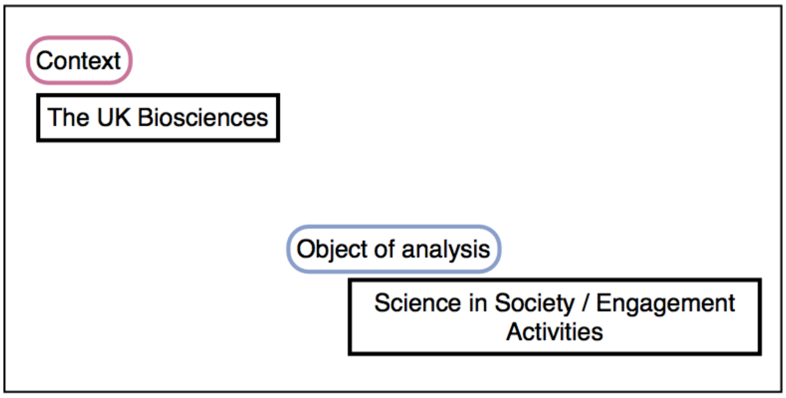

Figure 4.2: *Initial phenomena of interest and relevant context*

a) opens up space for methods beyond formalised engagement processes and b) does not reify any existing policy categorisations, which makes it possible to look broadly at the processes by which the ethical dimensions are produced and dealt with. Helpfully, the primary actors are largely the same. This 'biosciences context' could then be furnished with the actors that coalesce around science and society / engagement activities in the UK (*Figure 4.3*). Here, I was predominantly interested in the actual research process, defined initially, perhaps naïvely, as what goes on in the lab. Of course, I now take this to be only a small part of research, of science, but the party remains the same – scientists. A second major arena was 'policy'. To be sure, there are many different groups that play into this field – professional societies, government, industry, transnational governance organisations, transnational research funders. The list goe4s on, and it is only relatively recently that serious attention is being directed towards these bodies. At the time however, it was UK research funders that were taken to be the powerful (in terms of holding the money and shaping some of the structural aspects of science), but under-explored group.

In the summer and autumn of 2011 a comprehensive scoping of the UK biofuels field was conducted. This had the dual purpose of grounding a sometimes nebulous sense of inquiry and moving forward in practical terms by identifying parties to contact for empirical work. The process is represented in *figure 4.4*, which translates the abstracted biosciences actor-map and grounds it in the biofuels case and provides some examples of prominent actors. Funders were largely known, so attention focused on identifying external parties, government agencies and individual research groups. NGOs active in the biofuels field were identified using web searches to identify commentaries, self-published reports and news stories. Some were identified through their participation in prominent processes such as the submission of evidence to the Nuffield Council on Bioethics' (2011) Biofuels Report and to various parliamentary committees (e.g. House of Commons Environmental Audit Committee, 2008b). Both Google and Web of Knowledge searches were used to

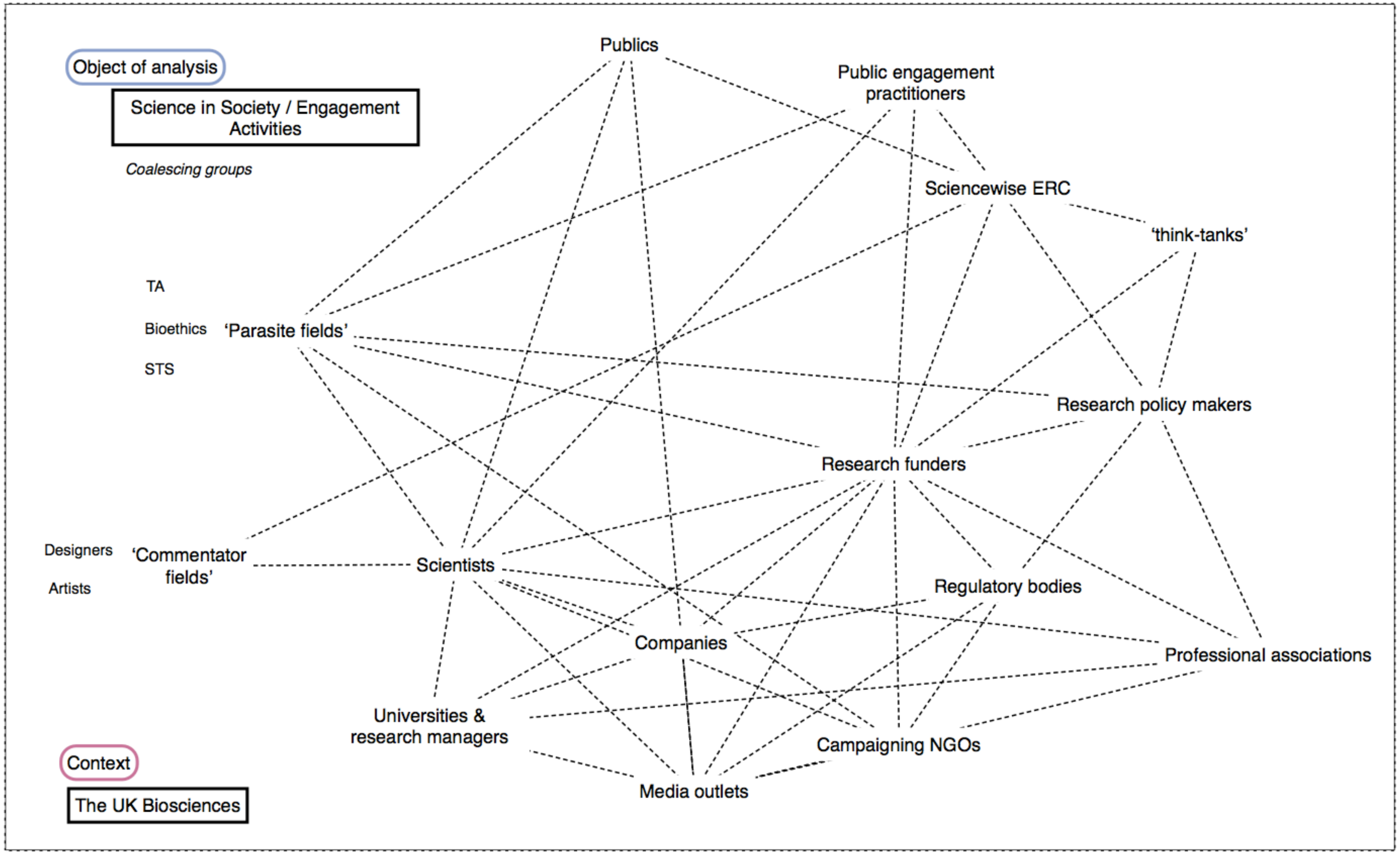

Figure 4.3: *Actors in biosciences*

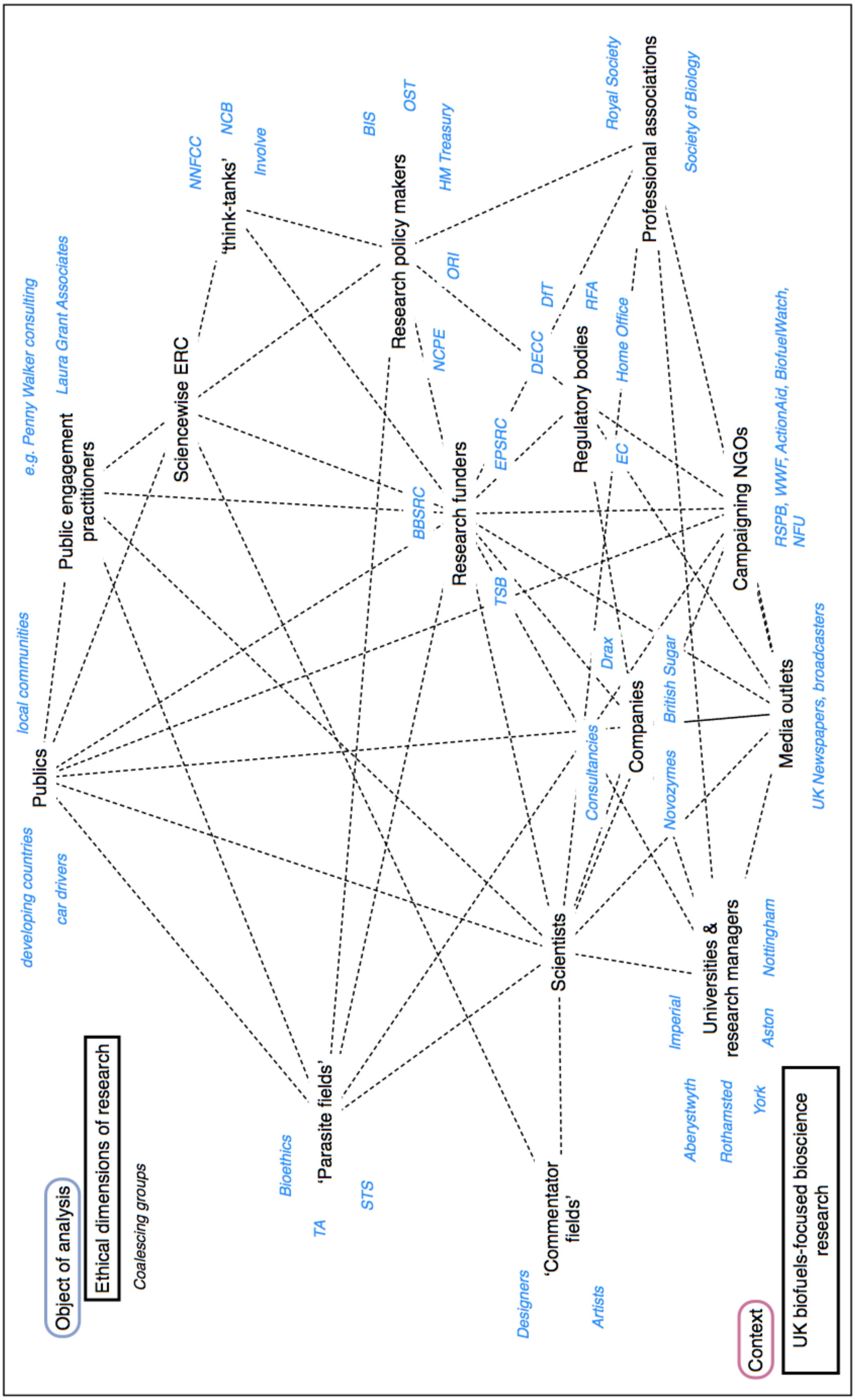

Figure 4.4: Actors in biofuels

identify scientists and published scientific papers in the UK in the field of bioenergy. These searches were supplemented by knowledge of individuals' participation in BSBEC, previous awarded funding which had been identified as being of relevance to bioenergy using the RCUK, EPSRC and BBSRC portfolio databases, and where possible, attendance at conferences. The latter proved particularly fruitful – for example attendance at just one national biofuels conference provided access to five different participants from three research organisations.

Here, it is possible to see how the project interfaces with the case study specificities. When making the translation from biosciences to biofuels, for example, some groups rise to prominence while others fade into the background. In the biofuels context many of debates are framed by concerns with European level biofuel policy. Policy therefore becomes particularly important to understand. New groups, for instance certification bodies, emerge. And further, the activities of NGOs become important to consider; as is common in many environmental controversies, they have been prominent, largely critical, voices, positioned by many to counter technology. Adopting the language introduced earlier in the chapter, during the mapping process it became clear that to maintain a 'mid-range' focus that covers a range of groups in enough detail to do justice to a particular context, and which moves out of the lab to new locations, requires significant resources. Thus, the first trade-off in granularity was made in the face of given resources by jettison a comparative design and adopting a single case-based approach. To a significant extent, this mid-range focus also dictated the kinds of methods and analytical lenses that would be employed, since micro-scale ethnographies were unlikely to provide the kind of breadth that I aimed to achieve with a one-man team (Jasanoff, 2010a).

At this early stage, two further acknowledgements are due. First, what is often neglected from theses is the extent to which vocational skills are important. Yes, theoretical and methodological knowledges help but throughout this process there was a distinct feeling that there was no replacement for actually going out, contacting people and doing research and then reflecting on this process as a way of grounding the questions, developing interests and improving my own abilities. A significant part of this early development then, meant getting to grips with the groups involved in science and society activities in the biosciences, working out how to ask questions in ways that (retrospectively phrased) wouldn't significantly lead to the research chasing its own tail, whilst also navigating the transition from natural to social sciences and the divisions between bioethical and STS forms of enquiry. Secondly the role of the LACE project[7] should be considered. As seen in *chapter two*, one of the largest

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[7] LACE has the strange status of appearing to be an acronym but not actually standing for anything. The LACE project was entitled Lignocellulosic Conversion to Bioethanol, which

projects from the BBSRC Sustainable Bioenergy Centre was a multi-stranded bid based at Nottingham. This project incorporated a 'social and ethical' research theme, which was conducted by researchers at the Centre for Applied Bioethics and the Institute for Science and Society (ISS). Now, this project and my own developed independently, but over time have unsurprisingly coalesced. This has provided me with a group of researchers with a shared case, particularly three PhD students, which has proved to be a significant resource for developing my thinking in the area. The LACE project also provided more functional resources, in terms of partial funding for my BBSRC policy secondment and the ability to fund some interview travel. It also, however, came with some competition for resources, namely scientists working in the area. Whilst not normally a problem, it did occasionally become apparent when contacting scientists. One opportunity to manage this is to develop shared interview schedules, as was done with the NGO interviews. Whilst this worked relatively well for the small population of interviews, this would have prevented the kind of in-depth exploration with scientists that I was able to produce by pursuing my own interview agenda.

4.3.2 Producing empirical material

Here I outline the development of methods to produce data, namely the development of an interview guide and the sourcing of documents, and the process of interviewing.

Ethics approval and the interview guide

Towards the end of the initial 'scoping' period, an interview guide and participant information sheet (*Appendices 1 and 2*) were developed and ethics approval was sought and granted through the University of Nottingham School of Biosciences procedures. Of course, a signed form does not grant acceptability and throughout the process, the comfort of participants was confirmed. Significantly, what ethics forms do not cover is a notion of care for the data; throughout the analytic process, I was therefore careful when making representations of positions and interpreting text. To do so is a matter of ethics as well as robustness. All interviewees were to be offered anonymity as a means to ensure more open discussions that had the possibility of going 'beyond the party line'. This, of course is a trade-off that is made between being able to generate different data and being able to easily build direct links and specific comparisons between participants in other similar studies in the field (Boucher, 2010; e.g. Pilgrim and M. Harvey, 2010). Whilst some participants were happy to waive their anonymity, others were not. Had all waived anonymity, a different decision might have been taken regarding identification of participants.

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could most obviously be abbreviated as LiCe. The project partners opted against this, instead choosing to build a link to Nottingham's industrial heritage as a centre of lace production.

A significant amount of work went into the development of the interview guide, which was initially developed for NGOs in conjunction with members of the LACE project (Theme C: Social and Ethical Aspects). This interaction helped significantly when framing questions for the first time. Here, interviews covered the main topics of: an exploration of key ethical and sustainability issues; questioning the acceptability of different scenarios; exploring the ways that ethical and social aspects relating to biofuels could best be managed and the points at which this might be best achieved (including certification); and the role of science and scientists in the biofuel controversy. One of the major concerns during this process was how best to actually access accounts of ethics from interviewees. Because of this, the guide developed as the interviews progressed, for example to include new points of interest from previous interviews, re-frame questions for NGOs and scientists, and add notes about the specific phrasings of certain questions. The most notable development was to focus more on the ways in which scientists themselves dealt with ethical issues in research, something NGOs would be less vocal about. Ultimately each interview explored the three main topics of:

1. Initial constructions of ethics and responsibility
2. Biofuel-specific impacts and responsibilities
3. Experience of 'ethics agendas' or reflective activities

I made use of a school of biosciences journal club, of which I was a part, to test out questions and discussions and conducted a series of pilot interviews with both animal scientists in the School of Biosciences and members of ISS. Ultimately, although quite an extensive and structured guide, the most fruitful strategy was to adopt a conversational approach that followed the flow of discussion, probing where interests would allow. This does not mean that questions were completely composed 'on the hoof'; in fact some questions were quite carefully phrased, based on the experience with NGOs, to ensure that they were clear and would open up avenues for discussion rather than elicit confusion.

Interviews

Interviews with NGOs were conducted first, between December 2011 and February 2012. In conjunction with the social and ethical strand of the LACE project, fifteen NGOs were initially identified as active in the biofuels field. Two of these were removed as they (or their biofuels representative) were based abroad and representatives of the remaining thirteen organisations were contacted. Of these, one declined for reasons of time, one person was no longer with the organisation and had no replacement, three did not respond and one was not conducted because we were unable to agree a mutually convenient time. Although a formal approach letter was advised and constructed, I soon found that less formal and more personal approaches, including contact by telephone provided more fruitful access for NGO representatives. With that said, all individuals were approached as key stakeholders within the bioenergy sector, who were seen to be suitable for interview because as holders of expertise rather than because of their campaigning positions. Of course, the reality is that these positions are sometimes inseparable, a factor which is in part mitigated by my approach to analysis which does not seek to take occasional attempts to convince me of facts at face value.

Those that did respond were usually enthusiastic to participate. Ultimately seven NGOs agreed to interviews, which lasted for between forty-five minutes and three hours (mean length 1h35m). All were conducted in person, usually at the organisation's office, except for one which was conducted by Skype at the request of the participant (CS6). Additionally, all but one (CS5) of the interviews was conducted one-to-one. CS5 was conducted jointly with two people and here quotes are differentiated as CS5a and CS5b. The participating NGOs range in size, primary concern and geographical focus and are characterised in *table 4.1* below. At the start of the interview the anonymisation, data storage process and interview use was explained and initial consent was confirmed. This was then confirmed again and recorded at the end of the interview and once again in follow up emails that were sent several days later.

Participant	Size	Geographical Focus	Primary Focus	Gender
CS1	Medium	UK	Environment	Male
CS2	Large	International	Environment	Male
CS3	Medium	International	Development	Male
CS4	Small	UK	Environment / Technology	Female
CS5 (A & B)	Large	UK & International	Environment	Female, Male
CS6	Medium	UK	Environment	Female
CS7	Small	International	Environment / Technology	Male

Table 4.1*: Profiles of participating NGOs*

Six of the organisations could be described as having predominantly an environmental focus, although two of these could be equally characterised as being technology-orientated. One organisation was primarily an international development organisation. As shown in *table 4.1*, of the seven, two are relatively small organisations. These are classified as having less than twenty full-time 'employees' but in reality are often loose groups of fewer than five people that wholly dedicate their time. Three organisations have been classified as of medium size (20 - ~200) employees and two are large organisations with more than 200 employees. The organisations also have a range of geographical areas of concern. Of course, these categories are by no means exclusive, for example organisations, both large and small, may operate primarily in the UK but have major international partners or form international networks with other national organisations. They do, however help to show how biofuels are a geographically diverse suite of technologies, and hint at some of the complexities in NGO-networks.

In identifying appropriate organisations, it was also important that representatives for the topic of interest were actually distinguishable. This often proved difficult. For larger multi-issue organisations, commentaries on developments relating to biofuels are often provided by high-level representatives (e.g. Doug Parr, Chief Scientist of Greenpeace) who have a known media identity but who have numerous responsibilities and are highly sought after. In many ways, they could be considered 'elites' (Stephens, 2007; Undheim, 2003). Conversely, smaller organisations were often quite opaque meaning that despite a visible organisational identity, the individual members were often difficult to identify. This is by no means accidental – many of the smaller organisations often take up activist positions – a point highlighted to me when, at the end of the interview CS4 expressed that they were often wary of taking part in academic studies, because of concerns about the motivations of the researchers, and of ultimately being co-opted as legitimating voices in arguments for the very things that they were campaigning against. This insight perhaps explains the fact that of the representatives that declined to be interviewed, four either represented elites or small, activist groups.

Interviews with scientists were conducted over a longer, more sporadic period between April 2012 and March 2013. (During a six-month period in the summer of 2012, I completed a research associate position on the EST-Frame project that in part examined the status of policy-oriented biofuel assessment[8]). Contact followed a similar form to the NGO employees, in that a standardised letter and participant information form was sent. In all, twenty-two interviews were conducted with scientists with interests in bioenergy at nine different institutes in the UK (*table 4.2*).

The participants include 13 men and 9 women. Cut another way they comprise 10 early career stage (research fellows); 5 mid-stage (lecturer, reader, principal investigator, project leader); and 7 senior scientists (professors, director of research). Additionally, researchers self-identified as working in a variety of fields, ranging from the 'fundamental' and generic (e.g. Biochemistry, Microbiology) to application-oriented and biofuel-specific (e.g. Miscanthus Breeding & Ecophysiology).

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[8] An overview of these secondments and the overall research process is provided in Appendix 3.

Participant Identifier	Organisation Type	Career Stage	Disciplinary Identification	Gender
S1A	University	Professor	Biological Chemistry	Male
S1B		Research Fellow	Biochemistry	Female
S2A	University	Research Fellow	Biochemistry	Male
S2B		Research Fellow	Microbiology	Female
S2C		Research Fellow	Molecular Biology / Chemistry	Female
S3A	Research Institute	Project Leader	Miscanthus Breeding & Ecophysiology	Male
S3B		Principal Investigator	Plant Genetics	Male
S3C		Professor	Molecular Biology / Plant Genetics	Male
S3D		Principal Investigator	Molecular Biology / Plant Genetics	Female
S3E		Research Fellow	Sustainability Science	Female
S4A	University	Professor / Director of Research	Plant Biologist	Female
S5A	University	Professor / Director of Research	Energy	Male
S5B		Reader	Plant Physiology	Female
S5C		Senior Lecturer	Marine Biology	Male
S6A	University	Research Fellow	Experimental Biology	Male
S6B		Research Fellow	Botany	Male
S7A	University	Professor	Plant Biochemistry	Male
S7B		Research Fellow	Plant Biochemistry	Female
S8A	University	Professor	Microbiology	Male
S8B		Professor	Biochemistry	Male
S8C		Research Fellow	Materials Chemistry	Male
S9A	University	Research Fellow	Plant Biologist	Female

Table 4.2: *Scientists interviewed across nine organisations (represented as numerical value in identifier)*

Consequently, some researchers had built careers working primarily with aspects of bioenergy, whereas others saw it as more of an emerging funding opportunity. Participants' career stages extended from post-doctoral fellows through to directors of research. Despite the variation, all researchers either held or worked as part of a bioenergy-orientated grant at the time of interview. Whilst this sample was not intended to be representative of the research field, the heterogeneity of participants goes some way to showing that technical bioenergy research is multifaceted and diverse, drawing in a range of 'traditional' disciplines, including chemical and process engineers (who are not represented in these interviews). The cultures and social voices of scientific disciplines and organisations can be very different, making it important to cut across these categories (Knorr-Cetina, 1999). Participant identifiers are bi-dimensional, representing the research institution numerically (1, 2, 3 etc.) and the individual within that institution alphabetically (A, B, C etc.). Thus participant S3D is the fourth interviewee at the third research institution. When quoted, extracts are coupled to paragraph numbers within the transcript, making it possible to see roughly where in the interview quotes are taken from.

The majority of interviews were conducted in person at the interviewee's organisation, usually in their office. Two were conducted via Skype video calls at the request of the researcher (S4A and S9A). Interviews lasted between 41m and 1h49m (mean length 1h04m). Interviews were ended when they reached a natural conclusion or at the end of time allotted by the participant. Again, the processes of anonymisation and storage, and use were explained at the start of the interview, initial consent was recorded and then confirmed again at the end of the interview. In addition, consent forms were digitally signed as PDFs either during the interview or shortly after. At the end of the interview, participants were asked to provide descriptors by which they would be happy to be identified, which have been used to produce the categorisations in *table 4.2*. Whilst some have reported differences regarding the ability to generate 'rapport' through telephone or Skype-based interviews (Opdenakker, 2006; e.g. Sturges and Hanrahan, 2004), I did not notice any significant difference. Certainly the fact that video-based communications enabled some body cues may have helped. If anything, these form of interviews produced more easily analysable transcripts, since questions were more carefully worded, responses were clearer and there was less talking over each other. The only exception to this was with S9A, which experienced technical problems with the internet connection, but which ultimately produced a transcript that was similar in length.

<u>*BBSRC*</u>

Whereas I used interview transcripts to provide access to individual responses, here I rely primarily on BBSRC-published documents. This decision was made following a one-month secondment at the BBSRC offices in Swindon during the summer of 2013. During this time, I produced a report that examined the status and rationales for public and stakeholder engagement in bioenergy at the BBSRC, two sets of activities which form part of the BBSRC's construction of responsible research funding in the area. During the secondment, a range of internal and external documents became accessible. These, supplemented with new observational knowledge, were judged to represent a resource-efficient way to produce a longitudinal analysis of the constructions of the task of ethics embedded in BBSRC actions, which would not easily be possible with interview-based methodology. Thus, the decision was anchored by trade-offs in resource and analytic scope.

The closeness of my work with the BBSRC might bring with it charges of bias or conflicts of interest, especially given that part of the intention of the secondment was to produce a report for their policy structures. However, in much the same way as the analysis of the interviews was permeated with quite vivid memories of the ways that participants reacted to particular questions, my embedded time at BBSRC-convened activities, culminating with the one-month secondment instilled in my perspective details that would otherwise be unavailable to me. Such experience represents a shift from an organisation initially envisioned as a homogenous, opaque, mass to one comprised of a series of people operating from within a pretty non-descript office block in Swindon. Responding in part to questions of what the documents represent, it attuned me, for example, to the fact that documents produced by this organisation are constituted by and constitutive of groups within the organisation. These documents have a political life and serve political ends, that I have attempted to be sensitive to. For example, in some internal and high-level strategic documents, particular phrases and languages, which embed particular motivations for action, are mobilised by particular teams because they provide the formal legitimacy to carry out their day-to-day roles, which in themselves allow for much more flexibility in meaning. Put simply, these experiences were central to the context-sensitivity that I made a plea for in *section 4.2*.

Between 2010 and 2013, a corpus of approximately 400 BBSRC-related documents was compiled. The majority of these were published by the BBSRC, although some were externally authored and made reference to the organisation and its activities. (Examples of such documents include the BBSRC's submissions to external enquiries (e.g. House of Commons Innovation Universities Science and Skills Committee, 2008; House of Lords Select Committee on Science and Technology, 2010)). Documents were largely publicly available on its website, or on archived versions of the BBSRC website, accessible through the National Archives. Some internal 'protected' documents are also included, although these would all be available through freedom of information requests. Permission to make reference to these was granted by BBSRC staff. Documents (*table 4.3*) were also a mixture of 'glossy' externally-facing publications and more 'procedural' documents which give

Total		**395**
Externally Published		77
Internally Published		318
	Website news and press releases	13
	* Public strategy documents and policy statements	32
	Annual reports	12
	Deliverable reporting & impact	43
	Funding (guidelines, information on projects)	30
	* Engagement & dialogue	58
	* Internal reports for strategy formulation	20
	Committee & panel minutes and papers	110
	* Bioscience for Society Strategy panel	33
	BBSRC sustainable bioenergy outreach group	8
	BBSRC sustainable bioenergy outreach group	49
	Industrial biotechnology and bioenergy strategy panel	2
	Strategy board / research advisory panel	18

Table 4.3: *BBSRC document types included in the corpus of data. Externally published documents include, for example, submissions to parliamentary reports, reports from think tanks such as the New Economics Foundation and Demos, publications from other research councils and from RCUK. Most attention was paid to the starred (*) categories of i) Public strategy documents and policy statements, ii) engagement and dialogue, iii) internal reports for strategy formulation, and iv) documents from the Bioscience for Society Strategy Panel.*

insight into internal BBSRC processes (e.g. meeting minutes) or policy making (e.g. funding reviews).

My analytic intention was to develop an understanding of how the BBSRC constructed a sense of 'the ethical' through its research funding policies, decisions and activities. It therefore asked three questions: 1) How has the BBSRC responded to the controversy surrounding biofuels; 2) How does the BBSRC construct ethics as part of its research funding and governance processes, and; 3) How does the BBSRC distribute responsibility within the research funding process? To answer these questions, I first made use of documentary sources to develop an extensive chronological map of key bioenergy-related activities that were relevant for the purposes of the project. This allowed me to understand the reasons for the BBSRC's vision for research and ethics, and the ways in which they have changed over time. I then subdivided activities bi-dimensionally into bioenergy specific versus general categories, and engagement versus funding policy to analyse activities in more detail. Overall, around 100 documents were utilised in the production of this map. Varying levels of analysis were conducted: all documents were screened for relevance, around 100 were read in detail, with around 40 being subject to a more thorough reading and coding within the software package MaxQDA when deemed to be important.

4.3.3 Working with data and theory

Here, I outline the process of moving from 'data' to 'analysis'. In doing so, I aim to emphasise and take seriously the accounts discussed in the prior sections that seek to emphasise the fundamentally blurred nature between 'conceptual' and 'empirical', and between 'data' and 'theory' to demonstrate that the insights produced herein are thoroughly grounded within the context of the project. Analysis of the interviews was conducted first, during which a conceptual framework was developed through close iteration between theory and data. This was then mobilised to approach the later analysis of the BBSRC's discourse and activities. From the outset, it is important to be clear that one consequence of this 'blending' is the production of a series of analyses which, although unified by an overarching approach, home in on particular and varying aspects of 'the ethical'.

Interviews

Analysis, if taken to be reflection on the data and the generation of insights, began alongside the first interviews and continued, on and off, for a two-year period. Immediately following the NGO interviews, usually on my way back to Nottingham, I produced short reflections on the process considering what I would improve, what I thought was missing and what was useful, notable features of the conversations such as particularly enthusiastic or parts where conversation ebbed, and how I might change the way questions were phrased to deal with some of the tensions in understanding that occurred. Ultimately, my initial thoughts about what constituted 'good data' rarely corresponded with the role the interview played in analysis, but these short reflective sessions proved indispensable in solidifying a tangible memory of the interview process as I progressed with the analysis.

To render data analysable, all interviews were recorded, transcribed and anonymised. Despite the above discussions, neither a Jefferson nor Jefferson Lite system of transcription was adopted. Acknowledging my previous concerns about this fundamentally shifting the objects of analysis in ways that would not align with my broad research goals, I want to add that this decision is significantly dictated by resource. To be blunt, twenty-nine interviews produced almost 39 hours of speech and 256,794 words to be dealt with. Transcribing at Potter and Hepburn's lower limit of 20:1 (as opposed to my 4:1 transcription rate) would represent a total of 780 hours spent transcribing, not to mention the significant increase in data that would be produced; clearly an unreasonable sample-detail trade-off given the time and resource constraints of the project.

Throughout this process I made use of software, both in the form of qualitative data analysis programmes, and mind mapping programmes such as Scapple. Initially coding and analysis for NGO and Scientist transcripts was carried out in QSR nVivo 10 but after an initial coding, the process was moved to MaxQDA 11 because of its simplicity and more intuitive interface, allowing the analysis to be conducted at minimum distance from the actual data. To elaborate, heuristically, the image of the analytic process that I carry is one of a table top with transcripts, highlighters and diagrams scattered across it. I wanted to be able to move bits of text around to identify particular repertoires, commonalities and tensions within and across the interviews. Although all qualitative data analysis software structures the analysis in ways that are different to pure-paper-based work, nVivo is perhaps best likened to a chest of drawers that contain all the transcripts, codes and notes underneath the table-top. To produce an analysis within the software, I often felt constrained by the need to metaphorically remove one transcript, look at it, and then replace it back in the drawer before being able to work on another piece of text. In contrast, MaxQDA operates much more flexibly; Four workspaces allow you to easily compare transcripts, see the coding system that you're developing, and easily draw out selected quotes whilst comparing them to the wider context of the interview that they are taken from, a point advocated by Potter and Hepburn. In this way, MaxQDA allowed me to work more closely and in a more immersive way with the data that nVivo would not. As I coded, I made use of the software to keep track of codes that were lacking or absent in some transcripts and abundant in others. This had two purposes. The first being evaluative, opening theories up to alternative explanations, for example by considering cases where they might be absent. The second was to ensure that insights were not missed and that the transcripts were given relatively equal amounts of attention.

The formal analysis of interviews (e.g. coding and drawing out theoretically-linked insights) was a three-stage process, rocking between the interviews with NGOs, the scientists and then returning back to the NGOs. During 2013, I produced a relatively rough analysis of my interviews with NGO representatives. This was based on a combination of deductive and inductive coding. It focused predominantly on the ways in which they framed ethical issues (i.e. why issues were important, and the kinds of issues that were deemed to be important) and the way that they distributed responsibility for addressing these issues. This analysis, including some of my dissatisfactions with it, fed through to inform the interviews conducted with scientists working in the field of biofuels. As the interviews with scientists were progressing, a second-stage analysis was developed.

Conducting the second, more extensive set of interviews made me reflect on what exactly I was trying to achieve, and the ways in which I might be able to achieve it. In this sense, the ensuing analysis was a direct result of the data that emerged, pointing to one way that the realities of the relationships between 'data', 'analysis' and 'theory' are incredibly blurred. Let me elaborate. Despite presumptions about the kinds of analysis that will be produced, the kinds of theoretical frameworks that will be employed and the concepts that will be mobilised, until the data actually exists, these are incredibly nebulous and hypothetical situations. Approaching them with a predefined and rigid analytic framework would likely be counter-productive and also runs the risk of producing an analysis that matches data to answer questions set by the presumptions of the analyst. Thus, following the interviews with scientists, I began to embed myself in the data. I read articles that seemed to attempt to achieve similar goals, reflected on the ways that they achieved them, and discarded ones that didn't achieve what I was trying to. Notably useful articles came in the form of Burchell (2007b), Davies (2008), Hobson-West (2012), Kerr, Cunningham Burley and Amos (1997), McCormick and Boyce (2009), Wainwright et al. (2006) and Waterton (2005). These approaches' conceptual tools, such as boundary work, the co-production of ethics and science, and the social construction of technology, acted as sensitising concepts to the kind of analysis that I was interested in producing to best-answer the questions that I had set out. By grounding myself in such literature, I also opened up the possibility for discussion and comparison with and generalisation to broader debates within the construction of ethics in scientific and technological arenas.

Two further approaches were also of assistance. The first was discourse analysis, which was widely employed within the studies above. Discourse analysis is a broad church, including the interactionist school of discursive psychology that Potter and Hepburn (e.g. Hepburn and Wiggins, 2005) align themselves to, as well as alternative approaches, such as that adopted by (Michael and Birke, 1994) who have convincingly adopted an approach that seeks to analyse 'shared assumptions and representations'. This latter approach, coupled with that of, for example Davies

(2008) is, for reasons discussed in the above sections, much closer to my own than that of Potter and Hepburn. The second is Glaser and Strauss' (1967) grounded theory. For the reasons outlined in the section above, particularly relating to the performative nature of method and the need to bind studies to theory-methods packages and their ontological commitments, I did not formally adopt such processes. Rather, they acted as ways to focus my gaze to develop inductively derived observations about the ways that, for example, scientists discursively constructed a sense of ethics further and the ways in which they were able to distribute responsibility for the impacts of research.

Thus, this second analytic phase can be summarised as follows. To examine how different meanings and understandings of ethics were constructed through interactions between participant and interviewer, the analysis is drawn broadly from discourse analytic approaches (Silverman, 2006b). Through several readings of transcripts, broad interpretative codes (Flick, 2009) were attached to sections of text. Some of these were derived deductively, being attached to sections that were of immediate relevance to the research interests described above (e.g. defining ethics, boundaries of scientific responsibility, experience of reflective tools). Others emerged through a more inductive process by developing concepts about similar ways that participants talked about ethics (e.g. the distancing or tying of research to application). This broad range of codes was then explored in more depth with links between respondents being drawn and tested, and all codes being refined. Essentially, the coding process as a part of the analysis was approached as a means of both data reduction and data complication (Coffey and Atkinson, 1996), allowing the analysis to focus on the most relevant text for my interests (Cohen et al., 2007a 462). Throughout the analytic process, extensive use was made of tables, summaries and mind maps to organise portions of text and develop concepts around participants' talk. Such representations are valuable because of their ability to act as heuristic devices during the analytic process because of their ability to, "assemble organised information into an immediately accessible, compact form", making it easy to draw justifiable conclusions or move to a deeper level of analysis (Miles and Huberman, 1994, p. 11).

Analytically, my initial aim was to develop an understanding of the different constructions of ethics that individuals presented in the interviews. To do this, a cursory framework was developed onto which different codes were mapped (*figure 4.5*, below). This framework was guided by readings of academic literature and focused on several key points: motivations, manifestations, 'realms, non-realms and boundaries', 'points', and character nodes of 'ethics'. Each point was loosely defined to ensure a basic level of consistency. It is important to note that the framework was not a strict formula to be applied to texts; different points were moved around, not all were used for each participant and links were joined to help develop ideas about the way that participants spoke about ethics. It was used as a heuristic guide. For each

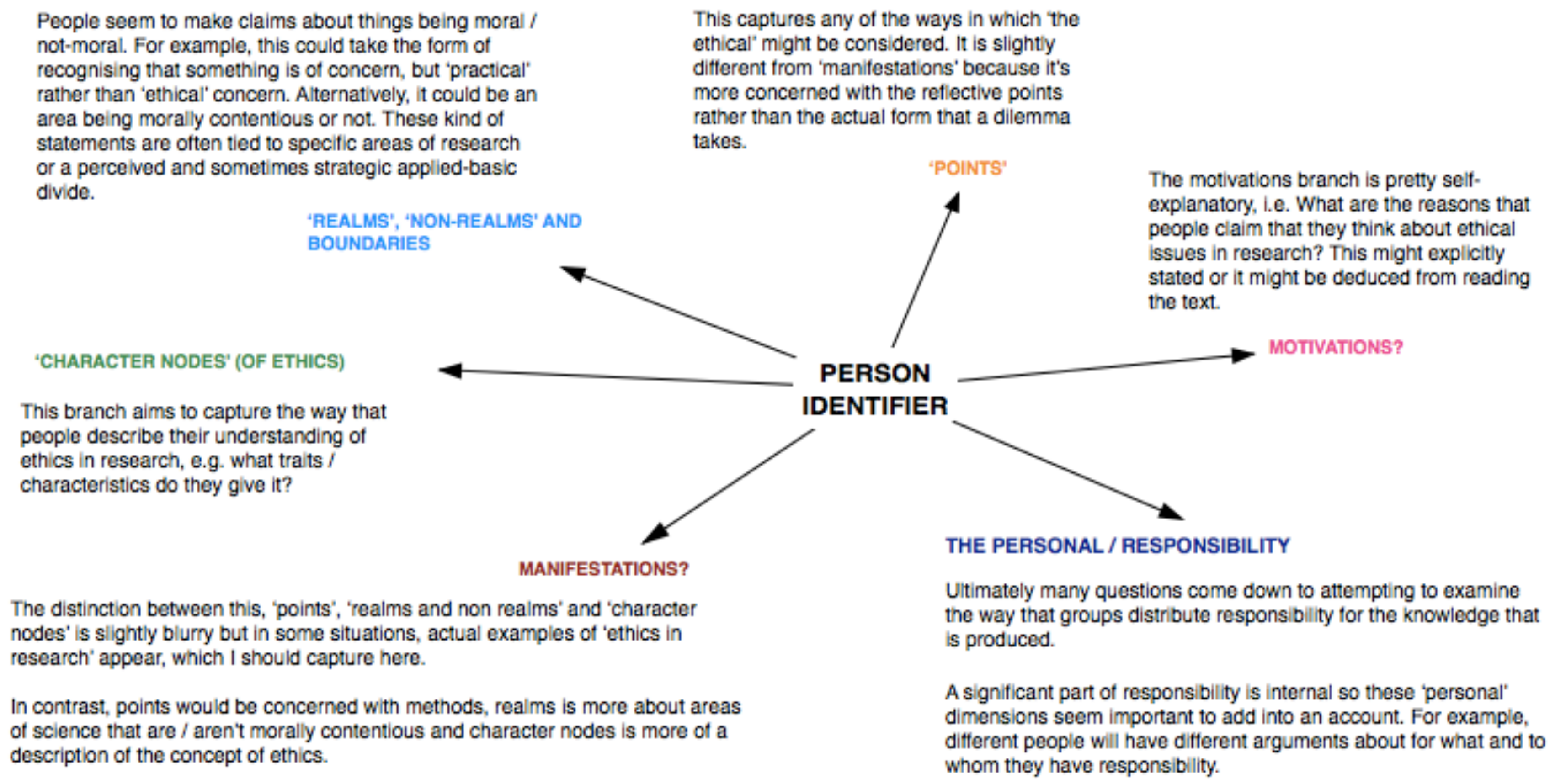

Figure 4.5: *Copy of cursory framework that was used to develop coding of transcripts*

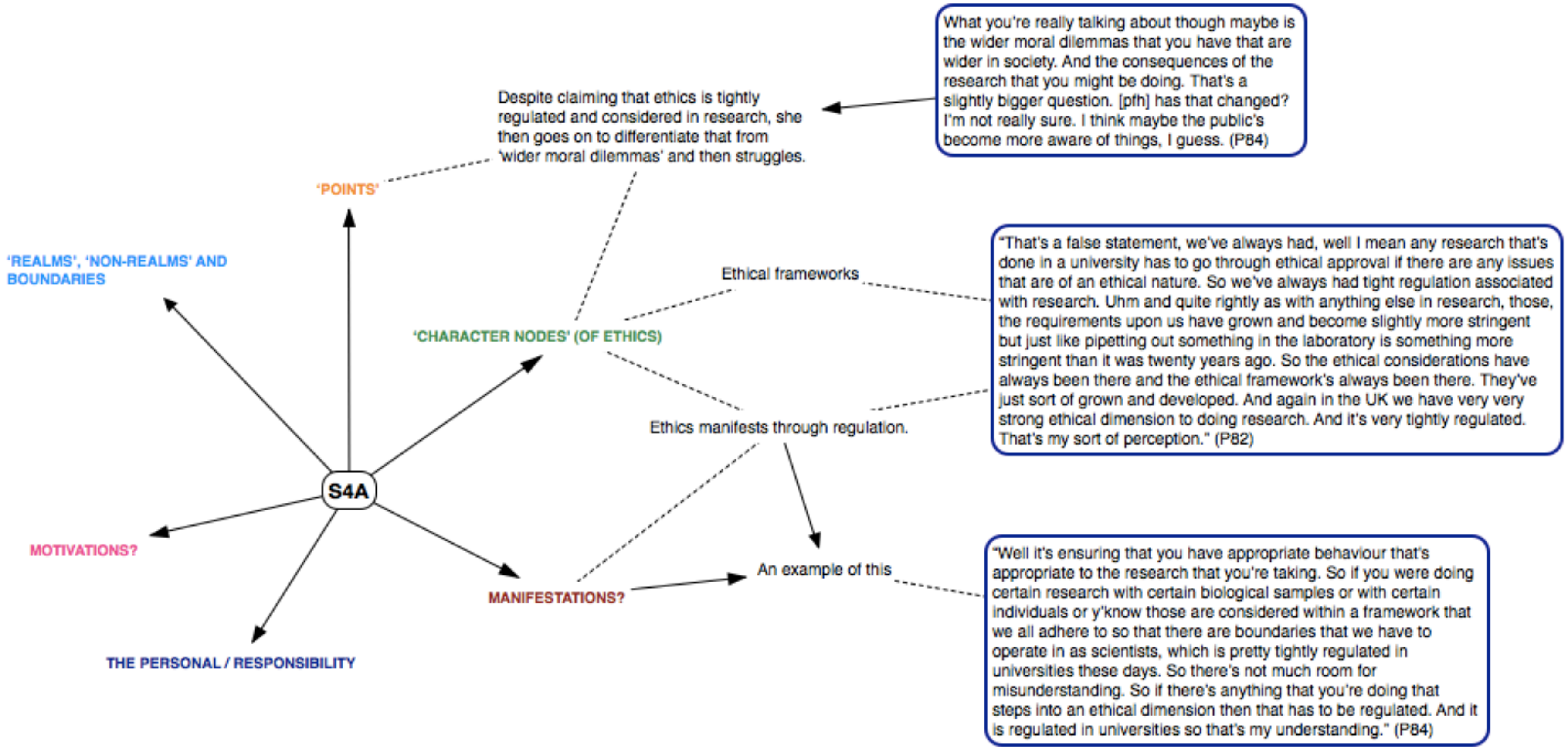

Figure 4.6: *Example of S4A's mindmap. Key quotes are collected and attached to different strategies and structures.*

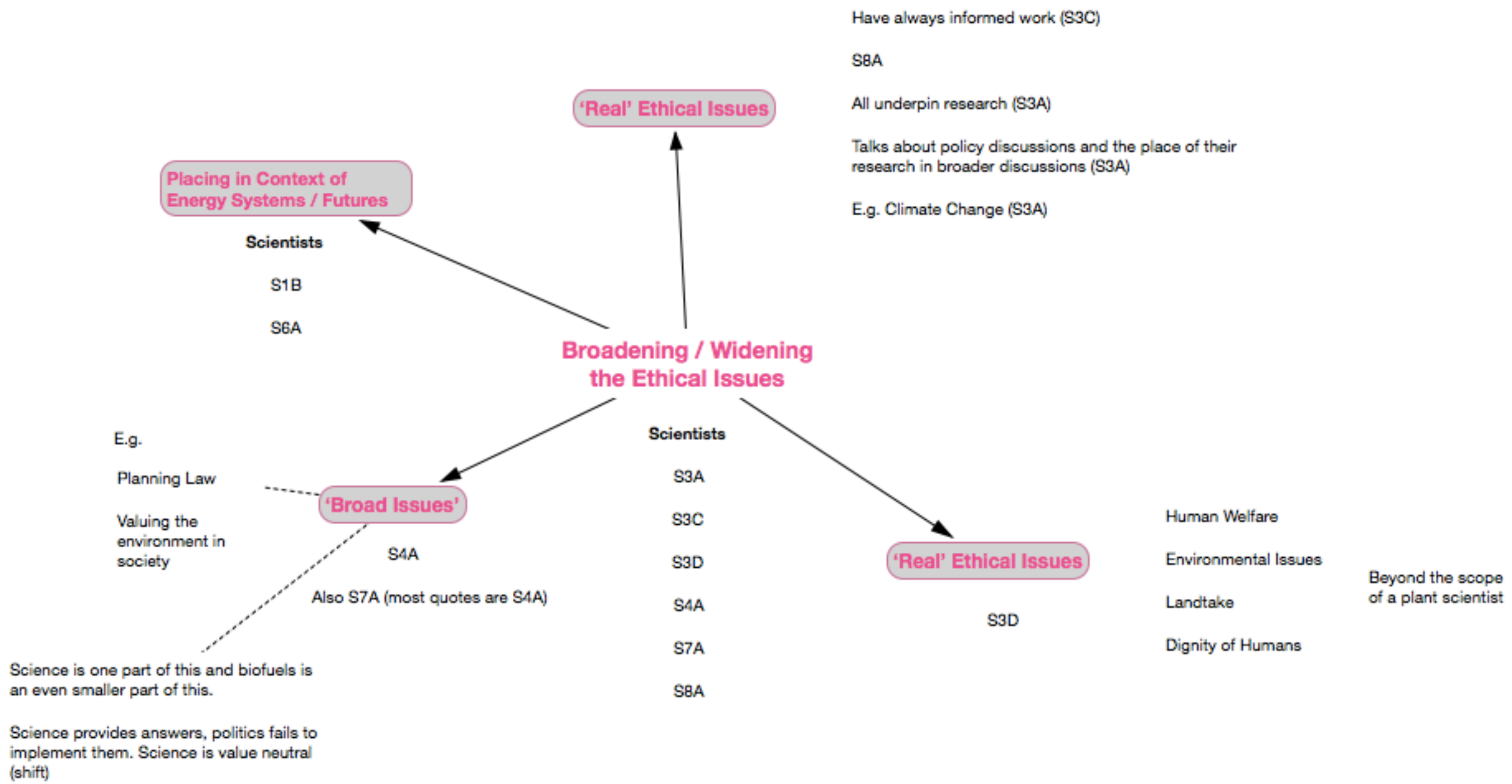

Figure 4.7: *Recurring tensions and commonalities were collected in a second set of mindmaps that cut across the participants, which were used as the basis to generate prose.*

participant, the framework took the form of a mind map (e.g. *figure 4.6*, below) onto which quotes were collected and comments made. Following this, I developed individual position maps of the key tensions and commonalities that the different interviewees had in what they were saying, for example around 'what ethics means to them', or 'types and forms of ethical issues' (of which an extract is provided by *figure 4.7*). These were then summarised into prose, from which I drew out commonalities, tensions and interesting anomalies, linking them to academic literature. This process was intensely iterative, with movements going backwards and forwards between stages. As it progressed, I worked more closely with mind maps, diagrams, summaries and other organising tools such as tables, always ensuring that quotes were tightly related to the insights being generated. Towards the end of the process, as I began to write up, the insights that I generated were more tightly sighted within the lens of the initial 'sensitising concepts' such as boundary work. In this way, I ensured the analysis I produced was original, but aligned to larger theoretical bodies without being driven by such bodies to simply reproduce the exact same insights. Following this process, it was then possible to return to the NGO data set with a renewed purpose and approach to analysis, resulting in the chapter contained within the thesis.

Analysis of BBSRC's activities

My analysis of the BBSRC's response to the biofuels controversy was conducted following my placement at the research council in 2013, which supplemented the present material. A summary of this report is included in *Appendix 4*. Despite covering an extensive period of time and significant amounts of documentary sources, it is somewhat simpler to document, since activities and documents represent discrete items that are easily subdivided and comparable. Data was first reduced to a manageable and relevant amount by screening. Here, the major decision was in terms of where to draw boundaries around the analysis. Clearly, activities outside the formal bioenergy arena also constitute the BBSRC's organisational response. Because of resource limitations, a decision was made to focus predominantly on formally defined 'engagement activities', the oversight and advisory activities provided by the BBSRC Bioscience for Society Strategy Panel and where available meeting minutes from BBSRC Council and the Industrial Biotechnology and Bioenergy Strategy Panel, as well as major corporate policy documents. Taken together, these activities and documents represent a relatively well-balanced image of the discussions and activities that the BBSRC embarked on that might have constituted 'the ethical' in the field. Using the software described above (i.e. Scapple, MaxQDA and Papers 3.0), I interrogated individual documents relating to specific activities to develop an understanding of the ways that the BBSRC as a whole and its constituent teams construct and enact a sense of ethical research in each activity. Particular focus was directed towards a series of strategies and reviews, strategic and delivery plans, meeting minutes and submissions to consultations that occurred between 2006 and 2013. In much the same way as the interviews were analysed, each document was interrogated to build up a picture including, but not limited to, codes around the following:

Research Visions

a. What vision of research is presented?
b. The kind of research should be fund funded?
c. What biofuel production system is envisaged?

Responsibilities

d. BBSRC's responsibilities
e. Individual scientists' responsibilities
f. The boundaries / limits of responsibilities

Ethical issues

g. Concern with ethical / social / environmental issues
h. What is / isn't seen as being of concern?
i. How should issues of concern be addressed?

Activities

j. The goals of specific activities
k. Who should or shouldn't be involved in activities?
l. What is the presented purpose of the activity?
m. What role does it play in research governance?

As with the interviews conducted with scientists, these questions formed a loose framework to guide my analysis, acting as interpretative codes for the individual documents and important questions to ask when interrogating the activities as a whole. In order to produce a holistic picture of the discussions that were going on in the research council surrounding bioenergy funding, I produced an overarching map, based on the documentary sources.

Before concluding the chapter, I want to briefly mention the relationship to existing bodies of work within my analysis of the BBSRC. In a manner similar to the interviews, I made use of existing studies of scientific organisations (Bijker et al., 2009; e.g. Guston, 1999; Hilgartner, 2000; Kearnes and Wienroth, 2011). Here, the notion of boundary organisations dominates. However, in contrast to similar studies for the interviews, many of these studies are relatively opaque in terms of being translatable to this context, partly because their goals were different, and partly because they were based on traditional ethnographies. They did, however, provide conceptual orientation as to how one might conceive of the BBSRC (e.g. as boundary organisation) and point to some concerns that go alongside that. Much more fruitful in terms of actually guiding the analysis were three bodies of work. First, the work of Stirling (2008) in sensitising me to different underpinning rationales for engagement that might exist and the consequences of that; Second, a number of somewhat disenfranchised articles published by Brian Wynne (Doubleday and Wynne, 2011; e.g. Wynne, 2007b; 2006) that urged consideration of the specificities of context in terms of what engagement might look like within scientific organisations as well as an increased attention to the implicit visions that research funders create outside of formalised engagement programmes; Third, related to this, the 'mid range literature' on the sociology of expectations as a means to sensitise myself to such concerns.

4.4 Coda

I want to end this chapter with a brief conclusion. The overall point is a simple one; all research is riddled with decisions and tensions that shape its final form. Whilst the trade-offs are intractable and ultimately insurmountable by resource, they can be made visible. Rather than disavowing that, this chapter represents an attempt to consider and take seriously some of the most important methodological challenges – the 'mess' of research – in a constructive way. This is, I believe, what is needed to generate a robust, defendable and considered piece of work.

Doing so, however, inevitably leads to a further question: How far should one seek to address and pursue methodological ruminations? Even in writing this chapter, I have made choices about sections of my own practice to include and exclude in an effort to produce something of acceptable length for the work at hand. As others have claimed, exercises in radical reflexivity, such as Ashmore's (1989) can produce voluminous amounts of material whilst placing their owners at risk of ultimately "knowing nothing" (Collins and Yearley, 1992, p. 302). As some of the participants in later chapters will argue, this could conceivably be placed as beyond the bounds of what is necessary and reasonable. To claim as such, however, assumes that the paradoxes and tensions should be resolved at a philosophical level before proceeding further. Rather, I have suggested that it is acceptable to acknowledge the many tensions, pay attention to the differences that matter and exercise 'care for the data'. Paying attention to these concerns means that both chapter and thesis inevitably end up taught amongst intersecting tightropes of metaphysical, methodological and political preference that will be acceptable to some and less acceptable to others.

To address tensions in defining bioethics in the previous chapter, I prioritised an approach which implies that 'the ethical' might be most constructively thought of as something to be constructed (or co-produced) in contextually-specific and varying ways. It may, for example, be shaped by heterogeneous motivations, implicit visions and different strategies to 'get work done'. Similarly, to address many of the tensions presented in this chapter, my general strategy has been to reject fine bright demarcations between 'theory' and 'data', between different scales, and between 'metaphysics' and 'politics'. I have positioned the present study on the edge of an acceptable level of granularity between depth and breadth in the face of specified resources. And I have emphasised the value of an analytic approach which is guided but inducted, which blends data with theory, and which is sensitive to the contexts of production. When all of these orientations are taken together, it becomes possible to see that each of the forthcoming chapters will 'look' differently. This should not be mistaken for analytic anarchy; whilst they vary in terms of the dimensions of 'the ethical' that they home in on and the extent to which they make claims to extend discourse to action, for instance, they are unified by an overarching approach to the object of study. Thus, I position my work as operating fundamentally at the 'mid-range', in its various understandings, rolling with the diversity and associated tensions. This is, I believe, one way to continue to produce novel work within the social studies of science and technology that shows not just that things could be otherwise but why they remain and how they might also be pieced together in different ways.

Chapter 5

Non-governmental organisations, values and the role of research

In chapter two (*Biofuels research, technology, policy and controversy*) we saw that the modern incarnations of biofuel technologies have been deployed globally since the 1970s. In the UK they were coupled to renewable energy policy. However, biofuels remained of marginal significance, in part because of unfavourable assessments and alternative technology options that were perceived as more promising. It was only around 2002 and 2003 that they were firmly driven onto the political agenda, and assessments started shifting to more positive stances as policy makers began considering the ways in which their use could be fostered. A controversy around the impacts of widespread biofuel use developed and peaked around 2007-08. This controversy has shifted in focus with changing policy goals and stakeholder debate and the scientific community has been prominent in virtually all aspects of it.

Chapter three traced the ways that ethical issues within science and technology have been managed, again with a focus on the United Kingdom. It introduced a conceptualisation of ethics as a task to be done and then discussed the ways that this task can be carried out and considered the actors responsible for doing it. Considering ethics in this way makes it possible to see how within the biosciences the 'task of ethics' has broadened beyond merely research ethics towards conceptions that include consideration of, for example, the impacts of research for society and the environment, and the relationship between the research (which includes researchers) and society. These changes have prompted, or at least sit in parallel with, claims for the need to 'open up' the research system to a broad range of actors, often under the guise of democratising science.

The developments described above form a backdrop for this chapter's analysis of the voices of non-governmental organisations (NGOs), which emanates from a short set of in-depth and semi-structured interviews with representatives from a range of NGOs active in the biofuels field. Despite a paucity of 'lay' voices in chapter two, NGOs are increasingly being enacted into the governance processes, often as representatives of a public voice which is seen as necessary to legitimise developments within a broad range of technoscientific arenas (Ferretti and Pavone, 2009). As NGOs have taken up this mantle, they have been central to challenging biofuels' environmental, human and energy-producing credentials, mobilising a wide range of strategies to fortify their positions. Most obviously this includes large-scale media campaigns, but they have also acted to challenge, critique and mobilise scientific knowledge, some of which has been produced in-house or commissioned (B. Allen et al., 2014; e.g. BirdLife Europe, 2011).

A small cohort of social scientists has examined the role of NGOs within the biofuels debate (Boucher, 2013; e.g. Mol, 2010; Pilgrim and M. Harvey, 2010), and a small but emerging body of literature within STS deals with the status and activities of NGOs in matters of science and technology more broadly (Eden et al., 2006; Jasanoff, 1997; Yearley, 1996; e.g. 1992). Nevertheless, Eden, Donaldson and Walker (2006) are correct when they attest that such studies tend to conceptualise NGOs in relation to political theory or as social movements. Eden and her compatriots' (2010; 2006) are relative anomalies in producing work that focuses specifically on NGOs' knowledge-making actions. Rarer still is work that is oriented to examine how the ethical dimensions of developments within the biosciences are formulated by organisations outside traditional publicly-funded scientific communities (Flipse et al., 2013) or outside traditional ethics task-spaces (e.g. research ethics committees and public bioethics committees). However, if science is increasingly seen to spill out of tightly defined laboratories, into other non-traditional spaces with non-traditional actors that compete for credibility and legitimacy in sociotechnical matters, then focusing attention on these actors (e.g. NGOs) presents an obvious means to generate deeper analytic insights for our understandings about the nature of ethical concerns in science.

Overall then, I consider NGOs to be increasingly prominent actors in the governance of biofuel development and deployment. Because of present analytic scarcity and methodological necessity (introduced in the previous chapter), I see it as important to question the ways that they construct the ethical dimensions of research and distribute responsibility for addressing them amongst those involved in knowledge production. My primary concern dovetails with the approach reported in Eden, Donaldson and Walker (2006) and Eden (2010) by adopting an analytic orientation that draws on, amongst other things, notions of boundary work (Gieryn, 1999) and that touches on debates about the boundaries between scientific and political worlds. Put another way, discussions of 'the ethical' are inseparable from discussions about the science-society relationship and the role of different forms of knowledge within that relationship. However, my approach is set at a slight angle to the above studies; whereas they are primarily concerned with making inferences about the discursive power of heterogeneous and fluctuating demarcations of knowledge and expertise in maintaining and adopting particular organisational positions within controversies, I am more concerned with mobilising an STS analysis to tell us something about the nature of 'the ethical' and its consequences for research governance. My departing questions are therefore threefold: (i) How do NGOs position themselves in relation to the production and governance of knowledge; (ii) how do NGOs construct issues related to the development and production of biofuels; and (iii) what responsibilities do NGOs ascribe to different individuals and organisations (such as themselves, scientists, research funders and policy makers) within a system of knowledge production?

To address such questions, the chapter is structured as follows. First, I consider the position of NGOs within the governance and production of scientific knowledge (*section 5.1)*. To do so I reflect on the absence of a 'traditional' public voice and the ways that NGOs have been problematically positioned by academics and other actors as representatives of a public voice within the biofuels controversy. I suggest, following Eden (2010), that a more fruitful position suggests that NGOs might be better considered to 'hybridise' conventional demarcations between science and society. Second, (*section 5.2*) I consider the ways in which different NGO representatives mobilised issues associated with the development and deployment of biofuels. One consequence of this is to highlight that issues are therefore neither interminably ethical nor present. Nor do they exist in isolation. Indeed, part of their nature is that they are suitably vague as to allow them to be mobilised in multiple ways for diverse normative ends. The latter stage of the chapter (*section 5.3*) contains an analysis of the way that NGO representatives presented the relationship between 'the ethical' and the responsibilities of those involved in the development of biofuels. To do so, I relate different positions throughout the chapter to prescriptions for the structuring and steering of knowledge production, i.e. 'how the task of ethics should be embedded within research funding, governance and practice'.

5.1 Absent voices in the development of biofuels

Recall that the biofuels controversy achieved some public salience around 2007-08, and continues to receive occasional media attention. However, debate both was and continues to be largely framed in technical terms and conducted amongst communities of technical and policy experts. As such, one of the most notable omissions is the lack of a 'public' voice: in this debate there appears to have been little appetite for citizens in their lay capacities to comment on or influence the debate, technological development, and policy. There have certainly been few points at which this could occur and one might be tempted to argue that as such, it is difficult to imagine what this involvement would actually look like. Certainly, this was a claim of at least some NGO representatives that I spoke to,

> "The problem with biofuels is that we don't necessarily think that the consumer pressure will develop for a number of reasons. For example, I feel that it's too processed for somebody to make the connection, so you buy say fuel at the pump which has 5% biofuel, too processed compared to a table." (CS2, pa.31)

If one were to conduct an empirical investigation into this, they might hypothesise that the debate has been conducted at too higher level for non-expert input. As an example, a significant point of contestation in recent debates has been around methods of greenhouse gas accounting when modelling land use change and the notion of 'leakages' between different uses (Buchholz et al., 2009; Ostwald and Henders, 2014). As the very existence of a controversy has shown, this is something that technical experts disagree over and policy experts have difficulty interpreting (Resnik, 2014). Alternatively, one might also suggest that biofuels' material nature is often delocalised and opaque, which lends some theoretical credence to anecdotal suggestions like that of the NGO representative above: biofuels' impacts increasingly occur in geographically distant countries to those where consumption of the final product occurs. Thus, whereas biofuels as a whole are seen to be controversial, it is biomass energy plants that have had the most notable public interventions in the United Kingdom, commonly at the planning stages of development when plants are being sited (BBC, 2013; Spalding Today, 2014; Upreti, 2004; van der Horst, 2007).

Nevertheless, there have been some notable attempts to actively involve citizens in the debate around biofuels and their regulation. As suggested in previous chapters, this should be seen in light of trends within science, technology and policy making more broadly that have increasingly advocated more and better public involvement in decision making, to varying results (e.g. HM Government, 2012). DECC's 'My 2050 carbon calculator'[9], for example uses modelling to allow individuals to create their own visions of future energy supply and demand, and position biofuel use as a part of this. Equally, the BBSRC made moves to involve members of the public in a national bioenergy 'distributed dialogue', which will be discussed in *chapter six*. These examples could be criticised for excluding specific visions and types of public, failing to move beyond the constituencies of already-interested individuals, and for the often piecemeal way that they embed the suggestions of previous independent evaluations, but they are nevertheless attention-worthy because of their position on an otherwise sparsely populated landscape.

Despite a superficially silent 'public voice', previous chapters have shown that NGO activity has permeated both debates about biofuels and about the ethical and social aspects of science and technology, often shaping the research that is done. This latter capability has long-been recognised in studies such as Steven Epstein's seminal work around AIDs activists in California, who were famously able to influence the research

[9] http://my2050.decc.gov.uk [Accessed 20/9/2014]

agenda around biomedical research by being seen as 'credible' and thus shaped both the epistemic practice of biomedical research, as well as the values embedded within it (Epstein, 1995). Specifically in relation to emerging technologies, organisations such as GeneWatch, EcoNexus and ETC Group each position themselves as playing roles in monitoring technological developments and drawing attention to any 'ethical' issues associated with them. These territorial claims within civil society, particularly from activist groups, should be taken seriously; they are increasingly seen as a credible challenge for the ethics task space from the bioethics profession (J. Evans, 2012, p. 75) and agenda-setting reports increasingly seek to enact them in the development of technoscientific projects (e.g. see BERR, 2009).

Others, such as Mohr, Raman & Gibbs (2013) have suggested that NGOs might represent one form of 'public' amongst several other publics. By using the term 'publics' rather than 'citizen' or 'public', studies of public engagement in science and technology seek to emphasise that rather than being singular, neutral, static, unified and representative, public groups are multiple, are almost always 'interested', can be convened or self-mobilise, and almost always do so in fluid ways (Wickson et al., 2010). Mohr, Raman and Gibbs (2013) suggest four role-types of publics, including campaigning, civil society publics, diffuse and latent groups. Within this typology, NGOs most clearly represent a campaigning public, claiming to speak for a specific population, but which, like Epstein's activists, have become recognised stakeholders in the political and scientific process in their own right. Such legitimacy has been recognised by others, particularly in environmental and sustainability issues, where environmental NGOs could be said to have carved out a niche of 'moral legitimacy' (Mol, 2010) within evolutionary models of governance and regulation (Nill and Kemp, 2009; A. Smith et al., 2005).

Of course, these changes are not to be acknowledged without some critical retorts. For example, speaking in relation to synthetic biology, Joyce Tait (2012, p. 579) pointedly argues that new modes of governance and the inclusion of participatory methods for appraising science and technology have simply resulted in a "shift in power away from industry and commerce towards advocacy groups with equally limited claims to represent 'society'". In a similar vein within biofuels it has recently been argued that a core group of environmental NGOs acted to mobilise scientific research around biofuels opportunistically as a means to further their broader political goals in different areas of activity (Pilgrim and M. Harvey, 2010).

So, whilst NGOs are perhaps most prominently known for lobbying against the widespread and large-scale use of biofuels, such positions are problematic in that they tend to homogenise the debate as largely being dichotomous with biotechnology and energy industries on one side and environmental NGOs on the other (e.g. Hansen, 2014). However, when considering the role that NGOs play in shaping the ethical dimensions of biofuel development and deployment, this is clearly not a homogenous field. At a basic level, different organisations lobby to different extents and there are well-acknowledge nuances and tensions in the positions that they take. For example, a joint anti-biofuel media campaign ("Tell the Government to choose the right biofuel or the orang-utan gets it" (Greenpeace, 2007)) from RSPB, Friends of the Earth, Greenpeace, Oxfam and WWF had accompanying text that was carefully worded, at the request of WWF's more moderate position, to avoid calling for a moratorium on all biofuel production. When the campaign subsequently shifted to become stronger, WWF withdrew from the consortium (Pilgrim and M. Harvey, 2010). Some have sought to emphasise these differences and the temporal fluidity of positions, noting that at the turn of the century, NGOs took a more optimistic stance (Raman and Mohr, 2013). These characterisations, however often fall into a similar trap of unifying early NGO positions, which as the previous *biofuels, technology, policy and controversy* chapter sought to show, was not the case, even at the turn of the century. One key goal of this chapter is thus to explore the potential heterogeneity and tensions between the positions of different organisations, especially with regards to the way in which they position and challenge values within scientific knowledge and the biofuels debate.

When confronted with questions about their campaigning position changing, the interviewed organisations commonly rebutted that 'the scientific evidence shifted' (e.g. CS5 pa.83-85). Points such as these allude to a deeper question about the relationships between NGOs, scientific knowledge and the status of different forms of research. Some of the NGO representatives claimed this as the spark for their interest in the case; some referred to the much-cited Fargione (2008) and Searchinger (2008) papers and a more general scientific upswell as reasons for beginning to focus on biofuels. Others go further, discursively positioning the production and review of science as a central part of their organisational activities. Furthermore, this NGO-funded research is increasingly being recognised as legitimate and valuable. In a report to government, AEA Technology, a large consultancy company spun out from the previous UK Atomic Energy Agency, acknowledged that in some cases research conducted by these organisations about topics such as the impact of biofuels on the drainage of peat wetlands in biomass-producing locations is the only source of information (AEA Technology, 2008).

A third area of heterogeneity is in terms of the relationship to regulation, and governance more broadly. Whilst NGOs as a whole are commonly sought out as a set of stakeholders within policy making and governance at both national and international levels (e.g. DTI, 2007), their self-positioning and willingness to engage within this framework varies significantly. In the biofuels field for example, some — commonly the smaller and more activist-focused organisations — eschew these interactions whilst others are tightly involved in governance activities such as the certification of biofuels, wood, and other products or the consulting and advising of industry[10].

In what follows, I take a less binary stance to those described above. Setting issues of a representative public to one side, I note that these non-governmental actors *have* become politically prominent and credible voices within the biofuels debate and science and technology governance more generally. In many ways (and as critiques such as those offered by Pilgrim and Harvey (2010) highlight), NGOs serve to 'complicate' or 'hybridise' the boundaries between science and society (Eden, 2010). In this case, as with many others, NGOs both consume, utilise, fund and produce research but the political legitimacy of their positions is maintained in quite different ways to 'scientific legitimation' (Eden et al., 2006; Horlick-Jones and De Marchi, 1995). For now, I want to defer the consequences of such differences in legitimacy until the final chapter, so that I can integrate the positions of NGOs, scientists and the BBSRC and generate some comparative insights.

5.1.1 NGOs in the production of knowledge

In the above section, I introduced some of the roles that NGOs play in a controversial technoscientific arena that has a notable absence of participating public voices. Rather than suggesting that NGOs are able to unproblematically play the role of public proxy in articulating ethical concerns, I have pointed to a number of ways in which they might complicate the relationship between science and society. One way that this occurs is in terms of their relationship to research, a theme that I briefly explore in more detail here. At a basic level, this varies in terms of whether they claim only to consume or whether to also produce scientific knowledge (*Table 5.1*). All of the organisations that I spoke with have some kind of research focus, pointing to a fundamental agreement that science is at least a dominant *lingua franca* within the biofuels debate, even if they refrain from deciding whether it is the *right* one. Research is thus something to be engaged with and in. This intermingling of science with environmentalism and environmental governance is a trend long acknowledged in studies of science and NGOs (Yearley, 1989). Specific scientific activities, however, are mobilised in several different ways.

Table 5.1 is derived from interview transcripts. It draws attention to an engagement baseline: all groups claim to keep abreast of new developments within the field by reviewing scientific literature. Some (e.g. CS4, CS5, CS6) cited the publication of scientific studies at the time that the European Commission was implementing blending targets as the reason for directing attention to biofuels or for changing their

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[10] E.g. see the roundtable on sustainable biofuels, which has a number of rights-based and environmentally-focused NGOs within its governance network. (http://rsb.org/about/organization/rsb-members/).

stance on policies to promote their use. This continual review of the scientific knowledge is thus seen as a pre-requisite by all for substantive engagement in debates around the development and use of biofuels.

Research Activity	CS1	CS2	CS3	CS4	CS5	CS6	CS7
Reviewing existing literature	■	■	■	■	■	■	■
Producing reports	■	■	■	■	■	■	■
Advising industry		■					
Working with sustainability certification schemes		■					
Conducting natural science research			■		■		■
Implementing and developing technologies			■				■
Advice / oversight of public research funding activities			■	■			

***Table 5.1**: NGOs' interactions with research activities. Shaded cells indicate involvement.*

Other NGOs claimed a more active role in the production of research. CS4, for instance, wholly self-position as a 'research organisation'. Although the definition of this is difficult to pin down, in terms of credibility and space this is certainly a different form of research organisation to established scientific organisations. Other organisations make use of in house or externally-commissioned research teams to underpin the work that they do. Whilst the most ubiquitous form of research conducted here is perhaps best described as a kind of 'biofuel assessment', some organisations are directly engaged in developing and deploying biofuel and bioenergy technology schemes. This was never described as 'basic science'. Indeed CS3 described this as a form of 'action research'. Again, this could be in house, or through collaboration with external partners, often universities. Collaborations such as these begin to hint at the relatively small and close scientific-campaigning network within the UK: a number of organisations, actually collaborated with scientists in my own interview pool.

At a third level, a number of organisations were directly involved in the governance of biofuel development and deployment at different points. CS2, for example, is well known for being closely involved in the development of sustainability certification schemes, processes which are often heavily reliant on technical data and monitoring at a local level. These organisations adopt the stance that "if we're not at the table then we have no influence" (CS4, pa.244), something which has been astringently criticised by other organisations. Other groups, such as CS3 and CS7 have been brought into the governance processes of BBSRC, being seen as desirable for being a critical voice in the direction of engagement processes — a position often similarly ascribed to social scientists and bioethicists.

Again, as I have suggested, rather than taking this as a failing, I suggest that these actions open up questions about the ways in which NGOs gain and maintain legitimacy within debates on science and technology, and the ways in which they might challenge traditional notions of scientific credibility and the nature of expertise. To begin to interrogate this role, questions about the way that traditional boundaries between ethics and science, different forms of knowledge production and varying distributions of responsibility are important to explore in more detail.

5.2 Mobilising issues

In this section I focus on the ways in which NGO representatives deployed and positioned different 'issues' relating to the development and deployment of biofuels during interview. In *chapter two* I showed how debates relating to the development and production of biofuels bind up a wide constellation of issues that it is worth summarising before moving forward. Dominant production models of biofuels have been critiqued, with claims that large-scale models have led to land grabs and the eroding of local, often poor, communities' land rights. The forms of agriculture that are commonly employed for the production of biofuels have been implicated in the reduction in soil quality, water availability and nutrient availability. Prominent within the debates has been a realisation that the production of biofuels adds increasing pressure to an already high but ultimately finite land use burden, which, because the demand is from industrialised and wealthy nations often results in energy production being prioritised over food production (famously described as the food versus fuel debate). In Europe, debates have often been framed in terms of greenhouse gas emissions, partly as a result of the dominant goals of European policy. The credibility of greenhouse gas reductions has been debated and has dominated much recent discussion, especially at a policy level. This part of the debate has been conducted in quite technical terms, using accounting methodologies such as life cycle analysis. One particular shift in this respect has been the development of a notion of indirect land use change (ILUC), which emerged from claims that when quantifying the (GHG) impacts of biofuel production, it is also important to take account of biofuels' ability to displace other uses of land, which also have impacts to be accounted for.

Now, all of the above issues have been extensively treated within academic literature. In the remainder of the chapter I do not wish to provide a count of 'ethical issues' and an analysis that replicates the treatments to provide moral evaluation of biofuels' status. My reasons for making reference to the multitudinous issues above are to note that almost all were aired by this small sample of interviewees, emphasising both their dominance, but also their diversity. In the subsections that follow, I make use of a number of different issues as examples to point to trends in the nature of debates around controversial technoscience (the subsection 5.2.1, *problematising biofuel production*). Issues can be strategically deployed and bounded, being tied to broader narratives about technology in society, to problematise biofuel production. One consequence of this is to highlight that issues are therefore neither interminably ethical nor present. Nor do they exist in isolation. Rather, they are contingent on particular contexts and depend on their continued deployment. In subsection 5.2.2, (*ILUC as a site of contestation*) I use the particularly contested notion ILUC as case in point to show how issues can be mobilised: Although ILUC is a shared 'issue of concern' amongst actors, it is suitably vague as to be endowed with 'interpretative flexibility' (Pinch and Bijker, 1984), allowing it to be mobilised in multiple ways for diverse normative ends. These first two subsections serve to emphasise fundamentally diverse and malleable nature of ethical discourse. Such insights lead me, in the third subsection, to consider the presence or absence of a separation between what is 'ethical' and what is 'scientific'. Differences in this separation have consequences for the way kinds of concern that can be articulated, the ways in which they should be addressed and by whom, which I consider in the next section (*5.3*).

5.2.1 Problematising biofuel production

Interviews did not solely focus on the issues that have been widely discussed elsewhere; NGO representatives did raise issues and questions that are less common in discussions about biofuels, and in some cases unique to an individual interview. CS1 and CS5b suggested that whilst discussions around biofuels have focused on sustainability, almost "everything about bioenergy right now is about sustainability of source and none of it is about sustainability of use" (CS1, pa.105), with CS5b suggesting that biofuels use in situations where there were no alternatives, "if the focus were on aviation fuels, for example" (CS5b, pa.139), might be more acceptable. CS5b affiliated a discussion of end use with one of scale: "whilst there still are land use implications [with aviation], the scale is somewhat more limited and can potentially be limited more easily by taxation" (CS5b, pa.139). Others disagreed, suggesting that if biofuels are to be "genuinely sustainable, it will always be at a very small scale" (CS6, pa.68). NGO representatives such as CS4 and CS6 emphasised the importance of small-scale, local production, in achieving sustainable biofuel production. This was not universally agreed upon. Despite finding industrial scale "a bit of a scary term" (CS3, pa.29), CS3 emphasized that production systems do need to be sustainable at an economic level as well as environmentally and this is often easier for growers to achieve at a larger scale, perhaps through a cooperative, which "seems to work seems to work very well with coffee and tea, and other plantations when they're done in the right way" (CS3, pa.32). Both CS1 and CS2 acknowledged that there are questions about whether a system should be aiming for high-efficiency and high-intensity or the converse. CS4, however, rebutted arguments about efficiency with reference to 'Jeven's Paradox' whereby efficiency improvements can result in increased rather than decreased consumption (Alcott, 2005).

The above quotes begin to indicate that what is deemed to be relevant and acceptable is debated even within this small cohort of NGOs. Further, and as will be elaborated on, assessments of biofuels' sustainability are bound up with broader narratives within the interview and differing perspectives on, for example, more or less acceptable end uses and the rights of producers in developing countries. These are not just technical matters. Additionally, it is possible to examine how NGO representatives occasionally deployed novel arguments to continue to problematise biofuel production systems that others might find acceptable. Consider the example of 'used cooking oil' as a biofuel feedstock. When asked whether 'used cooking oil' would represent an acceptable feedstock for biofuel production, CS4 replied:

> "So on one level it sounds really good. But then you have to say to yourself, 'why is there so much waste cooking oil in this country?' 'Well there's an awful lot of fish and chip shops and other deep frying going on.' 'How good are chips for human health? Should we be producing all this waste from cooking oil?' I think that's a major problem, we shouldn't be doing so much frying probably, [...] and there's this issue now of genetically modified cooking oil [...] So the thing about oil I think is that on the surface it seems very positive but there are all sorts of synergistic issues and the diet issues." (CS4 pa.174- 176)

In the UK, used cooking oil provides 35% (610.4m litres) of total biofuel feedstock (DfT, 2014). The use of used cooking oil ties in to discussions about the acceptability of wastes and by-products as potential biofuel feedstocks. Here, it was commonly argued that careful differentiation is needed, perhaps by conceiving of a "hierarchy […] between those materials that are genuine wastes and a problem to deal with […versus] wastes which can potentially be used in other ways […versus] agricultural wastes" (CS5b, pa.119), such as straw, which might provide ecosystem services. Of this hierarchy, "the only genuine waste is used cooking oil" (CS6, pa.92), which is otherwise "just going to go to land fill" (CS1, pa.46). Used cooking oil was sometimes used to express scepticism about the biofuel project as a whole – "there's not a lot on offer" (CS6, pa.92); "well that says something about how much we have available" (CS1, pa.44) – but was otherwise viewed as acceptable. In the block quote above however, CS4 problematises this feedstock by connecting its availability to 'synergistic issues'. These broader issues are used to maintain a position on biofuel production that favours alternative courses of action to lower greenhouse gas emissions, such as reducing fossil fuel consumption: "I think the reduction of energy use can be part of a synergistic process around health and wellbeing." (CS4, pa.176).

Discursive strategies such as CS4's are interesting because they not only show that the presentation of issues and wider value-judgements are interminably interlinked, but both the issues and their linkages are deployed and drawn in and out of focus strategically as a wider debate evolves. Coupled with a broad examination of the issue-types raised in the sample, they also begin to highlight a particular 'broadening' dynamic of debates and policy making on the subject of biofuels (and perhaps renewable energies more generally). All but one NGO directly referenced land use change associated with biofuel deployment as a major issue. Of these, all included indirect land use change within that assessment. In contrast, a smaller number, and much less interview time, was spent discussing the food impacts of biofuel production, with some such as CS2 and CS3 disputing the causality or significance of first generation crops' impact on food security– people need food and fuel – a position likely unimaginable in 2007. The 'facts' with respect to food impacts are not settled; some still dispute the causal links between biofuel production and food prices (FAO, 2008; HM Government, 2010b). Rather, the issue is rendered irrelevant because policy debates have increasingly coalesced around the land take of biofuels and the GHG emissions associated with their production, with emerging technologies such as lignocellulosic biofuels positioned as 'non food-competitive' production chains that should be incentivised through policy instruments within Europe.

Under this new regime, the use of alternative feedstocks such as used cooking oil and those provided by emerging, 'advanced', production chains are thus favoured because they are widely viewed to ameliorate previous problematised production pathways. However, in responding to previous issues, these technologies often inadvertently identify new problems such as ILUC. Some, such as CS4 couple them to broader 'synergistic issues'. In doing so, CS4 is able to open-up both the means as well as the ends to questioning, making alternative options for greenhouse gas reduction viable again in ways that traditional risk-assessment and technocratic policy cultures tend to close down (Melo-Martin and Meghani, 2008). These broader problem-framings are often difficult to predict from a purely technocratic and single perspective but are nonetheless valid criticisms to be accounted for, as evidenced by recent attempts to include them in policymaking (Alberici et al., 2014; Nelson, 2014). Policy-making processes vary in their claims to be technocratic, scientific, or evidence-based, but all embed value-judgements. In the following section, I use the notion of ILUC as a case in point to demonstrate the malleability of specific issues.

5.2.2 ILUC as a site of contestation

Recall that the issue of ILUC has dominated recent debates and is largely a result of the their technical nature. Two academic studies published in the journal *Science* (Fargione et al., 2008; Searchinger et al., 2008) showed that restricting biofuels to those produced on land previously used for agriculture was not enough to stop land-use change because the activity that took place before biofuel production, which is not subject to land restrictions, would be displaced and result in net land-use change. If biofuel production leads to an increase in the total demand for land, land-use change will prevail. The authors argued that it did not matter whether land-use change makes way for biofuel production directly or for some other agricultural activities displaced by biofuels production. If these changes were accounted for in LCA then biofuel production would be seen to increase rather than reduce GHG emissions, contradicting a central motive for biofuel development.

However, the notion of ILUC has been contested at ontological, substantive and normative levels; in terms of its existence, its relevance, and the consequences that flow from its acknowledgement (or rejection). It was also contested in interviews with NGO representatives, which provides an opportunity to examine the ways in which different groups respond to and problematize particular parts of a confluence of scientific knowledge, ethical dimensions and politics. Doing so is a step on the way to exploring the responsibilities that they place on scientists and scientific organisations. Interviewees constructed at least four problem diagnoses within the ILUC debate:

1. Policy ignores evidence 2. Politics meddles with science	Problem of politics
3. An 'excess of objectivity' 4. Epistemic uncertainty	Epistemic problem

First, several participants argued that the publication of what they saw as a substantial and robust body of scientific research emerging at the time that European biofuel targets were being set was the spark for becoming involved in campaigns around biofuel use. None of the groups advocated a totalitarian 'anti-science' perspective but rather problematized specific aspects, for example with respect to the kind of outputs that are prioritised, or in terms of the (lack of) interaction with policy, as argued by CS5a:

> "So I think from our perspective, biofuels policies have developed to encourage increased use in biofuels that's probably ahead of the science in way. So biofuels policies were being introduced with relatively high targets at a point when there's an increasing body of scientific evidence saying that the impacts could be quite damaging [...] Policy's driving the industry but research is showing that

> it's problematic. Policies are setting targets that are too high given that the research is showing that it's problematic. So the policies are driving biofuels development at a level which is probably going to lead to environmental and social damage." (CS5a, pa.17-21)

Here, the problem is set up in what are familiar terms within science studies; scientists have produced unambiguous and robust knowledge that hasn't been put into action by policy makers. The solution, from CS5a's perspective, then is to follow the science more closely. This applies to both the specific example of ILUC and to biofuels more broadly. Either way, this means taking the impacts, demonstrated to exist by researchers, into account in the assessment and deployment of biofuels. Similar points were made by CS1, CS2 and CS6. For these organisations, the evidence on indirect land use is overwhelmingly clear" (CS6, pa.40) and it is the policy that is problematised. Scientific research has demonstrated the ontological status of ILUC insofar as it exists and it therefore deserves attention. Claims to inaction, perhaps because of complexity and uncertainty within the situation, are regarded as "an industry argument that's used as a get out of jail free card" (CS5a, pa.29). However, as we shall see, quite differing prescriptions about what this action should be, 'based on the science', follow.

CS2 suggests that certification of greenhouse gas emissions for biofuels is one way in which ILUC might be addressed. However, the process is indicative of a second problem that stems from the intertwining of science and politics: the presentation of value judgements as scientific fact. In Europe, certification standards are attached to biofuels from specific production chains and sources. These standards include GHG values that are based on modelling and LCA. CS2 suggests that when the European Commission released the GHG values for European production and Brazilian production the values were skewed in European favour more than was expected. He suggests that this is because of a normative judgement: "they wanted to protect European production" (CS2, pa56). CS2's criticism is not that there was a normative judgement, but rather that risks about production stability were allegedly incorporated into a 'scientific' analysis, "changing the numbers" (CS2, pa56). The *means* is thus problematised; a normative decision is presented as scientific fact when the reality is an opaque negotiation process.

Now, others outside of this sample would highlight that LCA, certification standards, and modelling more generally, embed their own value judgements. Echoing Kuhn, (1977, pp. 356-367; 1970) who argued that "epistemic values such as simplicity, scope, theoretical elegance and fruitfulness influence choices between [different] models and theories", Diekmann and Pieterson, point to the fact 'non-epistemic' judgements such as wellbeing, safety and sustainability shape modelling as much as epistemic ones (Diekmann and Peterson, 2013, p. 208). This is relevant to LCA: Cherubini et al (2009) have shown that when deriving indirect land use change factors, different assessments of 'risk' are incorporated. These differing assessments of risk are then incorporated into the final LCA, which can produce wildly differing 'facts' regarding a particular biofuel's GHG emissions. The point here, however, is that the problem was presented by both CS5 (a & b) and CS2 as one of scientific facts intertwining with political processes and either being ignored or bastardised.

It was suggested that a third problem prescription around ILUC comes in epistemic form: what Daniel Sarewitz has termed an 'excess of objectivity' (Sarewitz, 2004; 2000). Sarewitz contends that in complex and uncertain situations, such as many environmental problems, more knowledge might not necessarily resolve disagreements. CS2, for example, suggested that there are currently conflicts in evidence amongst scientists, which produces a high level of uncertainty about the most appropriate action,

> "There is a lot of scientific uncertainty about ILUC and that's one of the problems, there are lots of disagreements about scientists on both how significant the impacts are and especially how to address theses impacts. And I think we got to a point when there is agreement that the ILUC impacts are significant but the answer on how to address it, there is still quite a lot of debate about what to do." (CS2, pa.56)

Here, the uncertainty represented is less about acknowledging the ontological reality of ILUC, and is more concerned with reasons and methods for action, of which there are a range of possibilities, even amongst NGOs. CS5 (a & b) maintain that the application of ILUC factors, based on modelling, to accredit different types of biofuel is an acceptable route to follow. They deem the scientific basis to be robust. For CS6 however, problems come when trying to allocate indirect land use change through the use of factors.

> "I actually think that's totally impossible to do anything credible that way because the indirect impacts are so manifold; You know they are not simply hectare for hectare displacement, they are also the impacts of related policies, for example in relation to land tenure – what impact will they have on ecosystems? – the infrastructure, if you create new plants, new roads, new transport networks as a result of biofuel investment, those will have massive impacts on forests and other ecosystems too, which almost certainly not factored into ILUC studies on the whole." (CS6, pa.40)

CS6 contradicts the perspectives of CS5 and advocates CS2's later suggestion of employing the precautionary principle. She challenges the ability to model land use changes, not by undermining the technical methodology that has led to the characterisation of ILUC as it currently stands, but by broadening the indirect impacts away from just greenhouse gas emissions to also include 'impacts on ecosystems'. She uses the scientific evidence to bolster her position that "the only thing that's logical for one to do to address it is to suspend of scrap biofuels targets or the policies driving this" (CS6, pa.40). This presents the forth problematisation: ILUC can be presented as having a dual-certainty. It is ontologically concrete; it exists. Epistemologically however, its impacts are opaque — as a society we are not certain enough to be able to quantify how much of an impact ILUC has in order to protect against those impacts. Rather than suggesting that politics and policy makers are the problem, CS6 thus suggests that ILUC represents a fundamental epistemological problem that will never be rectified, strengthening the case for abandoning the use of biofuels (and indeed bioenergy more generally). Again, the decision is cast as rational and logical, devoid of normative judgement.

This brief analysis of the way that different NGO representatives interpret ILUC thus forces to the fore the normative decisions that surround the issue. Although all agree upon it as a 'thing', its status and problematic nature are contested. Whilst some suggest it can be addressed through current accounting methodologies, others are less convinced. In doing so, all cast their arguments in rational, scientistic terms. A point in hand here, that works to further demonstrate the issue's contingency, is that the prominence that ILUC receives as an issue can be viewed as an artefact of the currently dominant biofuels policy frame of reference (Palmer, 2014). ILUC is only significant, and ontologically concrete, when accounting for land use solely in terms of biofuels rather than, say, agriculture as a whole is the frame of reference (Boucher et al., 2014). To this end, keep in mind that certain participants (CS3 and CS4) are absent from these discussions. ILUC thus represents an 'issue of concern' amongst actors, but one which is suitably vague as to endow it with interpretative flexibility that allows it to be mobilised in a range of ways to deploy it to particular normative ends. One willing to take a stronger position would hold it as fundamentally multiple (Law, 2012; Law and Urry, 2011). A question then, for another study, is how and why ILUC 'holds together' as a concept. I now turn to three specific demarcations that can be made about the nature of matters of concern within the development and deployment of biofuels.

5.2.3 Different ways of demarcating issues

In the subsections above I have suggested that specific issues can be strategically deployed. Here, I want to focus on the demarcations that were made around issues as a whole. When discussing the issues associated with biofuel development and use, some made explicit efforts to define separate issues in terms of type. Although numerous separations may be possible, here I consider a practical-ethical delineation that was made by some participants, most notably CS1 and CS7. In contrast to this explicit separation of the moral dimensions of biofuel development and deployment, other NGO representatives argued with a similar normative bent without a clear demarcation between 'technical' and 'ethical'. In each, biofuel production is seen through a lens, acting as a 'master frame', that sculpts all other issues. By drawing attention to these three positions, two consequences follow. First, they have implications for research management and the distribution of responsibility (*section 5.3*). Furthermore by emphasising diversity, it becomes possible to see that ultimately they are all master frames, representing choices rather than fixed realities. As others have highlighted, recognising this is in many ways an important step to providing space for a notion of 'the ethical' that exists beyond fixed points within research practice (Levidow and Carr, 1997; e.g. see Melo-Martin and Meghani, 2008; Wickson and Wynne, 2012; Wynne, 2001).

So, some made a clear delineation between ethical questions versus technical questions:

> "I think if you've got actual people who are trying to do the engineering of second-generation biofuels I don't think the ethical things are likely to be uppermost in their minds, only because [until] quite recently that's not their problem." (CS7, pa.10)

In the quote above, CS7 presents 'technical science' and 'ethical questions' as fundamentally discrete categories, both in terms of status and in terms of responsibility. A similar remark was made by CS1 when he presented "an ethics side of things" (CS1, pa.12) as being of an essentially different order to the issues associated with the technical implementation of biofuels. These positions were maintained throughout the interview. For CS1, technical questions included land use impacts, the loss of energy in the conversion processes between biomass and biofuel, carbon debt, identification of sustainable scales of production and questions about the spatial distribution of impacts. To illustrate why CS1 considered practical issues as such, consider the issue of 'carbon debt',

> "**This is a more technical question**, this is again where scientific analysis would be valuable, […] about carbon debt. If I cut down a forest, then I burn it with my bioenergy plant, I haven't done a carbon neutral process. It's only after I've cut that down and then re-grew it for 100 years without then cutting it back down that I'm carbon neutral (CS1, pa.105, emphasis added)

This is a technical question because it can likely be answered through an empirical study. Essentially, it is a question of collecting evidence about the immediate greenhouse gas release from the production of one unit of bioenergy and then modelling that against a projection that indicates how long it would take for that greenhouse gas to be removed from the atmosphere by new trees. Without this information there is a risk that as a society, we might make poor judgements about the best course of action for energy production. The ethical issue thus comes in the form of making decisions about what an acceptable greenhouse gas balance and associated payback period would be. Conversely, CS1 considered the role of genetically modified crops in biofuel production and questions regarding the use of resources as constituents of his 'ethical' category.

> "The big question which I think is being asked and will be asked is if you've got a really scarce resource, how do you use it. […] **That's absolutely ripe for ethical questions** and that plays to the idea of globally does the UK need to use less bioenergy […] to help people who can't afford other things or don't have the option to have other things. […] And then there **are interesting ethical questions** about how GM plays into this. […] a biofuel you burn is not probably going to put those genes into you […] it's probably not going to produce toxins that you ingest […] so how does that play out in the debate around bioenergy?" (CS1, pa.105 emphasis added)

In contrast with the 'technical' issue of carbon debt, the questions of resource allocation and genetic modification are framed as being of an ethical order. The former, he suggests ties into questions which are commonly discussed using a language of distributive justice and are viewed as wholly value-based judgments rather than being empirically answerable questions. The positioning of genetic modification is more complicated. For CS1, questions around genetic modification become ethical because the standard empirical measures that have been used in relation to genetically modified foods are no longer relevant. Thus, in terms of standard measures of risk, genetically modified biofuels may be much more acceptable. For CS1, once risk assessment methodologies are deemed flawed, the role of values within decisions about biofuels' use come to the fore.

Contrast this demarcation with CS4, who explicitly approached the production and use of biofuels through the lens of a,

> "small research organisation […] with the expressed purpose of being able to look at the implications of the rise of new technologies and their impacts on local communities, biodiversity and ecosystems" (CS4, pa.12).

From the outset, CS4's claims ownership of over what many would characterise as 'ethical' issues within the development of science and technology. CS4 and her organisation are therefore interested in performing the 'task of ethics' (Evans 2012). To go further, she has actively been sought out to oversee the activities of public research funders in science and society events, "despite [past] experience of [her] being an extremely awkward customer in a GM debate" (CS4, pa.195). However, issues are not described in ethical terms and the focus is clearly guided by a primary problem diagnosis that opens up a different set of prescriptions regarding the use of biofuels, which is visible throughout the interview. This problem diagnosis is described as "a belief that technology was going to be the answer" (CS4, pa.14). As with all of the organisation's technologies of interest – geoengineering, synthetic biology, and lignocellulosic biofuels – careful analysis had shown "that basically we had the same problems arising again and again" (CS4, pa.12).

This position binds a deep-green notion of sustainability with a rebuttal to the 'corporate takeover of science' and its entrenched sense of techno-optimism

(Monbiot, 2003). Citing the European Environment Agency report *Late Lessons from Early Warnings* (Harremoes et al., 2000), CS4 explains that the "deep desire by the BBSRC, and so-forth, to find something where Britain could star" (CS4, pa.14) is particularly problematic because it neglects to acknowledge that, "very often, the advantages, will appear before the more subtle side effects" (CS4, pa.118) as has happened numerous other examples. In this scenario, research is positioned as the solution to any problem that might arise: "'Ok. There'll be a problem in the future. OK, if we make money, we'll research out of solving the problem because it's alright, it goes like this.'" (CS4, pa.112). As I will explore later, and as CS4 indicates, such a perspective foregrounds different approaches to biofuel production and to research, particularly emphasising 'local' knowledge, small and local scales of production, and more holistic research programmes.

A third framing of biofuel development and use has similar consequences for prescribing research and production to the one above. CS3 works for a medium-sized international charity focused on local, sustainable development. This NGO has coalesced around the development and deployment of biofuels because it is "widespread, but there are huge sustainability issues" (CS3, pa.6). Further, the ways that biofuels have been implemented have been incredibly problematic for producers in developing countries. Nevertheless,

> "In the right circumstances, particularly if they're able to bring energy into very rural communities and also bringing energy to very remote agricultural areas which have very little access to energy. They have the potential to be very high quality energy fuels that can be burnt much cleaner than traditional wood and charcoal." (CS3, pa.20)

This organisation's interest and concern with biofuels flow from a nexus of human and environmental sustainability impacts. Throughout the interview, CS3 raised many of the issues commonly associated with biofuels. Like many, he emphasised the tripartite nature of sustainability in the familiar terms of a 'triple bottom line' of environmental, economic and social impacts (Elkington, 1998; Norman and MacDonald, 2004). But whilst technical interpretations of the sustainability and specific environmental consequences of biofuels have dominated, CS3 emphasised an acceptable biofuels scenario which was much more concerned with production practices and much more focused on a holistic, integrated production system:

> "Going back to the sustainability point of view of, for the resource sustainability, you should be producing the agricultural products sustainably and you shouldn't be degrading the land and economically. Can you produce fertiliser sustainably? Generally the answer is no, actually, so we're living in the short term because you can't produce the amounts of fertiliser that we're currently using. So ideally, you have a closed organic system, which works indefinitely.

> Which self-perpetuates itself. [...] And maybe this indirect land use is another facet of that." (CS3, pa.82)

Greenhouse gases were not introduced into any of his discussions around the impacts of biofuels. Instead, CS3 focused on drivers for biofuel use as being able to move, in general terms, away from fossil fuel use and improving energy use at a local level. CS3 links ILUC to his definition of sustainability, which is easiest to maintain in terms of ensuring fertility and quality of land without using external inputs. By focusing on this kind of definition for sustainability, indirect land use impacts are essentially null and void; the issue is split into ensuring the sustainability of all agricultural practices and then making choices about the allocation of energy production and food production: "there are always these sorts of choices. We need to get our energy from somewhere and we need to get our food from somewhere" (CS3, pa.84). ILUC just becomes another reason to advocate for his favoured kind of production system.

Clear parallels can be drawn between these three frames and wider technoscience policy debates. An obvious example is in relation to GMOs and longstanding attempts that have been made to cleave 'universal and pure' scientific truths from their inherently social, contingent, locally produced and normatively committed origins in regulatory forms of science such as risk assessment (Melo-Martin and Meghani, 2008; Wickson and Wynne, 2012; Wynne, 1992). The position held by CS1 and CS7 echoes that of formal and dominant regulatory discourse such as that of the Food and Drug Administration (FDA) in the US, the European Food Safety Authority (EFSA) and the European Commission in Europe which claim to be explicit in their acknowledgement of normativity, bisecting it from technical discussions (Levidow and Carr, 1997; Meghani, 2009; Wynne, 2001). In contrast, the latter two positions, of CS4 and CS3, seem to hold an implicit normative position, of 'anti-techno-optimism' and 'sustainable, local production'. Normative commitments are clear at the outset, although not necessarily self-reflexively.

As a whole, the different lenses draw boundaries around the types of questions that can be asked, the kinds of people that can ask them, and the kinds of answers that can be given in response. In relation to GMOs, for example, assessments that present crops and seeds as "decontextualised biological entities" frames out questions around their cultural, economic, legal, aesthetic and personal significance (Melo-Martin and Meghani, 2008, p. 305). As soon as a different lens is taken, both issues of concern and evaluations of technological artefacts or sociotechnical practices vary significantly. CS1 and CS7 delegate 'technical' and 'ethical' tasks to their respective experts. CS4, however, tightly binds all issues with the means and ends of a technological trajectory. In doing so, all parties involved in its development are responsible for considering such issues. Finally, recall CS3's absence from the ILUC debate. His 'local sustainable development' lens frames issues through the impacts on the communities, subverting common concerns with ILUC. Once again, normative issues and practice are bound together but with a much narrower field of concern and less concern for distributing responsibility broadly than CS4.

Now, one might postulate that those operating with different lenses might ascribe responsibility for the 'task of ethics' differently, particularly in relation to roles for individuals and science as an institution. In turn, this would have consequences for the structural features of knowledge production, such as the ways that research funding should be organised. In the next section, I will elaborate more specifically on such prescriptions for research practice.

5.3 Problems with and prescriptions for knowledge production

Whist the majority of NGO representatives maintain that in controversies, more research would be valuable, there were differences in: 1) the specifics of the kinds of research that were prioritised; 2) the suggested location of normative judgements and; 3) the responsibilities ascribed to different individuals and organisations (such as themselves, scientists, research funders and policy makers) within a system of knowledge production. The dominant perspective was that science should act as a robust evidence base, which informs normative decisions (in the form of policy). Where problems currently exist, a 'tweaking' of focus within funding might largely rectify them. However, a clutch of representatives was uncomfortable with this separation, of science and action, arguing instead for two varying models of research, each of which put values up-front in the research process. Both were at pain to emphasise 'holistic approaches to knowledge', which flattens existing hierarchies, in this approach.

5.3.1 Turning towards impacts

Some NGO representatives held a position whereby the impacts of biofuel production had been credibly demonstrated by legitimate 'scientific' research. In such cases, policy makers must simply acknowledge these issues. (The previously described issue of ILUC forms one good example here). This i) does not undermine current models of research, and ii) means that related adjustments would largely rectify problems that have so far emerged. These adjustments take the form of: a) focusing research on impacts of science and technology; b) being less eager to deploy technologies. This line of argumentation was often (but not always) coupled to claims of a separation between the ethical and the practical outlined in *section 5.2*. For example, CS1, who made a hard separation between 'ethical' and 'empirical' questions, suggested that,

> "Where science has a role I think in the bioenergy and biofuels debate is to be really absolutely clear about where about land efficiency of biofuels and future potential land of you know crop yield improvements and how far we can go

> with that, because there are lots of clearly inflated claims. […] So that's an area for science [...] 'what are the real impacts of bioenergy?' […] And that's probably it, so what can the technology do and what might it do from a sort of non market interest in this, scientific analysis perspective. And what are the impacts of this on the environment in clear sorts of ways. Those are probably the areas that I think science and scientists need to engage." (CS1, pa.102)

Such a stance in defining the role of 'science' links down to the responsibility of individuals:

> "CS2: I'm not sure if I understand. I think [...] when you talk about biofuels, you talk about so many issues in one pot, so you talk about conversion issues, to issues of using GMOs to water use, to land use issues. So I think it's a broader concept, so I think individual researchers will probably be responsible for part of this discussion as opposed to if you have GMOs, probably the GMO topic is complex, it's not just GMO GMO. […]
>
> Rob: There seems to be a debate around biofuels, but whether or not it's possible to engage with that, or whether or not there's any value in doing that is quite a big question.
>
> CS2: Well, I think there is value because there are a number of fairly big questions where you would need more research, more what I think it's un-useful sometimes, or I find it very damning, the interpretation of the scientific evidence." (CS2, pa.74-76)

In this truncated back and forth, CS2 is responding to my probing about the role of scientists in addressing the ethical dimensions of biofuel developments that were discussed earlier in the interview. Clear in the quote is his struggle with the allocation of individual responsibility. Notice how he responds in the first instance by emphasizing the heterogeneity of issues. This means that individuals will likely be responsible for addressing small and specific parts of concerns, defined as impacts. This is affirmed by his re-interpreting the question about engaging with ethical issues as, 'is there any point in scientists engaging with policy'. He thus plumps for a collective and distributed form of responsibility, where the role of scientists is to act as knowledge producers for "fairly big questions" on which we can make more informed decisions.

Note that these prescriptions do not just stop at suggesting more research. They also prescribe the kinds of knowledge that are needed, namely about biofuel impacts. While CS1 collected his in one neat paragraph, CS2's were extensively littered throughout the interview, pointing to questions around ILUC; water use; the processes required to make use of marginal land; the impacts of certification schemes; ways " to identify pathways which are delivering the services that we need in an efficient way" (CS2, pa.64); ways to assess and improve the whole-system efficiency of biofuel use; means to "identify the lower-risk biofuel patterns" (CS2, pa.64); the identification of positive biofuel development in terms of biodiversity (CS2, pa.66); and the ways in which it might be possible to make use of European-derived biomass (CS2, pa.70).

The implication of the positions adopted by CS1, CS2 and CS5 (a & b; below) is that the role and responsibility of scientists are to provide knowledge to be made use of by others. The ethical dimensions of biofuel production (i.e. their impacts) could be addressed by increasing the generation, dissemination and authority of knowledge regarding the impacts of biofuels to aid their deployment. If the responsibilities of scientists were to be extended at all, it would be to engage in debates about biofuels, acting as 'honest brokers' of evidence (Pielke, 2007) to counter the 'pseudo-science' that could sometimes make its way into decision making processes. The subtext to these positions is that responsibility for de-problematising biofuel development and deployment, ensuring that it is 'ethical', rests at a higher level than the individual. To be explicit here, recall CS1's earlier exclamation that the only way one can decide whether or not research and deployment should happen is "through iterative debate and politics" (CS1, pa.95), with knowledge about impacts feeding through to inform policy, a point made explicit by CS5a, below:

> "We do our own policy development, which is informed by [...] in-house science, so primary and secondary research, [...] people on the ground actually measuring the impacts of miscanthus on birds for example, and then people with more of an overarching view who pull together more of the science." (CS5a, pa.100)

Questions of where responsibility lies for determining *which* knowledge is generated and *about what* were generally eschewed. CS5 however, were much more ready to place explicit responsibility on research funders and to problematise currently dominant orientations of science within public research funding.

> "I think certainly research councils have funded elements of sustainability, environment and social [work] within their research streams but still to date the focus has been technological improvement and not the wider issues. [...] Big research projects [...] had a wide remit [...] but that always seemed like the weakest part of the whole chain, to look at the wider implications of them. [...] So I think there needs to be more funding of sustainability, that side of the industrial development, because I think that's kind of neglected. In some ways it's left to us, NGOs, to point out these problems and [...] it shouldn't be down to charities to have to do that. [...] If you want sustainable biofuels you have to consider how they interact with the wider environment, not just how you produce them, you know, how you make them out of material and use them but also what the wider implications of that production is. [...] It's all very well researchers going out into the public, or going into schools or public engagement events and say we're developing these great technologies for producing biofuels but there's no consideration of what compromises

> ecologically and environmentally we're going to have to take unless demand is changed. And how they fit into the big picture is not really considered very well and not addressed." (CS5b, pa.129-131)

Here, CS5b is explicit in the realignments that need to be made to knowledge production; responsibility should be placed on those steering science to fund more research into the impacts of the technologies that are being developed to solve particular problems. Ultimately, others did not make prescriptive claims regarding who was responsible for ensuring the 'right' scientific knowledge is produced, suggesting that as long as the debates could happen at a societal level, they would be happy. CS5b however, is forthright: The current distribution of responsibility, he claims, is one where NGOs have to produce knowledge about impacts, which is then also contested in a governance system which places NGOs and their knowledge about impacts on the one side and those wishing to develop and deploy technologies on the other. To this end, and despite his contemporaries' suggestions that they ascribe to a science speaking to action model, he is less certain, seeming to rally for more integrated forms of knowledge in the development of technology. The implication here is that such integration might allow better technological choices to be made in light of alternative actions, such as reducing energy consumption. In the next subsection, I investigate such calls for holistic forms of knowledge production in more detail.

5.3.2 Holistic knowledge production

Other NGO representatives, such as CS3 and CS4, explicitly and consistently emphasised the value of a more holistic research programme. Again, these positions have implications for the kind of knowledge that is prioritised, the acknowledgement of ethical dimensions and the responsibilities of different groups. Talking about his own research within the NGO, CS3 says,

> "To be honest any project we try to work through to the actual implementation on the ground right through to the policy-making to have the maximum impact. So any project you wouldn't do in isolation, to try to capture the learning from the project and then take that to other people and policy-makers and get that scaled-up, trying to do it simultaneously." (CS3 pa.16)

Recall from *section 5.2* that CS3 also emphasises the importance of involving local communities in the development of technologies. Throughout the interview, CS4 was at pains to argue that any new technological development, "has to be based on real knowledge" (CS4, pa.100) because local "relationships [with the land] are incredibly important" (CS4, pa.30); people know "how to deal with issues in their locality" (CS4, pa32). She recounts a story of a university-based scientist telling her, "that you could put your hand in the soil and come up with dirty fingernails, and you're immediately a lower-grade person" (CS4, pa.102), supplementing it with her perspective of "farmers who drive around in tractors with computers inside them, telling them how much pesticide to apply feel superior to the farmer who actually knows the soil and knows the pattern of soils on their land, the water courses and all the rest of it" (CS4, pa.102).

Both NGO representatives thus advocated a twofold notion of holistic research that refers to (a) an integration of knowledge that commonly lies outside a traditional model of scientific practice, and (b) that refers to an integrated project that is concerned with not just the development of a technical artefact but also with other social practices and consequences that flow around the artefact. Whilst CS3 was less prescriptive about the process of achieving this notion, CS4 was more dogmatic that this is not simply about funding more work on 'impacts' under a traditional model of science. Instead it is important to acknowledge "the balance of power of the different elements" and seek to 'flatten' existing, false and problematic hierarchies of power and expertise.

In contrast to those that employed a separation of science from ethics, these participants made explicit reference to the responsibility of researchers. For CS3 (pa.88),

> "Researchers certainly have some responsibility. The reason why we're doing the research is to improve livelihoods, reduce poverty and the focus here is on increasing energy access for the poor. So we're very much bought into that but I don't know if necessarily all researchers are but I think they should be. Ideally, if you're bringing out research you need to have some idea of what the target, or what the reason for doing it is, and what are the implications of that. […] If the research is focused on increasing energy access, increasing sustainable renewable energy, particularly bioenergy, then yeah, I think it should be engaged in sustainability."

CS4 viewed reflexivity of individual scientists and the questioning of basic assumptions as a stepping-stone on the way to her notion of a more acceptable and holistic form of knowledge production. Individuals are responsible for this:

> "Then of course when it comes to being responsible, the scientists were saying, 'well it shouldn't be us, we've got our obsessive little tunnel vision stuff.' And it's true that scientists have to specialise to such a degree, even Stephanie, she was looking at one part of one gene when she was doing her work. But interestingly enough, she was never such an obsessive scientist that she didn't think. She told me that she was always worried about what people were putting down the sink because there wasn't enough regulation going on of that. And so at least she was thinking of that whereas other people weren't. So scientists were saying, 'it's somebody else's job to make me reflexive'." (CS4, pa.212)

Here, CS4 recounts her experience of a large-scale public engagement exercise run by one of the UK research councils. She compares the position of scientists taking part in the event with that of one of her colleagues, an ex-scientist, who she did view as reflexive and engaged in the consequences of her work. CS4 views this as a vital stepping-stone towards her notion of a more acceptable and holistic form of knowledge production. Likewise, CS3 suggests that 'all researchers should be' engaged in the ethical and social dimensions of their work. This is especially important if research is to have a practical application; "just coming up with a new solution, a new technology […] is not the answer. […] So much of it revolves around people's perceptions and their habits" (CS3, pa.46).

Despite advocating for changes to individuals' practices, like others in the sample, both of these participants struggled when distributing responsibility in terms of stimulating reflection on the assumptions and broader implications of research. CS3 suggested that "ultimately the people who are funding research" (CS3, pa.90) might have the ultimate responsibility, but also didn't think that he had "the answer to that really" (CS3, pa.90). Similarly, when the discussion moved to discuss the barriers to encouraging reflexivity, CS4 hesitated, noting that "one of the problems for scientists is that as far as genetic modification was concerned if you criticised it, you put yourself in a position where you might never do any desk work again" (CS4, pa.218), which is at least in part attributable to the "difficulty in funding and getting supported" (CS4, pa.220) in research. For these participants then, scientists are not just 'honest brokers', science is not just a value-neutral form of truth to provide evidence for policy making. Scientists do have responsibilities within the debates on biofuels beyond this. But at the same time, engaging beyond this level raises a large number of problems that seem difficult to resolve at an individual level under the currently dominant systems of research funding and governance, problems that I will return to in the concluding chapter.

5.4 Value-lead and value-veiled research

In this chapter I have examined the position of NGOs within debates about the development and deployment of biofuels, the ways they construct and mobilise the ethical dimensions of such debates, and their relationship to the responsibilities within a system of knowledge production. Although a small sample of interviews must be treated with care, the data produced has elicited diverse insights, which moves the investigation of the thesis forward. I departed, in *section 5.1*, by reflecting on the role of NGOs as knowledge producing and knowledge mobilising entities that, rather than being considered as proxies for 'the public' are better-conceived as entities that 'hybridise', in different ways, the boundary between 'science' and 'society'. This might happen as they challenge the distinction between 'political' and 'scientific' worlds and the ways that they deem particular decisions to be legitimate (C. A. Miller, 2001), or it might happen as they challenge the distinction between 'lay' and 'expert' as they review, conduct and mobilise technical forms of knowledge (Eden, 2010). The remainder of the chapter has sought to emphasise that NGO

Section 5.3.3	Frame	Dominant policy frame (technical assessment of impacts) CS1, CS2, CS5	Anti-techno-optimism CS4	Sustainable, local development CS3
Section 5.3.3	Claimed recognition of ethical issues	Explicit recognition of normative claims CS1, CS2, CS5, CS7	No explicit recognition of normative claims CS4, CS6	CS3
Section 5.3.3	Issue dimensions	Technical questions separated from ethical questions (fact – value separation), focus on impacts CS1, CS2, CS5	Selection of relevant knowledge and value-judgements tightly bound. Techno-optimistic knowledge is prioritised, leading to neglect of environmental hazards. CS4	Relevant knowledge is judged through the ends of supporting community development sustainably. Issues are sharpened or defocused through this lens. CS3
Section 5.4	Prescription for responsibility and research	Expertise-based responsibility ascriptions. Delegation of ethical questions to politics / ethicists, with scientists acting as knowledge providers. Knowledge of impacts required. CS1, CS2, CS5	Responsibility is distributed across development and deployment. Consequence is slower, more considered, development. CS4	Responsibility is distributed. Researchers have responsibility to ensure that project aligns with end goal. CS3

Table 5.2: *The insights from sections 5.3.3 and 5.4 can be summarised in tabular form. Three different problem frames are discernable, with two different discursive acknowledgements of 'the ethical'. These frames can be aligned with different ways of demarcating the ethical dimensions of biofuel development and deployment, which either separate or bind the ethical from the empirical. Such frames and delineations have consequences for distributing responsibility for addressing 'the ethical'.*

representatives deploy different forms of knowledge, employ different dominant problem framings, and problematise and mobilise research in different ways.

As such, *section 5.2* made it possible to examine both the nature of ethical concerns and the way that different groups mobilised them. The presence of a wide range of shared issues points to the development of a 'normative regime' (Pickersgill, 2013) that structures the form that discussions take; particular issues are produced by actors present in particular socio-political contexts. They act as 'surrogate targets' - structuring features to normative debates that bind up a wide range of perspectives, ideologies and judgments about the weighting of particular trade-offs. To take an example, consider ILUC. The issue of ILUC arises because of a need to account for the *entire* GHG emissions that are attributable to particular biofuel production chains. In itself this represents a second-order desire to ensure that they meet a claimed end of mitigating climate change, defined in terms of GHG reductions, and to ensure that biofuels are 'sustainable', which is again defined in technical terms. ILUC therefore provides a point at which a wide range of contestations can be articulated, so long as they are articulated in terms that are commensurate with the dominant discourse. In Evans' (2002, pp. 11-44) Weberian framework, the debate can be seen to have been rationalised in terms of 'ends' (addressing climate change by reducing GHG emissions), leaving only the 'means' by which this is achieved open to debate. Discussions have thus moved from a 'thick' to 'thin' format, which one might be tempted to suggest is a natural dynamic of a debate's maturation.

This structuring feature, like sustainability, must be engaged with to take part in high-level normative discourse but can be challenged in varying ways. As shown in *section 5.2.2*, ILUC can be diagnosed as a result of several different afflictions, stemming from both claims of politicking, or more fundamental epistemic issues. Alternatively, it might be eschewed by adopting alternative definitions of sustainability, to which it is tied. We therefore saw that despite many commonalities with issues raised across the biofuel debate as a whole, some NGO representatives presented unique arguments and deployed unique framings to maintain particular positions. Both ILUC itself and the coupling of biofuel production to a range of 'synergistic issues' around human health provide good examples. Particular issues are therefore endowed with strategic political capital, and are highly personalised. To steal terms from the social construction of technology, ILUC as yet maintains 'interpretative flexibility'; it has not yet 'stabilised', resulting in 'closure' (Bijker, 2009). Were this to happen, the opportunities to bind different judgements and issues would be fewer. We might then hypothesise that actors wishing to subvert dominant discourses would be more likely to adopt stronger strategies, such as debating ILUC's epistemological visibility, challenging its ontological status or eschewing it altogether by taking up alternative challenges, such as the idiosyncrasies pointed to above.

A key theme running through the latter stages of the chapter (*section 5.3.3* and *5.4*; table 5.2) emphasised the presence and absence of a discursive separation between 'ethical' issues and 'empirical' issues. A key issue is that, as the dispersion of participant identifiers shows, one should be tentative in drawing solid conclusions from the small interview cohort, something ultimately derived from the small population of potential interviewees within the bounds of the case study. Nevertheless, across the group, it is possible to delineate between two general trends. The first is to adopt a position that discursively demarcates between 'ethical issues' and 'empirical' or 'technical' issues. Such a position takes for granted the previous boundary work that has lead to the technical framing of debates surrounding the development and deployment of biofuels (Eden et al., 2006), and uses such dominant, scientific discourses to challenge existing policies, technologies or knowledge claims. Because of such a demarcation, a technocratic approach to distributing responsibility tends to be adopted, which delegates ethical questions to the level of political debate or to specialists. Scientists are charged with producing knowledge that can plug into and inform such debates. A second, but less stable, trend is to adopt an implicit normative position, which then underpins judgements about the development and deployment of biofuels. By refuting such demarcations, one is able to suggest that choices about appropriate forms of knowledge and value judgements are inextricable. Associated with these positions are prescriptions that locate responsibility for consideration of the ethical dimensions of development and deployment within the production of knowledge, either at a project or individual level.

Although each sequence appears distinct from the other, neither makes wholly satisfactory recommendations for research governance. Both seek to veil the normative decisions that permeate debates about the development and use of any form of science and technology. The suggestion of employing a strict fact-value separation, where science provides knowledge to action, depends on the refutation of scientific enquiry as social activity, replete with value judgements large and small, that has been underpinned by thirty years of social scientific examinations. Equally problematic for the present enquiry is that this position leaves little room for individual agency and local action, which therefore does not sit well with growing evidence – for example from the above variations in framing – for a conceptualisation of 'the ethical' as fundamentally malleable, heterogeneous and context-specific. At the same time, although the alternative constructions and prescriptions might appear better aligned to perspectives from STS, they neglect the fact that they represent equally assumed value-judgements about the appropriate orientation of biofuel development and deployment, about what counts as being of concern and how it should be addressed. Furthermore, they offer no solution to the very real burden of individual researchers carrying responsibility for the 'task of ethics':

> "Everything that you do in the lab, everything that you think about, you've always got to have this thing at the back of your mind. Could this have an ethical dimension? And what I mean, it sort of drives you mad in the end. At first we thought it could be quite simple, but in the end because you can't possibly work out all the ramifications you have to in a sense just say 'look let me get on with this bit of research, at the weekend I'll think about what it means.' […] And the ethics are human things that we put in after so to mix the two things together in a scientific enquiry just clouds the picture. […] But on the other hand, to actually have a definite ethical component that comes in and shines the light on it, and says what might this mean, is very important." (CS7, pa.10)

This quote comes from CS7, a scientist now working for an NGO. He very clearly grapples with the ways in which ethical dimensions of work can be integrated into research. He struggles with delineating the boundaries of individual responsibility, hinting at what Pickersgill (2012) has referred to as a potential 'paralysis of reflexivity', and ultimately suggests that consideration of broader questions might lie outside of professional scientific life, to be thought about 'at the weekend'. At the same time, he recognises the value of having an ethical component within research and technology development. As his absence in the latter half of *table 5.2* attests, CS7 occupies an interesting position of claiming a scientific-ethical separation, but not delegating responsibility for the task of ethics to 'experts' or 'society'. To be sure, ejecting 'the ethical' from knowledge production is unsatisfactory, particularly in relation to "wicked problems" (CS7, pa.36). For CS7, wide-ranging normative decisions should not be dictated by policy, in ways that others within the sample might be happy with.

An increasingly common development, as NGOs continue to hybridise the space between 'ethical' and 'technical', is the production of reports that make projections of the ways in which a future scenario – of wholly renewable energy – might be met. The Centre for Alternative Technology (P. Allen et al., 2007; Centre for Alternative Technology, 2013; 2010; Todd et al., 1977), WWF (WWF, 2011), Green Alliance (Phillips et al., 2006), RSPB (BirdLife Europe, 2011) and the UK Tar Sands Network (Chivers, 2013) have all published notable examples. These reports often make recommendations for future technology development to achieve their favoured scenarios. Although all reports embed a normative vision, they make the component explicit to varying degrees. Making reference to a similar report that he was involved in producing, CS7 suggests that,

> "what's interesting about what we've been doing is that it actually comes the other way round. It's ethically driven, it's come from the ethics and then the ethics have said well this, these and these are the likely prospects, these are unlikely prospects, what would be a fully ethical solution to the physical dilemma." (CS7, pa.12)

These reports adopt a 'backcasting' approach, a particular form of normative forecasting, that has emerged from traditions in constructive technology assessment (Van Den Ende et al., 1998). In a backcasting approach, the characteristics of an acceptable future scenario are identified at a defined point in the future. Present-day innovation and research direction is then based on the possibility of meeting these criteria. CS7 claims that this is a fruitful way to address the ethical dimensions of biofuel development and deployment, by allowing ethical judgements to be made explicit, whilst also allowing empirical insights to be generated in focused ways. It therefore goes some way to acceptably distributing responsibility for the 'task of ethics', producing a 'value-lead' form of knowledge production.

The proposal of backcasting then, as a form of explicitly normative agenda setting, might address concerns about the implicit normative judgements that pervade technoscientific development, as well as addressing problems about a paralysis of reflexivity. Such suggestions chime in relative harmony with recent calls to embed varying notions of responsible innovation within research governance (Fisher and Maricle, 2015; e.g. Guston, 2014; Owen, 2014; van Oudheusden, 2014). Both this suggestion, as well of those of other NGO representatives, places an increasing responsibility on those involved in the steering and shaping of research agendas, most prominently the research councils. And furthermore, given the prominence of such approaches from NGOs within the energy sector, one would be wise to reflect on the potential for contestations of the task of ethics that might emerge amongst various communities of theory and practice. To this end, in the next chapter I will consider how the Biotechnology and Biological Sciences Research Council (BBSRC), the largest public funder of non-clinical biosciences in the UK, constructs 'the ethical' and distributes responsibility for such a task.

Chapter 6

BBSRC: Managing a controversial priority

6.1 Launching a bioenergy programme

The BBSRC chose the start of science and engineering week in March 2007 to announce the launch of its 'bioenergy initiative', committing up to £20m to 'more than double' public funding in the area (BBSRC, 2007a). This commitment was later emphasised in its delivery plan for 2008-2011, which placed bioenergy research alongside 'systems biology' and 'ageing' as one of three priority areas (BBSRC, 2008a). Noticeably, early discussions about bioenergy acknowledged a need to take note of 'societal issues' (BBSRC, 2006a, p. 37). This need eventually manifested with the integration of social and ethical research into a flagship bioenergy programme, the BBSRC Sustainable Bioenergy Centre, as well as a string of other 'engagement' activities.

The decision to significantly increase funding for bioenergy can be interpreted in many ways. One would be to view it primarily as a response to changes which began in the 1970s, with the requirement of research councils to demonstrate more 'strategic', 'accountable', or value-for-money approaches to the funding of research. Certainly the reviews that informed this prioritisation of bioenergy made explicit reference to higher government drivers, such as the publication of the 2003 Energy White Paper (DTI, 2003) and DTI's 2004 Renewables Innovation Review (DTI, 2004). Alternatively, these decisions might be seen as sensible evolutionary steps, guided by the scientific community which was represented on the review panels, that were indicative of promising areas of bioscience research irrespective of external priorities; In some senses, bioenergy in the context of the biosciences simply represents an extension of 'sustainable agriculture', which was a previous priority area. Cast in either light, these funding decisions and their surrounding council-directed activities embed positions regarding (for example) the worth of different forms of knowledge, the status of different actors in producing such knowledge, on desirable future sociotechnical configurations for biofuel production and use, and on the ways that responsibility for the implications of such configurations should be distributed. Some activities are presented by the BBSRC as open acknowledgements of the normative commitments and ethical ramifications of funding decisions: Activities such as the public dialogues were explicitly presented as attempts to embed some form of ethical reflection in the light of biofuels' controversial nature into the BBSRC's decision making. Others, such as the way that research programmes are structured or the priorities that are addressed, on the surface at least, appear to be addressed with less self-awareness of the embedded normativity.

This chapter is about the way that the BBSRC responded to the debate and controversy that surrounded the biofuels field when it made the decision to increase funding to in the area. Given the permeations of normativity throughout research council discourse and action, the enquiry looks beyond the research council's programme of engagement. The chapter will argue that its activities and funding policies enact varying constructions of ethical research and distribute responsibility for addressing ethical dimensions of bioenergy research in different ways. To do so, it examines the implicit positioning of the BBSRC, the way that it oriented its research funding programme, the underpinning rationales for engagement, and the way that responsibility for addressing ethical issues was distributed amongst different actors. It draws on the corpus of documentary sources introduced in *chapter four* and the conceptual work done in *chapter three* around boundary organisations (Guston, 1999; Meyer and Kearnes, 2013), calls to examine implicit normative visions of the future (Wynne, 2011; 2006) and Daniel Fiorino's (1989b) notion of 'rationales' in environmental governance. As a whole these dimensions allow us to consider how the organisation has constructed 'the ethical'.

Tracing the BBSRC's discourse and actions shows that the research council has in the main positioned itself as an advocate for the biosciences whose activities will unquestionably produce benefits for society. 'Issues' are presented as barriers that must be overcome for societal gains to be realised. This strategic positioning has gradually amplified with significant shifts observable in 2008 coming in the form of a notion of 'impact'. The BBSRC has also been sensitive to contexts surrounding its research. In the bioenergy case, the research council's early attitude towards the wider issues associated with biofuel development and deployment shifted from initially deferring responsibility to external parties to framing them as being worthy of consideration. In this regard, it embarked on two activities: the integration of social science, life cycle analysis (LCA) and agricultural economics into its flagship research programme, and an associated programme of public engagement. The underpinning rationales for particular kinds of engagement within the BBSRC are heterogeneous: fluctuating over time, across the organisation and depending on the audience that is being engaged. Whilst externally facing discussions embed substantive and normative rationales for inclusion, internal documents often point to instrumental rationales that position engagement as a means of securing the economic benefits that technological progress can bring.

The remainder of the chapter sets out a brief review of the BBSRC structure, positioning it within the wider science policy landscape and providing a theoretical orientation to approach an analysis of this research organisation (*section 6.2*). The chapter then highlights the performative nature of the BBSRC's actions and discourse with respect to the construction of a sense of 'ethical research' by analysing the BBSRC's research governance activities in the area of bioenergy between 2003 and 2014. For clarity and ease, my analysis is subdivided into 'funding' and 'engagement'. As such, I first consider how the research council positioned its bioenergy programme, and the broadly visions of research and biofuel production that it embedded within this positioning (*section 6.3*). I then turn to the way that the research council, during a series of engagement activities and related documents, framed issues associated with bioenergy and embedded particular and varying motivations for engaging with them (*section 6.4*). In line with the rest of the thesis, my ultimate goal is to question how this (set of) actor(s) constructs the task of ethics and distributes responsibility for its completion, and think about what this means for the role of the BBSRC, which is a recurring thread throughout my analysis. I address these questions in the final section (*6.5*) by collecting the prior analyses to shed light on the reasons for the aforementioned fluctuations. It suggests that they raise at least three fundamental questions about the public value of research, the kinds of benefits that are prioritised within research funding, and the abilities of existing theories and interventions that aim to make research more 'responsible', which I introduce in this chapter and return to at the thesis' close.

6.2 BBSRC at the science-policy interface

Here, I sketch out some of the key features of the BBSRC, providing insight into its location within the science governance landscape in the UK, adding detail about its internal organisational structures that will become prominent in the later sections. As always, my aims here are multiple. In line with my prescriptions from *Chapter four*, there is a methodological intent of rendering the case work comparable by providing conceptual parity with the few other studies that exist of similar organisations (e.g. Bijker et al., 2009; Kearnes and Wienroth, 2011) and sketching some of the coarse features of the organisation out for comparisons that may come in the future. Coupled to this is a heuristic intent, which aims to demonstrate the explanatory power and proclivities of the employed approach, for instance by showing how the notion of boundary organisations accounts for particular discourses and actions. The third intent has the analytic lilt of introducing three key themes that will stay with us for the remainder of the chapter, and that I will expand in the discussion (*section 6.5*). These are: the BBSRC's use of 'remit' and its definition of interdisciplinarity; differences in issue framing and rationales; and the embedded visions for research within the research council's discourse and action. Each is important to consider if one seeks to understand how the BBSRC constructs the ethical dimensions of research in biofuels and distributes responsibility for the task of addressing them.

The BBSRC comprises one of numerous organisations that operate in the British research funding landscape. Self-described as the largest public funder of the non-clinical biosciences, its annual budget for the 2015/16 financial year is approximately £422m (BIS, 2014). The total funding allocations for the entire public research base are determined in HM Treasury spending reviews, currently ring-fenced at £5.8bn (in cash terms for 2015/16 not adjusted for inflation; BIS, 2014). These funds are allocated through a 'dual-support' mechanism via the Department for Business, Innovation and Skills (BIS). Funding is sub-allocated to capital spending on infrastructure (£1.1bn), funding for research projects for distribution through the research councils (£2.7bn), and direct funding to higher education institutes, based on results of the Research Excellence Framework (£1.6bn). The remaining amount is distributed to actors and activities that include the government's science in society programme and the national academies (BIS, 2014). In addition to the science budget, the government also funds 'Innovate UK' (formerly the Technology Strategy Board) with around £500m p/a, which was established to build links between academia and business to translate public funds into commercially viable products and processes (HM TreasuryBIS, 2014). Other government departments have their own ad-hoc budgets and significant amounts of income also come through international, charitable and industrial streams.

Recall from *chapter two* that the 1993 Government White Paper, '*Realising Our Potential*' set the ground for a restructuring of the (now seven) research councils (HM Government, 1993). The BBSRC in particular resulted from the merging of the Agriculture and Food Research Council (AFRC) and the incorporation of biology into its remit from the preceding Science and Engineering Research Council (SERC). The research councils are unified by an additional organisation, Research Councils UK (RCUK), which provides a strategic co-ordinating role for various administrative services, policy statements and advocacy within Westminster. Whilst RCUK is not a legal entity, the research councils are classed as non-departmental public bodies, with each individual remit enshrined in Royal Charter, as below:

> a. To promote and support, by any means, high-quality basic, strategic and applied research and related post-graduate training relating to the understanding and exploitation of biological systems;
>
> b. To advance knowledge and technology, and provide trained scientists and engineers, which meet the needs of users and beneficiaries (including the agriculture, bioprocessing, chemical, food, healthcare, pharmaceutical and other biotechnological-related industries) thereby contributing to the economic competitiveness of Our United Kingdom and the quality of life;

c. To provide advice, disseminate knowledge, and promote public understanding in the fields of biotechnology and the biological sciences. (HM Parliament, 1993)

The BBSRC's formal remit, then, is threefold: to promote and support various forms of bioscience research, to advance knowledge and technology and train scientists, and to act in both an advisory and engagement capacity to society and politicians. As we shall see, the terms of reference within the Royal Charter provide a foundation but come with enough flexibility to be reinterpreted and deployed in different ways to suit particular ends. This occurs both in high-level documents, such as the Strategic Plans and Delivery Plans, as well as when justifying specific activities.

Also recall from *chapter two* that the British Government maintains the 'Haldane Principle' as one of its central tenets of research agenda setting. This commitment has recently been re-emphasised and specified to mean that Government is mandated to set 'general strategic directions' while decisions about which projects to fund are left to actors from the scientific community (BIS, 2010). The practical result is that the government does advocate for particular sociotechnical futures, for example as envisaged in the recent identification of its 'eight great technologies', and has recently gained the capacity to direct specific ad-hoc capital funding towards such technologies (HM TreasuryBIS, 2014). This funding power puts increasing pressure on research councils to ensure that 'research budgets' align with such governmental priorities. So whilst specific project funding is determined in house at the research councils, this comes on the advice of a wide range of advisors, and government priorities determine, to a significant extent, the broad direction and priorities of the funding councils.

Nevertheless, as if to emphasise the separation of science from government, the research councils are located eighty miles West of Westminster, in Swindon. The BBSRC's main office houses around 300 staff, organised into groups, units and teams (BBSRC, 2013a). The organisation is led by a council consisting of the chief executive (currently Jackie Hunter, a pharmaceutical industrialist), a chairman and between 10-18 other members. At least half of the council members are to be elected based on their academic credentials, but external stakeholders, including 'users' (largely from bioscience industry) and government representatives are also present. The BBSRC's council is directly accountable to government through BIS, and members are appointed by the Secretary of State for Innovation, Universities and Skills. Essentially the council operates as a group of 'village elders', whilst the day-to-day running of the organisation is lead from within the Chief Executive's office, with hierarchical groups, units and teams sitting below (*Figure 6.1*). Senior staff members are a mix of previously professional scientists, people with regulatory experience, and specialists from more traditional business areas (i.e. finance, human resources).

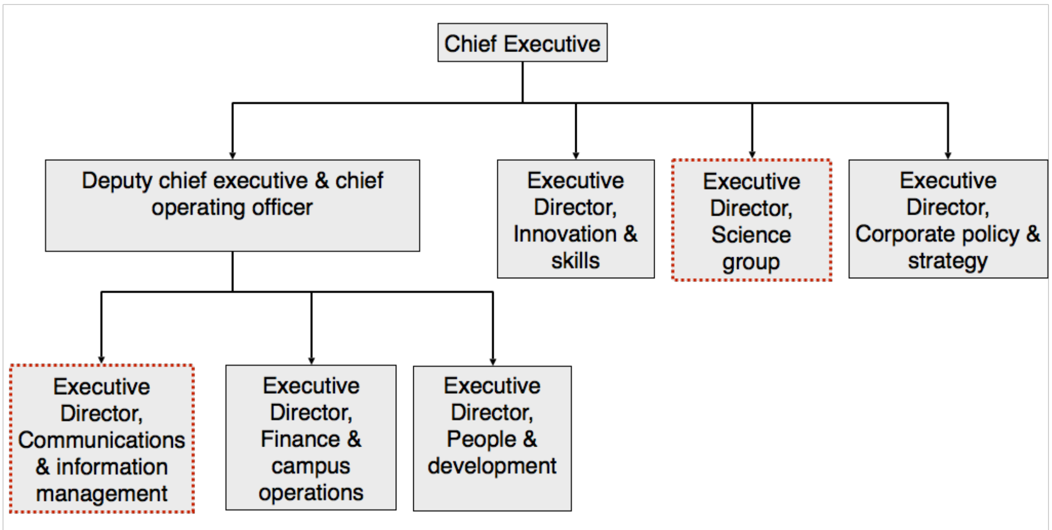

Figure 6.1: *Organogram of BBSRC with key groups for biofuels and bioethics outlined in red. Adapted from* *http://www.bbsrc.ac.uk/organisation/structures/executive/executive-index.aspx*

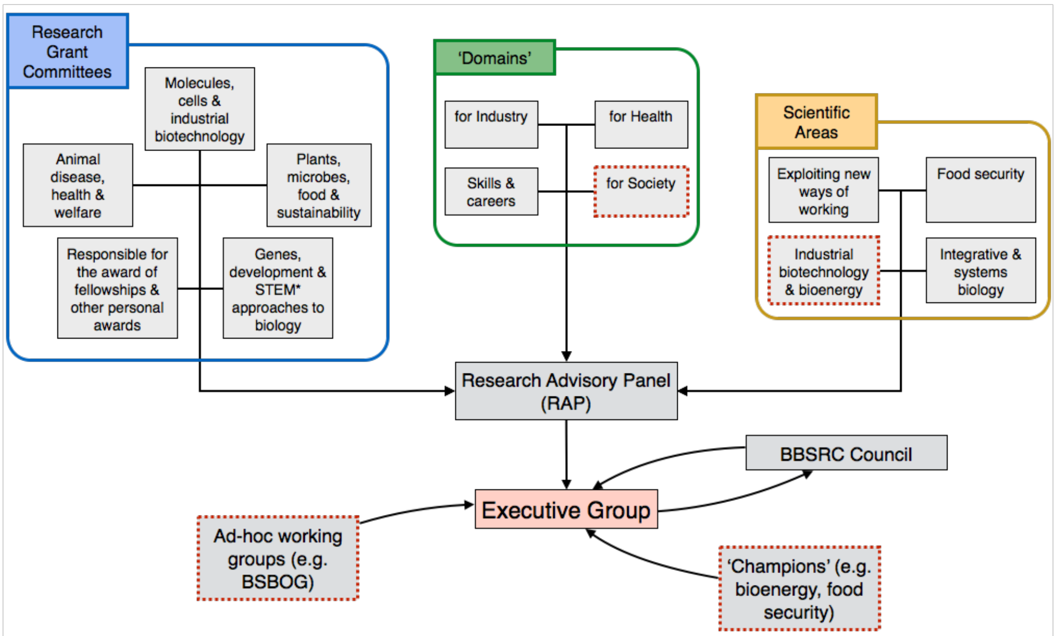

Figure 6.2: *Interaction between different components of BBSRC advisory structure with key groups outlined in red. Advisory panels in 'research grant committees' are a mix of previously professional scientists, people with regulatory experience, and specialists from more traditional business areas (i.e. finance, human resources).*

Groups, units and teams are seated together on separate sides of a quadrangle on the ground floor of the research council office block. They are diverse, occasionally shifting to match new priorities, but are set up with clearly defined remits. In this respect, staff movement is relatively fluid but quite often internal. The most recent significant re-structuring took place in 2007-08 and resulted in the BBSRC's strategic advisory structures being rationalised. For the purposes of this chapter, the major groups to be aware of are outlined in red in *figure 6.1*: 'Science' and 'Communications and Information Management'. The former houses the strategic unit for industrial biotechnology and bioenergy and the latter houses the 'science in society' arm, in the form of the External Relations Unit (ERU). Note that while its 'domains' and 'scientific areas' are composed predominantly of individuals external to the research council (e.g. academics, industrialists, other stakeholders) primary means to meet its objective could be seen as the distribution and administration of research funding, the actual administration part in this respect of the BBSRC is comparatively small; a far greater amount of organisational work goes into determining priorities, setting strategy, external relations, building foreign links than the day-to-day administration of research grants.

Whilst the day-to-day running of the BBSRC is maintained by its groups, units and teams, and overseen by its executive group, the BBSRC makes extensive use of advisory committees and experts in guiding its operations and policy setting (*Figure 6.2*). In addition to the council, strategic advisory panels exist for each priority area of research (scientific areas; in yellow), for various priorities that map onto specific units within each of above groups (domains; in green), and for making decisions about research grant applications (research grant committees; in blue). The chairs of each of these panels sit on a higher-level 'research advisory panel' whose remit is to feed directly to executive group. Additionally, a number of individual 'champions' have been appointed to promote and drive priority areas of research, and various occasional ad-hoc working groups are frequently appointed. Importantly, both exist in relation to bioenergy in the form of Duncan Eggar, the Bioenergy Champion and the BBSRC Sustainable Bioenergy Outreach Group (BSBOG). In total, BBSRC has the ability to formally draw on the expertise of around 400 individuals (count as of May 2014; 174 of these are in its grant reviewers 'pool'), predominantly from academia and industry, but occasionally from other areas including NGOs, lobby groups and specialist organisations. Of course, informal unquantifiable interactions on a day-to-day basis would greatly extend this pool.

Chapter three introduced the notion of 'boundary organisations' (Guston, 1999) as a means to understand the activities of organisations operating in the interstices of scientific and political worlds. Recent activity around the concept has suggested that organisations might be thought of as producing 'hybrid' kinds of knowledge that aim to fulfil, to varying degrees, the characteristics needed to maintain political and scientific legitimacy (Am, 2013; C. A. Miller, 2001). When the above information is seen through the notion of boundary organisations, the BBSRC becomes a visible point of convergence between a range of different (selectively curated) groups and interests. It is engaged in fundamentally political activities, having to enrol the support of a wide range of actors to achieve its mandated tasks. Simultaneously, it must mobilise and support scientific knowledge bases to defend those activities. The organisation must therefore negotiate and manage manifest boundaries, for example between scientific and social worlds, scientific knowledge and other knowledges, disciplines, kinds of research, ethical and unethical, experts and lay people. To fund research, provide advice and foster public interaction, it must (amongst other things) convene and collaborate with its sibling research councils to demarcate between research remit and provide unified positions, it must enrol the support of prominent actors in the biosciences arena to support and lobby for its continuing funding streams and it must maintain the work that it does as 'ethically unproblematic'. Achieving these goals is unlikely to be possible by adopting singular and consistent messages or forms. Instead, given the multiple agendas of different parties, the multiple goals of the organisation and its internal teams, and the shifting context in which the BBSRC operates, the research council's success is likely to depend on its ability to construct particular rationales and arguments for the actions that it takes at any given time, opening up space for some of the rhetorical strategies and structural realignments that we will witness below.

Having embarked on some contextual groundwork, I will now turn to the documented discussions and activities of the BBSRC as it set out to make bioenergy a funding priority. I am primarily concerned with the ways that the research council explicitly sought to construct its activities as 'ethical' and I therefore adopt a two-pronged narrative that draws attention to the process of funding bioenergy research and 'engagement activities' that are explicitly positioned to address 'societal issues'. In other contexts, the latter have come under scrutiny from academics (e.g. Macnaghten and Chilvers, 2014) but much less attention has focused on funding policies and practices, which also embed notions of responsibility, of appropriate 'issues of concern', and particularly, of desirable ends for research. Recent examinations of engagement have suggested a limited penetration within the culture of scientific organisations (Mohr and Raman, 2012; Wynne, 2011; e.g. 2006). These funding processes represent an important alternative avenue for analytic attention. The forthcoming sections therefore begin a narrative that does not take existing demarcations of ethical and non-ethical at face value.

To show how the BBSRC has constructed the ethical dimensions of biofuel development and deployment, the two subsequent sections contain a bifocal analysis that extends over a timeframe of 2003-2014. During this period, the BBSRC placed bioenergy as one of its funding priorities, ramped up activity in the field by launching a 'bioenergy initiative', funded a large 'virtual' BBSRC Sustainable Bioenergy Centre, and later aligned bioenergy with a rising priority of industrial biotechnology and biorefining. It also embarked on a series of activities with the stated intention of addressing a range 'societal issues' that surrounded the priority area. First, I examine the way that the research council constructed its research funding programme in bioenergy, thus making judgements about the appropriate outcomes of publicly-funded research in the area (*section 6.3*). My work here is chronologically ordered. Following this, I concern myself with the way in which the ethical dimensions of biofuel development and deployment have been framed, and the way in which the BBSRC has embedded differing rationales for engaging with and managing such concerns (*section 6.4*). In doing so, it draws attention to the heterogeneity of positions between high-level, generally externally facing documents, internal discussions that often accompany the planning stages of engagement activities, and finally the rationales that are discernible in practice. Throughout both of these sections, there is a sub-narrative that points to the ways that the BBSRC "presents – even creates – itself as a character" (Hilgartner, 2000, p. 13) in the research governance landscape, positioning bioenergy research and engagement as part of that role. At the end of the chapter I tease out this sub-thread, alongside asking how the task of ethics is framed, and how responsibility is distributed amongst parties both internal and external to the research council (*section 6.5*).

6.3 Bioenergy funding discourse and action

Roughly three transitions are visible in the vision of bioenergy research: bioenergy as sustainable agriculture; bioenergy as sustainable second-generation biofuels; and bioenergy as industrial biotechnology. Amongst these transitions are two high-level framings for research funding, contained within corporate strategy documents of roughly 2003 and 2007-onwards. Alignments in research funding have shifted along several spectra, between basic and directed research, ambivalent and specific sociotechnical configurations, and loosely defined to increasingly specified research outputs. In doing so the BBSRC has policed its disciplinary remit, and as will be outlined in the discussion, re-oriented itself in relation to the different terms of reference outlined in its Royal Charter. The instigators for the research council's polymorphisms can be traced to external dynamics, such as the level of controversy and government pressure to deliver economic returns on investment. Of course, such actions offer different judgements about the kind of research that should be promoted and the kinds of production that are more desirable for society, all of which are normative concerns that are worthy of attention.

6.3.1 Bioenergy as sustainable agricultural priority

Recall from *chapter two* that bioenergy, and in particular biofuels, went through a period of renewed hope between 2002 and 2007. During this time, British reviews external to the BBSRC (e.g. DTI, 2004) attempted to re-position the research councils as having a fundamental role in driving forward innovation in this area. By 2005, BBSRC's agenda setting panels had suggested that bioenergy might be a worthy priority area. Proceeding down a well-trodden path, the BBSRC Strategy Panel (now the Research Advisory Panel) consequently commissioned a review from a committee of high-level experts to explore how best to prioritise and then to operationalise research in this area. The resulting report (the bioenergy review; BBSRC, 2006a) recommended that research be placed as one of the BBSRC's priority areas and specified two areas of production as pertinent for unilateral action from the research council: "photosynthetic carbon fixation pathways in crops, and maximising biomass processing efficiency" (BBSRC, 2006a, p. 5), that is understanding the ways in which plants create energy and biomass through photosynthesis and improving the conversion of biomass to biofuel.

Although the first major bioenergy-specific document was published in 2006 and most of the action happened after this point, we must rewind just a few years to consider how the BBSRC initially presented its vision for bioenergy research and production, and how this would impact on society. To do this we need to look to a series of documents outlining the BBSRC's corporate strategy that are hierarchically published on a roughly ten, five and three-year basis. Strategic visions provide an overarching orientation, which strategic plans transpose into action-oriented frameworks. Subsequent delivery plans outline deliverable objectives and how they will be achieved in a functional sense. These documents act to frame subsidiary activities for the periods in question and therefore provide an opportunity to examine how the research council formally presents its role and vision for bioscience research.

Now, as the cartoon that I presented at the start of the thesis demonstrated (p.13), novel processes for the production of liquid fuel from biological material have been a long-promised outcome from investment in bioscience and biotechnology. This cartoon offered a utopic vision of biotechnology's manifest benefits for society at a time when actors were making a push for the area to gain policy support (Bud, 1994, p. 173). In many respects, 2003's *Ten Year Vision* (BBSRC, 2003a) and *Strategic Plan* (BBSRC, 2003b) are just as hyperbolic as the promise offered in the 1970s. The *Ten Year Vision*, for example, looks to a society where the biosciences have integrated knowledge gained from the twentieth century's 'reductionist approaches' to mobilise 'predictive' and 'integrative' [read systems] approaches to biology — a form of knowledge production that makes use of computing and new experimental tools to mine large amounts of existing data and produce accurate models of biological processes from 'genomic' and 'post genomic' approaches. It presents a vision of knowledge production in which "disciplinary boundaries have begun to disintegrate" (BBSRC, 2003a, p. 2). And often with what is quite striking imagery of hope, the document envisions this form of biology to be employed to enable manifold benefits for the UK, framed in terms of "quality of life and economic development",

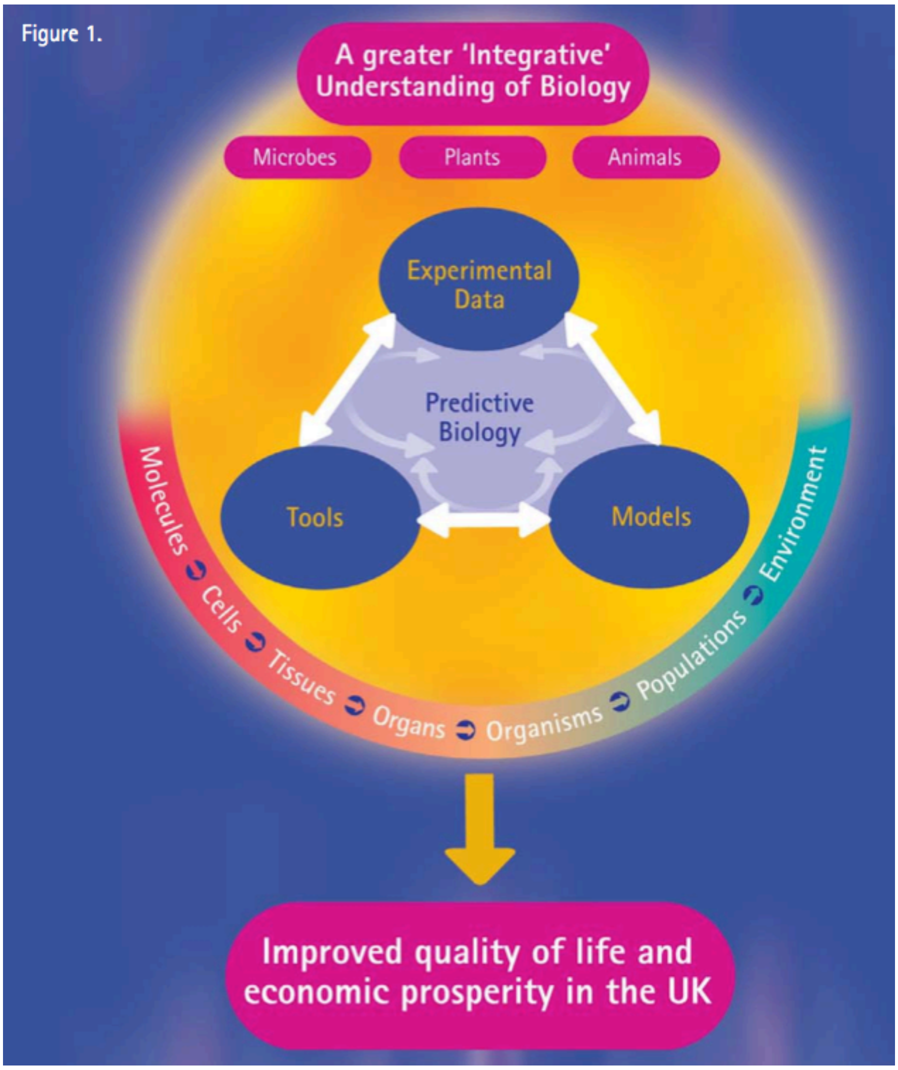

Figure 6.3: *Characterisation of (BBSRC, 2003a, p. 3)*

schematically characterised as a soft yellow unidirectional arrow that flows from the biosciences to society (Figure 6.3, BBSRC, 2003a, p. 3).

Despite decided vagueness about the kinds of benefits that would be produced and the way in which these benefits would be realised, both documents locate agricultureas one of three priority areas for funding, where a key objective is to,

> "Identify traits important for multifunctional and sustainable agriculture - such as disease resistance, resource use efficiency, developmental regulation, high value products and replacements for petrochemicals." (BBSRC, 2003b, p. 11)

Framed by these documents, the bioenergy review therefore advocates that BBSRC's research ultimately move in the direction of a production system that makes use of biorefining and multi-use, low input crops based firmly in a broader "context of sustainable agriculture and integrated land use, according to the principles set out in the BBSRC's previous review of sustainable agriculture" (BBSRC, 2006a, p. 31). As the quote below shows, the bioenergy review authors use this as a justification for holistic knowledge:

> "It is important that bioenergy solutions that may result in changing land use are implemented with appropriate research, monitoring and mitigation, if necessary, for example in relation to water use, fertiliser/pesticide regime, biodiversity impacts, changes in soil microbiology from growing biomass crops (effects of physical, chemical and biological factors) and wider ecological factors" (BBSRC, 2006a, p. 31).

Now, the bioenergy review explicitly positioned itself to as a response to high profile developments within government such as the 2003 Energy White Paper (DTI, 2003) that represented mounting pressure to fund bioenergy research. At the time that the bioenergy review was commissioned however, bioenergy research was covered by a triad of flagship public research programmes: SUPERGEN (Sustainable Power Generation and Supply), RELU (Rural Economy and Land Use), and TSEC (Towards a Sustainable Energy Economy). These programmes had recently been brought under the coordinating role of the Research Councils Energy Programme (RCEP). Each programme represented a public investment of around £20m and sizeable proportions were dedicated to bioenergy research. By 2007, for example, the SUPERGEN Bioenergy Consortium's initial investment of £2.9m had risen to £6.4m (BBSRC, 2006a). Each programme was also a large cross-council consortium project that to varying degrees adopted a 'whole systems approach' and aimed to integrate insights from technical, economic and social fields. Perhaps rightly then, the BBSRC bioenergy review characterised the bioenergy funding landscape as 'crowded'. It diplomatically recognised the benefits of multi-disciplinary projects whilst rhetorically carving institutional space using the notion of 'underpinning bioscience research' which might be unilaterally funded to "strengthen bioenergy options for the future" (BBSRC, 2006a, p. 13). Such a vision explicitly excludes, through the use of bioscience as sole remit, the integration of multidisciplinary programmes, as emphasised in a later response from the BBSRC to a parliamentary committee that investigated the public funding of renewable energy research:

> "BBSRC's scientific remit dictates that the renewable energy research funded by BBSRC is exclusively in bioenergy, including the biological generation of hydrogen" (House of Commons Innovation Universities Science and Skills Committee, 2008, p. 225).

The rhetorical device of 'underpinning bioscience research' has a second role in the bioenergy review by acting as a response to the heterogeneity of bioenergy production pathways and a perceived uncertainty about their future:

> "There are many possible biomass and bioenergy crops, multiple possible microbial processing routes, and several possible usages of bioenergy feedstocks (combustion, liquid biofuels and bulk bioproducts). It is, however, not yet clear where the balance of the economic and environmental considerations will ultimately lie, and this may well be dependent on future technological development. We consider that basic and enabling bioscience will be necessary to develop future options for bioenergy, especially substantial improvements in the efficiency of biomass production and utilisation, within a framework of environmental and economic sustainability." (BBSRC, 2006a, p. 6)

And even though the bioenergy review did recommend two areas of research to prioritise, it was careful to present these as ambivalent paths to,

> "Removing key biological barriers to a broad spectrum of bioenergy solutions, in the process addressing issues of fundamental biological interest, and thereby funding excellent basic science almost irrespective of strategic outcomes" (BBSRC, 2006a, p. 24).

Thus, despite envisaging some specific, but as yet unspecified, production pathway to eventually dominate, and albeit within a context of 'sustainable agriculture', which will provide benefits for society, the review views accurate predictions as impossible to make. The research council therefore hedged its bets, employing the notion of 'underpinning research' as a means to recommend an ambivalent stance about specific technological configurations. This ambivalence is present at two levels: prioritising between bioenergy for electricity and heat versus liquid biofuels, and in terms of specifying favourable production pathways within each end use (for example an acid-based production process versus heat-based conversion process).

6.3.2 Bioenergy as sustainable second generation biofuels

In the months that followed the bioenergy review, the BBSRC began to mobilise bioscientists for a research programme into bioenergy, using the proxy of Alistair Darling (then Chancellor of the Exchequer) to launch its £20m 'bioenergy initiative' at the start of UK Science Week 2007 (BBSRC, 2007b). The call continued many of the themes introduced in the bioenergy review. It was justified in relation to existing policy drivers for biofuel use. It suggested that achieving the government's blending targets was a complex environmental, economic and political challenge, but claimed that a significant bottleneck in penetration came from present limits on "the available range, efficiency and cost effectiveness of biofuels and their utilisation" (BBSRC, 2007c). These barriers were positioned as "essentially a biological challenge on which the tools of modern molecular and cell biology, physiology, and bioprocess engineering can be brought to bear" (BBSRC, 2007c). And furthermore, it explicitly separated industrial biotechnology from biofuel production, stating that approaches such as biorefining would be "addressed outside of the framework of the call" (BBSRC, 2007c). Accordingly, applications for three levels of research were sought:

> a. "At least one flagship multidisciplinary centre for bioenergy research [...] to bring together a range of research from biochemistry to systems-level research [...] delivered in a meaningful and long term association with the industrial base. [...]
>
> b. Programme grants to assemble and sustain multidisciplinary teams and pursue an interdisciplinary programme of work [...]
>
> c. Networking grants to establish multidisciplinary networks within the UK science base and across to industry with a view to promoting research coherence and focus in the area of bioenergy and of developing ideas for future research." (BBSRC, 2007c)

In the negotiation period 2007 - 2009, the BBSRC cherry picked parts of submitted proposals to produce a five-year, £19m, 'virtual centre' that was distributed across the country. Six major projects were funded, led by five organisations: the University of Cambridge; the University of Nottingham (2 projects); Rothamsted Research; the University of York; and the University of Dundee. Three smaller projects were conducted at the University of York, the University of Portsmouth and the University of Newcastle (BBSRC, 2014a). 'Sustainability analysis' was incorporated into one project, 'lignocellulosic conversion to bioethanol' (LACE) at the University of Nottingham, with LCA to be conducted by partners at the University of Bath. The resulting evolution of the Bioenergy Initiative was launched in January 2009 as the 'BBSRC Sustainable Bioenergy Centre' (BSBEC; BBSRC, 2009a) and was framed as highly strategic and wildly interdisciplinary. Professor Douglas Kell, the new Chief Executive, introduced bioenergy as one of the ways that the BBSRC was taking "an holistic approach to achieving more effective translation of the UK's world-leading bioscience into wealth creation and public good impacts" (BBSRC, 2009a). This framing is emphasised in the accompanying promotional material (*Figure 6.4*), which presented BSBEC as offering a comprehensive programme that investigated the growth, composition, deconstruction and fermentation of biomass to produce fuel. A range of industrial partners would help to ensure that research outcomes had real-world world utility, and the sustainability of any resulting processes would be

Figure 6.4: *Information sheet produced for the launch of BSBEC (BBSRC 2009b, p.8)*

ensured by a sustainability analysis that sat across the breadth of the programme (BBSRC, 2009b).

Impact

During the crest of the biofuel controversy, the 2007 annual report and 2008 delivery plan presented bioenergy as one of the BBSRC's flagship activities and maintained its position alongside crop science. They also signalled the start of increasing elaboration on the form of 'societal benefits' and the ways in which they would be derived from BBSRC-funded research, namely by fostering 'impact'. The 2007 *Annual Report*, for example, located delivering 'economic and social impact' as one of the research council's raisons d'être, alongside ensuring 'a healthy UK science base' and 'embedding science in society' (BBSRC, 2007b).

The 2007 *Annual Report* and the 2008-2011 *Delivery Plan* were the first strategic documents since the publication of the Warry report (published in December 2006, DTI, 2006b). Notoriously, the Warry report made recommendations regarding the ways in which the research councils could increase their economic returns on investment, leading to the rise of the 'impact agenda'. The Warry Report had its own impact on the rhetoric and actions of the BBSRC. In contrast to the previous strategic renditions that presented BBSRC's goals as delivering the six categories of excellent science, tools and technology, people, knowledge transfer, partnerships and an effective organisation (cf. BBSRC, 2003b), the 2008 Delivery Plan is drenched in the rhetoric of impact, placing in bold, underlined, capitals its headline, "delivering excellence with impact" (BBSRC, 2008a, p. 1). In these terms, 'impact' broadly translates into, "increased interactions with business" through means such as redistributing £50M to research which is "directly relevant to industry", creating 'research and technology clubs' which are jointly funded with companies in the biotechnology sector in exchange for access to research outputs, embarking on joint funding with the technology strategy board, and "providing up to £15.5M to strengthen business awareness and focus on academic research through entrepreneurship and commercialisation." (BBSRC, 2008a, p. 1). Under this re-framing, UK bioscience is positioned as 'an asset' to be protected and nourished under the care of BBSRC in order to generate economic and social capital in the form of "innovative industrial processes and evidence-based policies for tackling global challenges to the UK's economic and social wellbeing" (BBSRC, 2008a, p. 1).

In this repositioning, bioenergy is framed as one of five major societal and policy issues, as an opportunity to help mitigate climate change, justified by reference to the Stern Review (2006) which had previously outlined the economic and social importance of addressing climate change. However, by making more explicit the strategic and impact-driven purpose of BBSRC-funded bioscience, the research council also needed to address any negative impacts of its research. Thus, a BBSRC response to the House of Commons Environmental Audit Committee, acknowledges:

> "Growth of biofuel crops may impact on the amount of land available for the growth of food. In addition, the use of crops already grown for food will reduce the amount of that food available for human consumption. Focusing on second generation biofuels (e.g. use of straw and agricultural waste as a feedstock) may help to address this problem." (House of Commons Environmental Audit Committee, 2008b, p. 153)

In the above extract the BBSRC frames its response to what was quite a complex question about the ethical issues associated with biofuel production solely in terms of the potential for biofuel production to compete with food production. It positions one particular technological trajectory, second generation biofuels, as having the potential to alleviate these concerns. This discursive response was mirrored in structural changes to the bioenergy initiative; It would now focus on second generation biofuels (BBSRC, 2008a). Furthermore, in a response to the House of Commons Innovation, Universities and Science Committee, the BBSRC claimed that it would seek to encourage "collaborative research between biologists and engineers, physical scientists and researchers in social and environmental sciences" as one means to address social and ethical issues (House of Commons Innovation Universities Science and Skills Committee, 2008, p. 225). Of course, the earlier *bioenergy review* and the initial funding call inferred a definition of interdisciplinary as 'different biological approaches'. Together with the 2007 Bioenergy Policy statement, it claimed to recognise that,

> "the conduct and application of the science we support can raise ethical and societal issues. [… The BBSRC] are engaged in research that investigates such issues, for example as part of the cross-Research Council 'Rural Economy and Land Use' programme." (BBSRC, 2007d, p. 1).

By 2008, it was therefore no longer enough for the research council to be engaged in cross-council activities to contextualise and shape its bioenergy research programme, an implicit acknowledgement of which is visible in the subsequent 2010 bioenergy policy statement (BBSRC, 2010a). The application-oriented focus of the bioenergy initiative demanded its own set of 'sustainability researchers' to ensure that the envisaged applications would not result in societally or environmentally detrimental outcomes.

6.3.3 Bioenergy as industrial biotechnology

So, up until the funding of BSBEC, bioenergy as an agricultural priority coupled to plant science dominated BBSRC's bioenergy research agenda; the production of products other than fuel from biomass, and using alternative processes to second generation techniques were very much a vestigial mass. However, towards end of the

2000s, the notion of a 'bioeconomy', powered by the practice of 'biorefining' and 'industrial biotechnology' has begun to gain currency, rising to prominence in UK policy with the publication of the BERR (2009) report, *Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy* (IB-2025). Produced by the 'Industrial Biotechnology Innovation and Growth Team', a panel of high level policy makers and business representatives in the sector, a cynic would be forgiven for seeing its recommended vision fifteen years into the future as a *fait accompli*; a vision where the UK is "easy to do business in with 'two front doors' providing guidance and support for: Research and development, and; Industrial demonstration and scale up" (BERR, 2009, p. 5). Echoing earlier discussions regarding the development of biofuels, the report suggests that "a connected and favourable research and policy environment and increased levels of technology development are critical to UK being able to attain" returns from a 2025 industrial biotechnology sector worth between £4 billion and £12 billion (BERR, 2009, p. 7). Moreover, it positions "the pace of technology development as one of the most important factors that determine the rate of market growth" (BERR, 2009, p. 10). And as with previous reports relating to biofuels, this review placed an onus in its recommendations on the BBSRC, together with the EPSRC and Technology Strategy Board, to create research-funding programmes that would feed directly through to industrial application.

In response to the BERR report, subsequent strategy documents from the BBSRC realigned bioenergy alongside industrial biotechnology. Indeed, in a later 2010-11 annual report Douglas Kell, Chief Executive at the time, framed the entirety of the BBSRC's purpose with the strapline, "delivering a sustainable bio-based economy" (BBSRC, 2011a, p. 3). In the years to come, between 2010 and 2015, industrial biotechnology funding was intended to dwarf that of bioenergy at roughly a ratio of 2:1 (£22m vs. £12m rising to £30m vs. £14m by 2014-15; BBSRC, 2011b). And continuing another familiar trend, the BBSRC commissioned an external review into the research needs of bioenergy and industrial biotechnology to help prioritise and drive funding in this area. The catchily titled, *BBSRC support for bioenergy and industrial biotechnology: the use of science and technology to support energy, chemicals and healthcare industries* (the industrial biotechnology review; BBSRC, 2011c) takes the IB-2025 report at face value to claim that,

> "if BBSRC is to help the UK realise both the sustainability aspects and economic value of IB, it will need to reverse this decline [in research investment] through increased funding to IB research, training and knowledge exchange in the coming years" (BBSRC, 2011c, p. 1).

Two further recommendations are of particular importance:

> "Recommendation 9: BBSRC should seek to diversify its portfolio of fundamental, underpinning research in bioenergy to focus more on next generation sources, in particular the generation of [...] direct replacements for

> petrol, diesel and aviation fuel. The use of systems and synthetic approaches will be of particular importance in delivering this aim. Redrafting BBSRC's current council-wide priority in bioenergy may be one way in which such diversification could be encouraged. […]
>
> Recommendation 11: BBSRC should seek to co-ordinate and build upon the current expertise in the UK plant science research community and expand research in the area of non-food crops by encouraging plant scientists and breeders to translate their research towards more industrially relevant non-food areas. This should involve encouraging plant scientists to work alongside engineers to ensure traits are selected for improved processing as well as for desirable end products." (BBSRC, 2011c, p. 2)

In the above recommendations, the industrial biotechnology review thus suggests a realignment of bioenergy away from second generation, lignocellulosic technologies and towards the 'next generation'. This generation is dominated by biorefining approaches to production which intend to utilise algal sources (both macro and micro) or engineered microbial sources to produce a range of components. Recommendation 11 is focused, alongside the majority of its siblings, on pushing through BBSRC-funded research to useable end products. In doing-so it thus recommends that the research council encourage existing researchers to produce non-food crops with direct engagement with engineering principles — that new crop varieties be developed that are more readily processed using biorefining approaches.

Taking forward the recommendation of the industrial biotechnology review, the BBSRC have recently funded a string of programmes, including Networks in Industrial Biotechnology and Bioenergy (NIBB), an £18m investment in collaboration with the EPSRC (BBSRC, 2014b), as well as a series of 'strategic Longer and Larger grants (sLoLas) and a second round of the Integrated Biorefining Research and Technology Club (IBTI) which is a collaborative funding partnership with the EPSRC and industry (BBSRC, 2014c). These programmes are explicitly intended to work closely with end-users, largely industrial partners, to reduce "dependency on petrochemicals […] helping the UK to become a low carbon economy" whilst simultaneously aiding "high value multi-billion pound industries" in increasing the sustainability of their products (BBSRC, 2010b, p. 1).

Finally, in the absence of public controversy, there is scant reference to 'societal considerations' beyond suggesting, in familiar but updated terms, that societal benefits will accrue, allowing individuals to,

> "maintain affordable, sustainable lifestyles (through increased use of bio-renewables) whilst meeting key legal obligations (e.g. the Climate Change Act 2008: reducing greenhouse gas emissions by 80% by 2050)" (BBSRC, 2014c).

Indeed, aptly drawing parallels with early reports regarding the funding of bioenergy, the BBSRC has once again mobilised 'bioscience as remit' to demarcate consideration of ethical, social, or environmental dimensions of the research as being responsibility of other research councils:

> "the sustainability issues surrounding the growth of non-food crops and the effects of land-use change upon the natural environment would be an area of interest to NERC. Similarly, issues surrounding the adoption of biofuels, such as economics and social acceptability would be within ESRC's domain." (BBSRC, 2011c, p. 15)

6.3.4 Taking stock

This section has taken three turns to explain how the BBSRC has positioned its bioenergy funding programme over roughly a ten-year period. We have seen how biofuels were placed onto a research agenda as an agricultural priority. As the programme progressed, a vision of biofuel production emerged which initially remained part of this priority area – to be sure, the initial funding call explicitly excluded approaches such as biorefining which would be "addressed outside of the framework of the [bioenergy] call" (BBSRC, 2007c) – but this gradually shifted towards a vision underpinned by industrial biotechnology and biorefining techniques. Although both early and later visions were framed in relation to government drivers, early visions were explicitly ambivalent about technological trajectories. Rhetorically at least, this is no longer the case.

This section also makes it clear that differing framings of research might, or might not, embody responses to previous ethical concerns, thus representing (or not) a form of institutional learning that seems to be so-craved amongst STS communities (Chilvers, 2013). Initially, the development of biofuel production methods was positioned as one route to 'multifunctional' and 'sustainable' agriculture. The presence of these two terms, and the absence of the previous phrase 'plant biotechnology' (e.g. BBSRC and Museum, 1994; Straughan and Reiss, 1996) is not accidental. As has been recounted elsewhere (Doubleday and Wynne, 2011; e.g. see Wynne, 2011), in the wake of a market rejection of the most recent application of plant biotechnology — genetically modified crops — in Europe, the BBSRC began to reframe its agricultural biotechnology portfolio. Agenda setting reviews in the field at the time, covering sustainable agriculture (BBSRC, 2002) and crop science (BBSRC, 2004), rhetorically re-aligned the end goals of bioscience-funded research away from industrial production systems and towards a vision of agricultural production systems that, for example, utilised fewer inputs and were more efficient. In doing so, the BBSRC introduced a notion of 'public good plant science' as a means to distance itself from controversy (Doubleday and Wynne, 2011; Stengel et al., 2009), into which a bioenergy programme was to fit.

BBSRC's early vision for its bioenergy research programme is perhaps best characterised as vaguely action-oriented under the terms that were set out in its corporate planning documents in 2003. During this time it policed its disciplinary boundary, so that visions of a future where "disciplinary boundaries have begun to disintegrate" (BBSRC, 2003a, p. 2) can be easily read as referring to the boundaries between different bioscientific fields. This policing can be viewed as an active response to manage pressure from external actors in government, to an assessment of the existing funding situation, and a desire to defend the research council's priority of advocating for and fostering the national bioscience research base. This policing, however, is best viewed as a form of boundary work, shaped in part by perceptions of palpable public controversy. In such situations, the research council has shaped its research funding agenda to respond to it. In the case of biofuels, this is most evident with the broadening of 'remit' to include social scientists, LCA and economists into its flagship bioenergy programme. However, in other situations, the BBSRC defaults to a notion of 'bioscience for public good', mobilising its formal remit to demarcate areas of investigation beyond pure bioscience. This notion of 'bioscience for the public good', unless challenged by controversy, is assumed to be an increasingly technologically-driven society and there is little consideration of the implications that such imagined futures might hold beyond advancing better 'quality of life' and economic prosperity. As such, in the absence of controversy, no such presence was deemed to be required in the industrial biotechnology orientation of funding in areas other than synthetic biology (which in their own right stem from perceptions of controversial nature of genetic modification techniques). This is despite many of the deeper concerns regarding land-use change and biomass supply being raised by even the staunchest advocates as being a significant barrier for the 'bio-based economy' and the success of industrial biotechnology (e.g. BERR, 2009, pp. 61-62). In the next section I shift the focus of analysis slightly, to examine the organisation location of 'the task of ethics', as formally acknowledged in engagement programmes, considering the issues that are deemed to be most relevant and the 'rationales' for engaging with them.

6.4 Bioenergy engagement discourse and action

In the last sentence of its recommendations, the bioenergy review suggested that the BBSRC take any opportunity to conduct public engagement "activities addressing societal aspects of bioenergy research and its applications" (BBSRC, 2006a, p. 38). This was justified with reference to studies that 'quantitatively ranked' bioenergy as negatively perceived by the public. To this end, from 2007 onwards, the research council embarked on a programme of engagement in bioenergy, explicitly targeted at addressing 'societal issues'. As was usual, this was led from within the External Relations Unit (ERU) and its associated Bioscience for Society Strategy Panel (BSS). Discussions within the panel began in April 2007 following one of its member's involvement in a BBSRC bioenergy event (BBSRC, 2007e). ERU produced a policy statement later that year (endorsed by Executive Group and published online in

2008) and activities culminated with the establishing of an oversight group for BSBEC, a public dialogue in bioenergy and a series of (ultimately two) stakeholder workshops conducted in 2013.

Between 2007 and 2013, BSS intermittently discussed bioenergy as ERU developed various plans for public engagement. As BSBEC launched in early 2009, a proposal (later accepted) was tabled that the centre should include a unified group to oversee public engagement activities (BBSRC, 2009c). This panel was "tasked primarily to develop and deliver a programme of communication and public engagement around the work of BSBEC" (BBSRC, 2009d). Both the public dialogue and stakeholder workshops are thus children of circumstance, spawning out of interactions between BSS and ERU, and later ERU and the BSBEC communications and public engagement group (BSBOG[11]). To elaborate, during 2010 the BBSRC began to express frustration at the,

> "Lack of flexibility and innovation; audience [being] confined to representative groups; limited number of researchers who can be involved; and [the fact that] their 'top-down' nature does not encourage spontaneous adoption by researchers or public engagement professionals." (BBSRC, 2010c)

Therefore, the bioenergy dialogue drew inspiration from 'new models of dialogue' such as the think-tank Involve's 'distributed model of dialogue' (Anderson et al., 2010) and facilitation methods such as 'Democs Games' (New Economics FoundationEdinethics Ltd., 2012). The above frustration was paired with the nature of the bioenergy research centre BSBEC, which was geographically fragmented and involved a wide range of actors, making a unified approach complex, despite intentions (BBSRC, 2009e). A decision was therefore taken to make use of a 'toolkit' of resources (a draft ethical matrix, future scenarios and resources for schools) that had been developed by the BSBOG, and to encourage researchers and public engagement practitioners to hold their own dialogue events across the country. The results from each event would then returned via participant feedback forms, be assimilated and analysed by the co-ordinator to be fed into BBSRC strategy and policy. In contrast to traditional dialogue approaches, the bioenergy dialogue was envisaged to run for "a significant period of time, potentially several years" (BBSRC, 2011d). Its objectives were fivefold:

1. "To enable PIs and others to undertake public engagement activities around bioenergy research and the issues surrounding it

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[11] BSBOG stands for BBSRC Sustainable Bioenergy Outreach Group, which replaced the BSBEC CPE panel. I use the acronym BSBOG throughout for continuity.

2. To develop public engagement tools and resources that can adapt to the changing science, and the evaluation and outputs of the public engagement activities
3. To use outputs of public engagement activities to inform BBSRC, PIs, strategy and policy
4. To allow principal investigators refine their research direction to improve the social relevance of their research
5. To contribute to the national debate about the contribution that bioenergy and industrial biotechnology could make to the UK's future" (BBSRC, 2011e, p. 39).

In late 2012 the BBSRC appointed a 'bioenergy dialogue coordinator' to manage the project for a year. It set up a 'process sounding board' comprised of individuals external to the research council (Dr Rob Doubleday, University of Cambridge; Simon Burrall, Involve; and Alison Crowther, ScienceWise) to "advise BBSRC on the theory behind and process of the dialogue" (Collingwood Environmental Planning, 2014a). BSBOG was to have overall oversight of the process and provide a link, via ERU, to BSS, IBBE, researchers and other parties within the BBSRC. A pilot event was run in January 2013 at the Dana Centre in London where the research council delivered 'training' for BBSRC researchers and practitioners (attended by myself) and then trialled the dialogue toolkit, which was then released later that year. Throughout 2013, a total of 11 bioenergy dialogue events were run. Three of these (the pilot, and the final two events) were run by the BBSRC, with seven being run by external parties. (During my research, I attended four of these events in various capacities). In total, approximately 160 people took part (BBSRC, 2013b). The 'pilot' phase of the bioenergy dialogue ended in September 2013, was reported on by BBSRC (2013b) and evaluated by Collingwood Environmental Planning (2014a; 2014b). As of writing, its future status is currently unconfirmed, although the toolkit remains on the BBSRC website for use.

The BBSRC also embarked on a series of stakeholder workshops in bioenergy, which I also attended. The early intention of these workshops was loosely framed, simply to "discuss some of the key issues facing the bioenergy sector" from the perspective of 'non-public stakeholders' at three locations across the UK (BBSRC, 2013c, p. 1). In the time between the initial proposal and the first workshop, the goal of the workshops was elaborated on: They now aimed to "bring together a range of stakeholders with knowledge of bioenergy to enable open discussion on the issues, opportunities, and challenges associated with the subject", to "provide valuable insight in to stakeholder views", which could then be taken into account "policy in this key strategic area is developed" (BBSRC, 2013c). The first workshop convened a range of participants from NGOs, industry, government and academia and was structured around a paper published by a member of the LACE programme

(Hammond et al., 2012) that examined risks associated with biofuel development in the UK. Participants discussed the Hammond et al. paper, using it to frame discussions throughout the day. This workshop was followed by a later event held in July 2013 at the University of York, which brought a similar audience together to discuss biofuels, this time facilitated more loosely to allow participants to identify topics of interest, discuss them in more depth and then attempt to translate these discussions into action for the BBSRC (Penny Walker Consulting, 2013). As I shall return to in *section 6.5*, it is difficult to identify specific outcomes from these workshops.

6.4.1 Issue framing and the motivations for engagement

During the period and in relation to the engagement activities in question, the BBSRC has presented a range of 'issues' to be engaged with. It has also presented a range of implicit and self-aware motivations for engaging with such issues. In this section I draw attention to the way in which such 'issue framings' and 'rationales' have varied over time and between teams of people within the organisation. Particular attention is paid to differences between high level, 'agenda setting' documents, such as the strategic plans; 'action framing' documents such as public-facing policy statements; and 'action initiating' documents that frame activities such as the public dialogue and stakeholder workshops. I close with consideration of how these documentary discourses relate to practice. As with the previous section, woven throughout are varying presentations of the BBSRC's self-created identity, which I will draw out in *section 6.5*.

In analysing the BBSRC's corporate and implementation documents, it is possible to distinguish between at least three rationales for engagement and two different types of issue framing. With respect to the former, recall that *chapter three* differentiated between instrumental, substantive and normative rationales for engagement (Fiorino, 1990; Stirling, 2008). An instrumental rationale places the engagement as a means to a predefined end. A substantive rationale assumes that engaging a diverse set of perspectives in decision-making can produce better decisions or innovations. A normative perspective is occupied with including diverse voices because, simply put, it is the 'right' thing to do in a democracy (Marris and Rose, 2010). The same differentiation is put into practice here. With respect to issue framing, I pay attention to 'first order' framing and 'second order' framing. In a first order frame, the BBSRC presents changes associated with the nature of scientific knowledge or technological developments as being worthy to engage with as ends in themselves. In a second order frame, the BBSRC presents the changes that knowledge or technology raises as worthy of engaging with through a proxy, usually 'the public' or 'societal opinion'. Across the organisation's documents, these issue-framings and motivations are deployed in diverse ways.

Issue framing and rationales in agenda setting documents

At the highest level, in both internally and externally facing documents, issues are generally framed by the BBSRC as 'second order', that is as 'societal issues' or 'issues of public concern'. These second order issues are generally approached with a highly instrumental rationale, although they are tempered by a number of statements, particularly in later externally-facing documents, suggesting tensions both internally within the organisation as different groups forward their interpretation, and as a whole as the research council repositions itself in response to changing contexts.

The BBSRC's (2003a) *strategic vision*, for example, discusses public and stakeholder engagement, and a wider context in which the research council operates under the heading 'science for society':

> "Greater dialogue between researchers, those who use the outcomes of research and the wider public will help to ensure that the UK as a whole benefits from its world-leading bioscience." (BBSRC, 2003a, p. 5)

Perhaps unsurprisingly for a body tasked primarily with funding science, the BBSRC chose largely to black box the processes that go into accruing social and economic benefit from the biosciences, schematically representing them as a soft yellow unidirectional arrow (*Figure 6.3,* p.162). Throughout the document 'predictive biology' is largely positioned as neatly translating into social and economic benefits with engagement set to facilitate this. This position is reiterated, and indeed reinforced, in the (2003b) *strategic plan* and later (2008a) *delivery plan*. These documents make use of 'societal benefits' and 'impact' respectively to frame the entirety of their contents. For example, the BBSRC's primary mission is presented as one of,

> "foster[ing] a world-class bioscience community for the UK [whose] science supports a number of key industrial stakeholders in the bioindustries that are essential if society is to reap the benefits of basic research" (BBSRC, 2003b, p. 5).

Thus, the BBSRC is unequivocally cast as primarily an advocate for the bioscience community in the UK. Secondary and tertiary roles of "providing training" and "encouraging discussion" that are present in the earlier ten year vision (BBSRC, 2003a, p. 2) are reinterpreted as objectives five and six, "knowledge transfer" and "partnerships", that are essential to achieve if society is to receive the cornucopian wealth that will flow from bioscientific knowledge. Stakeholders, although relatively diversely defined are presented in a passive light as receivers of benefits:

> "The breadth of BBSRC's research remit means that its science impacts across society, offering benefits to individuals, industry, policymakers, and the wider community." (BBSRC, 2003b, p. 3)

These highly instrumental rationales for engaging with the public and other stakeholders are, however, somewhat complicated by later statements, sometimes in the same documents. The (2003a) *strategic vision* for example suggests that,

> The basic science upon which this vision rests is extremely important, but it must be set against a moving background of wider issues, such as emerging and future Government policies, international developments in science, the activities of other research funders, and the increasing need to engage society in scientific developments. Some of these contextual matters are difficult to predict. BBSRC and the science community must be flexible enough to respond, and for this reason the vision is a 'live' document." (BBSRC, 2003a, p. 5)

Here, whilst the BBSRC does position engagement with end-users of research and the public as fundamental to producing benefits from bioscience, the latter half of the quote positions the BBSRC as an advocate for a research community that is *responsive* to wider contextual changes. Similarly, under the heading of 'partnerships' the strategic plan elaborates on the need for engagement:

> "An increasing number of advances at the forefront of the biosciences, such as cloning, genetic modification and stem cells, raise wider issues for society. This makes it imperative for BBSRC to identify public attitudes in the early stages of research so that these may be addressed in developing research programmes, and fed through to technology developers, policymakers and others." (BBSRC, 2003b, p. 22)

Similarly, a later (2010d) annual report builds on the instrumental articulations within the delivery plan (2008) to suggest:

> "BBSRC funds research in areas of high public interest including, for example, stem cell science, synthetic biology, nanotechnology, crop biotechnology, biofuels and the use of animals in research. We remain committed to: raising public awareness of the research we support and its implications; enabling public participation in shaping our policies and funding strategies; and ensuring that BBSRC-supported scientists are aware of societal issues around their research and address them" (BBSRC, 2010d, p. 30).

In documents replete with text emphasising the benefits that the biosciences will bring to society these quotes begin to somewhat temper that apparently unproblematic and linear process. Drawing on previously controversial examples, these statements recognise that the biosciences have the potential to re-shape the way in which society understands life. These issues are, however, recast by the research council, using the notion of 'societal issues' and 'public attitudes' to research. Understanding what people think about developments in the biosciences – gleaming "intelligence about societal issues" (BBSRC, 2008a, p. 8) and working "closely with the research community, industry, policy makers and the public […] to enhance our understanding of users' needs and deliver a full range of impacts" (BBSRC, 2008a, p.

23) – is thus vital for the research council, but to what ends beyond the obviously instrumental is unclear.

Further, the above quotes present a wish to be responsive and express a desire to "embed science and society in our [the BBSRC's] decision making" (BBSRC, 2008a, p. 8). To do so however, the BBSRC places the onus on public understanding about the goals of BBSRC-funded research to date. Statements such as these are interpretively flexible and can be read in at least two ways. The first positions engagement with external parties as a means to gain acceptance for developments in the biosciences. The second is more responsive, allowing for the shaping of specific developments, and a co-evolving research agenda. Both interpretations embed an instrumental rationale (i.e. engagement is necessary to give advances legitimacy and utility) but the latter also embeds a normative and potentially substantive rationale (i.e. engagement is a democratic imperative and may produce better knowledge). Whilst terminology such as 'responsive' may point towards the latter interpretation, experience shows that the devil is in the detail; these rationales are sensitive to the many specificities of encounters, such as the framing and timing of activities, the inclusion and exclusion of parties, and which parties get to decide on the definition of key terms such as 'benefit', significantly shape the ability for democratic and substantive rationales to be realised.

Thus, despite problematising 'the public', and a broader gaze making the strength of an instrumental motivation clear, there appears to be some, at least discursive, space to open up normative and substantive rationales for engagement. Such space is perhaps broadest in the most recent 2011-2015 delivery plan (BBSRC, 2011b). Although continuingly casting the BBSRC's prerogative increasingly as one of 'securing impact', this document presents public engagement as follows:

> "Many advances in bioscience challenge the way in which we view the world and our place within it. They become part of our understanding of the world, and influence the way we think about engineering, computation and physics; examples are neural networks and selection in evolution. Other conceptual and experimental advances such as stem cells, GM, synthetic biology and cloning have had both positive and negative impacts on societal views.
>
> BBSRC […] will continue to positively engage the public, be it through [public] dialogue […] or through ensuring that the scientists we fund go out into their communities to […] widen public understanding. For example, we will help to develop […] training to enable researchers to engage effectively with ethical and related societal issues. […] Through this we will ensure that our bioscience is grounded in society's needs, and it has the trust and support of the UK public.
>
> We will engage with the issues raised by the research we fund, in particular relating to our three grand challenges. […] We are establishing broad-based outreach groups [in bioenergy and global food security] to deliver integrated

> programmes of communication and public engagement that will enable public participation in debate and help to ensure that our policy making and funding decisions take account of the views, aspirations and needs of the wider public."
> (BBSRC, 2011b, pp. 15, emphasis added)

This extensive extract embeds several issue framings and rationales for engagement. Issues of concern include the way the biosciences change the way we understand life and the way we think about other disciplines, and the fact that developments in the biosciences have positive and negative effects on societal views on bioscience and biotechnology. The statement presents the BBSRC's programme of public engagement, which includes dialogues, BSBOG and public engagement training as being the three main ways that these issues will be addressed. Thus, such programmes should allow engagement with both first and second order issues on the part of scientists as well as the research council. The instrumental motivation remains, for example present in the notion of public trust, but there is clear rhetorical space for substantive and normative motivations for engagement in the suggestion that the BBSRC's research be aligned to wider views and needs of society. Again, how much space is provided in practice depends largely on the answer to questions such as 'which views and values are given airtime?' and 'how are they weighted *vis-a-vis* other drivers?'

Note the reframing from first to second order issues emphasised in the second quote, however. This could be interpreted in a number of ways. The significant semantics could betray a true underpinning concern with public perceptions on the impact of being able to 'get bioscience done' rather than a first order concern with the actual ways in which society is shaped by new knowledge. Alternatively, it might provide a brief insight into the internal negotiations and variances within the organisation. These high-level documents are produced by groups across the organisation and, importantly, have to be approved at senior levels by Executive Group and The Council. In these situations, wording matters. Instrumental rationales have political currency because they have long been institutionalised in public understanding of science, and later public engagement, programmes. Shifting the status quo is risky; in contrast grounding engagement in the rhetoric of public trust, which was introduced in the wake of the House of Lords Science and Technology Committee report (2000), has become readily accepted by audiences external to the Communications and Information Management Group (*Figure 6.1*, p.157). They therefore allow members of the organisation with responsibility for those activities to 'get work done'.

I now turn to internally facing agenda-setting documents. In 2012, the external relations unit produced a Corporate Strategy for Communications, Engagement and Dialogue. Like the externally-facing strategic planning presented above, this internal policy document aims to provide an overarching approach to the activities within the ERU's remit. It seeks to integrate stakeholder and public engagement more tightly, placing each as components of ‘corporate stakeholder engagement’ (BBSRC, 2012a). A broad motivation for engagement is clearly captured within the communications strategy. Here, ‘corporate stakeholder engagement’ is constructed as an essentially instrumental process to ensure that the environment remains favourable towards bioscience research, which BBSRC have an obligation to fund and support. In order to ensure that the environment remains favourable – i.e. with industry support, minimal negative legislation, controversies that are well handled, and ultimately a favourable spending review – BBSRC will aim to achieve three sets of objectives (BBSRC, 2012a, pp. 10-12), summarised as:

1. Demonstrating Impact and value	Measurable through being able to mobilise support when necessary, and increasing the number of scientists who engage with external parties
2. Engaging in Dialogue	Demonstrable through the incorporation of a diversity of views into strategic decision-making
3. Maintaining a public licence to operate for the biosciences	By demonstrating that BBSRC are responsive to external views and by ensuring that scientists have a good public image

The most significant statement above is ‘a public licence to operate’. Previous documents have been overt in representing the task of the BBSRC as one primarily of supporting the bioscience community by ensuring there is an environment that is favourable to bioscience research in the UK by increasing ‘understanding’ or addressing a ‘public trust deficit’ (Wynne, 2006), this document claimed that there is,

> “an expectation that we should deliver not just excellent science but should do so in a way that is responsible to society. There is increasing pressure from external forces (the media, NGOs, science policy bodies and the academic social science arena) for all Research Councils to demonstrate how they are being responsible” (BBSRC, 2012a, p. 8).

To justify positions such as this, the document introduced a notion of ‘licence to operate’. Although this partially moves the problematisation away solely from ‘public concerns’, acknowledging a wide range of other forces, it also maintains an instrumental rationale. This instrumental rationale for engagement is based on several assumptions. First, it assumes that BBSRC’s primary purpose is to create a favourable environment for bioscience research (which may be the case). This means that it must mobilise political power to defend and develop the bioscience research base. Second, it follows that conducting engagement is one means to ensure a favourable environment and maintain a ‘licence to operate’ for bioscience research. It therefore assumes that BBSRC is able to influence the broader public and political perception of bioscience research through dialogue, and that this influence will affect measurable outcomes such as the funding that BBSRC receives.

It seems sensible to question the above logic. The factors that shape a 'licence to operate' are complicated and interrelated, stemming from a crucible that includes the relative merit and controversy attributed to bioscientific developments in relation to other areas, science in relation to other political priorities and the changing values of individuals within society. As an example, first generation biofuel research could be said to have lost its 'licence to operate' but this unlikely to be because of a lack of engagement; it is more likely the result of a complex controversy that emerged around the practice of using crops to produce liquid fuel, and is part of BBSRC's response to wanting to fund research in the area. As we have seen, a 'licence to operate' is shaped by potentially problematic or controversial research and technologies, which may or may not stem from public money or the UK and have a range of paths into public consciousness. In these situations, if coupled to a commitment to fund research irrespective of outcome, public engagement may serve to further alienate communities who may wish to be engaged with in the future (Parry et al., 2012). Let us now turn to a series of 'action framing' documents in the field of bioenergy.

Action framing documents in bioenergy

The extracts so far have considered the overarching framing of issues and engagement from the perspective of the BBSRC. Before progressing further, attention is due to the ways in which the research council presents issues with bioenergy and engagement in the field through a series of action-framing documents. Policy statements are written to set out the BBSRC's position, primarily in what it views as potentially controversial areas. Other statements have covered topics around stem cells (BBSRC, 2006b), the use of GM in crops and animals (BBSRC, 2011f), the misuse of research (BBSRC, 2007f), impact (BBSRC, 2012b; 2008b) and the use of animals in research (BBSRC, 2013a). In this regard the original bioenergy policy statement was no exception. As is common for such statements, this document incorporates a discussion of 'ethical and societal issues':

> "BBSRC recognises that the conduct and application of the science we support can raise ethical and societal issues. Concerns have already been raised about the impact of growing bioenergy crops on land use, fibre, food availability and prices, and on biodiversity. We are engaged in research that investigates such issues, for example as part of the cross- Research Council "Rural Economy and Land Use" programme. We promote constructive discussion about issues raised by our science and have an active programme of public engagement and dialogue in this area. (BBSRC, 2007g, p. 1)

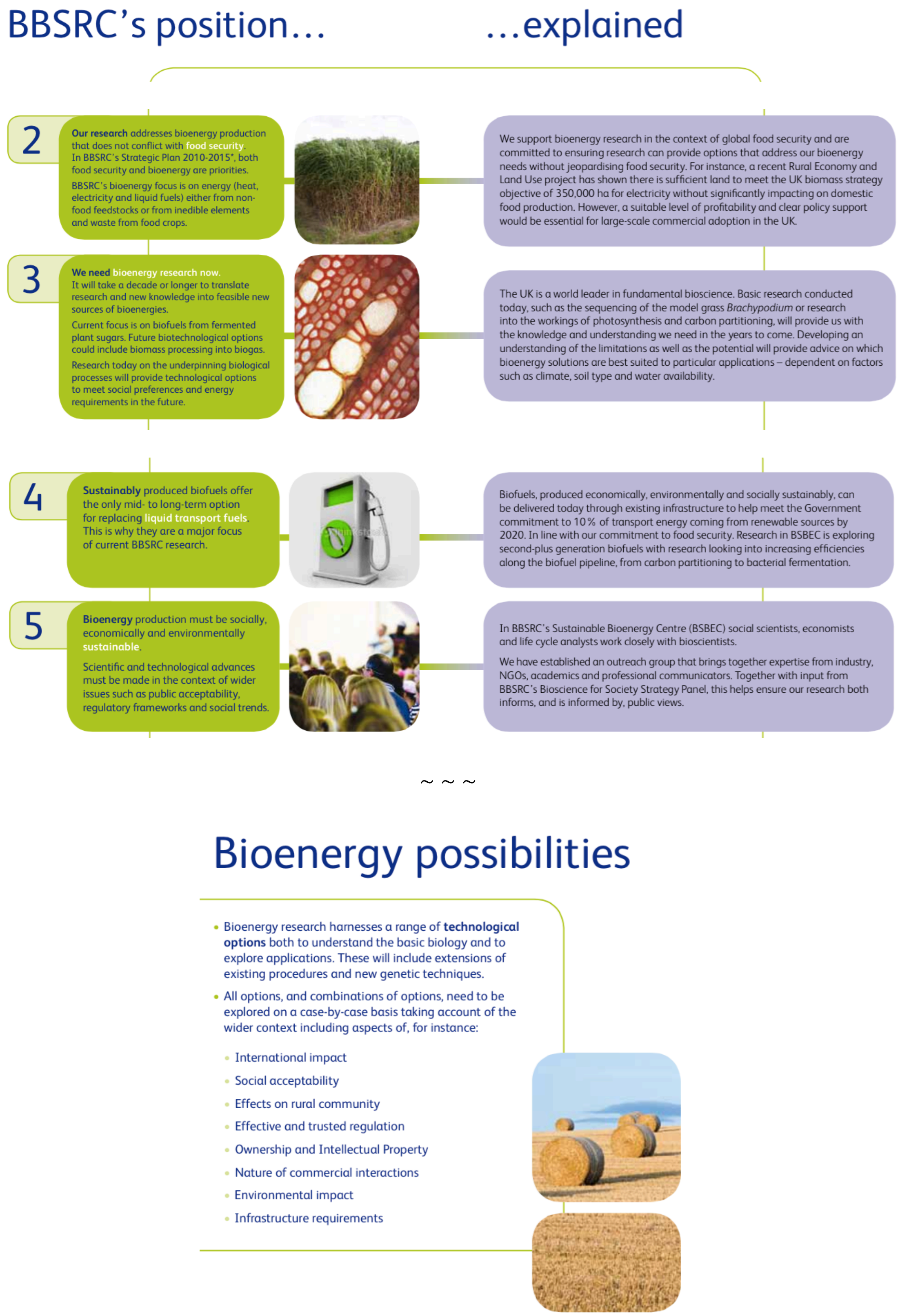
The statement closes with a paragraph on the 'use of genetic technologies in bioenergy research':

> "Genetic technologies will be key to understanding the role and behaviour of plant and microbial genes involved in energy capture and conversion, and BBSRC supports laboratory-based research that uses genetic techniques in this way. The information gained from these experiments may be used subsequently in conventional plant breeding [...] as well as in potential transgenic crops or microbes with new or novel traits. We recognise that the development of transgenic organisms raises ethical and social issues and, although it is not our role to make policy decisions about the growth of new transgenic crops, we actively seek opportunities to engage in discussion about the use of GM technology that fall within the scope of our work." (BBSRC, 2007g, p. 2)

This externally-facing document categorises 'ethical and societal' issues as those surrounding the impact of bioenergy on land use requirements, fibre and food availability, and biodiversity; all prominent issues within biofuel debates at the time. It supplements this list with 'genetic techniques', notable in bioenergy debates for their relative scarcity, which it views as inherently controversial - 'transgenic organisms raise ethical and social issues'. Two points follow. First, the policy statement is perhaps best viewed as a means to pre-emptively manage concern about a potentially controversial area of research funding. Second, when taken as a whole, the statement transects what is best described as a 'dichotomy of responsibility'; deferring responsibility for decisions about the 'application' of transgenics outside of research to other undefined parties who are responsible for making policy decisions about the growth of such crops. Simultaneously however, it seeks to show that the research council *is* attending to other concerns regarding the deployment of biofuels, by drawing attention to previously commissioned research that its sister councils have funded. In doing so, the statement suggests that 'ethical and societal issues' are worthy of engaging with in themselves by researchers for the successful deployment of biofuels as a suite of technologies, positioning scientific investigation and public discussion as means to consider them; a first order issue framing and substantive rationale for engagement.

The 2010 update of the bioenergy position statement takes a much glossier form than its predecessor (*Figure 6.5*). It includes an overview of the funding portfolio at the time, a seven-point position statement regarding bioenergy research, a section entitled 'bioenergy possibilities' which seeks to place bioenergy research in a wider context as well as some closing 'facts and figures'. The centre two pages consist of seven carefully-worded position statements and associated expansions - a mix of contextual drivers, justifications and examples of decisions.

The statement, in a somewhat idiosyncratic format, can be viewed as an attempt to situate the BBSRC's bioenergy funding position in a wider context. It locates research



BBSRC's position… …explained

2 **Our research** addresses bioenergy production that does not conflict with **food security**. In BBSRC's Strategic Plan 2010-2015*, both food security and bioenergy are priorities.

BBSRC's bioenergy focus is on energy (heat, electricity and liquid fuels) either from non-food feedstocks or from inedible elements and waste from food crops.

We support bioenergy research in the context of global food security and are committed to ensuring research can provide options that address our bioenergy needs without jeopardising food security. For instance, a recent Rural Economy and Land Use project has shown there is sufficient land to meet the UK biomass strategy objective of 350,000 ha for electricity without significantly impacting on domestic food production. However, a suitable level of profitability and clear policy support would be essential for large-scale commercial adoption in the UK.

3 **We need bioenergy research now.** It will take a decade or longer to translate research and new knowledge into feasible new sources of bioenergies.

Current focus is on biofuels from fermented plant sugars. Future biotechnological options could include biomass processing into biogas.

Research today on the underpinning biological processes will provide technological options to meet social preferences and energy requirements in the future.

The UK is a world leader in fundamental bioscience. Basic research conducted today, such as the sequencing of the model grass *Brachypodium* or research into the workings of photosynthesis and carbon partitioning, will provide us with the knowledge and understanding we need in the years to come. Developing an understanding of the limitations as well as the potential will provide advice on which bioenergy solutions are best suited to particular applications – dependent on factors such as climate, soil type and water availability.

4 **Sustainably** produced biofuels offer the only mid- to long-term option for replacing **liquid transport fuels**. This is why they are a major focus of current BBSRC research.

Biofuels, produced economically, environmentally and socially sustainably, can be delivered today through existing infrastructure to help meet the Government commitment to 10 % of transport energy coming from renewable sources by 2020. In line with our commitment to food security. Research in BSBEC is exploring second-plus generation biofuels with research looking into increasing efficiencies along the biofuel pipeline, from carbon partitioning to bacterial fermentation.

5 **Bioenergy** production must be socially, economically and environmentally **sustainable**.

Scientific and technological advances must be made in the context of wider issues such as public acceptability, regulatory frameworks and social trends.

In BBSRC's Sustainable Bioenergy Centre (BSBEC) social scientists, economists and life cycle analysts work closely with bioscientists.

We have established an outreach group that brings together expertise from industry, NGOs, academics and professional communicators. Together with input from BBSRC's Bioscience for Society Strategy Panel, this helps ensure our research both informs, and is informed by, public views.

~ ~ ~

Bioenergy possibilities

- Bioenergy research harnesses a range of **technological options** both to understand the basic biology and to explore applications. These will include extensions of existing procedures and new genetic techniques.
- All options, and combinations of options, need to be explored on a case-by-case basis taking account of the wider context including aspects of, for instance:
  - International impact
  - Social acceptability
  - Effects on rural community
  - Effective and trusted regulation
  - Ownership and Intellectual Property
  - Nature of commercial interactions
  - Environmental impact
  - Infrastructure requirements

Figure 6.5: *Excerpts from the 2010 Bioenergy position statement (BBSRC, 2010a, pp. 3-5)*

decisions in a wider policy landscape of government renewable commitments. From the document's list of positions and elaborations, food security and sustainability are presented as being of particular importance. First, impacts on food security are presented as being addressed through a focus on second generation biofuels, that (seemingly unproblematically) make use of marginal land, and either non-food crops in their entirety or components of existing crops (BBSRC, 2010a, p. 3). The document draws on a domestic model of biofuel production and research from a previous Rural Economy and Land Use' (RELU), is used to suggest that there is sufficient land in the UK to produce government targets of bioenergy without impacting on domestic food production. However, the capacity to make use of this is predicated on effective government policy to ensure economic sustainability (BBSRC, 2010a, p. 3). Sustainability concerns are to be addressed by integrating social scientists, LCA and economists into the BSBEC 'virtual centre' and 'public views' are being addressed through the BSBEC Outreach Group (BBSRC, 2010a, p. 3).

Setting up a context that the BBSRC is responding to produces a tension; the research council now has an obligation to contribute to research applications while at the same time paying attention to the sensitive nature of this context. Note that to negotiate this tension, the statement couples research outputs to concern for 'contextual issues' and once again mobilises the notion of 'underpinning research'. The claim "we need bioenergy research now" (BBSRC, 2010a, p. 3) is thus substantiated not because it will provide applications directly, but because it will produce 'underpinning knowledge' of the "limitations as well as the potential" which can then be translated into technologies that sit well with 'social preferences' (BBSRC, 2010a, p. 3). This coupling of underpinning knowledge to social preferences has three consequences: First, it allows the BBSRC to claim that it is producing research with social applications; Second, it predicates the understanding of successful applications on a holistic approach to research that is aware of wider issues (a substantive rationale); Third, it allows the BBSRC to claim that the research that it funds is flexible and open to social shaping, free from being pinned to a particular technological trajectory, a point bolstered by a delegation of factors such as economics and policy to the control of external parties.

These action-framing bioenergy documents therefore draw attention to a disjuncture with the more general discourse in many of the high-level, agenda-setting and externally facing corporate documents. This is especially true in the period after bioenergy had been nominated as an explicit funding priority, and once the decision had been made to focus on second generation biofuels and to integrate social, economic and LCA strands into BSBEC. For example, the 2008 delivery plan presented BSBEC as directly addressing the first order "societal, environmental and economic" issues (BBSRC, 2008a, p. 3). Similarly, the 2010 strategic plan framed bioenergy as existing within a complex web of "environmental, technical and policy challenge[s]" (BBSRC, 2010b, p. 9) which again require multidisciplinary collaboration to produce relevant knowledge and robust solutions to a 'major societal and policy challenge'. Statements such as these present the need for collaborative research as very much a substantive one in response to first order issues: There is no reference to the public here. Such clarity is striking in the face of much of the ambiguity present regarding motivations beyond the instrumental highlighted in the paragraphs of the previous section.

Issue framing and rationales in action-initiating documents

In this penultimate turn, I consider internally-facing, action-initiating documents, such as the bioenergy review (2006) and two bioenergy dialogue proposals that were presented to the bioscience for society strategy panel in the form of 'discussion papers' (2007, 2009). Here, first-order issues are broadly re-framed as second-order issues, and although an instrumental rationale dominates early documents, in later ones rationales are often unclear. For example, the 2006 bioenergy review echoes the position statements above to present a number of 'first order issues'. Concerns regarding the sustainability of biofuel production are acknowledged. Specifically this relates to the likelihood that,

> "burgeoning demand for biofuel feedstocks in the UK (amongst others) is likely to lead to contribute to unsustainable agricultural practices internationally, particularly in the developing world." (BBSRC, 2006a, p. 38)

In this instance, the bioenergy review demarcates its ability to influence policy and practice, deferring responsibility to external parties in addressing it. As such the authors draw a boundary between 'research' and 'application'. The report acknowledges the legitimacy of first-order concerns (about land, water and nutrient usage, as well as generically-defined environmental issues). It then reframes them through the lens of 'societal issues'. The document suggests that such issues must be considered as part of a wider framework but is unforthcoming with suggestions as to the means. In their second-order form however, the BBSRC does have a role to play. Making reference to its terms of reference, the review authors comment that it "is within the remit of BBSRC's mission to generate public awareness, disseminate knowledge and encourage public engagement and dialogue" (BBSRC, 2006a, p. 38), carving organisational legitimacy for a future engagement programme. The rationale for this programme, at least from the perspective of the authors, is that due attention to the 'broader aspirations and concerns' is warranted because,

> "in a recent survey, the public perception of biomass as source of energy was quantified as extremely negative, with nuclear energy viewed only marginally less favourably" (BBSRC, 2006a, p. 38).

Thus, first order issues are re-framed as second order ones and public engagement is prescribed to address them underpinned by an instrumental rationale that aims to improve public perception and awareness of bioenergy. Once again, we see that reframing from first-order, substantively motivated concerns to second-order, instrumentally-motivated concerns ties into an accepted mandate within the organisation, making problems 'doable' (Fujimura, 1987).

This presentation of issues and rationales is echoed in an initial proposal for public engagement that built on the mandate provided by the bioenergy review (BBSRC, 2007h). Let us take the issue-framings first. Under the heading of 'public engagement and dialogue', it links "public concerns" to the trio of issues around "land use, food availability and prices, and on biodiversity" (BBSRC, 2007h). Previous public engagement, it claims, had "identified concerns about the ecological and biodiversity impacts that might be associated with land use or combustion of these [non-food bioenergy] crops" (BBSRC, 2007h). The paper elaborates that,

> "Research commissioned by RCUK [(McGowan and Sauter, 2005)] demonstrated that there was low public awareness about biomass crops, and low levels of acceptance compared with other sustainable energy sources. The researchers suggested that low awareness might be a reason for low acceptability, which was also suggested by research commissioned by the AEBC [(Corr Willbourn Research and DevelopmentDevelopment, 2005)]." (BBSRC, 2007h)

The initial proposal for a bioenergy dialogue presented to the Bioscience for Society Strategy Panel thus distils the findings of what are quite nuanced reports (e.g. Corr Willbourn Research and DevelopmentDevelopment, 2005) to link public concerns and low levels of acceptance to low awareness of biomass, with a subtext that increased awareness might build support for bioenergy. As such, the paper proposes a range of methods to develop an understanding of different issues, both to feed into 'decision-making' and to develop dialogue and communications strategies. The initial proposal for public engagement includes a series of events across the country to deliver a range of 'key messages' (*Figure 6.6*) that ultimately echo many of the earlier orientations of the research council, to demarcate between 'basic' and 'applied', emphasising the nurturing remit of the BBSRC, and seeking to diversify energy choices whilst remaining ambivalent about particular technological configurations (BBSRC, 2007h).

Finally, the dialogue proposal introduces genetically modified plants for use in bioenergy as one potential means to offer "opportunities for the use of GM in optimising and increasing the diversity of bioenergy options" whilst also offering "the potential to satisfy increasing fuel needs, whilst maintaining adequate levels of food production" (BBSRC, 2007h). Genetically modified plants were presented as one means to bypass problems with bioenergy's competition with food production. The proposal suggests that,

Key messages

Science:
- The UK has an excellent plant and microbial science research base
- BBSRC institutes have a clear role to play in developing a critical mass of expertise and facilities relevant to bioenergy research
- BBSRC's focus is on basic and enabling bioscience research

Energy mix:
- We need to strengthen and diversify energy choices
- Bioenergy will be an important part of the future low-carbon energy mix

Drivers:

Economic
- There is a vibrant SME bioenergy sector in the UK
- The UK needs to be energy independent

Environmental
- Bioenergy can be low-carbon and sustainable

Context
- UK bioenergy research must be developed in the context of strong development and investment in the US and Europe
- BBSRC investment is cognisant with the RC energy programme

Figure 6.6: *'Key Messages' to be delivered by the bioenergy dialogue, presented in the initial proposal for public engagement in bioenergy (BBSRC, 2007h).*

> "whilst the move to GM bioenergy crops could provide benefits, such as high biomass varieties which reduce the amount of land needed for their growth, the use of GM on a large-scale could present concerns in terms of their impact on biodiversity and biosafety, and societal issues about the involvement of multinational organisations and the dependency of farmers on GM crops" (BBSRC, 2007h).

Here, the paper presents genetically modified plants as a potential solution to existing problems with the deployment of bioenergy and couples them to a tier of potential issues including 'impacts on biosafety and biodiversity' as well as 'societal issues' as barriers to their use.

On the one hand, it speaks in certain terms about the benefits of biofuels – "bioenergy *has* an important part of the UK's future low-carbon energy mix." (BBSRC, 2007h) – making the overcoming of issues important to realise that potential. But at the same time, the (2007h) bioenergy paper does seem to represent a genuine effort to engage with a range of people about the goals of research, with a desire to input into strategy and direct, in a small way, the kinds of research that are done. And yet, if 'dialogue' is viewed as understanding how a beneficial technology can be realised, delivering a range of 'key messages', and barriers to application are seen through the lens of public concern, it is difficult to move beyond an instrumental rationale. Furthermore, note the importance of timing here: the BBSRC's funding and structure would largely be agreed by the time the engagement programme actually happened.

Much of the above position is echoed in the May 2009 BSS Papers (BBSRC, 2009f), reiterating similar concern with public concerns. During this period, biofuels had grown increasingly contentious as an area of development and deployment, and the funding structure of the BSBEC programme had largely been agreed. The document reflects these changes, but it also introduced a new set of objectives for a dialogue in the area. Thus the paper sets out to ask the BSS to advise on the ethical and social issues associated with bioenergy and the ways in which the BBSRC should address them, particularly in terms of revising the BBSRC's aforementioned position statement and programme of engagement with the public and 'special-interest groups'. It opens:

> "Bioenergy has received considerable negative press in recent years, tending to focus on issues such as:
>
> - Bioenergy derived from food crops distorts food markets and pushes up food prices
> - International bioenergy markets promote the destruction of rainforests to plant energy crops such as palm oil
>
> In the UK there is public scepticism around bioenergy and biofuels (see Appendix 1) and as an energy source it is less well understood and less popular than other 'renewable' sources, for instance wind power." (BBSRC, 2009f, p. 2)

In the two years that followed the announcement of the bioenergy initiative, biofuel controversy had increased. The paper recognises this, opening with 'negative press' and 'public concern' as being primary issues facing the bioenergy funding programme BSBEC. It makes reference to social science work in its appendix from Upham, Shackley and Waterman (Upham et al., 2007). These authors suggested that despite relatively little being known about bioenergy, individuals tended to: be sceptical of its environmental credentials, particularly where substantial transport distances are included in production; be concerned about local-level and material impacts of bioenergy development such as haulage, and the ecological and landscape impacts of crops. Further, local and small to medium-scale production was viewed positively (Upham et al., 2007). Thus, what are quite nuanced perspectives from members of the public as they relate to bioenergy are again only partially read: as scepticism, low popularity and low understanding. The paper then progresses to introduce BSBEC and the ways in which the programme addresses ethical and social issues:

> "Ensuring that bioenergy is economically, environmentally and socially sustainable is core to BSBEC's programmes. The Centre is focused on 'second

> generation' or sustainable bioenergy. Sustainable bioenergy aims to lessen the negative impacts of bioenergy production. It is bioenergy that is derived from either non-food crops which can be grown on marginal land not used for growing food (principally willow and miscanthus) or from the non-food parts of crops (i.e. waste straw or grain husks)." (BBSRC, 2009f, p. 2)

Here, issues associated with biofuel development and deployment are firstly condensed down to 'competition with food production' and 'the destruction of land with high ecological importance' which are then seen as relevant for the research council to address, but only after passing through the dual lenses of 'negative press' and 'public concern' as being challenges to research in the area. Recall from earlier in the chapter that BSBEC was framed as achieving the BBSRC's vision of 'sustainable second generation biofuels'. This paper reiterates that vision, emphasising that this orientation is an explicit response to prominent issues within the debate around biofuels, aiming to 'lessen the negative impacts of bioenergy production' by making use of marginal land or non-food components of crops or wholly non-food crops.

There is, therefore, a mixture of issue-framings within this final document. Whereas significant emphasis is placed on a perceived public hostility to bioenergy, the structural orientation of the bioenergy programme was presented as a direct response to first-order problems with biofuel development and deployment. Again, the underpinning rationale here is difficult to tease out, as the renewed objectives for a bioenergy dialogue embody:

> i. "Increased public awareness of sustainable bioenergy research, to help facilitate an informed debate around the ethical and other social issues that such research will invoke
>
> ii. Enabling BBSRC to hear and listen to public concerns and aspirations regarding bioenergy so that these views can be fed into BBSRC research funding strategy
>
> iii. Enable BSBEC researchers to develop a wider appreciation / understanding of the public's views of their field." (BBSRC, 2009f, pp. 2-3)

The objectives can be rephrased as: (i) increase public knowledge of bioenergy so that informed debate about the issues that it raises can be had; (ii) allow the BBSRC to understand what the public thinks about bioenergy so that it can direct research to match those thoughts; and, (iii) allow researchers to understand what members of the public think about their research. Again, we can see that the BBSRC was keen to send out the individual programmes on programmes of public and stakeholder engagement. Individuals within the BBSRC were discussing this largely in terms of 'public concerns' but the reasons for doing so weren't clear — these could be instrumental (to smooth through the technology) or they could be to help involve perspectives to modulate it to public needs and effectively address issues. These are

Document Type	Issue Framing	Rationale
High level, agenda-setting, externally-facing documents *(e.g. Strategic vision (2003); Delivery plans (2008-11, 2011-15))*	In general, issues are cast as 'societal issues' of public interest, although more recent also include first order framings.	Generally highly instrumental, but tempered by statements such as 'research council responsiveness'
High level, agenda-setting, internally-facing documents *(e.g. Communications and public engagement strategy (2012))*	Second order concerns – BBSRC must maintain a public licence to operate.	Instrumental rationale
Topic-specific action-framing documents *(e.g. Bioenergy policy statements, bioenergy review)*	Issues framed as first order – i.e. they are worthy of engagement in their own right	Substantive
Internal, action-initiating documents *(e.g. BSS Discussions, business cases for activities)*	Second order framings dominate	Instrumental rationales, with normative and substantive twists in more recent documents

Table 6.1: *Overview of issue framings and rationales amongst BBSRC engagement documents.*

very similar motivations but subtly different, and I will reflect on them in the closing discussion.

6.4.2 A diversity of motivations

So far, we have seen how the BBSRC frames issues and motivates itself for addressing them in documents, and in internal discussions leading up to implementation. This can be summarised, as in *table 6.1* (facing page). Both internally- and externally-facing agenda-setting documents published by the organisation tend to embed second order issue framings which places public acceptability as the pertinent concern to be addressed. They also embed incredibly instrumental rationales for action, based predominantly on the notion that the BBSRC's primary responsibility is to foster the biosciences. However, the presence of variation within these documents, which has tended to increase chronologically, is perhaps best-viewed as an artefact of internal negotiations and the political capital of different, well-established, phrases that particular teams mobilise to provide space that allows them to continue their work and defend their remit. In contrast, carefully-worded policy statements tend to adopt substantive and instrumental rationales, with first order concerns that should be engaged with in their own right. Finally, internally-facing, action-initiating documents have tended to adopt second order framings as a means to justify research, with instrumental rationales. Again, this might be viewed as an artefact of the processes of negotiation within the research council. At the same time, however, more recent documents, such as the final business case for the bioenergy dialogue complicate the instrumental rationales, for example, by making reference to a desire of encouraging researchers to reflect on the ethical and social impacts of the research that they are doing, as in objectives one and four below:

1. "To enable PIs and others to undertake public engagement activities around bioenergy research and the issues surrounding it

4. To allow principal investigators refine their research direction to improve the social relevance of their research" (BBSRC, 2011g)

Now whilst helping to constitute the character of an organisation, documents should not be taken as being representative of the entire realities of daily practice. Here, my own work completed during secondment to the BBSRC (R. D. J. Smith, 2013), drew on interviews with staff at the BBSRC to emphasise that for some, there is more at stake than simply legitimising research-funding decisions. This was, for example apparent in some of the discussions with members of the Communications and Information Management Group (CIMG). Individuals noted that during on-going public engagement training for scientists, a wide range of motivations for public engagement are often discussed, ranging from the functional (e.g. increased employability) through to more substantive and normative reasons (e.g. engagement acts as a reality check, exposes you to diverse values; a moral obligation to transparency) (BBSRC, 2013d). Having considered both the assumptions within research funding and engagement discourse and action, I now conclude by reflecting on the way that the organisation distributes responsibility for 'the ethical' and ultimately creates a role for itself between social and scientific forms of life.

6.5 Distributing responsibility, creating a character

In this chapter I have traced the BBSRC's discourse and actions over a twelve-year period. From this analysis, several themes can be teased out, themes that provide insight into the way that the BBSRC managed the ethical dimensions of its research funding and distributed responsibility for addressing them. Moreover, the longitudinal focus and analytic approach adopted here make it possible to see how the way in which constructions and distributions have changed.

In the main, the research council has positioned itself as an advocate for the biosciences whose activities will unquestionably produce benefits for society. 'Issues' are largely presented as barriers that must be overcome for societal gains to be realised. This strategic positioning has gradually amplified with significant shifts observable in 2008 coming in the form of a notion of 'impact'. The research council's discourse and actions are significantly attuned to the contexts surrounding its research funding activities and to do so it has varyingly interpreted the terms of reference contained in its Royal Charter to ground decisions and definitions, such as in relation to its definitions of interdisciplinarity and funding remit. In the bioenergy case, the BBSRC's early attitude towards the wider issues associated with biofuel development and deployment shifted from initially deferring responsibility to external parties to framing them as being worthy of consideration. In this regard, it embarked on two activities: the integration of social science, life cycle analysis (LCA) and agricultural economics into its flagship research programme, and an associated programme of public engagement. The underpinning rationales for particular kinds of engagement within the BBSRC are heterogeneous: fluctuating over time, across the organisation and depending on the audience that is being engaged: Externally facing discussions embed substantive and normative rationales for inclusion, whereas internal documents often point to instrumental rationales that position engagement as a means of securing the economic benefits that technological progress can bring. Importantly, however, future attention is required to provide an in-depth interrogation of the rationales that flow around engagement practice. Now, these insights allow me to consider: a) how the research council has distributed responsibility for the task of ethics, and b) what this and these insights mean for the role of the BBSRC. I take these reflections in order.

6.5.1 Distributing responsibility for the task of ethics at the BBSRC

In 2006, the BBSRC was faced with a dilemma characterised relatively well in the bioenergy review. The research council needed to respond to government pressure to fund bioenergy research, but judged the funding landscape to be crowded. To proactively manage this dilemma, the research council made use of the notion of 'underpinning bioscience' to allow itself to act unilaterally with the intention of mobilising the existing plant science community to build capacity in bioenergy research. This use of remit worked to articulate definitions of interdisciplinarity that were limited to combining different biological approaches of analysis. The research council also responded to a rapidly developing socio-technical network by maintaining a relatively technologically-ambivalent position whilst at the same time being keenly aware of previous controversies (most prominently around 'plant biotechnology'), resulting in an initial orientation that emphasised the importance of low-input, multipurpose and sustainable 'public good crop science' (BBSRC, 2004).

This ambivalent but bioscience-specific orientation was abandoned during the 2007-09 negotiation period: In contrast to the broad but bioscience-oriented bioenergy initiative, BSBEC's focus was on "'second generation' bioenergy research that uses non-food crops and woody biomass as its feedstocks" (BBSRC, 2009a, p. 15). The contents of the programme demonstrated that the focus was on biofuels in all but name. This shift embodied an abandonment of 'bioscience as remit' and represented a broader definition of interdisciplinarity, as sustainability themes of social science, agricultural economics and life cycle analysis (LCA) were integrated into what was originally a plant science programme. All of these changes can be cast as responses to maintain the BBSRC's activities as acceptable in the face of a dynamic context: The focus on 'second generation' biofuels was explicitly positioned as a response to the food versus fuel controversy; The purpose of integrated sustainability analyses was presented as ensuring "that the research addresses societal issues as well as scientific and technological challenges" (BBSRC, 2009a, p. 15); And in line with wider debates, 'societal issues' were framed in the language of sustainability.

Whereas initial assessments cast responsibility for the impacts of biofuel development and deployment as outside of the research council's responsibility, preferring to maintain a claimed neutrality of future options, a crescendo in controversy resulted in the drawing in of responsibility; 'responsibility' now meant ensuring that the kinds of biofuels that were advocated by the BBSRC's programme needed to be seen to be sustainable, which required a change to the agenda. However, practical authority for conducting this work fell to the social scientists, LCA practitioners and agricultural economists. Previous experiences with public dialogues, as well as the fragmented make-up of BSBEC, shaped the form that the bioenergy dialogue took. The objectives of enabling researchers to partake in public engagement', informing policy and strategy, and contributing to the national debate have all been part of the desires of previous dialogues (IPSOS Mori, 2012; MRC et al., 2008) with varying degrees of success (Grant and Gardiner, 2011; Mohr, 2008; Rowe, 2012). However, the bioenergy dialogue shifted the delegation of responsibility from market research companies, to individual researchers in the field. This approach *prima facie* aligns to the objective of enabling researchers to undertake public engagement and consider the wider implications of the work that they may be doing; in this case researchers are encouraged to play an active role in their own dialogues where they discuss the 'ethical issues' of their field, while the BBSRC acts as enabler of reflection by developing framing tools for discussion.

Finally, the undulations in agenda setting have enacted particular visions of technological futures. As the BBSRC responded to controversy, re-framing the orientation of its funding towards increasingly specific ends, it has created a narrowed vision of research outputs. This initially occurred in the shift to 'second generation' biofuels, but has continued as the research council has continued to shift towards a vision of production that is more tightly attuned to industrial biotechnology. Such shifts in implicit normative visions are to be expected, but the consequences of them are best understood by considering the way in which responsibilities are distributed internally within the research council.

Recall from the start of the chapter that the research council operates on a compartmentalised basis; hierarchically organised groups, units and teams are responsible for delivering different aspects of corporate strategy through policy statements and activities. These compartments are supplemented by a web of advisory committees. Activities formally designated to address 'ethical and societal issues' are contained within the remit of one cluster of people, the external relations unit (ERU). As such, and as the case of bioenergy shows, other actors within the BBSRC frequently delegate 'the task of ethics' to this unit and its panel (*Figure 6.7*, facing).

The clear demarcation of engagement across the BBSRC is demonstrated well by the case of bioenergy. Despite this demarcation, the example also demonstrates the complex web of interactions set up to oversee engagement. In 2006 the bioenergy review suggested that public engagement and ethical issues should be addressed, and subsequently enlisted ERU to draft a policy statement and programme of public engagement on the matter (BBSRC, 2007h). ERU drew on its respective advisory panel (BSS) to help guide and review these activities (*Figure 6.8*), eventually convening a 'working group' (BSBEC CPE, later renamed BSBOG) to oversee the process of engagement for the whole of BSBEC (BBSRC, 2009d). BSS's advisory capacity was thus supplemented with the BSBEC CPE panel and, for the bioenergy dialogue, a 'process sounding board' (*Figure 6.8*, facing), set up to act as a panel of external engagement experts (without any mandatory power) to be called upon by the bioenergy dialogue coordinator. Formal responsibility for bioenergy engagement

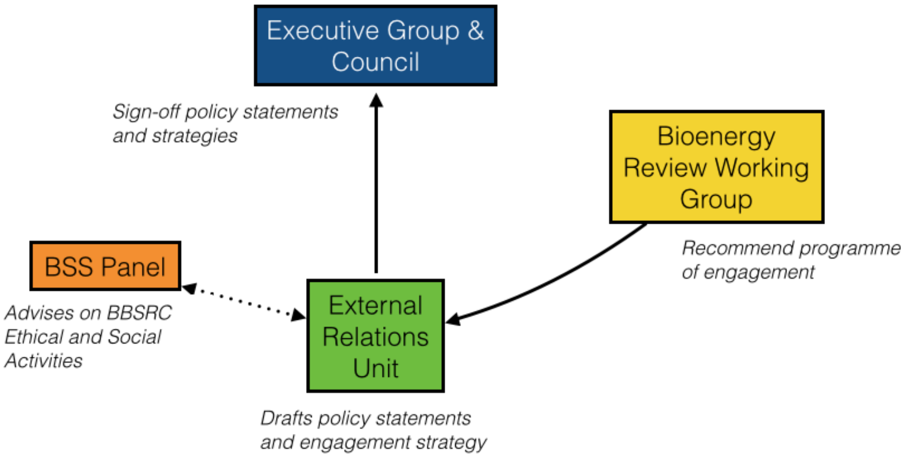


Figure 6.7: *Delegation of the task of ethics within the BBSRC, 2006-2010*

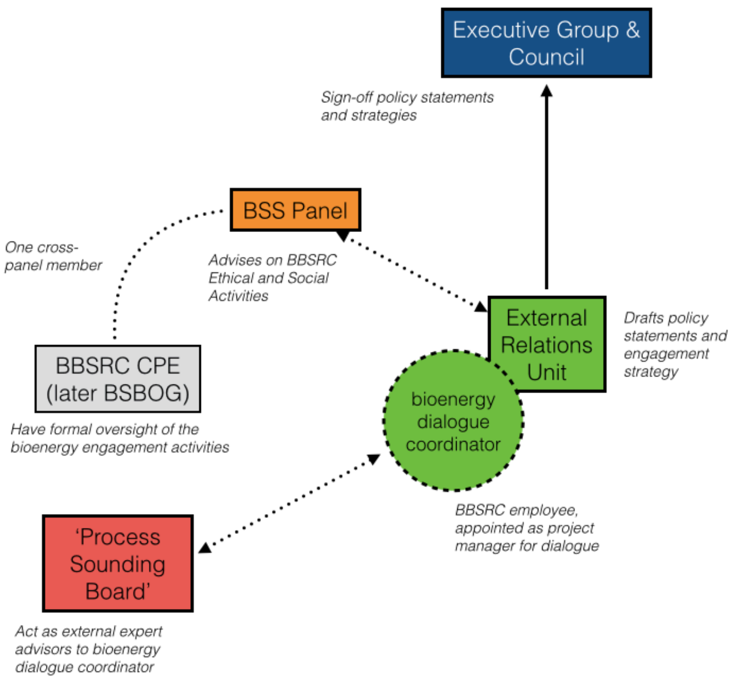


Figure 6.8: *Delegation of the task of ethics in bioenergy within the BBSRC, 2010-2013*

activities therefore rest within ERU, with formal oversight to be provided by BSBOG. Shared membership of this group with BSS, other panels, such as the IBBE panel, and across BSBEC PIs was intended to provide both the means to provide organisational 'buy-in' and a route through to inform strategy.

In some respects, BSBOG could be said to have succeeded in its purpose. The formal review of governance of the bioenergy dialogue drew on interviews with BBSRC employees to conclude that there was good organisational buy-in to public dialogues as a whole (Collingwood Environmental Planning, 2014a). Despite this buy-in, and perhaps because of the clear ownership of public engagement, there is a noticeable tendency from other teams to defer to ERU when discussing both the motivations for conducting public engagement and actually conducting the activities (R. D. J. Smith, 2013). Now on the one hand, this form of delegation is necessary for the organisation to function. On the other however, it presents a significant barrier when attempting to take the outputs of public engagement through to strategy-forming, embedding institutional learning and reflexivity that has been prescribed (Chilvers, 2013; e.g. Wynne, 2006). At an ideological level, despite the day-to-day deference, individuals are likely to maintain their own perceptions of what the role of public engagement should be in decision-making in BBSRC. At a pragmatic level, the deference and complex web of oversight means that 'timing' plays a fundamental role in shaping the form and outcome of engagement activities; by the time the bioenergy engagement activities had been completed, there was no potential for them to shape research funding practice in either bioenergy or industrial biotechnology.

6.5.2 The changing role of the BBSRC

To conclude, I consider the way that the BBSRC has varyingly constructed its role within research governance, at the interface between political and scientific forms of life. To do so, I draw on Stephen Hilgartner's incisive and articulate work at the US National Academy of Sciences (Hilgartner, 2000). Hilgartner draws on the metaphor of performance articulated by Goffman to draw distinctions between 'front stage' and 'back stage', and teases out a wide range of strategies that science advisors use to construct themselves in varying lights at particular points of time. As we have seen, the BBSRC has exercised similar malleability in interpreting and emphasising particular parts of its role. For clarity, these roles can be mapped against its formalised terms of reference. Loosely translated, the three terms of reference within the BBSRC's Royal Charter equate to: the provision of scientific advice to government and society; enabling societal benefit; and, supporting the development of the biosciences.

In early orientations (between 2003 and 2006), the research council largely positioned itself as 'defender of the biosciences', from which impacts and benefits would inherently flow. Interdisciplinarity, although emphasised, was defined within the biosciences. As biofuels were placed as a funding priority however, a rebalancing occurred in response to government pressure to demonstrate economic impact. This, coupled with increasing controversy in the biofuels arena meant that the BBSRC reinterpreted its terms of reference to orient them towards ‘producing benefits’. With a much tighter-coupling to research outputs, it was also required to reframe its version of interdisciplinarity, broadening it to include the social sciences and economics. This increasingly strategic realignment has continued, with more recent documents positioning the research council as delivering on ‘societal grand challenges’, perhaps most clearly set out in the 2010 *strategic plan*, which declares the 21st century *the age of bioscience* (BBSRC, 2010b, p. 1). In doing so, it re-deploys the the 2003 strategic plan's 'priority areas' to fit with the new impact-driven world of UK research, explicitly setting out three grand challenges that demand bioscientific input:

> "feeding nine billion people sustainably by 2050 [i.e. food security]
>
> developing renewable ‘low carbon’ sources of energy, transport fuels and chemicals to reduce dependence on dwindling oil reserves [i.e. industrial biotechnology and bioenergy]
>
> staying healthier for longer as lifespans increase and society ages [i.e. health]" (BBSRC, 2010b, p. 1).

The consequences of this new role is best captured by the 2011-2015 delivery plan:

> "BBSRC has moved from the position of a funder to an "investor" of public funding in excellent fundamental and strategic bioscience to achieve the greatest short, medium and long–term returns for society and the economy. It is a shift in culture that we are determined to see through, showing leadership, employing deep sector knowledge, working with others and with regard to the sustainability of UK bioscience." (BBSRC, 2011b, p. 9)

Whilst the consequences of this shift are relatively opaque, at least one shift is visible in the subsequent 2013 refresh of the strategic plan:

> "New technologies can be disruptive to society and they can raise social, ethical and legal issues. As an investor in research BBSRC recognises its responsibly to engage with these issues and to support our researchers to do the same." (BBSRC, 2013e, p. 21)

Thus, by explicitly recasting itself as a facilitator, or more accurately ‘investor on behalf of the public’, the BBSRC explicitly opens itself up to questions about the kinds of voices that are dictating and steering funding choices, the kinds of futures that are selected and the ones that are shrouded out. Questions about the ‘public value of science’ (Stengel et al., 2009) thus become fundamental to ask for any conception of ‘the ethical’ in a new age of grand challenges.

Chapter 7

Scientists' constructions of the ethical: Issue types and strategies

So far, I have drawn attention to and discussed the intrinsic role that scientists played in the development, assessment and societal discussion of biofuel use. Chapter two presented the argument that scientists and scientific knowledge were both central to debates around the use of biofuels. In chapter three, I suggested that what is deemed to be of relevant 'ethical concern' has shifted within academic debates. It is, however, unclear how this broader concern with 'the ethical' exists within bioscience research contexts. Whilst the chapter analysing the discourse and actions of the BBSRC largely focused on practices within the organisation, it noted that the research council has recently begun to make explicit reference to the need for scientists to engage with the ethical and social context of their work. Certainly, biofuels raise a wide range of issues that seem to warrant broad ethical reflection but the previous chapters have pointed to uncertainties regarding both the responsibilities of scientists and the ways in which they, as individuals might actually construct different understandings of the ethical dimensions of their work.

This penultimate chapter therefore focuses on the making of 'the ethical' within research visible in the accounts of scientists; on questions that provide insight into the ways that terms come to be defined as ethical or not, on the ways in which such allocations might influence and shape scientific practice, and how these categorisations and transformations might loop back to affect the ways that policy is implemented. In doing so, the chapter examines the ways in which twenty-two scientists in the UK construct 'the ethical' in talk about their research and the implications of this for a notion of social responsibility within research practice. Siting my analysis in a body of literature that provides examples of the ways that scientist talk about ethical dimensions in complex, diverse and nuanced ways (Burchell, 2007a; e.g. Kerr et al., 1997; Michael and Birke, 1994; Pickersgill, 2012; Wainwright et al., 2006), I make a tentative suggestion that researchers develop a concept of ethics alongside their own research. This concept is therefore malleable;

shaped by research experiences and adeptly deployed in different circumstances by individuals for both strategic and pragmatic purposes – that is to get work done. It is therefore inseparable from research, co-evolving with practice, policy and everyday life. Such a malleable concept of the ethical has implications for research policy, particularly concerning individual and collective responsibility. It also raises issues regarding the current points at which ethical dimensions might be considered in the research process.

The chapter unfolds as follows. First, in *section 7.1*, I examine the ways that the twenty-two scientists interpreted the term 'ethics' and the diverse ways in which they cast different issues in relation to their own practice. Second, in *section 7.2*, I outline four different discursive strategies that emerged in an inductive and iterative process that blended the interview data with theory. These four strategies allow researchers to manage the ethical dimensions of their work, for example by shifting them in and out of relevance. The consequences of taking such diversity seriously are considered in the concluding *section 7.3*.

7.1 Constructions of 'the ethical'

In analysing the constructions of ethics that emerged during interviews, I first wish to turn to the responses that interviewees gave when asked to 'define what ethics meant as part of the research process'. Here, the majority of researchers (n=18) constituted 'ethics' in one of three clear and ordered ways - either as 'frameworks', 'impacts' or 'research integrity', which are described below. In subsequent subsections however, I note that further analysis suggests that the utility of these academically common and institutionalised conceptualisations might be limited in representing 'the ethical dimensions' of biofuels-relevant research in day-to-day practice. As a result, I suggest that efforts should be focused on developing a new, more contextually aware and personal notion of ethics within research.

7.1.1 Three common conceptualisations of ethics

The idea of using frameworks as devices for decision-making around ethical issues in science is common (e.g. see K. K. Jensen et al., 2011; Kaiser et al., 2007; Mepham, 2000). It is of no surprise then that researchers used such a metaphor as a way to articulate the normative aspects of their research. Rather than being a heuristic tool to structure normative decisions within a research project, here a framework was most frequently characterised as an underpinning guide to research in much looser terms such as "a broad philosophical framework (S2A, pa.56) or a "context" (S3A, pa.44) to work within. This context was often positioned as vague and hard to define, but important. As S3A put it, "if you're not looking at that whole picture, then you're not going to be able to get a feel for whether you're actually creating more problems than you're solving" (S3A, pa.44). In the field of bioenergy, such a context is often wider debates about land use, sustainability, food versus fuel issues and climate change, all of which could be seen as co-producing 'wicked problems' (Mohr and Raman, 2013; Palmer, 2012). Despite this complexity, some participants positioned an understanding of this ethical framework as fundamental to research - ostensibly on a par with "space, money, time and people" (S3D, pa.38).

A second way that people initially presented ethics was in terms of practices commonly captured by the term 'research integrity'; characterised in terms that drew on ideal traits of a scientist (e.g. 'honesty', below), or in terms such as 'maintaining the standards of the experiment' or 'being efficient' in the way they work. As S7B considers,

> "Ethics as part of research. So I would say not doing anything dishonest, so not trying to manipulate outcomes, being honest about the data that you're producing, and honest about the outcomes and how you present it to people. Because it can be easy to, because science isn't black and white, despite what people think it should be, it's hugely full of grey areas and caveats when you get your data, so being honest about them I would say." (S7B, pa.34)

At the point of experimentation and data generation, S7B contends that there is epistemic uncertainty. There is flexibility to interpret findings in many ways and make claims based on those interpretations. For this participant, ethics at least partially translates into a demand that individual researchers are both rigorous in their method and careful in the knowledge claims that they make from experimental data. Honesty about the caveats and processes of collection and interpretation will allow others to interrogate the validity of suggested knowledge. Of course, this idea of 'research integrity' is a well established concept and in this sense is fundamental to 'good' science:

> "You can't publish anything if you're not 100% satisfied that you've been, you've approached it in the right way and what you're saying is exactly correct. […] I guess that's the only real aspect." (S6B, pa.109)

Along with the oversight processes of Research Ethics Committees (RECs), ideas about research integrity are perhaps the most common way that ethics is directly spoken about in research policy (Weil, 2002). Both Responsible Conduct of Research programmes in the US (Pimple, 2002) and the universal ethical code for scientist, *Rigour, Respect and Responsibility*, in the UK (Government Office for Science, 2007), which many scientific bodies sign up to, each place research integrity as central tenets.

Whilst some researchers constructed a sense of ethics around the analogy of a framework, and a significant amount made use of the idea of research integrity, the majority framed 'the ethical' in terms of considering the outcomes or consequences of their research. Again, a vagueness was visible, framed in terms such as: considering the “impacts on society from our point of view” (S3B, pa.43); “thinking through to the end” (S1A, pa.18); deciding whether research might “have some outcome that could be [positive or] negative for some part of society” (S7A, pa.28); or a “sense that biofuels should be more democratic than previous petrochemicals” (S2A, pa.58), that generally scientists, “should be trying to improve society’s lot in life” (S2A, pa.58). Once again, this particular conception of the ethical is unsurprising given the prominence of assessment methodologies in the governance of technoscientific arenas and the institutionalisation of phrases like ‘research impacts’ and the ‘science and society’ relationship within UK research institutions. Research into the development of biofuels clearly has its ultimate desire in application (although as we have seen in previous chapters, and as will be discussed later, this applied-basic boundary is entirely malleable). In each of the above presentations, the scientist relates themselves to the applied context of their work, positioning ethics as ‘considering the consequences of application’ and then linking that back to the research at hand. Indeed for many, working within an explicitly applied research context demands that due consideration be paid to the potential social, political, environmental or ‘moral’ impacts of the research and any subsequent technological artefact or practice.

7.1.2 Ethical (in)visibility

Despite the sometimes rudimental articulations and the obvious differences in the level of focus - ranging from quite high-level thoughts to low-level, relatively micro, concerns to do with the practice of science in the laboratory - researchers almost unanimously agreed that consideration of ‘the ethical’ was important to the practice of science. As one principal investigator puts it,

> “None of us should be doing research without some concept of what we’re doing, what the ethical implications, directly in our day-to-day work, but also at a bigger level, what the potential consequences are if what we do is ultimately successful and goes out and does have an impact on the world (S3D, pa.38).”

At the same time as ‘ethics’ being referred to in these initial terms, and despite it being described as important, just under half of the researchers that I spoke with either prefaced or accompanied statements about the nature of ethics with phrases such as, “for me, ethics is a very difficult term to define” (S2A, pa.56) and “sorry, they’re not easy to answer” (S1B, pa.32). Others commented on the relative nature of ethics. As a reader in plant physiology describes, people have “very different ideas of what it [ethics] means” (S5B, pa.44).[12] This idea of the relative nature of ethics was questioned by others, who asked “who defines what is ethically acceptable and not? Is

[12] Bear in mind that nearly all of those interviewed did actually present an articulation of ‘the ethical’, usually in one of the three ways described above.

it society? Is it the government? Is it committees?" (S3B, pa.43), suggesting that your idea of the ethical would likely be determined by the "value system in which you live, have been brought up in" (S3C, pa.76). All of these quotes suggest that for many, pinning down an understanding of 'the ethical' was at least challenging and in some cases problematic.

Further, when discussing practice some scientists claimed that ethics essentially played no role in their daily routines and was not discussed within 'the lab': "Well I don't know... I've never given it a second thought if I'm honest" (S2B, pa.83) or "I've been fairly disappointed by how infrequently it's mentioned since [her undergraduate degree] (S3D, pa.42). For S6B, a research fellow in botany, despite research integrity being "fundamental" and wider impacts being important at a basic level, he struggled to see how they impact on his research:

> "So there's that aspect of it. But I guess does that play, it doesn't really play a role in my research at the moment" (S6B, pa.111).

And similarly, for S1B, a research fellow in biochemistry,

> "You don't really think about it, or you're not necessarily encouraged to think about it because you come to work and you're in the lab and you've got a certain number of objectives to complete that are written into grants or that your boss has given you to have done and I don't know, there's no real point where you just sit down and think 'oh, what social impacts?' and I think maybe scientists, we don't always think that's important because you're quite removed I guess from the final output of your work. And your final output might just be that you write it up in a journal and you move onto your next work so you just don't really talk about those kind of things." (S1B, pa.89)

How might one interpret such quotes? They highlight a number of tensions in relation to the ethical: This is something which is claimed to be tangible, material and fundamental to practice versus an ethical that is nebulous, hard to grasp and difficult to define with little impact on practice; Something which is important, but which plays little role in day-to-day research.

Some researchers suggested that the reason for the difficulty in considering ethics in the research process might be because of a lack of 'ethical expertise' (S3D) because "there is no formal training in ethics" (S2A, pa.56). And some authors, most notably scientists and philosophers of science have made similar claims – that in order to instil a sense of ethics in research, one should focus on the training of scientists (Beckwith and Huang, 2005; e.g. see Breithaupt, 2011; Wolpe, 2006). A similar position is advocated by research funders, as evidenced by BBSRC recently establishing 'public engagement training' for researchers, which aims to "inspire and support you to carry out effective public engagement that reflects upon the social and ethical perspectives of your work”[13]. However, just as calls for education of the public assume an inability for them to engage with the context of scientific debates, such schemes and discussions thereof (e.g. see BBSRC, 2009g) suggest that scientists are incapable of engaging with the ethical content of their work, taking the notion of a public knowledge deficit and recast it in terms of an ‘ethics deficit’. To be sure, this is not to say that more and better training will not provide benefits in the form of much-needed institutional space for ethical reflection and will make some contribution to the production of a more ‘socially robust’ science (or at least more enlightened graduates). However, here I wish to focus more on the ‘nature’ of ethics as an attempt to begin to challenge some of the more dominant conceptualisations within research policy and bioethical discourses. First, I consider the kinds of ‘issues’ that were viewed as being of concern by scientists.

7.1.3 Complicating ‘issues’

As a collective, scientists articulated a wide range of issues that were important to consider. An overview is presented in table 1. Issues are grouped into those classified as inherently ‘moral’, impacts derived from research into / the deployment of biofuels, broader issues that were often presented as being part of the biofuel context, and issues related to research in general.

Considering the far left column in table 1, almost half of the ‘issues’ were related to the impacts of biofuel production. This mirrors the previously discussed ‘definitions of ethics’. Across the interviews as a whole, a preponderance of thirty-six different issues were raised, covering a broad range of topics including but not limited to: feedstock choice; land salination; impact on communities; efficiency of production and of work; animal experimentation; food versus fuel; the role of genetic modification; GHG emissions; the impacts of invasive species; land use; human welfare; and the all encompassing notion of democracy in science and the development of technology. Of these, the potential for biofuels to conflict with food production (raised by 12 individuals), the use of genetic modification (n=9), industrial collaboration (n=7) and impacts on land use (n=6) were the most widely viewed pertinent issues. Concern with GM, despite its relative absence from biofuel debates echoes the BBSRC’s concerns about the public perception of GM methods and the need for care to be taken in this area.

Many of the issues presented in this table are deserving of extensive analytic treatment in themselves, treatment that cannot be provided here, but as earlier

[13] BBSRC public engagement training, available at: http://www.bbsrc.ac.uk/funding/awardholders/public-engagement-training.aspx [Accessed 11/2/2014]

Issue Group	Issue	Total
'Moral' Issues 28	Food vs. Fuel	12
	GM	9
	Animal Experimentation	4
	Medical Ethics	3
Research / Technology Impacts 34 (52)	Waste	5
	Water Use	5
	Crop Choice	4
	Efficiency (of Production / in Work)	2
	Farmer Choice / Impacts	2
	GHG Emissions	2
	Land Use Change (specifically ILUC)	2
	Landscape Change	2
	Nitrogen Use	2
	Algal Microclimates	1
	Biodiversity Impact	1
	Exotic Species / Crop Traits / Invasiveness	1
	Impact on Community	1
	Land Salination	1
	Soil Carbon	1
	Tourism Impact	1
	VOC emissions	1
Broader Issues 23	Land Use (& Marginal Land)	6
	Fossil Fuel Depletion / Energy Transitioning	4
	Sustainability	4
	Level of Production Centralisation / Plant Location	3
	Climate Change	1
	Energy Alternatives	1
	Energy Security	1
	Global Resource Allocation	1
	Human Welfare	1
	Planning Deregulation (& Land Implications)	1
Non-biofuel specific (but relevant) 19	Industry / Commercialisation	7
	Policy / Research Intertwining	4
	Research Funding (including hype and expectations)	4
	Democracy / Democratic	2
	Guarding against 'short term wins'	1
	Public Access to Data / Transparency	1
		104

***Table 7.1**: Issue counts and types, presented by scientists. Totals represent the number of participants who raised the issue. Overall total therefore represents the total count of issues identified across the sample. The bracketed number (52) under Research / Technology impacts represents the inclusion of food versus fuel and land use changes as impacts of biofuel production, although these issues were also characterised as 'moral' and 'broader'.*

chapters have shown, has been given in both the scientific biofuels literature and adjacent fields, such as STS and bioethics (Gamborg et al., 2011; Mol, 2010; 2007; P. B. Thompson, 2012). Soil carbon impacts, land use impacts and competition with food are all under scientific scrutiny. Topics of 'hype' and 'expectations', and the interface between science and politics, for example have become stalwarts within STS (N. Brown and Michael, 2003; e.g. Hedgecoe, 2003; Hedgecoe and Martin, 2008).

The majority of researchers positioned their own research as having the potential to solve widespread issues, such as 'food versus fuel'. Some, however, acknowledged the complexities in this area. In response to my suggestion that the success of his research could actually lead to future normative choices about allocating digested plant walls between animal food and fuel, S7A, a professor, shrugged and commented "yes, good point [laughs]. Can't win sometimes" (S7A, pa.126). Comments such as this might represent a sense of futility that sometimes rose to the surface in some of the interviews that is important to consider as scientists are increasingly encouraged to think about the consequences of their research and design programmes accordingly. Taken together, the diversity of issues and the above response point to an 'acute socio-ethical tuning' of scientists; issues of concern span issues fundamental to the research process (e.g. with the process of gaining funding) through research and associated technological impacts, to broad questions about distributive justice and sustainability. This has lead others, such as Brown and Michael (2001) and Hobson-West (2012) to declare scientists as 'sociologically sophisticated actors', a point echoed here. Of course, being aware of 'ethical issues' does not mean that such issues automatically warrant consideration.

Now, in contrast to work which seeks to structure ethical debates (e.g. see Gamborg et al., 2011; P. B. Thompson, 2008), my interest here is on shedding light on a number of analytically interesting points that might then be used to complicate the ways in which one conceives of 'the ethical' within research practice. Therefore, in progressing I wish to point to two trends that emerge when turning attention to the nature of ethical issues in a broader sense. These trends cut across several 'issue types' and point to a level of nuance in many of the accounts of participants as a whole, particularly when extending their accounts into the future. This nuance leaves notions of the ethical as being easily definable and bounded as fundamentally problematic. As we will see, some of these accounts will serve to introduce a number of later strategies for managing the ethical dimensions of research. I have split them into two groups, that emphasise the unexpected or unpredictable nature of 'the ethical' and that draw attention to the promissory discourses within the sample and some of the contestations of such discourses within the same group. Doing so serves to emphasise the heterogeneity and contingency of 'the ethical'.

Ethical visions produce unexpected ethical issues

Some researchers commented that their work either directly responds to, or is broadly influenced by various sets of ethical concerns. A core response here is the fact that in the UK research is almost entirely conducted on 'advanced' biofuels in response to concerns that first generation biofuels might compete with food production. However, responding to ethical issues could produce new, sometimes unexpected, issues that needed to be addressed and subsequently shaped the research trajectory. For S5B, this manifested in a project that they were a part of which aimed to utilise agave, a Mexican succulent commonly used to produce tequila, to produce biofuels. The selection of this plant was based on a number of factors, but primarily its low water-usage, non-food crop status and ability to grow in arid landscapes. These traits have been seen as beneficial following concerns about both direct and indirect competition with food crops. In developing the plant during the project, team members also explored the realities of application. In doing this, they discovered that "this possible planting up marginal and desert land is maybe not universally attractive to everybody in all parts of the world […] marginal lands can have their own appeal (S5B, pa.136)". As a result, the project is no longer researching with the intent of deploying the underpinning science in the application that they initially proposed.

A similar issue can be seen when thinking about the selection of crop traits in a more specific sense. In the UK, many of the researchers working in the biofuels field are plant scientists. For them, the development of crops and plants is ultimately their major research output. Recall that plant scientists working on second-generation biofuels commonly focus on either breaking down the cell wall to enable better access to fermentable components, or on developing new traits for non-edible crops or crop parts. When developing these new traits, researchers aim towards an imaginary 'perfect crop', an ideotype (S6B, pa.165). Like the project described above, this ideotype changes and responds to new developments, both technical and ethical. One researcher anticipates this: you know that these issues "will come up and you know you then, then that has to be something that you're thinking about addressing kind of like at some point potentially in the future" (S6B, pa.159). In response to concerns about 'food versus fuel' and mitigating climate change, the ideotype of a crop has become one which is high yielding and vigorous with low water input, low nitrogen input, requiring few pesticides. Essentially then – and as S3D explains – in selecting for 'environmentally friendly' traits in miscanthus (a dedicated energy crop), one also selects for a set of alternative environmental problems – in this case an extremely invasive exotic species – which may or not be foreseen and that one must protect against through de-selection of other traits. Here those traits equate to seeding and rhizome spreading but in doing so, another issue arises - seeded crop varieties are likely to be necessary to be economically viable to grow (S3D, pa.88).

These two similar examples serve to illustrate the ways in which both broad research trajectories and individual decisions respond to perceived ethical issues, often by altering their visions of outputs. However, in doing so, they are liable to produce a range of new, potentially unforeseen issues which must be considered and addressed (i.e. the value of undeveloped land and invasiveness). In the following section, I highlight a second area where visions / imagined futures and ethical issues converge.

Promises and contestations

Research funding and its commercialisation cut across broad swathes of issues, as set out in Table 1. Almost all of the issues that fall into the 'non-biofuel specific' category relate to this in some way. Here, I consider some of the complementary and contested claims across the whole set, drawing particularly on the issues of funding, commercialisation and sustainability. Such a discussion highlights that 'issues' were rarely presented in an isolated form.

A number of researchers posited that biofuels might offer the chance for a more 'democratic' production system: that perhaps biofuels should be more "democratic than previous petrochemicals were" (S2A). This more 'democratic' production system generally translates into a more decentralised model of production than the one that currently dominates petroleum production. Despite most agreeing that in reality, commercialisation of research would only happen with the involvement of industry (e.g. S2A, S3C, S5A, S7B), one researcher (S7B) suggested that there may be technical reasons for decentralisation:

> "There's also […] the involvement of industry versus government […] but the problem is if you don't then who's going to step in? […] And it's sort of the type of industry because the interesting thing I think about biofuels is that I think it doesn't have, the power can be a bit more spread. […] Whereas actually biofuels is a bit more, I think could be a bit more democratic in a weird way. In a sense, because it's a, because it has quite a low energy density plant material, you can't transport it too far or you start to lose any profits quite quickly, so one model for extraction could be almost that you have each village, each village could have a very small processing plant, at least processed to a certain point, which means that actually profits become a bit more spread." (S7B, pa.120)

In this quote, S7B agrees that realistically, commercialisation of the research is going to rely on industry investment and development. However, she couples potential technological options to the way that this investment occurs and what the final market would look like. The constraints imposed by the realities of the technology and the material (i.e. the low energy density and bulk of biomass) that is being worked with might result (in the UK at least) in a more heterogeneous market, which would alleviate concerns about the dominance of a few big companies that have previously marred other biotechnologies. Echoing Winner (Winner, 1986a), she suggests that there might be political and normative implications that are fundamentally embedded within the nature of the technology. Therefore decisions such as funding allocations and the structuring of research programmes are not benign. There are choices to be made regarding the final system of production. Nevertheless, some tied the realities of commercialisation to their more sceptical claims. In a number of discussions, researchers claimed that they themselves had either witnessed the sidelining of scientists or made general statements of the kind (e.g. S2A, S6A, S7A). Despite this scepticism, most did argue that on the whole the biofuels field was responsive to a broader social, ethical, political and environmental context. Sustainability and a concern with the wider context had always been driving biofuels research, which some claimed to be, "sewn up pretty tight" (S3D, pa.156):

> Well they've always been there. Originally, back in 1990 when I started, the [pause] there were mountains of food in the EU, right, so too much food was being produced and […] the land base was coming from set-aside and that was a very simple justification for where would you put your bioenergy. Now I think we were all aware of the rise in population and nobody was quite sure about how food production technology would whether it would keep up with it or whether it would outpace it. […] So back then it was kind of set-aside, and climate change. I mean climate change has always been on the agenda […] I mean every proposal that ever went in will start off with something along the lines of, 'the two major global challenges are, 1) increasing CO2 in the air' and it went may, will, is, causing [laugh] global warming. Because the confidence in the global warming story has been ratcheting up during the time that we've been doing this research. [laugh] (S3A, pa.46-54)

S8C made a similar point, claiming that the bioenergy field might actually avoid some of the overblown claims that could be dangerous in fields such as medical research.

> "**S8C:** You might claim that you're going to find a cure for cancer or Alzheimer's but you might be going about it in a way that might raise ethical issues. Not quite so clear-cut in my mind, whether the ends might justify the means.
>
> **Rob:** Whereas for this kind of research it's very firmly?=
>
> **S8C:** =I think it's been thought out in greater detail up front because I think it has given weight to the yes, it's the reason that these areas of funding in bioscience have become priorities. […] greener, better environmental credentials, that's why the funders. The funders have identified that's important. Global warming et cetera, we need to do work on this in biosciences. What are we good at? Biotechnologies. We'll propose funding programmes, we'll sort of offer up initiatives in those areas. So that's the sort of logic I think. I suppose in the medical world it would be quality of life." (S8C, pa.124-128)

For both S3D and S8C, the biofuels field represents a research field that responds to a concerted concern with both broader issues, of excess land allocation as a result of agricultural policies that resulted in excess food production in the 1980s and 90s

(Okken, 1991), and later the impacts of climate change. For them, notions of sustainability fundamentally underpin the work that goes on in this area, with the latter (S8C) suggesting that this concern helps to ensure that the support given to research is not set upon questionable foundations, as might be the case in other fields such as medical research. Of course, mobilising concern for an issue within grant applications, a widespread practice (Upham and Dendler, 2015), should not in itself lead one to conclude that this represents substantive engagement. This was a subtext to much of S2A's articulations, who contrasted the way that the biofuels project was "sold to the world" (S2A, pa.22) with the realities of research; although the "majority of people working in the area are doing so with the best of intentions, there's very little oversight" (S2A, pa.26). As such, there is currently no way of knowing how substantively research projects are engaged with the grand challenges to which they tie themselves in public and grant application stages. Taking the notion of sustainability as a case in point:

> "It's difficult to know how to measure how green your process, your technology is, in any meaningful sense. Because what does that mean? Something as simple as reducing carbon emissions, possibly at the cost of storing up some sort of problem for later generations, you just go and somehow throw all your carbon in a hole in the ground. Does it simply mean that natural is good, which is one of these things that runs through the field and I think appeals to consumers as well?" (S2A, pa.40)

S2A deconstructs the notion of sustainability in ways similar to many of the NGO interviewees (in chapter 6), finding superficial notions of 'green' and 'sustainability' highly problematic. Drawing attention to metricised conceptions of sustainability, the researcher suggests that any attempt to credibly measure sustainability is futile. Measurements have implicit value judgements and once again, decisions made on those value-laden measurements have the potential to produce future issues. Unreflective conceptions of 'naturalness' are equally problematic and impoverished, often reverting to equations that place natural as a proxy for 'good', which ultimately act as public relations tools. Currently, he argues, that it is therefore difficult to see statements in research grants as much more than artefacts being produced by current research funding mechanisms, which,

> "Create the vested interest of any researcher in that first and foremost what you want to have is a job at the end of it. So in that respect all of those things affect the purity of what you're doing, and I guess in some way it must bias in the end, your approach, what you're doing" (S2A, pa.34).

Again echoing some of the more critical NGOs, S2A ultimately links what he sees as superficial engagements with issues back to the self-invested situation of researchers. This self-investment ultimately impacts on the structure, practice and epistemic quality of the knowledge produced. This, for him, is *the* major issue in research.

Now although many acknowledged that vested interests, from both research funding and commercial involvement might be problematic, S7B, another research fellow, suggested that for her this 'vested interest' could have a unique consequence:

> "I've written, we've written a grant and I've said that I would do x, y and z and really detailed science language and my aim is to produce x, y and z outputs which would fit with what I would said I would do. So the theoretically I could just leave it at that but I think that you would reasonably say that you had done what you were asked to do." (S7B, pa.60)

To demonstrate this, she draws on the example of miscanthus, a favoured energy crop in advanced biofuel research:

> "So there was this thing about looking at miscanthus […] On paper it's great so it doesn't use much water, it doesn't use any fertilisers, blah blah blah, but the thing is you have to harvest it once it's completely died back [… when] all the nutrients have gone back to the rhizome underground […] leaving just carbon in the grass above more or less. […] The thing is, that's round about January or February in the current climate and all the farmers were like, 'well have you ever tried to harvest a field in January? All our tractors are going to get stuck.' And so, and that's the sort of thing that you go 'oh yeah, huh. Right'. And so you could actually do all this work and it could be for nought" (S7B, pa.60)

For this researcher, investment in a particular field at an early stage in her career actually created an obligation to go beyond her research proposals: The application of her research is ultimately intertwined with the success and continuation of her future profession. A research grant that was tightly focused on elucidating the molecular characteristics of the plant cell wall could arguably be met by research solely inside the lab. However, for success beyond this, she needed to "go a bit further" (S7B, pa.60) and engage substantively with the material and contextual nature of her research. Doing so has not just epistemic benefits – it produces better knowledge – but also professional benefits – a more sustainable career for herself.

So far I have drawn attention to the range of issues that emerged in these discussions with biofuel scientists. The breadth and diversity here is notable. Although well-versed issues such as 'food versus fuel' and land use implications were prominent in discussions, others such as indirect land use change (ILUC) were less visible. Furthermore, the acute concern with GM, framed as an explicitly 'moral' issue alongside animal experimentation, signifies a chronic focus with issues of public concern. These observations suggest that scientists are at least superficially engaged with the ethical and social context of their work. To take delve deeper, I examined in more detail two novel and contested claims to substantive engagement (*Subsection 7.1.3)*. Taken as a whole and individually, this group of researchers point to some of the messy, uncertain and contingent nature of 'the ethical' within the development of biofuels, and indeed the biosciences more generally. The breadth of the discussions hints that consideration of 'the ethical' might not fit neatly into the original categorisation above of impacts, integrity and framework. To this end, in the section that follows I begin to unpick some further discursive repertoires that begin to complicate standard understandings of ethics.

7.2 Four strategies for managing 'the ethical'

The accompaniment of on the one hand clear ways of 'defining ethics' with on the other statements about the relative and nebulous nature of ethics, often in the same interview, indicates that there may be value in exploring a conception of 'the ethical' in research which is made and created alongside the research and as something which can be both actively and passively 'made more or less visible'[14]. In order to begin to characterise a more complex notion of ethics, below I present a number of empirically-derived 'strategies' that sit along a spectrum of visibility.

Sitting at the visible end of the spectrum, a process of 'translation' forms the major strategy (*subsection 7.2.1)*. This shifts an often-nebulous sense of the ethical to a specific, contextual, often application-oriented, issue of concern. Two subsequent strategies of 'shifting frames' (*subsection 7.2.2)* and 'embodiment in proxies' (*subsection 7.2.3*) have a less clear-cut and more pragmatic nature. On the one hand they hide ethical dimensions, making them less visible, but on the other they replace these dimensions with alternatives which are manageable and represent normative concerns. A key question here is whether anything is lost in the process of doing so. Finally, drawing on notions of 'boundary work' (Gieryn, 1999; 1983), I note that researchers often mobilised and moved the boundaries around their research and any associated ethical issues (*subsection 7.2.4)*. Although this is most commonly implemented to distance themselves and hide ethical dimensions, some researchers used these strategies to tie themselves to ethical obligations. This fourth and final set of strategies have clear implications for the construction of responsibility for the individual and at institutional level and in the subsequent chapter I focus on the consequences of a more malleable and constructed notion of ethics for

[14] Here, it is worth noting that two approaches to scientists' representations of ethics could be taken. The first would, to put it crudely, be to take their talk at face value. In this case, the consequence would be that traditional ways of thinking about ethics in research might not in themselves be useful. A second, more critical approach (adopted here) would highlight the ways that participants mobilise the uncertainties and vague aspects of ethics to manage ethical and non-ethical realms in various ways, in order to position themselves and their research as ethical but also 'legitimate', despite being potentially controversial. In both of these approaches normative implications follow for practice. Either work needs to be done to ensure that frameworks, impacts and research integrity are more readily translatable into real-research situations, or; Attention must be paid to the ways in which the boundaries between ethical and non-ethical are manipulated and managed to ensure that legitimate concerns and individual responsibilities are not 'framed out' of the practice of science.

'responsibility' and institutional structures such as research funding policy. In describing a series of strategies for managing the ethical dimensions of research, I note that an often key function of them is to allow scientists to do ethical research whilst preventing a kind of 'paralysis by reflexivity' (Pickersgill, 2012). To employ any of the strategies below requires work, either on the part of the researcher, the research funder, publics or any number of different actors that converge around a given technology (Fujimura, 1987).

7.2.1 Translating 'the ethical'

'From theoretical to contextual'

The first strategy, 'translation', involves the shifting of 'the ethical' from a dissonant theoretical discussion to a contextually specific resonant and local reality. Earlier in the chapter, I pointed to the fact that over half of the total 'ethical issues' raised related to the impacts of biofuel development and deployment. Within this group a total of seventeen different issue types were raised. Impacts including the impact of biofuel production on biodiversity, soil-carbon, farmers, the landscape, local populations were all raised. Researchers clearly have no trouble identifying potential ethical hurdles that their work raises. At the same time however, recall that they sometimes 'struggled' to articulate how the ethical dimensions relate to *their own* work. When impacts, the ethical, and the specificities of the research align however, rich, complex and occasionally enthusiastic descriptions of what 'the ethical' would be constituted by emerged. Consider the example provided by S5C, a marine biologist, who talks eloquently and positively about the ethical requirements if one is to 'have an impact':

> So if you want to have an impact, you've got to make sure that you know **how it's going to fit into business** and **whatever it is you want to target towards**. So if we want to have that impact we've got to know **who we're going to target it at, what they need**, if they we have to keep the people on side, if we lose our labour force because if you're talking about growing algae, you're talking about really industrial scale stuff **you need to keep your workforce on side**. Need to make sure they get something out of it. The **company you work** with, they need to see a product from the algae that they can utilise. They also want to, in this case, give **something back to the people**. Because from what I understand it, the locals lost quite a lot of their land whenever the company started setting up this business so I think there's a bit of sort of payback. Yeah. **It's trying to balance all those agendas and still deliver what the university wants**. (S5C, pa.115, emphasis added)

In this long quote, S5C casts the unattributed and passive notion of 'impacts' as the individual and active phrase 'have an impact'. In doing so, he presents a range of application-oriented and contextually grounded issues that *his* research would have to attend to were it to have a positive impact. They are contextually responsive – 'the locals lost a lot of their land'. Such concerns manifest in multiple ways: as issues with the workforce, the company, the university's goals, differences in the impacts at an industrial scale of production, balancing the different agendas of the different stakeholders, as well as not releasing an invasive species or a disease. Similarly, S5B talks about how ethical issues are most likely to become visible at the point of application:

> "I think, if we get to a point where we think yes, we can actually do this, we can actually engineer CAM [crassulacean acid metabolism] into these plants then of course you have to create the plants, you have to trial them in the greenhouse and ok you've introduced that but have you made them more susceptible to disease perhaps, or more susceptible to weediness? Or you know, there's all these other issues that then become incredibly important before you can, that's why for any genetically modified organism there has to be very very careful trials." (S5B, pa.144)

CAM is a carbon fixation pathway that allows some plants in arid conditions to store carbon dioxide captured at night, so that it can be metabolised during the day when there is light. This process reduces water loss from the plant, important in arid environments. Here, S5B is discussing attempts to engineer CAM into other plants so that they might have better water-retaining capabilities. In the quote above S5B does defer thinking about the ethical dimensions of her work in a substantive way until it there is a possibility that its application might be technically feasible. However, in making this link she couples 'the ethical' to the specifics of the application, envisaging some (questions of disease resistance and competition against other plants) but hinting that there may be others. When viewed in light of the earlier quote from this researcher ("marginal lands can have their own appeal" S5B, pa.136), it becomes clear that understandings of impacts and their contingencies were often complex, nuanced and seen as vital to consider if one is conducting research that is going to have application.

Perspectives indebted to actor network theory (ANT) within STS are helpful to delve a little deeper here. Traditional versions of ANT would define objects as "an effect of stable arrays or networks of relations" (Law, 2002, p. 91). These objects have a spatial existence in relation to such networks of relations. Borrowing from John Law, for example, to be able to point to a working boat we have to be able to identify a "hull, spars, sails, stays, stores, rudder, crew, water, winds" etc. which must all hold in place functionally (Law, 2002, p. 91). Similarly, if we are to point to the idea of, say a CAM-engineered plant or an algal biofuel production facility, the whole range of issues identified, and more must be visible and given attention. It is as the object is made that these issues are given any substantive meaning.

Parallels can be seen here between 'science' and philosophical renditions of ethics in that part of their power rests on their ability to produce totalising abstractions of concern; (almost) universal sets of ethical issues. This rendition, like science, "wrenches phenomena out of their specific contexts, makes parts meaningful independently of wholes, and recombines segments in ways that transgress boundaries fixed by law, custom, tradition or institutional practice" (Jasanoff, 2010b, p. 234). So whilst it is it is possible to produce a list of possible known (ethical) issues, to a large extent these have no substantive meaning for the researcher – and indeed carry little normative authority – until they are re-attached to the local, contingent and subjective circumstances and interactions within a given context. My claim here, then, is this idea 'the ethical' needs a material context. To do so, abstract ethical issues must be translated into contextually specific interactions. Once this occurs, researchers often talk eloquently and positively about the value of 'the ethical'. Making use of common conceptualisations, such as 'impacts', 'integrity' and 'as a framework', may help but work is still needed to ground the ethical dimensions of research in a contextual setting; they only have substance if a process of translation is initiated.

7.2.2 Shifting frames

'The issue isn't ethical, it's practical'

Recall that in chapter six (*NGOs, values and the role of research*) representatives of NGOs sometimes re-framed an issue as ethical, practical, technical or otherwise. Doing so had consequences in that alternative framings might require different answers for particular problems, or they might allocate responsibility and legitimacy for a task to different actors. Here, as ethical dimensions of research work are brought into being by being made visible, they may also be re-framed. Reframing can help to make them 'doable' or can shift the issue from relevance. This strategy of 'shifting frames' was most visible when scientists spoke about ethics as 'research integrity' or as 'issues internal to the process of science'. Such conceptions permeate academic and policy discussions of ethics within research (Government Office for Science, 2007; section 7.1; e.g. see Pimple, 2002; Resnik, 1996; Weil, 2002). However, as discussions with scientists progressed, a common move was to shift such issues as to be less about 'ethics' and more about doing good science, in the terms of 'good research', getting 'good results', or just being part of the character of being a scientist. As a professor in plant biology puts it:

> "I mean we do that [reflect on practice] all the time. That's the process of science. When I sit down in the pub after a day of science where we've been discussing our science, what do you think we're talking about? The latest football, or a reflective process on the day's events and discussing science and where we're at? Well I can tell you it's the latter." (S4A, pa.106)

For this researcher, reflecting and discussing the design and conduct of experiments to generate results and insight is all just part of being a scientist. It is an integral part of the practice of science. As S6A, an experimental biologist says, "if you have good scientific method you check yourself, you make an effort to attack the things you want to see" (S6A, pa.62). As a result of this rigour, one will "end up discovering more" (S6A, pa.62). He goes on to use stronger terms: "that's **the only way** to find something so it's not an ethical thing it's a practical thing" (S6A, pa.62, emphasis added).

In each of these examples, 'the issue' (research integrity) is shifted from being purely within an ethical domain to being of either practical concern, or to being central to the actual practice of science. In both cases, it becomes part of daily life and something that is both manageable and required. In the former, reflecting on the practice of science becomes tied to a sense of professional identity, of what it means to be a scientist (Burchell, 2007b). In the latter, instead of being of moral concern it is of epistemic concern, necessary to produce better knowledge, and scientists are in the epistemic business. Furthermore, the rationale for considering such an issue becomes a substantive one (Fiorino, 1990). By bringing them into the professional identity of scientists in the business of producing knowledge, these shifts allow ethics to be a central part of practice, and considered on a daily basis; the 'ethical' is re-framed and made useful, directly relating to the local context of their work. This second way of 'transforming the issues' allows ethical problems to be rendered context specific and 'doable', but also begs the question of the consequences of such reframing.

7.2.3 Embodiment

'Vectors are designed to be safe'

Whereas the previous two strategies transformed ethical issues by grounding them in context and re-framing them, a notion of 'embodiment' is concerned with the nature of the regimes and artefacts within scientific practice. Such a notion sits outside the departing categories of frameworks, impacts and research integrity, providing a new insight into the way that ethical concerns might be managed and the points at which this might occur. Regimes, such as a particular protocol or agreed best-practice, and artefacts, such as a molecular biology kit (M. Weiner and Slatko, 2008) or the standard parts that have become prominant in synthetic biology (Bensaude-Vincent, 2013), all structure the practice of science in normative ways. Ethical concerns can therefore be embodied as regimes that are agreed upon, and artefacts that are made, allowing them to become proxies for 'the ethical'. Ethical concerns therefore may be present within scientific practice but are written out of discussions or are fixed and no longer malleable. In a similar vein to the shifting frames strategy, this allows the research to be 'ethical' but for specific ethical concerns to be assumed. Instead of the task of ethics being done in the laboratory, it is pre-determined or done by parties in the wider sociotechnical network at different points in time.

In molecular biology, vectors allow the insertion of foreign chains for DNA into a host cell. Vectors come in the form of plasmids (small circular strands of DNA), viruses and hybrids thereof. Using the example of vectors S1A, a professor of biological chemistry, talked about the ways that vectors to be used in molecular biology were designed in response to concerns about the environment, and safety:

> "You know, the vectors that we use in molecular biology, in the early days they were designed so that they wouldn't go out into the environment. And then after that everybody just takes it for granted and nobody has to think about it much." (S1A, pa.63)

This professor explicitly notes that (at least some of) the ethical issues are addressed in the design of vectors for molecular biology (which stemmed from debate amongst scientists). As a result of this, issues - framed in terms of hazards and safety - are both built into the practice of science and managed through the design of vectors. These terms are seen as more manageable than terms such as 'avoiding public controversy', "which is almost impossible to predict" (S8B, pa.160). In these ways, the issue has been 'black-boxed' and the debate has been closed-down, which allows subsequent researchers to assume that the issue is dealt with and allows research to continue. S2C makes a similar point:

> "I would say the substrate streams that we have are quite safe to handle and also we're using a biocatalyst, they're safe as well. It's not like traditional organic catalysts which could be more dangerous or toxic so I wouldn't have that issue in my research but that is why this is such a big research area now, is that's one of the main advantages." (S2C, pa.171)

For this research fellow, the choice of substrate streams and catalysts in the processes that she works with has been influenced by concerns for environmental and human safety. This relates both to practice in the laboratory – the substrates are not a danger to herself or her colleagues and are easy to dispose of – and to potential commercialisations of her work. In fact she argues, research using her substrate streams is safer, less toxic, and thus potentially 'more ethical' than more traditional chemistry. In her opinion, these ethical embodiments are increasingly recognised by research funders and other scientists, demonstrated by the growth of the field. Although the initial motivations for work starting in this area and the initial definitions of terms such as 'safe' are not discussed, the health and safety advantages have in themselves become major driving forces for more research and development, thus they 'loop back' and are in themselves part of the enrolment of support in the constituting of a scientific field or industrial practice (Hedgecoe, 2010; Hronszky, 2012).

These quotes highlight the ways that matters of ethical concern can be embedded within practice, but they also show that there are points within the development of a technology or a scientific field in which the considerations of ethics can more more or less easily shaped. As discussed in chapter three, approaches such as the social construction of technology conceive of technoscientific fields as being dependent on the mobilisation of visions, the creation of large sociotechnical networks, the enrolment of support, and a process of stabilisation (Bijker, 2009; Pinch and Bijker, 1984). As fields and technologies are being constituted they are therefore more or less open to transformation and shaping (Collingridge, 1980). In the development of molecular biology, for example, issues became framed in terms of hazards and safety (Wright, 1994) – a narrow framing of ethics (along with risk and technical issues) (Melo-Martin and Meghani, 2008). Nevertheless, this consideration of ethics, albeit in a narrow form, was and continues to be seen as important for legitimating scientific research in the face of public controversy in order to allow research to continue in the future. Similarly, in the biofuels controversy, issues that were judged important to consider, such as sustainability, were framed in technical terms. A number of sustainability certification schemes were developed which judged biofuels based on a range of criteria. These schemes and standards are later mobilised by actors, including scientists in my interview pool:

> "I think the concept of sustainable biofuels, the bar's set pretty high and I think that's embedded. I think it has to be a genuine carbon benefit. We can't be relying on slave labour to produce it. We can't be, I think that is written in at quite a high level (S3D, pa.156)."

Here S3D is making reference to a range of mandatory certification criteria that were put in place by the European Commission as a result of the biofuels controversy. These certification schemes arose out of concern about the impacts that biofuels had on the environment and people. As the quote shows, they are later used by actors to delegate responsibility for consideration of certain ethical dimensions of research. Controversies thus provide one such opportunity to shape technoscientific practice (Rip, 1986). Because decisions that are made here – and of course at other points in the making of technologies — will produce procedures and artefacts with intrinsic moral qualities, questions such as 'who decides', 'how is the issue framed', and 'how is power flowing' are especially important to consider before the process is 'closed-down' (Stirling, 2008).

7.2.4 Using distance and ethical domains

'My research has lots of applications'

To summarise so far, a process of translation allows an abstract issue to be seen as local, complex and contingent. Shifting the issue's framing allows one to bring it into daily life. A process of embodiment allows moral concerns to be black-boxed and temporally transected. Finally, a strategy of 'distancing' allows individuals to locate and re-position *themselves* within a rhetorical space. This discursive strategy most obviously stems from initial issue-framings (as ethical or otherwise) and/or from locating the majority of ethical dimensions at the point of application. It is a very visible form of boundary work (Gieryn, 1999; 1983). To distance themselves, individuals draw up boundaries, for example between what is ethical and what is not (Hobson-West, 2012; Wainwright et al., 2006), between 'applied' and 'basic' research (Calvert, 2006) and between different disciplines. Thus, 'distancing' is in part a facilitated by two strategies that have been previously discussed and occurs in a (at least) two-dimensional space (*figure 7.1*). As made clear in the associated diagrams *(figures 7.1-7.6)*, each varying form of distancing is used to remove the researcher and their research from a domain associated with ethical concerns. I will provide some examples below.

I focus first on distancing that was based on the coupling of specific applications to a moral - amoral boundary that was previously created. Once again, recall that animal experimentation (n=4), the genetic modification of plants and animals (n=9) and 'food versus fuel' (n=12) were all framed as distinctly moral issues. In contrast to some 'impacts' and some issues relating to 'research integrity', there was no attempt to re-cast them as practical, technical or political. These are moral through and through. Because of their status, they require engagement and some ethical work must be undertaken. For example, in the case of biofuels and food versus fuel, "there is a debate there and I think the scientists need to be aware of that and take opportunities to explain it" (S1A, pa.14). Now, consider this quote from S8A, a professor in microbiology:

> "If it's a question of whether we should have biofuels for example, first or second-generation biofuels, there's an ethical question there I guess. I would have a view but uhm, [my] project is firmly engaged with second-generation biofuels so the ethical issues there, frankly I'm not quite sure what they are." (S8A, pa.46)

In response to a question asking him what he thought the issues with his research might be S8A, sees 'clear ethical arguments' surrounding genetic modification and

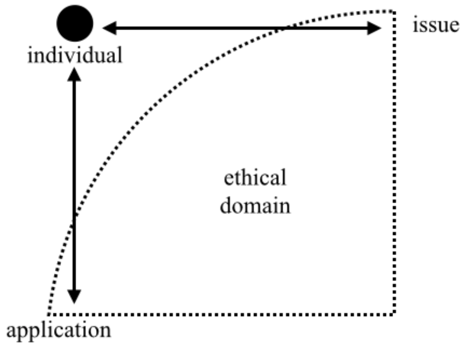


Figure 7.1*: The individual locates themselves in relation to previously demarcated domains, such as at application or particular issues*

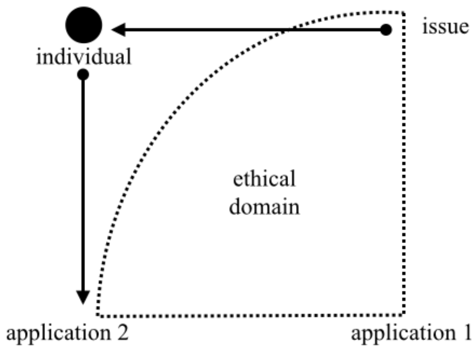


Figure 7.2*: The researcher acknowledges particular issues associated with a given research application as particularly moral (e.g. impacts on food security) and then removes themselves from the ethical domain by distancing from application 1 (first generation biofuels) and tying themselves to application 2 (second-generation biofuels)*

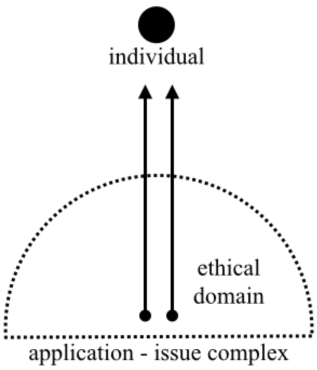


Figure 7.3*: The researcher acknowledges particular issues associated with a given research application (e.g. biofuels), and having initially tied themselves to producing applications, seeks to distance themselves from such application using the idea of basic research.*

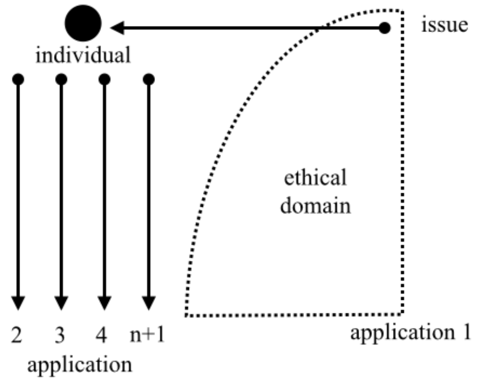


Figure 7.4*: The researcher acknowledges particular issues associated with a given research application as particularly moral (e.g. impacts on food security) and then removes themselves from the ethical domain by distancing from application 1 (first generation biofuels) and emphasising the heterogeneity of the different applications that their research could inform. Of course, what is not acknowledged is that this potentially ties themselves to other issues within a moral landscape. Instead, the heterogeneity allows a claim to value-neutrality*

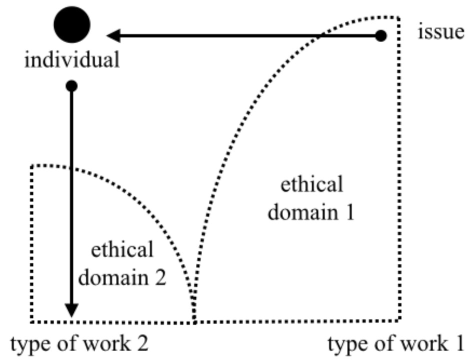


Figure 7.5*: The researcher acknowledges particular issues associated with a given field of research as warranting special concern (e.g. Craig Venter's synthetic biology). The field is novel and requires special consideration as it progresses. After initially tying themselves to that field, the researcher then distances themselves by relocating to a different, established field (e.g. by making reference to the techniques used) which has an ethical, but settled, nature (e.g. where concerns have been embodied).*

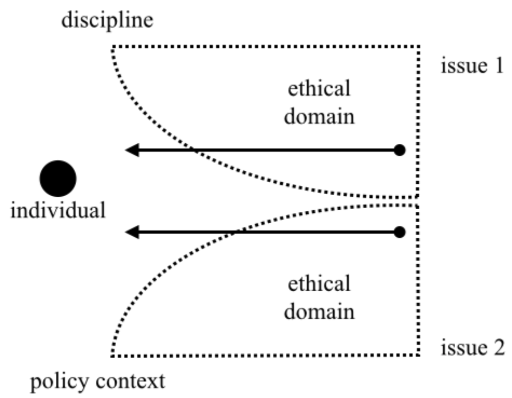


Figure 7.6*: The researcher acknowledges particular issues associated with a given research area but uses disciplinary identity or wider political contexts to distance themselves.*

around first generation biofuels, which he sees as competing with food production. Although he does not elaborate on why they are so, the point is that issues are framed as distinctly ethical rather than political, practical or technical. This professor draws up two boundaries: First a moral boundary between issues (the use of genetic modification and the production of first generation biofuels) and others, and second a boundary of application between first and second-generation biofuels. Moral issues require attention but are also coupled to particular applications. The strategic turn comes as the professor moves to distance himself from such applications; "[my] project is firmly engaged with second-generation biofuels". Although he works in biofuels and still claims to be involved in applied research, he uses a distinction between first and second-generation applications to cast 'the ethical' as being outside of his remit (*figure 7.2*). His research is therefore removed from a domain of ethical concern and remains unproblematic. Similar strategies were employed by researchers that made use of differentiations between applications that used waste streams, bacterial sources, or algae for biofuel production (e.g. S2B, S2C, S8B, S8C), all of which did not compete with food production and therefore avoided the necessity for moral work.

Claims to application are useful for practices such as gaining funding but become problematic when the majority of ethical concerns are in relation to the technological manifestation of successful research (e.g. S2C, pa.75-77). Repositioning oneself on a basic-applied boundary therefore becomes useful. In contrast to a strategy of discursively distancing themselves from one application and aligning themselves to another, some researchers made use of the coupling of ethically-framed issues to particular applications by entirely distancing themselves from interested *any* application (*figure 7.3*). Examples are provided by S8A and S7A, both researchers in the BBSRC Sustainable Bioenergy Centre (BSBEC) research programme:

> "I just see it as an opportunity to do some interesting research [...] and actually the end goal of making a biofuel is not the most interesting bit of that research to me. To me, conducting research into the biology of filamentous fungi is what has driven me for most of my career, so this is a chance for me to do more of that. On the other hand, the context [...] is there and never goes away and is something you've got to take seriously. Well it's just a guide if you like, it ring-fences what you're supposed to do and you've got to have a vision which is leading you towards that goal. [...] But the sort of research I do is not quick turnaround. It takes time. So it's quite feasible that I won't ever get to produce biofuel economically but I should have contributed towards doing that." (S8A, pa.54-56)

As previous chapters have shown, the BSBEC project very explicitly set out to conduct research to produce second-generation biofuels, which S8A accepts and has used to gain funding. His quote follows the earlier discussion about the application-orientation of his research and a subsequent expansion on the difficulties of many of the ethical issues associated with research, such as the definitions of waste and the use of marginal land to grow bioenergy crops. These issues, associated with the deployment of biofuels and research are important to the extent that immediately prior the quote, he claims 'that the people of Britain should have a say' (S8A, pa.52). Thus, they represent a tension and a question: what responsibility does he have for them? S8A 'switches' (N. Brown and Michael, 2001) several times between the issue being of relevance and being outside of concern. To do so, he draws on the applied-basic boundary, claiming that a broader context sits around his work but that really, he is not interested in application; it is the 'fundamental' science of filamentous fungi that really gets him going. To bolster this a temporal aspect is drawn in; although his work should ultimately fit within a context of biofuels, it is presented as 'quite feasible' that he won't ever produce an economically viable application.

S7A, a professor, makes a similar claim, saying that his work is interested in the cell walls of plants more generally. Again, despite collecting funding in an explicitly applied project he claims his research is:

> "Rather distant from the direct applications. It's not as if the work that we do would influence whether a tropical rainforest could be used or not. It's valid for everything" (S7A, pa.48).

Now notice how this quote, from S7A also highlights a further kind of distancing that draws on the diversity of applications (*figure 7.4*): Biofuels represent an extremely heterogeneous suite of sociotechnical practices. As S3C exclaims,

> "You're talking about a lot of different crops or maybe waste streams, you've got a number of different conversion technologies […] Y'know there's a whole range of stuff you can do with it. And the problem is some of those are good and some of those are bad [in terms of their impacts and qualities]" (S3C, pa.46)

Whilst such complexity within the biofuels project as a whole lead some scientists to conclude that everyone would be responsible for a small part, it lead others to distance themselves entirely from any kind of application. Thus, in a manner similar to the BBSRC in chapter five, S7A acknowledges particular issues associated with a given application as of moral relevance (in this example, environmental destruction) and then removes himself from that application by emphasising the heterogeneity of the different applications that his research could inform. Of course, what is not acknowledged is that this potentially ties him to other issues within a moral landscape. Rather than this providing a moral obligation to consider all issues, it is used to claim value neutrality, as if the issues all cancel out. The rhetorical demarcation is used to provide distance from the initial ethical issue-application coupling and its associated domain of ethical concern.

Before rounding up, I want to point to two further mutations of distancing discourse. Whereas in all the above quotes ethical issues were coupled to applications, this does not necessarily have to be the case; some scientists also coupled them to particular fields of research (*figure 7.5*). For example,

> "We're considering some of our organisms, making gene knock outs and putting genes into our organisms. That's synthetic biology but it really is just recombinant microorganisms. But the kind of stuff that Craig Venter does, that's completely different. Yeah, I do have some concerns about that. I think if you're doing large-scale synthetic biology then you've got to think very carefully and put safeguards in place to make sure that this could not go out into the environment." (S1A, pa.63)

This excerpt comes after a discussion of what ethics might mean in practice within research, especially in light of increasing attempts to encourage collaboration between social and natural scientists. Because synthetic biology is a 'field in the making', the term still has interpretative flexibility; it "means different things to different people" (S1A, pa.63). S1A initially categorises his approach as falling into the realms of synthetic biology in that his team are attempting to insert new genes into organisms to engineer them to produce novel products. However, as a whole synthetic biology has been contentious enough to encourage the British research councils to mandate for the inclusion of social scientists into all large-scale research projects (Calvert and Martin, 2009). S1A is aware of this and thus makes two steps. First, he seeks to distance himself from 'other' forms of research that might fall within the bounds of the definition ('Craig Venter' synthetic biology). To do so, he uses the notion of scale, implicitly contrasting 'large-scale synthetic biology' with wildly transformative and risky consequences to his own 'small-scale' fiddling. Second, he reattaches his research to an established and apparently legitimate field of research concerned with making recombinant microorganisms. Now of course, molecular biology was the birthplace of many modern bioethical techniques, so this is not an amoral field. Rather, the point is that it is better established than 'big' synthetic biology – concerns have been 'embodied' in practices and the vectors are safe – and is therefore less contentious than the emerging field. In making these movements, S1A is therefore able to distance himself from an emerging field and potentially unsettled ethical issues, and in a manner similar to that observed by Michael and Burke (1994), cast his own research as ethically unproblematic in relation to 'other research' – that going on in the US.

Finally, in presenting a series of discursive strategies for managing the ethical dimensions of research into biofuels, there is a risk that they be conceived of in an isolated, singular and logical process, detached from external context. This is clearly not the case. Here is a quote from S3B, a project investigator at a research institute:

> "So we don't have a lot of ethical issues when it comes to the medical side because we're not in that space. Err when it comes to, for example GM issues, uhm because Wales is a GM free [country]" (S3B, pa.43)

As has commonly been the case, he is responding to a question that asked him what the most important ethical and social issues with his research might be. In doing so,

as with the numerous other examples, he demarcates an ethical domain. But here notice a difference; there are two ethical domains. The first relates to a research field, medicine, and the second relates to genetic modification. He wishes to distance himself from each of these but achieves this in discrete ways (*figure 7.6*). To put distance between himself and the first set of ethical issues, he makes use of his own methodological and operational inclinations – 'we're not in that space'. This renders all ethical questions that commonly circulate within medical practice impotent. To address the latter, he draws on an external regulatory context – 'Wales is GM free'. Previous public debates about the acceptability of commercial uses of genetically modified organisms did not end in their favour in Europe. Thus, external context dictates that 'ethical research' (or to borrow the BBSRC's phrase, public good plant science) will not seek to commercially exploit genetically modified organisms for use in the UK. GM can be used as a scientific tool, but as S8B says, "I no longer have that [commercial] target" (S8B, pa.132). Here, then, in order to distance themselves from ethical issues, both S3B and S8B tie themselves, and defer, to a broader social and regulatory context.

7.3 What do these strategies do?

I have shown that the majority of researchers initially present concepts of ethics in ways that align quite well with conceptualisations of ethics within bioethical literature, within research funding policy, and within the governance of technoscience more generally - as a framework, as research integrity and as impacts (*subsection 7.1.1)*. This suggests that such macro-level features *do* act to structure the way that the ethical comes to be understood in more local, situated contexts. Furthermore, when discussing the kinds of relevant issues identified, many scientists presented their own research as operating in direct response to prominent ethical issues in the field of biofuels.

The tallies of issues that I presented serve to demonstrate the diversity and specificity of issues that exist across the sample, a point that I unpacked by latching onto claims that individuals made about ethics being hard to define, or explicitly caveating their initial constructions with uncertainty about how dominant ethical conceptualisations translate into practice (*subsection 7.1.2)*. Two categories of example were useful here. The first highlighted the unpredictability of the ethical dimensions of research for individuals and the second drew attention to the heterogeneity of perspectives across the sample. As a result of this discussion, I rebuffed suggestions from others in the field of an 'ethics deficit' amongst scientists, instead suggesting that it may be worthwhile putting effort into developing a concept of ethics, and ways of distributing responsibility for the 'task of ethics', which is malleable and context specific, allowing for unpredictability. In order to make some initial steps in constituting ethics in more malleable terms, I outlined a clutch of four discursive strategies that researchers mobilised in interview to make 'the ethical' more and less visible in their work (*section 7.2)*. Strategies of *translation* allow heuristically useful, but nebulous, conceptualisations of 'the ethical' to be given meaning and colour in highly localised and context-specific ways. Without this translation, ethical dimensions exist in no tangible sense. Similarly, by *shifting frames*, researchers were able to cast particular issues as less about ethical issues and more about dimensions of research that have significance, such as getting good results and generating new knowledge. Dimensions are thus claimed to be of epistemic concern, in addition to or instead of, ethical concern. Particular concerns can be *embodied* within standardised protocols, practices and tools. In making such claims, scientists thus point us to the practice of delegating moral labour to a range of proxies. Finally, by *playing on distance* and drawing boundaries around particular domains (both moral and otherwise), scientists were able to deploy a range of strategies to ensure that their work was cast as being unproblematic. In sum then, if one wants to move towards a broader, more malleable and local sense of 'the ethical', then these strategies point towards a number of features that should be attended to: by allowing space for the emergence of novel and unpredicted ethical dimensions; by considering whether or not it matters that issues are underpinned by 'epistemic' or 'ethical' rationales; of considering the importance of particular points in time where standards are being set; and by paying attention to the way that research can be positioned in relation to other ethically charged fields.

Many of the complementary studies of scientists' discursive strategies that I have referred to throughout this chapter have sought to emphasise that a significant part of what such strategies do is to 'allow science to be done' (Wainwright et al., 2006). Michael and Burke's (1994) study of researchers working in animal experimentation shows how the researchers draw up boundaries between themselves and "others" and discursively created socioethical fields to maintain that their work was ethical both ethical, and to "present British animal experimentation as relatively unproblematic" in relation to other contexts (1994: p.200). For others, 'flexible discursive boundaries' act to allow professionals to preserve their 'cognitive authority', "successfully negotiating a position of disinterested concern, which allows for a direct interface with society (government, education, patients) but ignores their own social location and vested interests" (Kerr et al., 1997, p. 300).

To be sure, there are cognitive, professional, reputational and libertarian motivations to these strategies; serious lapses in conduct or 'trust' can lead to the loss of the ability to practice science, or produce technologies. However, in my own sample, many of the reflexive moments from participants such as S1B, S5C and S7A, regarding the ability of their own research on second-generation biofuels to negate many of the ethical concerns of previous generations, brought with them uncertainty and personal concern. S1B was most succinct: "I guess there is the possibility that we're doing something bad" (S1B, pa.36), suggesting that some of this reflection happens outside the workplace: "in your own personal time you think 'what am I doing?'" (pa.93). Many others made similar remarks, drawing attention to personal environmental values (S9A), personal responsibility towards their local community (S1A, S3B), responsibilities as citizens (S2B) or the need to balance work against the "absolute [Christian] measures of loving your neighbour as yourself" (S3A, pa.76). Perhaps the most obvious example of this kind comes in relation to animal research:

> "So whether, do I feel comfortable in doing the research that I'm doing, and I'll give you a classic example of that. I started off my career wanting to go into medical research […] but I personally […] became upset at using animals for the research, from a personal point, not, you know not animal liberation but from a personal view that I didn't want to kill, I didn't want to […] have animals killed for my research. So when the opportunity came to move into plants, I know this sounds daft, I don't mind murdering a tomato. (S8B, pa. 116-118)"

Here S8B, talks in emotionally-loaded language about the way that he ended up working in plant science. As Hobson-West (2012) identifies, such repertoires 'abrogate responsibility' to society for the wider practice of animal experimentation whilst accepting responsibility for the individual practice (Kerr et al., 1997). S8B could therefore be cast as a 'tolerator' - someone who accepts the necessity for a contentious practice but who does not wish to partake in it themselves (Farsides et al., 2004). S8B therefore delegates the ethical work to others. The researcher brings his own moral insights to the research space, where it creates a dissonance between his view that research is needed ("not animal liberation") and the reality of him carrying out this research ("I […] became upset"), what Brosnan et al (2013) have termed 'tangible ethics'. But note; this has consequences for the researcher, causing him to move from one field of research to another. S1B's 'home musings' were perhaps more destabilising, ultimately leading her to pursue a career outside of research, where the benefits were claimed to be much more clear-cut. So, as others have emphasised (G. Davies, 2012; Pickersgill, 2012), scientific work also brings with it significant affective baggage, which should be accounted for; research can be stopped by both engaging and disengaging with the ethical dimensions of work.

Finally then, each of the discursive strategies that I have presented also has consequences for the responsibility of different groups in dealing with ethical dimensions of research (the way the 'task of ethics' is distributed). Each strategy allows one to relocate and shift the boundaries of responsibility, altering its distribution in the development and deployment of biofuels. For example, 'translation' brings the ethical dimensions into being within the specificities of a project and demands that they be addressed. Different framings of an issue come with varying consequences for responsibility. Whilst all framings allow an issue to be presented as relevant in the sense that it is worthy of consideration, they differ in the demands that they make in relation to who should be considering it; who should be doing 'the task of ethics'. Similarly, a notion of embodiment places issues as of importance but allows their consideration to be black-boxed and delegated to other actors, be that persons, things, policies or organisations. Finally, as might be expected, deferral casts those 'others' operating in ethical domains as being responsible for considering ethical issues rather than the 'self' in question.

Throughout this chapter I have sought to demonstrate that scientists operate within a complex regulatory, personal and social landscape. The strategies that I have put forward are not intended pejoratively, but to begin to draw attention to much of the 'mess' of being a scientist. To take account of such diversity, specificity and ultimately unpredictability is a significant challenge, both in conceptual terms and in terms of research policy. Nevertheless, I will turn to such a possibility in the concluding chapter.

Chapter 8

Rethinking 'the ethical'?

In this thesis I have sought to show how scientists, research funders and NGOs mobilised around the development and deployment of biofuels, each playing roles in a controversy that emerged following the creation of policies designed to significantly expand their use. This controversy, as well as broader debates about the role that the biosciences play in shaping society and the environment produced a 'regime of normativity' for research in the field. Whilst this regime structures research on many levels, from agenda setting down to individual practice, it is also shaped by new developments that stem from scientific research and political agendas. The example of biofuels has also allowed me to draw attention to shifting ideas about the ways that the 'task of ethics' should be distributed. For example, biofuels' widely dispersed nature and environmental framing helped to carve space for groups such as NGOs and social scientists to be actively brought into research programmes within the biosciences, although to what ends are unclear. This final chapter, then, draws together a selection of previous threads that have so far been teased out in explorations of the ethical within the development and deployment of biofuels. I use these findings to suggest tentative answers to the questions that have guided the research. I then use these themes as a point of departure for a broader discussion about the place and role of 'the ethical' in the development and deployment of science and technology, and the ways in which one *might* move beyond institutionalised conceptions of what 'ethics' is and where value judgements can be aired.

So far, I have used the biofuels controversy and subsequent responses to it as an opportunity to examine different constructions of ethics, ethical responsibility and ethical research. As set out in *chapter three*, I conceive of ethics in broad terms and as something that can be produced by different actors, with ethical boundaries being drawn in the process. In *sections 8.1*, *8.2* and *8.3*, I wish to refresh some of the key messages from the analytical chapters and present my overall line of argumentation. I do so with three goals: The first is to begin to build lateral linkages across the vertically-ordered chapters; The second is to point to some answers for the overarching research questions that have acted as points of departure and guiding lights for the research at hand; The third is both reflective and forward-looking. I am able to provide insights into current theory and practice but I do not wish to cast answers in sharp timeless focus. In refreshing my argument, I also want to make some fresh insights for future research to suggest how one might move forward with a new, alternative and more situated notion of 'the ethical'. To recap, the departing research questions were:

1. In what ways does each of the three groups of actors (scientists, BBSRC and NGOs) construct 'the ethical' within biofuels research?
2. How does each group negotiate and distribute responsibility in the development of biofuels?

Additionally, recall that the above two questions were paired with a desire to use the prominent concept of 'socially robust knowledge' (Nowotny et al., 2001) to unpack and reflect on what the goals of any re-worked understanding of ethics might be, and what any related intervention might look like. This is the primary focus of *section 8.3,* which necessarily also contains reflections on the limitations and directions for future work.

8.1 The ethical is locally situated and contingent

To begin to answer the first research question, consider the thesis' first order argument: What comes to be demarcated as 'the ethical' is inseparable from the context in which it is produced and it is therefore often unpredictable. I can identify two currents of dynamics that emphasise this point. One operates at a higher level to structure and frame in broad terms, debates about what is or is not 'ethical'. A second operates at more tailored, individual, levels that emphasise the very tangible, personal and tightly grounded contexts of research life. This first argument has two immediate consequences: that actors are able to deploy a range of discursive and material strategies to negotiate an ethical landscape, and that 'the ethical' ultimately takes far more varied forms than is currently accounted for in dominant philosophical discussions, research policies and regulation, and indeed within the high level normative regime of the context. I expand on these points in more detail below.

By examining the emergence of biofuels as renewable energy option, an area of interest for the biosciences, and as controversial practice, it is possible to see that the constitution of ethical issues (their 'form') and the ways that they are addressed (the 'task' of ethics) are both dictated by the situations from which they arise. At high levels, two structuring phenomena are immediately apparent. *First*, institutions within research provide particular ways that issues of concern can be addressed, and shape the kinds of concerns that can be addressed. As we saw in *chapter three*, dominant, questions of 'research ethics' have largely been reduced down to issues of plagiarism, animal welfare, health and safety and participant consent (e.g. see Pimple, 2002). Similarly, ELSI projects associated with genomics programmes in the US and the UK have traditionally focused on the 'objects' and 'outcomes' of research, a point lamented by research papers that instead push for a post-ELSI agenda that is (amongst other things) concerned with the 'processes' that go on within research (A. S. Balmer and Herreman, 2009; e.g. Rabinow and Bennett, 2012). *Second*, it was not a given that the practice of converting biological material into liquid transport fuel would become controversial and it is notable that when this did happen, controversy focused primarily on issues of greenhouse gas balances and sustainability rather than aspects that many within the biosciences might have predicted, that is the role of genetic modification and the industry interests in deploying research. The dominant and largely technicalised discourses of concern relating to sustainability, the impact on food prices and later indirect land use change acted as the primary means by which different normative, and often implicit, ideas about (for example) preferable roles and forms of agriculture, global justice and trade relations, had to be mobilised.

Taken together, these insights can be said to generate a 'regime of normativity' (Pickersgill 2012; 2013); a collective normative context that acts to legitimate certain voices, certain kinds of concern, and certain ways of addressing those concerns, whilst simultaneously silencing others. This observation can be compared to a recent article that considers the development of medical technologies. Conceiving of technology development as "purposive collective action that unfolds in a normatively heterogeneous context", Lehoux et al (2014) contend that this action is structured by three dimensions: orders of worth; regimes of engagement (i.e. discourses) that characterise commitments between actors; and 'situated judgements' that prioritise certain actions and concerns over others. Transposing to this study, we can see that within the biofuels context, a shared normative context has emerged, which is articulated in particular legitimate technical discourses of sustainability and greenhouse gas accounting. In the biosciences arena, these discourses merged with legitimate ways for carrying out the 'task of ethics', namely in forms of public engagement and interdisciplinary research funding.

However, talk of a dominant normative regime should not hide the very real differences – subterranean discourses of concern and responsibility – that actors mobilise in specific situations. Rather, these differences must be transposed and mobilised in the accepted discourse. The divergences begin to point to the diverse and local meanings of the ethical dimensions of research as well as the range of different strategies that people might employ to manage these designations: Throughout *chapters five*, *six* and *seven* I have drawn attention to the diverse ways that the ethical dimensions of research can be constructed, the ways that responsibility for addressing them can be distributed and the discursive and practical strategies that are involved in achieving this. Note that these are possible because 'the ethical' is malleable and contingent rather than existing as an enduring bedrock. Let us look at some of these strategies in more detail, making comparisons across groups.

The sample of interviews with NGO representatives discussed in *chapter five* elicited a diverse set of insights regarding the construction of ethical issues. Some presented unique arguments and deployed unique framings to maintain particular positions, for example tying biofuels to a range of 'synergistic issues' around broader human health, and emphasising local and temporally-extended forms of sustainable biofuel production that eschew dominant policy discourses around the importance of accounting for indirect land use change (ILUC). Furthermore, recall that whilst many viewed ILUC as being an issue of concern, there was a range of diagnoses that focused on problems of politics and problems of knowledge. Some NGO representatives maintained a clear division between 'ethical', 'technical' and 'political' problems, whereas others refused to draw clear distinctions. The different lenses here draw boundaries around the types of questions that can be asked, the kinds of people that can and should ask them, and the kinds of answers that can be given in response. 'Shifting frames' was also employed as a discursive strategy by scientists seeking to negotiate the ethical dimensions of their work. Here, the same strategy allows 'ethical' issues to be considered as routine aspects of scientific work; if an issue is practical its consequences are far more tangible than if it is worthy of concern for ethical reasons.

Scientists also employed strategies of 'delegation' and 'embodiment'; that is they offloaded portions of the moral labour of research to objects, protocols and standards. In *chapter seven*, the example that I provided was one of vectors used in molecular biology but the principle applies to other developments and other fields. If vectors, protocols, kits and standard parts are retrospectively used by researchers to simplify the ethical work as well as the practical work, then the processes that go into their setting and creation matters. The 'artefacts' do have 'politics' (Winner, 1986b) and these can be retroactively drawn upon to diffuse particular concerns. Thus, despite post-ELSI desires that wish to turn sociological and ethical scrutiny towards the processes, the end goals and objects – as well as the processes – matter and should not be neglected (Schyfter, 2013; 2011). One obvious arena of enquiry is the field of synthetic biology, which is saturated with the desire to produce standardised biological parts and kits (Frow and Calvert, 2013). Particular attention here is warranted given pre-existing charges that much of the rhetoric surrounding open-source registers of parts are more likely stem from the prohibitively high costs for commercialisation that would come with proprietary, protected property rather than a democratic or economically-disruptive ideal (Bensaude-Vincent, 2013).

So, the emergence of macro-level structuring discourses - or shrouded but powerful 'imaginaries' (Jasanoff and Kim, 2009) – has been traced but much more work is needed to elucidate the way in which these high-level normative flows interface, by rubbing-up against, being translated and potentially subverted, with local discourses and actions. Similarly, the development of standards, protocols and kits is one dimension of research that commonly sits outside dominant conceptions of 'the ethical' but which is deserving of further analytic attention as a site of concern, where formative and potentially constitutional boundary work is occurring (Jasanoff, 2011; Webster and Eriksson, 2008). A third arena of relevance that sits outside dominant discourses and methods comes in the means by which matters of concern often arise in unforeseeable and unexpected ways. At a project level, this might happen as a result of unconsidered factors, as in S5b's revelation that for many people, the desert is actually an environment with its own worth, meaning that conversion to agricultural land would not be the unproblematic activity that her project initially envisaged. At a higher level, recall S6b's insight that particular crop traits are being selected on the basis of pre-existing 'issues' and desires but that such traits have the ability to produce an ideotype prone to alternative problems, or with undesirable traits, such as invasiveness. Innovations then, are shaped by, amongst other things, ethical concerns. Although initially envisaged to be positive, such changes may, with hindsight prove to be quite clearly negative. This may be mundane but irritating (Helliwell, 2015), or it may be significant for environmental or human health (Harremoes et al., 2000). Here, one might be reminded of perspectives from various complexity studies such as Charles Perrow's incisive analysis of 'complexity, coupling and catastrophe', stemming from a diagnosis of a range of technological failures, such as three-mile island and leading to his coining of the term 'normal accidents' (Perrow, 1999). More recently, with much bombast, Taleb (2007) has urged us to stop trying to predict the consequences of complex social systems. Most recently, some formulations of responsible innovation (Owen, 2014; e.g. Stilgoe et al., 2013) have incorporated Guston's (2012) attempts to attune society to future consequences. I will turn to these suggestions later in a broader discussion but for now I wish to simply note that they are identifiable trends and novel areas of concern within discussions of 'the ethical' that have been identified by the project at hand and which are deserving of further attention.

Continuing the theme of diversity, my examination of the BBSRC's funding and engagement activities in bioenergy between 2003 and 2014 demonstrated a plurality of claimed motivations for engagement, a plurality of ways that it discharged the task of ethics, as well as implicit normative judgements that extend beyond such demarcated forms. For example, in tracing the BBSRC's discourse and actions the chapter demonstrated that in setting its research agenda, the BBSRC was responsive to a broader debate regarding the development of biofuels. This occurred in terms of policy drivers pushing for more biofuel use and the implications of advocating for greater use. In establishing its flagship research programme, the research council made rhetorical and structural realignments by framing the research as contributing to the production of advanced biofuels that would not come at the detriment of food security. It broadened its notion of interdisciplinarity, briefly abandoned its use of ‘bioscience as remit’ to incorporate social science, agricultural economics and LCA into its flagship programme, and embarked on a programme of public engagement.

The motivations behind these activities were presented in varying lights. Whereas structural renegotiations and externally facing policy statements presented the issues associated with biofuels in a substantive manner — that is, any successful deployment of biofuels required their consideration — other, internal documents presented much more instrumental rationales for engaging with issues — that is as a means to maintain public credibility. High-level corporate documents, tended to make use of a first-order instrumental rationale to justify activities surrounding engagement, whereby public ignorance and hostility to the biosciences are positioned as an impediment to research. In this rationale, the BBSRC is self-positioned as being a facilitator of unquestionable benefits that will result from the biosciences. All other activities fit within this master frame. Although the corporate strategy for communications, engagement and dialogue renegotiated this somewhat, it presents issues a second order - public concern - and maintains an instrumental rationale, just couched in terms of ‘maintaining a public license to operate’. When turning away from policy documents and towards practice, rationales become much more heterogeneous. In all cases, the instrumental frame presents ‘issues’, however they are defined, as barriers that must be overcome for societal gains to be realised. This strategic positioning has gradually amplified with significant shifts, observable in 2008, coming in the form of a notion of ‘impact’ as the research council increasingly pushes towards research to address ‘grand challenges’.

The final diverse dimension and underexplored arena of ‘the ethical’ that I wish to point to arises by drawing links between the positions of some NGO representatives with regards to research responsibility for the ‘task of ethics’ and the actions of the BBSRC. Recall that all NGOs were active in scientific arenas, and seemed to advocate some form of science-based decision making. However, the form that this decision making took varied significantly. Two dominant prescriptions were visible. The first, impact-focused model, recommends that the system of knowledge production be ‘tinkered with’ to adjust focus away from deployment and towards understanding the impacts of deployment. In this technocratic model, normative decisions are made in much the same way as they are now, but the kinds of knowledge available are different. Here, there is no acknowledgment of the implicit normativity of such arguments. The second articulation argued for an explicitly normatively-lead system of research. This could either occur by structuring research programmes differently or by approaching research funding with a view to identifying a desired future and then researching towards that with a conscious awareness of the judgments being made along the way. Again, specific examples of the varying ways in which different models of knowledge production embed varying normative judgements and the way in which these judgements loop back to shape knowledge production is a potential site of future work.

Part of my intention when examining the BBSRC's bioenergy activities was to respond to previous calls to investigate the implicit normativity that lie outside of demarcated ethical spaces, such as ELSI and post-ELSI research and public engagement programmes (e.g. A. Balmer et al., 2012; Rabinow and Bennett, 2012). In doing so, I sought to draw attention to the way that the research council's visions for bioenergy research steadily followed prominent government policy publications, such as the 2003 White Paper for Energy (DTI, 2003) and later the Industrial Biotechnology Taskforce (BIS, 2009). Whereas early visions were sensitive to previous controversies in agricultural plant science, latter visions appear less so. In realigning its visions for the desirable outcomes of strategic research, the BBSRC therefore advocates for particular futures and rejects alternative ones, which comes across as a less sensitive version of the suggestions made by NGO representatives. Considering the impacts of this realignment is vital, especially in light of the aforementioned push towards addressing 'grand challenges', and I do so in the closing section of the chapter.

There are, therefore, both remarkable similarities and some notable differences in the ways that different actors construct 'the ethical'. Each of the data chapters presented a series of discursive strategies that the different groups employed. Each group shifts the value-laden nature of scientific discourse and practice in and out of focus, for example by framing issues as practical or as moral. My study of the BBSRC went some way to demonstrating that these strategies also have a material nature; they distinctly shape action. Outside of the context of the BBSRC, it is difficult to point concretely to the material dimensions of 'the ethical' although other studies have begun to attempt to make such connections (Brodwin, 2008; Brosnan et al., 2013; Schuurbiers, 2011). This is both a limitation resulting from one of the many trade-offs in research design and a clear avenue for further study.

Many of these strategies do not sit well with traditional notions of research ethics. Despite defining 'ethics' in terms similar to three common conceptualisations, for many scientists 'the ethical' was seen to be unpredictable and nebulous; for the purposes of the project such dimensions did not exist until they were given specific, local contexts to operate within. When these were provided, issues were treated with humility and attention. (Consider S5C, S1A and S3B's accounts of the fundamental importance of considering the impacts on local community, be it farmers in the UK or populations in developing countries). And whilst such 'insights' might be frequently delivered at increasingly heightening volumes by proponents of public engagement and STS, I wish to emphasise that many of these concerns were justified in very personal, local and relational terms rather than, for instance, because of regulatory requirements. In this respect, recent academic concern with relational forms of ethics, centring on affect and emotion seem to be pursuing potentially fruitful courses (A. S. Balmer and Bulpin, 2013; la Bellacasa and Puig de la Bellacasa, 2011; Pickersgill, 2012; Puig de la Bellacasa, 2012), even if not completely satisfying as they currently stand (Giraud and Hollin, pers. comm.). The difficulty comes in making space for such conceptions within research governance. In the next section, I consider the ways in which responsibility for the task of ethics might be distributed amongst actors.

8.2 It is difficult to distribute responsibility for the task of ethics

How do different groups distribute responsibility for dealing with the ethical dimensions of biofuels research? When looking across NGOs, scientists and the BBSRC, one is struck by the tensions and similarities that exist across the whole. One that is particularly evident are the dual strategies of claiming 'distributed responsibility' across the network, and of 'individualising responsibility'. From the outset it is important to note that groups did not uniformly employ one strategy whilst others employed the corresponding one. Additionally, I wish to avoid elevating one over the other since neither is without its problems. To see this, we need only to look at the potential for reflexivity to set in place a demonic, paralysing machine (*chapter four*), and the fact that a seemingly common course for scientists who espouse individual responsibility is to either end up as critical (friends or opponents) to their former professions or to withdraw completely from academic life (e.g. the example of Frederick Soddy, as provided by Guston, 2012). Equally, claims of delegation to other actors seems well-tuned with phrases such as 'leaving it to the market' and to this end, similar studies have highlighted that such approaches tend towards specific forms of responsibility whilst failing to engage in high level discussions (Foley et al., 2012). At a more conceptual level, such suggestions of 'distributed responsibility' need to be reconciled with my earlier claims that the ethical concerns are closely tied to specific, local contexts rather than universal and dispersed forms. Ultimately these are knots that are too tight to be untangled here. Nevertheless, before turning to the notion of socially robust knowledge (*section 8.3*), it is possible to delve a little deeper into each chapter to help deliver an emergent whole. If the tensions in responsibility distributions are perennial, there might at least be ways to make them visible.

In my examination of bioethics (*chapter three*), we saw that the groups primarily tasked with considering and addressing the ethical dimensions of bioscience research have multiplied in recent years. Moral philosophical approaches from within the field of bioethics, and contributions from scientists working in the biosciences have been supplemented with other fields of theory and practice, including varying forms of 'assessment' concerned largely with the impacts of technoscience, public bioethics bodies, those employing perspectives from within the field of STS, as well as a range of campaigning NGOs that are especially active in fields of environmental controversy. At the same time, one should be careful to not conclude that this means an absolute delegation to these parties away from, for example, scientists and research funders. Instead, it might be better viewed as an opportunity for responsibility distributions to be tied to their contexts.

To this end, recall that individual researchers both delegated and embraced responsibility for engaging with the ethical dimensions of their work in ways similar to those identified by Kerr et al (1997). A popular strategy was to employ boundary work on the applied - basic boundary, replicating insights from previous studies (e.g. Calvert, 2006), which allowed them to delegate responsibility for wider moral concerns whilst still being able to claim economic (or social) benefits would flow from their work. Under these conditions, responsibility might be delegated to industry, those with the appropriate expertise such as social scientists and ethicists, or to research funders. However, sometimes within the same interview, scientists would provide highly nuanced and personalised accounts of their responsibilities. Whilst all claimed responsibility for immediately local dimensions of work, such as the integrity of experiments, some used personal lines of reasoning to extend their responsibility to outcomes, however tangential, that might stem from their work or their statements. What is particularly noticeable here is that in doing so, the wide range of factors that go into shaping the outcomes of research and influencing other parties' decisions, that are so often mobilised to delegate responsibility, get swept aside.

In *chapter six*, I showed how the BBSRC's distribution of responsibility has fluctuated. When initially considering how best to fund bioenergy research, it acknowledged that the application of its research had widely documented capabilities to lead to environmental damage and increase pressure on food availability, but placed the onus for considering and addressing such issues on external parties responsible for commercialisation and within global governance networks. Later in the day however, the research council began to shift to explicitly require its funded researchers to reflect on the very same ethical and social issues that it initially drew a boundary around. And to demonstrate that it took such issues seriously, the research council agreed to fund embedded social scientists, economists and LCA practitioners. Pushing further forwards towards the present day, the BBSRC has made use of 'bioscience as remit' to discount the funding of similar programmes in the same lineage that are oriented towards industrial biotechnology and bioenergy. So, fluctuations in the boundary of responsibility are visible in the research council's funding decisions. The research council has drawn in responsibility for considering and encouraging discussion of the ethical dimensions of the work that it funds, but looking internally, the 'task' is largely partitioned off to particular teams and advisory structures within the research council, namely the public engagement team and the Bioscience for Society Strategy Panel. As a whole such fluctuations could be taken as simple contradictions that exist within the activities of an organisation, but they can also be coupled to changes that have pushed the research councils to demonstrate more impact and directed research programmes with demonstrable returns on investment.

Some have taken similar approaches to my own (albeit predominantly in the field of nanotechnology) to explicitly examine discursive constructions of responsibility. Commonly, such studies lead to conclusions that, like 'ethical dimensions', responsibility is best considered to be "fundamentally multiple and contingent" (S. R. Davies et al., 2014, p. 143). Kjølberg and Strand (2011), for example, investigated the ways that different actors in nanotechnology discussed responsibility, noting that none referred to formalised European policy definitions. Instead when researchers were probed about why they were responsible they expressed "quite different views about what this means in terms of what scientists are for, and who they are responsible towards" (Kjølberg and Strand, 2011, p. 103). Similarly, McCarthy and Kelty (2010) question how responsibility is made 'do-able'. In a manner similar to my own treatment of 'the ethical', they conceive of responsibility as something that is "to be constructed, manipulated and pushed around" (S. R. Davies et al., 2014, p. 145), concluding – again in a nanotechnology context – that whilst working, scientists shift the location of responsibility, delegating it to external bodies such as the International Council on Nanotechnology, which act as 'filters' to purify societal questions into scientific ones. These works all lend credence to my own insights: If the form that 'ethics' takes looks quite different in different contexts, in a sense it is unsurprising that the way in which we distribute responsibility for addressing 'the ethical' is also highly malleable. However, multiplicity presents problems if one has any prescriptive intent. Ultimately, I think that many of the tensions present around responsibility in research couple to more fundamental questions about what research is for. Helpfully some assistance can be drawn on from work which is close to home.

Considering the discussions of NGO representatives provides insight into some of the tensions observable within the BBSRC's actions and scientists' discourses because it was possible to identify couplings between the task of ethics and styles of knowledge production. Recall that some diagnosed the problems with biofuel development and deployment as one of insufficient knowledge of the impacts of biofuels and too much focus on deployment, making a clear separation between 'political', 'ethical' and 'technical' decisions. In this case, science was viewed as providing unbiased information upon which to make judgements. The role and responsibilities of scientists extends to the production of knowledge and, where required, to act as 'honest brokers' of such information to enable political debate to occur. This position was most succinctly captured by CS1's (pa.96, my emphasis) claim that "the *only* way you deal with [large, ethical, problems] is through iterative debate and politics", but is also visible in BBSRC's early attestations that responsibility for the impacts of biofuel research are largely determined by market forces and the actors within them. These "demarcation discourses" (S. R. Davies et al., 2014, p. 146) embed a model of knowledge production dependent upon Mertonian norms of scientific enquiry (Merton, 1973), and where responsibility for consideration of the ethical dimensions of research is distributed across a range of actors. Others were less happy with such separations, instead arguing that ethical decisions are often bound up with scientific endeavours, perhaps best summarised by CS3's (pa.88) claim that:

> "Researchers certainly have some responsibility. The reason why we're doing the research is to improve livelihoods, reduce poverty and the focus here is on increasing energy access for the poor. So we're very much bought into that but I don't know if necessarily all researchers are but I think they should be. Ideally, if you're bringing out research you need to have some idea of what the target, or what the reason for doing it is, and what are the implications of that."

Under this model of knowledge production, research has a goal of achieving benefits for society. Individual researchers therefore have responsibility of securing those benefits from the projects that they are working on. Whilst responsibility for the task of ethics might be distributed across a network, individual responsibility at a local level is fundamental to responsible research. This may be achieved through 'reflexivity', perhaps stimulated by collaboration and small-micro scale processes such as 'midstream modulation' (Schuurbiers, 2011), or at higher level forms of scientific self-regulation as has recently called for in relation to CRISPR/Cas9 gene editing techniques (Baltimore et al., 2015; Lanphier et al., 2015). Finally, for others, such as CS5b and CS7, difficulty came in allocating individual responsibility without distracting from scientific endeavour. In these situations, responsibility was applied at a middling level, such as those steering science (e.g. research funders, and universities). Above all, this may require the development of new institutional structures and forms of building collective responsibility and participation (see Wickson and Forsberg, 2014).

Considering the tensions visible in scientists' and NGO representatives' discursive wrangling, as well as in BBSRC's actions, in light of these three different prescriptions makes it possible to see that what is potentially being struggled with here are (at least) three differing models of knowledge production and differing allocations of tasks that go with them. At least partially, notions of responsibility are tied to what model of knowledge production one ascribes to; 'the ethical dimensions', the ways in which they are addressed, and by whom will depend on the models of knowledge production that one preferences, as well as the specific contexts and associated materialities and contingencies that come with the sites of production (S. R. Davies et al., 2014; McCarthy and Kelty, 2010). However, to push further and consider what kinds of interventions might be preferable, let us now turn to a discussion that is explicitly grounded in claims about different models of knowledge production.

8.3 Tensions in heterogeneity

So far, as part of a 'diversity and deconstruction' problematisation (Beaulieu et al., 2007), I have made two claims. The first is that 'the ethical dimensions' of the biosciences are fundamentally situated within local contexts and therefore cannot be considered without those contexts. The second is that distributing responsibility is difficult to do because it is easily shifted amongst actors and in different contexts, creating a tension between individual and collective responsibility and different temporal and spatial scales. However, at various points throughout this thesis (e.g. *chapter four*), I have suggested that it is important for scholarship concerned with the social studies of science and technology to try to look beyond such deconstruction arguments to think about, for example, interactions at network level, perhaps with an 'interventionist' intent (e.g. Allhutter, 2012). I turn now with such an intent, using the notion of social robustness as motivation for intervention.

First, some context. In 1994, a volume edited by Gibbons et al. presented the claim that knowledge is increasingly being produced in 'socially distributed' ways (Gibbons et al., 1994, p. 4). This is to say that knowledge is being produced in sites and with actors that sit outside of traditional notions of the research institute and university. This claim was subsequently developed to suggest that in addition to being judged in terms of validity by an immediate scientific community, knowledge must also be judged in terms of its 'social robustness' amongst a broad range of actors (Gibbons, 1999; Nowotny et al., 2001). Now, Gibbons and his peers site their advocacy of socially robust knowledge on what are ultimately empirical claims that suggest that there was once a clear schism between 'pure knowledge' and 'application' that is now difficult to delineate. They class this new context as 'mode-2' knowledge production[15]. The premise of such a change has been fiercely contested, particularly by scholars outside science-policy circles (Bud, 2008; Hessels and van Lente, 2008 and references therein). The notion of 'socially robust knowledge' is thus perhaps best read as a normative claim; 'this is how science should be done and judged'. It is therefore something to strive for. With this caveat in mind, the mode-2 co-authors define 'socially robust knowledge' in relation to three dimensions,

> "First, it is valid not only inside but also outside the laboratory. Second, this validity is achieved through involving an extended group of experts, including lay 'experts'. And third, because 'society' has participated in its genesis, such

[15] Of course, other concepts have made similar claims from starting points that are less reliant on a potentially contentious past. Perhaps most famous are 'post-normal science' (Ravetz and Funtowicz, 1993) and the 'triple helix' (Leydesdorff, 2000). I choose to focus on the 'new modes of knowledge production' not in preference of one approach over the other, but rather as an acknowledgement of its pervasiveness throughout science policy discourse (e.g. see Hessels and van Lente 2008).

> knowledge is less likely to be contested than that which is merely 'reliable'." (Gibbons, 1999 p.C81-82).

Thus, they claim, knowledge must be reliable in contexts outside of the laboratory, and to be so its production must involve broader groups than traditionally dominant scientists. Nowotny (2003, p. 155) adds to this that robustness is only gained by "having been repeatedly tested, expanded and modified" by society which is also implicated in its production. Prescriptions for the practice of science follow from this suggestion in that "research activities now transcend the immediate context of application, and begin to reach out, anticipate and engage reflexively with those further entanglements, consequences and impacts that it generates" (Gibbons, 1999 p.C84). Only then will science and technology be attuned to public ends (Jasanoff, 2003). Gibbons, and others (e.g. Ziman, 1998), have used the above claims as precursors to suggest that ultimately 'socially robust' knowledge is constituted by: (i) the inclusion of different experts and non-experts into the setting of research agendas and of research itself; and (ii) the provision of space for informal encounters to allow for reflexivity concerning the context and consequences of work, that can then be 'internalised' to shape the research that is done and ultimately the knowledge that is produced.

So, socially robust knowledge is best thought of as a normative plea for particular kind of knowledge production. It has acted as a beacon, to guide calls for increasing institutionalisation of public participation in science and increased reflexivity amongst those doing and steering knowledge production. These two characteristics are not problematic in themselves. Instead, the 'problem' (if indeed that is the best way to characterise it) is that if we are to take the consequences of the first two insights within this thesis seriously, viewing 'the ethical' as being contingent on 'hyper-specific' contexts (Thaemlitz, 2009), then a (relatively) standard set of institutionalised 'methods' for addressing the 'task of ethics' is unlikely to be able to produce a singular and attainable form of 'robust' research. What is deemed to be 'robust', like what is deemed to be 'ethical', 'responsible', 'credible' or 'legitimate' is produced from a wide range of understandings as actors convene in particular technoscientific instances. When cast in this light, 'socially robust knowledge' might better be cast as a kind of (to once again borrow Latourian (1993) terminology) hybrid knowledges that hold together under the wide range of discursive and performative strategies that circulate in such situations.

As with all research processes, there are limitations to this study. These might be best understood as 'trade-offs' that have bounded and helped to constitute the work in its final form. For instance, particular voices, such as companies operating in the field of biofuels, are absent but play increasingly important roles in both producing and shaping knowledge production. Decisions were made about anonymity of NGO representatives that made it extremely challenging to link interview-generated discourse with publicly-facing discourse, thereby impeding any attempt to show how what is said links to what is done. Similarly, wishing to maintain a systemic gaze meant being unable to ground the research in the contexts of everyday scientific work.

Some of these trade-offs might have been tempered with increased resources and increased collaboration, for example with those in the LACE project. But to do so would likely come at the expense of others' own projects which, sometimes serendipitously, have informed my own research and driven it in new directions. These are relatively minor trade-offs that come with the messy, uncertain and sometimes uneasy process of research. Many, such as the commercial and organisational cultures of scientific knowledge production are relatively neglected (Wynne, 2011). There is, however, a more obstructive tension encapsulated within this chapter: What substantive prescriptions for research governance and practice are possible, whilst emphasising not just the context-specificity and malleability of 'ethics', but also that what socially robust knowledge looks like will also be tightly tuned to its context? Similar tensions are relevant for any work manoeuvring the STS canon with normative intent, so it is worth reflecting on them a little more to close.

So if we are searching for an understanding of 'the ethical' and seeking to make prescriptions for research governance and practice, where are we left? Firstly, one should be wary about prescribing singular or similar categories of institutionalised processes or discourses as a means to make the biosciences more 'ethical'. To be sure, as has been levelled at bioethics as currently institutionalised, to tend towards homogeneity risks rationalising rich, thick debate about both the means and ends of work (J. Evans, 2002) with 'thin' discussions that replicate issue types, with the potential to miss important contextual specificities, ultimately acting as legitimating force rather than interrogative tool. (To illustrate this point consider the similarities in issue types that have been characterised within ethical debates across the biosciences, similarities that ultimately lead the BBSRC to attempt a shift towards a 'distributed dialogue'). This should not be read as a suggestion to remove processes such as public engagement, technology assessment, ethics review or interdisciplinary work from the biosciences. Rather it is better understood as a plea for more critical and heterogeneous interactions (Wynne, 2007b).

Attention may be best directed towards developing ways of allowing for situated ethical judgements to be teased out and debated amongst actors in ways that are sensitive to context, with space for consideration about the means and ends of particular developments until, to borrow from SCOT (Bijker, 2009), acceptable closure is reached. Although methods and approaches for facilitating this are important, site-specific frameworks that help to develop cultures for such situated negotiations may be more fruitful. These suggestions chime with Mike Michael's recent call to pay attention to and make use of the "range of happenings which, in one way or another, 'overspill' the empirical, analytic, or political framing of those engagement[s]" (Michael, 2012, p. 528). Furthermore, operating specifically in interdisciplinary settings (as formally described), Des Fitzgerald and Felicity Callard have urged a move beyond the "arid rhetoric of interdisciplinarity" which tends to stifle rather than facilitate new forms of knowledge production (Fitzgerald and Callard, 2014, p. 3), instead pleading for a form of 'experimental entanglement' that are "modest, often awkward, typically unequal encounters that work to mobilize specific and often serendipitous moments of potential novelty in and outside the laboratory" and which do not take pre-existing divisions of labour as their departing point (Fitzgerald and Callard, 2014, p. 17). Whilst replete with discomfort and tensions between levels of scale, different forms of life and different, often competing imperatives, I do not believe a call for a different model of 'the ethical' to be a fundamentally paralysing proposal. Rather, there is much work to be done.

Bibliography

Abbott, A. (1988) *The System of Professions: An Essay on the Division of Expert Labor*. University of Chicago Press, Chicago.

ACARD, ABRC (1983) Improving Research Links between Higher Education and Industry. Cabinet Office, London.

ActionAid UK (2010) Meals per gallon: The impact of industrial biofuels on people and global hunger. ActionAid UK.

Adams, P.W., Hammond, G.P., McManus, M.C., Mezzullo, W.G. (2011) Barriers to and drivers for UK bioenergy development. *Renewable and Sustainable Energy Reviews* 15, 1217–1227.

Advisory Council for Applied Research and Development, Advisory Board for the Research Councils, The Royal Society (1980) Biotechnology: Report of a Joint Working Party. HMSO, London.

AEA Technology (2002) International resource costs of biodiesel and bioethanol. Department for Transport, London, UK.

AEA Technology (2008) Review of work on the environmental sustainability of international biofuels production and use. Department for environment food and rural affairs, London, UK.

Afionis, S., Stringer, L.C. (2012) European Union leadership in biofuels regulation: Europe as a normative power? *Journal of Cleaner Production* 32, 114–123.

AFRC (1983) Agricultural and Food Research Council, Corporate Plan 1984–1988. AFRC, London.

Alberici, S., Boeve, S., van Breevoort, P., Deng, Y., Forster, S., Gardiner, A., van Gastel, V., Grave, K., Groenenberg, H., de Jager, D., Klaassen, E., Powels, W., Smith, M., de Visser, E., Winkel, T., Wouters, K. (2014) Subsidies and costs of EU energy. Ecofys by order of European Commission.

Alcott, B. (2005) Jevons' paradox. *Ecological Economics* 54, 9–21.

Allen, B., Kretschmer, B., Baldock, D., Menadue, H., Nanni, S., Tucker, G. (2014) Space for energy crops – assessing the potential contribution to Europe's energy future. Institute for European Environmental Policy, London.

Allen, P., Helweg-Larsen, T., Bull, J., Girling, A., Harper, P., Atkinson, J., Ben Coombes, Meirion-Jones, P., Abdulla, T., Hampton, R., Livingstone, J., Swallow, N., Forbes, L., Waring, S., Josh, D., Harper, G., Abbess, J. (2007) Zero carbon Britain: An alternative energy strategy. Centre for Alternative Technology, Macynlleth.

Allhutter, D. (2012) Mind Scripting: A Method for Deconstructive Design. *Science, Technology & Human Values* 37, 684–707.

Am, H. (2013) 'Don't make nanotechnology sexy, ensure its benefits, and be neutral': Studying the logics of new intermediary institutions in ambiguous governance contexts. *Science and Public Policy* 40, 466–478.

Anderson, E., Burall, S., Fennell, E. (2010) Talking for a Change. Involve, London, UK.

Appell, G.N. (1980) Talking ethics: The uses of moral rhetoric and the function of ethical principles. *Social Problems* 27, 350–357.

Armstrong, A.P., Baro, J., Dartoy, J., Groves, A.P., Nikkonen, J., Rickeard, D.J., Thompson, N.D., Larive, J.-F. (2002) Energy and greenhouse gas balance of biofuels for Europe – An update. CONCAWE, Brussels.

Armstrong, S.J., Botzler, R.G. (2003) *The Animal Ethics Reader*. Psychology Press.

Ashmore, M. (1989) *The Reflexive Thesis: Wrighting the Sociology of Scientific Knowledge*. The University of Chicago Press, Chicago and London.

Balmer, A., Balmer, A.S., Bulpin, K., Calvert, J., Kearnes, M., Mackenzie, A., Marris, C., Martin, P.A., Molyneux-Hodgson, S., Schyfter Camacho, P. (2012) Towards a Manifesto for Experimental Collaborations between Social and Natural Scientists. https://experimentalcollaborations.wordpress.com (accessed 2.1.15).

Balmer, A.S., Bulpin, K.J. (2013) Left to their own devices: Post-ELSI, ethical equipment and the International Genetically Engineered Machine (iGEM) Competition. *BioSocieties* 8, 311–335.

Balmer, A.S., Herreman, C. (2009) Craig Venter and the reprogramming of life: How metaphors shape and perform ethical discourses in the media presentation of synthetic biology. In: *Communicating Biological Sciences: Ethical and Metaphorical Dimensions*. Ashgate Publishing, Farnham, pp. 219–234.

Balmer, B., Sharp, M. (1993) The battle for biotechnology: Scientific and technological paradigms and the management of biotechnology in Britain in the 1980s. *Research Policy* 22, 463–478.

Baltimore, B.D., Berg, P., Botchan, M., Carroll, D., Charo, R.A. (2015) A prudent path forward for genomic engineering and germline gene modification. *Science* 348, 36-38

Barben, D., Fisher, E., Selin, C., Guston, D.H. (2008) Anticipatory Governance of Nanotechnology: Foresight, Engagement, and Integration. In: Hackett, E.J., Amsterdamska, O., Lynch, M., Wajcman, J. (Eds.), *The Handbook of Science and Technology Studies*. MIT Press, Cambridge, Masachusetts.

Barnes, B. (1981) On the Conventional Character of Knowledge and Cognition. *Philosophy of the Social Sciences* 11, 303–333.

Barry, A., Born, G., Weszkalnys, G. (2008) Logics of interdisciplinarity. *Economy and Society* 37, 20–49.

BBC (2013) Dundee councillors object to plans for biomass plant. www.bbc.co.uk/news/uk-scotland-tayside-central. URL (accessed 9.22.14).

BBSRC (2002) Review of BBSRC-Funded Research Relevant to Sustainable Agriculture: A report for BBSRC Council. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2003a) Bioscience for Society: A Ten-Year Vision. "Towards Predictive Biology." Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC, (2003b). World Class Bioscience: Strategic Plan 2003-2008. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2004) Review of BBSRC-Funded research relevant to crop science. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2006a) Review of Bioenergy Research: A report for BBSRC strategy board. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2006b) Stem cells & BBSRC. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC, (2007a) New initiative to invest £20M in UK bioenergy. Available at: www.bbsrc.ac.uk. URL (accessed 6.18.14a).

BBSRC, (2007b) Annual Report and Accounts 2006-2007. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2007c) Call for Expressions of Interest for Capacity-building awards in Bioenergy Research (National Archives Snapshot taken 2007): http://webarchive.nationalarchives.gov.uk/20070305222232/http://www.bbsrc.ac.uk/science/initiatives/bioenergy.html (accessed 2.18.13).

BBSRC (2007d) BBSRC Bio*Energy Policy* Statement. BBSRC, Swindon, UK.

BBSRC (2007e) Minutes of the Bioscience for Society Strategy Panel Meeting held on 25 April 2007. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2007f) BBSRC statement on misuse of bioscience research. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2007g) Bio*Energy Policy* Statement (2007). Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2007h) Bioscience for Society Strategy Panel papers, October 2007. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2008a) Delivering excellence with impact: BBSRC Delivery Plan 2008-2011. Biotechnology and Biological Science Research Council, Swindon.

BBSRC (2008b) BBSRC Policy on maximising the impact of research. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009a) Annual Report and Accounts 2008-2009. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009b) BBSRC Sustainable Bioenergy Centre Information Pack.

Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009c) Minutes of the Bioscience for Society Strategy Panel Meeting held on 15 May 2009. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009d) Bioscience for Society Strategy Panel papers, September 2009. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009e) Minutes of the Bioscience for Society Strategy Panel Meeting held on 25 September 2009. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009f) Minutes of the Strategy Board meeting - 25 November 2008. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2009g) Bioscience for Society Strategy Panel papers, January 2009. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2010a) What is impact? Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2010b) The Age of Bioscience: Strategic Plan 2010-2015. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2010c) Bioscience for Society Strategy Panel papers, September 2010. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2010d) Annual Reports and Accounts 2009 - 2010. The Stationary Office, London, UK.

BBSRC (2011a) Annual Report and Accounts 2010 - 2011. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2011b) BBSRC Delivery Plan 2011-2015: Maximising Economic Growth in The Age of Bioscience. BBSRC, Swindon.

BBSRC (2011c) BBSRC Bioenergy Awards List, as of December 2011. http://www.bbsrc.ac.uk/pa/grants/AdvancedSearch.aspx (Accessed 6.9.14).

BBSRC (2011d) Business Case for a ScienceWise-ERC Grant to BBSRC for a Bioenergy Distributed Dialogue. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2011e) Bioscience for Society Strategy Panel papers, January 2011. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2011f) BBSRC's position on GM research in crops and other plants. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2011g) BSBEC Outreach group meeting agenda, 9th March 2010. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2012a) Corporate strategy for communications, engagement and dialogue. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2012b) BBSRC policy on maximising the impact of research. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2013a) Annual Report and Accounts 2012-2013. Biotechnology and

Biological Sciences Research Council, Swindon.

BBSRC (2013b) Bioenergy Dialogue: Final Report. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2013c) Report of Pilot BBSRC Bioenergy Stakeholder Workshop 28th February 2013, Norwich. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2013d) Why do public engagement? Benefits for different groups, why do they get involved? Flipchart notes of discussion during PE training in Norwich, April 2013. Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2013e) Strategic Plan: The Age of Bioscience (2013/2014 Update). Biotechnology and Biological Sciences Research Council, Swindon.

BBSRC (2014a) Bioenergy Initiative (BEN) [2008] Current; Completed Research Grants. Available at: http://www.bbsrc.ac.uk/pa/grants/AdvancedSearch.aspx (accessed 2.10.15a).

BBSRC (2014b) BBSRC Networks in Industrial Biotechnology and Bioenergy Accessed: www.bbsrc.ac.uk (accessed 5.29.14b).

BBSRC (2014c) Industrial biotechnology and bioenergy, BBSRC. Swindon.

BBSRC, The Science Museum (1994) UK National Consensus Conference on Plant Biotechnology, Final Report of the Lay Panel. The Science Museum, London.

Beauchamp, T.L., Childress, J.F. (1979) *Principles of Biomedical Ethics*., First Edition. ed. Oxford University Press, New York.

Beauchamp, T.L., Childress, J.F. (1989) *Principles of Biomedical Ethics*., Third Edition. ed. Oxford University Press, New York.

Beauchamp, T.L., Childress, J.F. (2012) *Principles of Biomedical Ethics*., Seventh Edition. ed. Oxford University Press, New York.

Beaulieu, A., Scharnhorst, A., Wouters, P. (2007) Not Another Case Study: A Middle-Range Interrogation of Ethnographic Case Studies in the Exploration of E-science. *Science, Technology & Human Values* 32, 672–692.

Beckwith, J., Huang, F. (2005) Should we make a fuss? A case for social responsibility in science. *Nature Biotechnology*.

Bensaude-Vincent, B. (2013) Ethical Perspectives on Synthetic Biology. *Biological Theory* 8, 368–375.

Berkhout, F. (2006) Normative expectations in systems innovation. *Technology Analysis & Strategic Management* 18, 299–311.

BERR (2009) IB 2025: Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy. A report to government by the Industrial Biotechnology Innovation and Growth Team. Department for Business, Enterprise & Regulatory Reform, London, UK.

Bijker, W.E. (1995) *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. MIT Press, Cambridge, MA.

Bijker, W.E. (2009) How is technology made? – That is the question! *Cambridge Journal of Economics* 34, 63–76.

Bijker, W.E., Bal, R., Hendriks, R. (2009) *The Paradox of Scientific Authority*. MIT Press, London.

Bijker, W.E., Hughes, T.P., Hughes, T., Pinch, T. (Eds.) (1987) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT Press, Cambridge, MA.

Biletzki, A., Matar, A. (2014) Ludwig Wittgenstein. In: Zalta, E.N. (Ed.), *The Stanford Encyclopedia of Philosophy*. http://plato.stanford.edu/archives/spr2014/entries/wittgenstein/.

Bioethics FAQs - Nuffield Bioethics (2015) Bioethics FAQs - Nuffield Bioethics.

Biomass Task Force (2005) Biomass Task Force Report to Government October 2005. Defra, London.

BirdLife Europe (2011) Meeting Europe's Renewable Energy Targets in Harmony with Nature. The RSPB, Sandy, UK.

BIS (2009) IB 2025: Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy. Department for Business Innovation and Skills, London.

BIS (2010) The allocation of science and research funding 2011/12 to 2014/15. Department for Business, Innovation and Skills, London.

BIS (2014) Science and research budget allocations for financial year 15/16 (No. BIS/14/P200). Department for Business, Innovation and Skills, London.

BIS (2015) Nurse review of research councils: call for evidence. Department for Business, Innovation and Skills, London.

Bloor, D. (1976) *Knowledge and social imagery*. University of Chicago Press, Chicago.

Blumer, H. (1969) *Symbolic Interactionism: Perspective and Method*. Prentice-Hall, Englewood Cliffs, NJ.

Bogner, A., Menz, W. (2010) How Politics Deals with Expert Dissent: The Case of Ethics Councils. *Science, Technology & Human Values* 35, 888–914.

Bomb, C., McCormick, K., Deurwaarder, E., K berger, T. (2007) Biofuels for transport in Europe: Lessons from Germany and the UK. *Energy Policy* 35, 2256–2267.

Borup, M., Brown, N., Konrad, K., Lente, H.V. (2006) The sociology of expectations in science and technology. *Technology Analysis & Strategic Management* 18, 37–41.

Bosk, C. (1999) Professional ethicist available: logical, secular, friendly. *Daedalus* 128, 47–68.

Boucher, P. (2010) Technology and Controversy: The Case of Biofuels. A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy in the Faculty of Humanities. University of Manchester.

Boucher, P. (2012) The role of controversy, regulation and engineering in UK biofuel development. *Energy Policy* 42, 148–154.

Boucher, P. (2013) Things, Names, Judgments, and the LRS Lens: A Critical Realist Analysis of the Biofuel Controversy in the United Kingdom. *Science Communication* 35, 241–265.

Boucher, P., Smith, R.D.J., Millar, K.M. (2014) Biofuels under the spotlight: The state of assessment and potential for integration. *Science and Public Policy* 41, 283–293.

Braun, D. (1993) Who Governs Intermediary Agencies? Principal-Agent Relations in *Research Policy*-Making. *Journal of Public Policy* 13, 135–162.

Breithaupt, H. (2011) Freedom and responsibility. *EMBO reports* 12, 744–744.

Brey, P. (2012) Anticipatory Ethics for Emerging Technologies. *NanoEthics* 6, 1–13.

Brodwin, P. (2008) The Coproduction of Moral Discourse in U.S. Community Psychiatry. *Medical Anthropology Quarterly* 22, 127–147.

Brosnan, C., Cribb, A., Wainwright, S.P., Williams, C. (2013) Neuroscientists' everyday experiences of ethics: the interplay of regulatory, professional, personal and tangible ethical spheres. *Sociology of Health & Illness* 35, 1135-1148.

Brown, M.B. (2009) Three Ways to Politicize Bioethics. *The American Journal of Bioethics* 9, 43–54.

Brown, N. (2003) Hope Against Hype – Accountability in Biopasts, Presents and Futures. *Science Studies* 16, 3–21.

Brown, N., Michael, M. (2001) Switching between Science and Culture in Transpecies Transplantation. *Science, Technology & Human Values* 26, 3–22.

Brown, N., Michael, M. (2003) A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects. *Technology Analysis & Strategic Management* 15, 3–18.

Brown, N., Rappert, B., Webster, A. (Eds.) (2000) *Contested futures: A sociology of prospective techno-science*. Ashgate Press, Aldershot.

Bryman, A. (2012) *Social Research Methods*, Fourth Edition. Oxford University Press, Oxford.

Buchholz, T., Luzadis, V.A., Volk, T.A. (2009) Sustainability criteria for bioenergy systems: results from an expert survey. *Journal of Cleaner Production* 17, S86–S98.

Bud, R. (1994) *The Uses of Life*. Cambridge University Press, Cambridge.

Bud, R. (2008) Upheaval in the moral economy of science? Patenting, teamwork and the World War II experience of penicillin. *History and Technology* 24, 173–190.

Bull, A., Bu'Lock, J. (1979) The living micro revolution. *New Scientist* 82, 808–810.

Burchell, K. (2007a) Boundary work, associative argumentation and switching in the advocacy of agricultural biotechnology. *Science as Culture* 16, 49–70.

Burchell, K. (2007b) Empiricist selves and contingent "others": the performative function of the discourse of scientists working in conditions of controversy. *Public Understanding of Science* 16, 145–162.

Callahan, D. (1999) The Social Sciences and the Task of Bioethics. *Daedalus* 128, 275–294.

Callon, M. (1986) Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In: Law, J. (Ed.), *Power, Action and Belief: A New Sociology of Knowledge?* The British journal of sociology, London, pp. 196–223.

Callon, M., Latour, B. (1992) Don't Throw the Baby Out with the Bath School! A Reply to Collins and Yearley. In: Pickering, A. (Ed.) *Science as Practice and Culture*. University of Chicago Press, Chicago and London, pp. 343–368.

Calvert, J. (2006) What's Special about Basic Research? *Science, Technology & Human Values* 31, 199–220.

Calvert, J., Martin, P.A. (2009) The role of social scientists in synthetic biology. *EMBO reports* 10, 201–204.

Calvert, J., Patel, P. (2003) University-industry research collaborations in the UK: bibliometric trends. *Science and Public Policy* 30, 85–96.

Cambrosio, A., Limoges, C. (1991) Controversies as governing processes in technology assessment. *Technology Analysis & Strategic Management* 4, 377–396.

Canakci, M., Sanli, H. (2008) Biodiesel production from various feedstocks and their effects on the fuel properties. *Journal of industrial microbiology & biotechnology* 35, 431–441.

Caniëls, M.C.J. (2011) *Research Policy*. *Research Policy* 40, 618–636.

Carolan, M.S. (2010) Ethanol's most recent breakthrough in the United States: A case of socio-technical transition. *Technology in Society* 32, 65–71.

Centre for Alternative Technology (2010) Zero Carbon Britain 2030: A New Energy Strategy. Centre for Alternative Technology, Machynlleth, Wales.

Centre for Alternative Technology (2013) Zero carbon Britain: Rethinking the future. Centre for Alternative Technology, Machynlleth.

Chambers, R.S., Herendeen, R.A., Joyce, J.J., Penner, P.S. (1979) Gasohol: Does it or doesn't it produce positive net energy? *Science* (New York, N.Y.) 206, 789–795.

Cherubini, F., Bird, N.D., Cowie, A., Jungmeier, G., Schlamadinger, B., Woess-Gallasch, S. (2009) Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations. *Resources Conservation and Recycling* 53, 434–447.

Chief Scientific Advisor (2002) Chief Scientific Adviser's Energy Research Review Group: Report of the Group. Office of Science and Technology, London.

Chilvers, J. (2013) Reflexive Engagement? Actors, Learning, and Reflexivity in Public Dialogue on Science and Technology. *Science Communication* 35, 283–310.

Chivers, D. (2013) Two Energy Futures. UK Tar Sands Network.

Clarke, A.E., Star, S.L. (2008) The Social Worlds Framework: A Theory/Methods Package. In: Amsterdamska, O., Wajcman, J. (Eds.), *The Handbook of Science and Technology Studies*. MIT Press, Cambridge, Masachusetts, pp. 113–137.

Coffey, A., Atkinson, P. (1996) *Making sense of qualitative data: Complementary research strategies*. Sage, Thousand Oaks CA.

Cohen, L., Manion, L., Morrison, K. (2007a) Approaches to qualitative data analysis. In: *Research Methods in Education*. Abingdon, pp. 1–14.

Cohen, L., Manion, L., Morrison, K. (2007b) Case studies. In: *Research Methods in Education*. Routledge, Abingdon, pp. 253–263.

Cohen, L., Manion, L., Morrison, K. (2007c) *Research methods in education, Sixth Edition*. ed. Routledge, Abingdon.

Collingridge, D. (1980) *The Social Control of Technology.* Open University Press, Milton Keynes, UK.

Collingwood Environmental Planning (2014a) Evaluation of the Governance of BBSRC's Bioenergy Public Dialogue (Interim Report). Biotechnology and Biological Sciences Research Council, Swindon.

Collingwood Environmental Planning (2014b) Evaluation of BBSRC's Bioenergy Public Dialogue (Final Report). Biotechnology and Biological Sciences Research Council, Swindon.

Collins, H.M. (1981) Introduction: Stages in the empirical programme of relativism. *Social Studies of Science* 11, 3–10.

Collins, H.M. (2004) *Gravity's Shadow: The Search for Gravitational Waves*. University of Chicago Press.

Collins, H.M., Evans, R. (2002) The Third wave of Science Studies: Studies of Expertise and Experience. *Social Studies of Science* 2, 235–296.

Collins, H.M., Evans, R. (2007) *Rethinking Expertise*. University of Chicago Press.

Collins, H.M., Yearley, S. (1992) Epistemological chicken. In: Pickering, A. (Ed.), *Science as Practice and Culture*. University of Chicago Press, Chicago, pp. 301–326.

Committee on Climate Change (2011a) Bioenergy Review. The Stationary Office, London.

Committee on Climate Change (2011b) Bioenergy Review. Technical Paper 2: Global and UK bioenergy supply scenarios. The Stationary Office, London.

Coombs, J., Hall, D.O. (1981) Editorial. *Biomass* 1, 1–3.

Coombs, R., Green, A., Richards, A., Walsh, V. (Eds.) (2001) Great Expectations: the construction of markets, products and user needs during the early development of gene therapy in the USA. In: *Technology and the Market: Demand, Users and Innovation*. Edward Elgar, Cheltenham, pp. 38–68.

Corr Willbourn Research and Development, Development (2005) A Report on a Deliberative Public Engagement Exercise concerning the use of Biotechnology in Non-food Agriculture for the Agriculture and Environment. AEBC.

Council of the European Union (2010) Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes, Official Journal of the European Union. 2010/63/EU.

Cruz-Castro, L., Sanz-Menéndez, L. (2005) Politics and institutions: European parliamentary technology assessment. *Technological Forecasting and Social Change* 72, 429–448.

Davies, G. (2012) Caring for the multiple and the multitude: assembling animal welfare and enabling ethical critique. *Environment and Planning D: Society and Space*, 30 (4) pp. 623-638. (2012) 30, 623–638.

Davies, G. (2013) Writing biology with mutant mice: The monstrous potential of post genomic life. *Geoforum* 48, 268–278.

Davies, S.R. (2008) Constructing Communication: Talking to Scientists About Talking to the Public. *Science Communication* 29, 413–434.

Davies, S.R., Glerup, C., Horst, M. (2014) On Being Responsible: Multiplicity in Responsible Development. In: Arnaldi, S., Ferrari, A., Magaudda, P., Marin, F. (Eds.), *Responsibility in Nanotechnology Development*. Springer, Dordrecht, pp. 143–159.

de Chadarevian, S. (2002) *Designs for life: Molecular biology after World War II*. Cambridge University Press, Cambridge.

de Vries, R. (1995) Toward a sociology of bioethics. *Qualitative Sociology* 18, 119–128.

de Vries, R. (2003) How can we help? From "sociology in" to "sociology of" bioethics. *Journal of Law, Medicine and Ethics* 32, 279–292.

de Vries, R. (2006) "Ethical concepts regarding the genetic engineering of laboratory animals." *Med Health Care Philos* 9, 211–225.

de Vries, S.C., van de Ven, G.W.J., van Ittersum, M.K., Giller, K.E. (2010) Resource use efficiency and environmental performance of nine major biofuel crops, processed by first-generation conversion techniques. *Biomass and Bioenergy* 34, 588–601.

DECC, DfT, DEFRA (2012) UK Bioenergy Strategy. The Stationary Office, London, UK.

DEFRA, DTI (2004) A strategy for non-food crops and uses: Creating value from renewable materials. Department for Environment Food and Rural Affairs, London.

DEFRA, DTI, DfT (2007) UK Biomass Strategy. Department for Environment, Food and Rural Affairs, London.

Delgado, A., Kjølberg, K.L., Wickson, F. (2011) Public engagement coming of age: From theory to practice in STS encounters with nanotechnology. *Public Understanding of Science*.

Demeritt, D. (2010) Harnessing science and securing societal impacts from publicly funded research: reflections on UK science policy. *Environment and Planning A*

42, 515–523.

Demirbas, A. (2009) Biorefineries: Current activities and future developments. *Energy Conversion and Management* 50, 2782–2801.

Department of Energy (1988) Energy Paper 55 Renewable Energy in the UK: The Way Forward. HMSO, London.

DETR (1997) A New deal for Transport: Better for everyone. Department of the Environment, Transport and the Regions, London.

DETR (2000a) Climate Change: The UK Programme (Summary). Department of the Environment, Transport and the Regions, London.

DETR (2000b) Transport Ten Year Plan 2000. Department for the Environment, Transport and the Regions, London.

DfT (2004) Towards a UK Strategy for Biofuels - Public Consultation. The Stationary Office, London.

DfT (2007) Low Carbon Transport Innovation Strategy. Department for Transport, London, UK.

DfT (2014) Renewable Transport Fuel Obligation statistics: obligation period 6, 2013/14, report 5. Department for Transport, London.

Diekmann, S., Peterson, M. (2013) The Role of Non-Epistemic Values in Engineering Models. *Science and Engineering Ethics*19, 207–218.

Doubleday, R., Wynne, B. (2011) Despotism and Democracy in the United Kingdom: Experiments in Reframing Citizenship. In: Jasanoff, S. (Ed.), *Reframing Rights: Bio-Constitutionalism in the Genetic Age*. MIT Press, Cambridge, MA, pp. 1–24.

DTI (1999) New & Renewable Energy: Prospects for the 21st Century. Department of Trade and Industry.

DTI (2003) Our energy future - creating a low carbon economy. The Stationary Office, London.

DTI (2004) Renewables Innovation Review. DTI, London.

DTI (2006a) Increasing the economic impact of Research Councils. DTI, London.

DTI (2006b) Increasing the economic impact of Research Councils. Advice to the Director General of Science and Innovation, DTI from the Research Council Economic Impact Group. 1–22.

DTI (2007) Meeting the Energy Challenge: A White Paper on Energy. The Stationary Office, London, UK.

DTI, DEFRA (2006) The Government's Response to the Biomass Task Force Report. Department of Trade and Industry and Department for the Environment, Food and Rural Affairs.

Dunlop, C.A. (2009) The temporal dimension of knowledge and the limits of policy appraisal: biofuels policy in the UK. *Policy Science* 43, 343–363.

Eden, S. (2010) NGOs, the Science-Lay Dichotomy, and Hybrid Spaces of Environmental Knowledge. In: Meusburger, P., Livingstone, D.N., Jöns, H.

(Eds.), *Geographies of Science, Knowledge and Space*. Springer Netherlands, Dordrecht, pp. 217–230.

Eden, S., Donaldson, A., Walker, G.P. (2006) Green groups and grey areas: scientific boundary work, NGOs and environmental knowledge. *Environment and Planning A* 38, 1061–1076.

Edge, D., Edge, D. (2003) Celebration and Strategy: The 4S After 25 Years, and STS After 9-11. *Social Studies of Science* 33, 161–169.

Edgerton, D. (2009) The "Haldane Principle" and other invented traditions in science policy. London.

Edwards, D., Ashmore, M., Potter, J. (1995) Death and Furniture: the rhetoric, politics and theology of bottom line arguments against relativism. *History of the Human Sciences* 8, 25–49.

Eklof, J., Mager, A. (2013) Technoscientific promotion and biofuel policy: How the press and search engines stage the biofuel controversy. *Media, Culture & Society* 35, 454–471.

Elkington, J. (1998) *Cannibals with forks: The triple bottom line of 21st-century business*. New Society Publishers Ltd., Gabriola Island, Canada.

Elsayed, M.A., Matthews, R., Mortimer, N.D. (2003) Carbon and energy balances for a range of biofuels options. DTI, London, UK.

Epstein, S. (1995) The Construction of Lay Expertise: AIDS Activism and the Forging of Credibility in the Reform of Clinical Trials. *Science, Technology & Human Values* 20, 408–437.

European Commission (2000) Green Paper: Towards a European strategy for the security of energy supply. Commission of the European Communities.

European Commission (2003) DIRECTIVE 2003/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 May 2003. Commission of the European Communities.

European Commission (2005) Biomass Action Plan. Commission of the European Communities, Brussels.

European Commission (2006) An EU Strategy for Biofuels. Commission of the European Communities, Brussels.

European Commission (2007) Biofuels Progress Report: Report on the progress made in the use of biofuels and other renewable fuels in the Member States of the European Union. Commission of the European Communities, Brussels.

Evans, J. (2000) A sociological account of the growth of principlism. *The Hastings Center Report* 30, 31–38.

Evans, J. (2002) *Playing God? Human genetic engineering and the rationalisation of public bioethical debate*. University of Chicago Press, Chicago.

Evans, J. (2006) Between technocracy and democratic legitimation: a proposed compromise position for common morality public bioethics. *The Journal of medicine and philosophy* 31, 213–234.

Evans, J. (2012) *The history and future of bioethics. A sociological view*. Oxford University Press, New York.

Eyre, N., Fergussion, M., Mills, R. (2002) Fuelling Road Transport: Implications for *Energy Policy*. Energy Saving Trust, Institute for European Environmental Policy and NCSA.

FAO (2008) The state of food and agriculture. Biofuels: Prospects, risks and opportunities. Food and Agriculture Organization of the United Nations.

Fargione, J., Hill, J., Tilman, D., Polasky, S., Hawthorne, P. (2008) Land clearing and the biofuel carbon debt. *Science* 319, 1235–1238.

Farsides, B., Williams, C., Alderson, P. (2004) Aiming towards "moral equilibrium": health care professionals' views on working within the morally contested field of antenatal screening. *Journal of Medical Ethics* 30, 505–509.

Felt, U., Fochler, M., Muller, A. (2009) Unruly ethics: on the difficulties of a bottom-up approach to ethics in the field of genomics. *Public Understanding of Science* 18, 354–371.

Felt, U., Wynne, B., Callon, M., Goncalves, M.E., Jasanoff, S., Jepsen, M., Joly, P.-B., Konopasek, Z., May, S., Neubauer, C., Rip, A., Siune, K., Stirling, A. (2007) Taking European knowledge society seriously: Report of the expert group on science and governance to the Science, *Economy and Society* Directorate, Directorate-General for Research, European Commission. European Commission, Luxembourg.

Ferretti, M.P., Pavone, V. (2009) What do civil society organisations expect from participation in science? Lessons from Germany and Spain on the issue of GMOs. *Science and Public Policy* 36, 287–299.

Fiorino, D.J. (1989a) Environmental risk and democratic process: a critical review. *Columbia Journal of Environmental Law* 14, 501–547.

Fiorino, D.J. (1989b) Technical and Democratic Values in Risk Analysis. *Risk Analysis* 9, 293–299.

Fiorino, D.J. (1990) Citizen participation and environmental risk: A survey of institutional mechanisms. *Science, Technology & Human Values*.

Fisher, E., Maricle, G. (2015) Higher-level responsiveness? Socio-technical integration within US and UK nanotechnology research priority setting. *Science and Public Policy* 42, 72–85.

Fishlock, D. (1974) Practical avenues for energy research. Financial Times.

Fishlock, D. (1975) Marshall the energy. *Nature* 254, 94–95.

Fitzgerald, D., Callard, F. (2014) Social Science and Neuroscience beyond Interdisciplinarity: Experimental Entanglements. *Theory, Culture & Society* 32, 3–32.

Flick, U. (2009) Text Interpretation: An Overview. In: *An Introduction to Qualitative Research*. Sage Publications, London, pp. 374–380.

Flipse, S.M., van der Sanden, M.C.A., Osseweijer, P. (2013) The why and how of enabling the integration of social and ethical aspects in research and development. *Science and Engineering Ethics*19, 703–725.

Foley, R.W., Bennett, I., Wetmore, J.M. (2012) Practitioners' Views on Responsibility: Applying *NanoEthics*. *NanoEthics* 231–241.

Fortun, K., Fortun, M. (2005) Scientific Imaginaries and Ethical Plateaus in Contemporary U.S. Toxicology. *American Anthropologist* 107, 43–54.

Fox, R.C. (1976) Advanced Medical Technology-Social and Ethical Implications. *Annual Review of Sociology* 2, 231–268.

Foxon, T.J., Gross, R., Chase, A., Howes, J., Arnall, A., Anderson, D. (2005) UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures. *Energy Policy* 33, 2123–2137.

Friends of the Earth, 2006a. Briefing: The use of palm oil for biofuel and as biomass for energy. Friends of the Earth.

Friends of the Earth, 2006b. Friends of the Earth submission to the Energy Review. Friends of the Earth.

Frith, L., Jacoby, A., Gabbay, M. (2011) Ethical boundary-work in the infertility clinic. *Sociology of Health & Illness* 33, 570–585.

Frow, E.K. (2009) A forum for "doing society and genomics." *EMBO reports* 10, 318–321.

Frow, E.K., Calvert, J. (2013) "Can simple biological systems be built from standardized interchangeable parts?" Negotiating biology and engineering in a synthetic biology competition. *Engineering Studies* 5, 42–58.

Fujimura, J.H. (1987) Constructing Do-Able Problems in Cancer-Research - Articulating Alignment. *Social Studies of Science* 17, 257–293.

Fuller, S. (1999) Science Studies through the looking glass: An intellectual itinerary. http://sciencewars.tripod.com/ullica1.html (accessed 1.6.15).

Fuller, S. (2005) Is STS Truly Revolutionary or Merely Revolting? *Science Studies*.

Fuller, S. (2007) *The knowledge book: Key concepts in philosophy, science and culture*. Acumen, Stocksfield, UK.

Funtowicz, S., Ravetz, J. (1994) The worth of a songbird: ecological economics as a post-normal science. *Ecological Economics* 10, 197–207.

Gad, C., Ribes, D. (2014) The Conceptual and the Empirical in Science and Technology Studies. *Science, Technology & Human Values* 39, 183–191.

Gallagher, K.S., Holdren, J.P., Sagar, A.D. (2006) Energy-Technology Innovation. *Annual Reviews of Environment and Resources* 31, 193–237.

Gamborg, C., Millar, K.M., Shortall, O., Sandøe, P. (2011) Bioenergy and Land Use: Framing the Ethical Debate. *Journal of Agricultural and Environmental Ethics* 25, 909–925.

Gee, S., McMeekin, A. (2011) Eco-Innovation Systems and Problem Sequences: The Contrasting Cases of US and Brazilian Biofuels. *Industry & Innovation* 18, 301–

315.

Geels, F.W. (2004) From sectoral systems of innovation to socio-technical systems. *Research Policy* 33, 897–920.

Geels, F.W. (2007) Feelings of Discontent and the Promise of Middle Range Theory for STS. *Science, Technology & Human Values* 32, 627–651.

Geels, F.W., Raven, R. (2006) Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973–2003). *Technology Analysis & Strategic Management* 18, 375–392.

Geels, F.W., Smit, W.A. (2000) Failed technology futures: pitfalls and lessons from a historical survey. *Futures* 32, 867–885.

Geertz, C. (1973) Thick description: towards an interpretive theory of culture. In: Geertz, C. (Ed.), *The Interpretation of Cultures: Selected Essays*. Basic Books, New York, pp. 3–30.

Georgianna, D.R., Mayfield, S.P. (2012) Exploiting diversity and synthetic biology for the production of algal biofuels. *Nature* 488, 329–335.

Giampietro, M., Ulgiati, S. (2005) Integrated Assessment of Large-Scale Biofuel Production. *Critical Reviews in Plant Sciences* 24, 365–384.

Gibbons, M. (1999) Science's new social contract with society. *Nature* 402, C81–C84.

Gibbons, M., Gummett, P. (1976) Recent Changes in the Administration of Government Research and Development in Britain. *Public Administration* 54, 247–266.

Gibbons, M., Scott, P., Limoges, C., Nowotny, H., Trow, M. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. Sage, London.

Gieryn, T.F. (1983) Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. *American Sociological Review* 48, 781.

Gieryn, T.F. (1995) Boundaries of Science. In: Markle, G., Peterson, J., Pinch, T. (Eds.), *The Handbook of Science and Technology Studies*. Sage, Thousand Oaks, California, pp. 393–443.

Gieryn, T.F. (1999) *Cultural Boundaries of Science: Credibility on the Line*. Chicago University Press, Chicago.

Glaser, B., Strauss, A. (1967) *The discovery of grounded theory: strategies for qualitative research*. Aldin, Chicago.

Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H. (1987) *Energy for a sustainable world*. World Resources Institute & Wiley Publishers, Washington DC.

Gomiero, T., Paoletti, M.G., Pimentel, D. (2009) Biofuels: Efficiency, Ethics, and Limits to Human Appropriation of Ecosystem Services. *Journal of Agricultural and Environmental Ethics* 23, 403–434.

Government Office for Science (2007) Rigour Respect Responsibility: A Universal

Ethical Code for Scientists. DIUS, London.

Grant, L., Gardiner, C. (2011) Synthetic biology dialogue: Follow up evaluation report. Laura Grant Associates.

Greenpeace (2007) Choose the right biofuel or the orang-utan gets it - now on video. http://www.greenpeace.org.uk/blog/climate/choose-the-right-biofuel-or-the-orang-utan-gets-it-now-on-video-20070606 (accessed 2.22.15).

Gressel, J. (2008) Transgenics are imperative for biofuel crops. *Plant Science* 174, 246–263.

Gross, P., Levitt, N., Kantrowitz, A.R. (1997) *Higher Superstition: The Academic Left and Its Quarrels with Science*, New Edition. John Hopkins Press.

Guice, J. (1999) Designing the future: the culture of new trends in science and technology. *Research Policy* 28, 81–98.

Guston, D.H. (1996) Principal-agent theory and the structure of science policy. *Science and Public Policy* 23, 229–240.

Guston, D.H. (1999) Stabilizing the Boundary between US Politics and Science: The Rôle of the Office of Technology Transfer as a Boundary Organization. *Social Studies of Science* 29, 87–111.

Guston, D.H. (2000) *Between politics and science: Assuring the integrity and productivity of research*. Cambridge University Press, Cambridge.

Guston, D.H. (2012) The Pumpkin or the Tiger? Michael Polanyi, Frederick Soddy, and Anticipating Emerging Technologies. *Minerva* 50, 363–379.

Guston, D.H. (2014) Responsible innovation: a going concern. *Journal of Responsible Innovation* 1, 147–150.

Guston, D.H., Sarewitz, D.R. (2002) Real-time technology assessment. *Technology in Society* 24, 93–109.

Hacking, I. (1992) The Self-Vindication of the Laboratory Sciences. In: Pickering, A. (Ed.), *Science as Practice and Culture*. University of Chicago Press, Chicago, pp. 29–64.

Hacking, I. (1999) *The Social Construction of What?* Harvard University Press, Cambridge, MA.

Haimes, E. (2002) What can the social sciences contribute to the study of ethics? Theoretical, empirical and substantive considerations. *Bioethics* 16, 89–113.

Hall, D.O. (1991) Biomass energy. *Energy Policy* 711–737.

Hall, D.O., Rosillo-Calle, F., Groot, P.D. (1992) Biomass energy: Lessons from case studies in developing countries 62–73.

Hammersley, M. (1992) *What's wrong with ethnography*. Routledge, Abingdon, Oxon.

Hammersley, M. (2012) Two methodological disputes. In: *What Is Qualitative Research?* Bloomsbury, London, pp. 1–27.

Hammond, G.P., Howard, H.R., Tuck, A. (2012) Risk assessment of UK biofuel developments within the rapidly evolving energy and transport sectors. *Proceedings of the Institution of Mechanical Engineers, Part O Journal of Risk and Reliability* 226, 526–548.

Hansen, J. (2014) The Danish Biofuel Debate: Coupling Scientific and Politico-Economic Claims. *Science as Culture* 23, 73–97.

Haraway, D. (1989) *Primate visions: Gender, race, and nature in the modern world of science.* New York and London: Routledge.

Haraway, D. (1992) Ecce Homo, Ain't (Ar'n't) I a Woman, and Inappropriate/d Others: The Human in a Post-Humanist Landscape. In: Butler, J., Scott, J.W. (Eds.), *Feminists Theorize the Political.* Routledge, Abingdon, pp. 86–100.

Harremoes, P., Gee, D., MacGarvin, M., Stirling, A., Keys, J., Wynne, B., Vaz, S.G. (2000) Late lessons from early warnings: the precautionary principle 1896 – 2000. European Environment Agency.

Have, ten, P. (2002) Ontology or methodology? Comments on Speer's 'natural' and 'contrived' data: a sustainable distinction? *Discourse Studies* 4, 527–530.

Healy, S. (1994) The recent European biofuel debate as a case study in the politics of renewable energy. *Renewable Energy* 5, 875–877.

Hedgecoe, A. (2001) Ethical boundary work: Geneticization, philosophy and the social sciences. *Medicine, Health Care & Philosophy* 4, 305–309.

Hedgecoe, A. (2003) The Drugs Don't Work: Expectations and the Shaping of Pharmacogenetics. *Social Studies of Science* 33, 327–364.

Hedgecoe, A. (2004) Critical Bioethics: Beyond the Social Science Critique of Applied Ethics. *Bioethics* 18, 120–143.

Hedgecoe, A. (2009) "A Form of Practical Machinery": The Origins of Research Ethics Committees in the UK, 1967–1972. *Medical History* 53, 331–350.

Hedgecoe, A. (2010) Bioethics and the Reinforcement of Socio-technical Expectations. *Social Studies of Science* 40, 163–186.

Hedgecoe, A., Martin, P.A. (2008) Genomics, STS, and the making of sociotechnical futures. In: Amsterdamska, O., Wajcman, J. (Eds.), *The Handbook of Science and Technology Studies*. MIT Press, Cambridge, Masachusetts, pp. 817–839.

Helliwell, R. (2015) Mundane Consequences of the Unintended. http://blogs.nottingham.ac.uk/makingsciencepublic/2015/03/13/mundane-consequences-of-the-unintended/. (accessed 4.20.15).

Hepburn, A., Wiggins, S. (2005) Developments in discursive psychology. *Discourse & Society* 16, 595–601.

Hessels, L.K., van Lente, H. (2008) Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy* 37, 740–760.

Hilgartner, S. (2000) *Science on stage: Expert advice as public drama*. Stanford University Press, Palo Alto.

Hine, C. (2007) Multi-sited Ethnography as a Middle Range Methodology for Contemporary STS. *Science, Technology & Human Values* 32, 652–671.

Hitchcock, G., Hughes, D. (1995) *Research and the teacher*, 2nd ed. Routledge, London.

HM Government (1993) Realising our potential: a strategy for science engineering and technology. HMSO, London.

HM Government (2002) Pre-budget report, November 2002. The Stationary Office, London.

HM Government (2004) Energy Act 2004, Chapter 20. The Stationary Office, London, UK.

HM Government (2007) Statutory Instrument 3072: The Renewable Transport Fuel Obligations Order 2007.

HM Government, 2010a. The 2007/08 Agricultural Price Spikes: Causes and Policy Implications. HM Government, London.

HM Government, 2010b. The 2007/08 Agricultural Price Spikes: Causes and Policy Implications.

HM Government (2012) The Civil Service Reform Plan. The Cabinet Office, London.

HM Parliament (1993) BBSRC Royal Charter.

HM Parliament (2008) Climate Change Act 2008. The Stationary Office, London.

HM Treasury, BIS (2014) Our plan for growth: Science and innovation (No. Cm 8980). HM Treasury and Department for Business, Innovation and Skills, London.

Hobson-West, P. (2012) Ethical boundary-work in the animal research laboratory. *Sociology* 46, 649–663.

Hoffmaster, B. (1992) Can ethnography save the life of medical ethics? *Social Science & Medicine* 35, 1421–1431.

Hollin, G. (2013) Social order and disorder in autism. University of Nottingham, Nottingham.

Horlick-Jones, T., De Marchi, B. (1995) The crisis of scientific expertise in fin de siècle Europe. *Science and Public Policy*.

Horst, M., Irwin, A. (2009) Nations at Ease with Radical Knowledge: On Consensus, Consensusing and False Consensusness. *Social Studies of Science* 40, 105–126.

House of Commons Environment Food and Rural Affairs Committee (2003) Biofuels Seventeenth Report of Session 2002-03 (Volume I). The Stationary Office, London.

House of Commons Environmental Audit Committee (2003) Pre-Budget Report 2002 (Fourth Report of Session 2002-03). London.

House of Commons Environmental Audit Committee (2008a) Are Biofuels Sustainable? The Government Response: Government Response to the Committee's Fourth Report of Session 2007-08. The Stationary Office, London.

House of Commons Environmental Audit Committee (2008b) Are biofuels sustainable? First Report of Session 2007-08 (Volume II - oral and written evidence). The Stationary Office, London.

House of Commons Innovation Universities Science and Skills Committee (2008) Renewable electricity - generation technologies. Volume II: Oral and written evidence. The Stationary Office Limited, London.

House of Commons Science and Technology Committee (1997) The Research Council system: Issues for the future. Fourth Report, Session 1996-97. The Stationary Office, London.

House of Commons Science and Technology Committee (2005) Human Reproductive Technologies and the Law: Fifth Report 2004-05. (Volume ii: Oral and Written Evidence). The Stationary Office, London.

House of Lords Select Committee on Science and Technology (2000) Third report: Science and Society. HMSO, London, UK.

House of Lords Select Committee on Science and Technology, Technology (2010) Setting priorities for publicly funded research. Volume 2: Evidence. HMSO, London.

Hronszky, I. (2012) Expectations and Visions in industrial practice: On the case of modern biopharmaceutics. *STI Studies* 8.

IEA (2004) Biofuels for Transport: An international perspective. IEA / OECD, Paris, France.

IEA (2007) IEA Energy Technology Essentials: Biofuel Production. OECD / IEA, Paris, France.

IFPRI (2006) Bioenergy and Agriculture: Promises and Challenges. International Food Policy Research Institute, Washington DC.

IPSOS Mori (2012) Public views on strategic priorities for Basic Bioscience Underpinning Health: Report on public dialogue pilot. Ipsos Mori and BBSRC.

Irwin, A. (2006) The Politics of Talk: Coming to Terms with the "New" Scientific Governance. *Social Studies of Science* 36, 299–320.

Jasanoff, S. (1990) *The Fifth Branch: Science Advisers as Policymakers*. Harvard University Press, Cambridge, Masachusetts.

Jasanoff, S. (1997) NGOs and the environment: From knowledge to action. *Third World Quarterly* 18, 579–594.

Jasanoff, S. (2003) Technologies of humility: Citizen participation in governing science. *Minerva* 41, 223–244.

Jasanoff, S. (2004a) The idiom of co-production. In: Jasanoff, S. (Ed.), *States of Knowledge*. Routledge, London, pp. 1–12.

Jasanoff, S. (2005a) Ethical Sense and Sensibility. In: *Designs on Nature. Princeton University Press*, pp. 171–202.

Jasanoff, S. (2005b) *Designs on Nature*. Princeton University Press.

Jasanoff, S. (2010a) A field of its own: the emergence of science and technology studies. In: Frodeman, R., Klein, J.T., Mitcham, C., Holbrook, J.B. (Eds.), *The*

Oxford Handbook of Interdisciplinarity. pp. 191–205.

Jasanoff, S. (2010b) A New Climate for Society. *Theory, Culture & Society* 27, 233–253.

Jasanoff, S. (2011) Constitutional Moments in Governing Science and Technology. *Science and Engineering Ethics* 621–638.

Jasanoff, S. (2012) Genealogies of STS. *Social Studies of Science* 42, 435–441.

Jasanoff, S. (2013) Fields and fallows: A political history of STS. In: Barry, A., Born, G. (Eds.*), Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*. Routledge, pp. 99–118.

Jasanoff, S. (Ed.), 2004b. *States of Knowledge*. Routledge, London.

Jasanoff, S., Kim, S.-H. (2009) Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva* 47, 119–146.

Jasanoff, S., Kim, S.-H. (2013) Sociotechnical Imaginaries and National Energy Policies. *Science as Culture* 22, 189–196.

Jensen, C.B. (2014) Continuous Variations: The Conceptual and the Empirical in STS. *Science, Technology & Human Values* 39, 192–213.

Jensen, K.K., Forsberg, E.-M., Gamborg, C., Millar, K.M., Sandøe, P. (2011) Facilitating ethical reflection among scientists using the ethical matrix. *Science and Engineering Ethics* 17, 425–445.

Kaiser, M., Millar, K.M., Thorstensen, E., Tomkins, S. (2007) Developing the ethical matrix as a decision support framework: gm fish as a case study. *Journal of Agricultural and Environmental Ethics* 20, 65–80.

Karp, A., Richter, G.M. (2011) Meeting the challenge of food and energy security. *Journal of experimental botany* 62, 3263–3271.

Kearnes, M., Wienroth, M. (2011) Tools of the Trade: UK Research Intermediaries and the Politics of Impacts. *Minerva* 49, 153–174.

Kelly, S. (2003) Public bioethics and publics: consensus, boundaries, and participation in biomedical science policy. *Science*.

Kerr, A., Cunningham Burley, S., Amos, A. (1997) The new genetics: professionals' discursive boundaries. *The Sociological Review* 45, 279–303.

King, N.B. (2002) Security, Disease, Commerce Ideologies of Postcolonial Global Health. *Social Studies of Science* 32, 763–789.

Kjølberg, K.L., Strand, R. (2011) Conversations About Responsible Nanoresearch. *NanoEthics* 5, 99–113.

Kleinman, A., Fox, R.C., Brandt, A.M. (1999) Introduction. *Daedalus* 128, vii–x.

Knorr-Cetina, K.D. (1981) *The Manufacture of Knowledge — An Essay on the Constructivist and Contextual Nature of Science*. Pergamon Press, Oxford.

Knorr-Cetina, K.D. (1999) *Epistemic cultures: How the sciences make knowledge*. Harvard University Press, Cambridge, MA.

Kovarik, B. (1998) Henry Ford, Charles F. Kettering, and the fuel of the future.

Automotive History Review 32, 7–27.

Kretschmer, B., Baldock, D. (2013) Addressing ILUC? The European Commission's proposal on Indirect Land Use Change. Institute for European Environmental Policy, London and Brussels.

Kuhn, T.S. (1970) *The structure of scientific revolutions*, 2nd ed. University of Chicago press, Chicago, IL.

Kuhn, T.S. (1977) *The Essential Tradition: Selected Studies in Scientific Tradition and Change*. University of Chicago Press, Chicago.

Kumar, S., Singh, S.P., Mishra, I.M., Adhikari, D.K. (2009) Recent Advances in Production of Bioethanol from Lignocellulosic Biomass. *Chemical Engineering & Technology* 32, 517–526.

L-B-Systemtechnik GmbH (2002) GM Well to Wheel Analysis of Energy Use and Greenhouse Gas Emissions of Advanced Fuel / Vehicle Systems - A European Study. L-B Systemtechnik GmbH, Ottobrunn.

la Bellacasa, de, M.P., Puig de la Bellacasa, M. (2011) Matters of care in technoscience: Assembling neglected things. *Social Studies of Science* 41, 85–106.

Lanphier, E., Urnov, F., Haecker, S.E., Werner, M., Smolenski, J. (2015) Don't edit the human germ line. *Nature* 519, 410–411.

Latour, B. (1987) Science in action: How to follow scientists and engineers through society. Harvard University Press.

Latour, B. (1992) Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts. In: Bijker, W.E., Law, J. (Eds.), *In Shaping Technology-Building Society. Studies in Sociotechnical Change*. Cambridge, Massachusetts, pp. 225–259.

Latour, B. (1993) *We have never been modern*. Harvard University Press, Cambridge, MA.

Latour, B. (2002) Morality and Technology: The end of the means. *Theory, Culture & Society* 19, 247–260.

Latour, B., Woolgar, S. (1986) *Laboratory Life: The Construction of Scientific Facts.*, 2nd ed. Princeton University Press, New Jersey.

Law, J. (1986) *Power, action and belief: a new sociology of knowledge*? Routledge and Kegan Paul, London.

Law, J. (2002) Objects and Spaces. *Theory, Culture & Society* 19, 91–105.

Law, J. (2004) *After Method: Mess in social science research*. Taylor & Francis e-Library.

Law, J. (2012) Notes on Fish, Ponds and Theory. Norsk Antropologisk Tidskrift 3-4, 225–236.

Law, J., Urry, J. (2011) Enacting the social. *Economy and Society* 33, 390–410.

Lederer, E.M. (2007) Production of biofuels "is a crime." The Independent 1–2.

Lee, S.K., Chou, H., Ham, T.S., Lee, T.S., Keasling, J.D. (2008) Metabolic engineering of microorganisms for biofuels production: from bugs to synthetic biology to fuels. *Current opinion in biotechnology* 19, 556–563.

Lehoux, P., Daudelin, G., Hivon, M., Miller, F.A., Denis, J.-L. (2014) How do values shape technology design? An exploration of what makes the pursuit of health and wealth legitimate in academic spin-offs. *Sociology of Health & Illness* 36, 738–755.

Lengwiler, M. (2007) Participatory Approaches in Science and Technology: Historical Origins and Current Practices in Critical Perspective. *Science, Technology & Human Values* 33, 186–200.

Levidow, L., Carr, S. (1997) How biotechnology regulation sets a risk / ethics boundary. *Agriculture and Human Values* 14, 29–43.

Levidow, L., Papaioannou, T. (2012) State imaginaries of the public good: shaping UK innovation priorities for bioenergy. *Environmental Science & Policy* 1–14.

Levidow, L., Papaioannou, T., Birch, K. (2012) Neoliberalising Technoscience and Environment: EU Policy for Competitive, Sustainable Biofuels. In: Pellizzoni, L., Ylnen, M. (Eds.), Neoliberalism and Technoscience. *Theory, Technology and Society*. Ashgate.

Levidow, L., Papaioannou, T., Borda-Rodriguez, A. (2013) Innovation Priorities for UK Bioenergy: Technological expectations within path dependence. *Science and Technology Studies* 26, 14–36.

Lewis, C.W. (1981) Biomass through the ages. *Biomass* 1, 5–15.

Leydesdorff, L. (2000) The triple helix: an evolutionary model of innovations. *Research Policy* 29, 243–255.

Lord Rothschild, V. (1971) A Framework for Government Research and Development (Cmnd 48140). HMSO, London.

Lovell, H., Bulkeley, H., Owens, S. (2009) Converging agendas? Energy and climate change policies in the UK. *Environment and Planning C: Government and Policy* 27, 90–109.

Luria, S.E. (1972) Penrose Memorial Lecture. Slippery When Wet Being an Essay on Science, Technology, and Responsibility. *Proceedings of the American Philosophical Society* 116, 351–356.

Lyall, C., Papaioannou, T., Smith, J. (Eds.) (2009) *The Limits to Governance*. Ashgate, Farnham.

Lyall, C., Tait, J. (Eds.) (2005) *New Modes of Governance: Developing an Integrated Policy Approach to Science, Technology, Risk and the Environment*. Ashgate, Aldershot.

Lynch, M. (2000) Against Reflexivity as an Academic Virtue and Source of Privileged Knowledge. *Theory, Culture & Society* 17, 26–54.

Lynch, M. (2002) From naturally occurring data to naturally organized ordinary activities: comment on Speer. *Discourse Studies* 4, 531–537.

Lynch, M. (2012) Self-exemplifying revolutions? Notes on Kuhn and Latour. *Social Studies of Science* 42, 449–455.

Lynch, M. (2013) Ontography: Investigating the production of things, deflating ontology. *Social Studies of Science* 43, 444–462.

MacKenzie, D.A., Wajcman, J. (1985) *The Social Shaping of Technology*. Milton Keynes; Philadelphia: Open University Press.

Macnaghten, P. (2006) Nature. *Theory, Culture & Society* 22, 347–349.

Macnaghten, P., Chilvers, J. (2014) The future of science governance: publics, policies, practices. *Environment and Planning C: Government and Policy* 32, 530–548.

Marris, C. (2014) The Construction of Imaginaries of the Public as a Threat to Synthetic Biology. *Science as Culture* 0, 1–16.

Marris, C., Rose, N. (2010) Open engagement: exploring public participation in the biosciences. *PLoS Biology*.

Mata, T.M., Martins, A.O.N.A., Caetano, N.S. (2010) Microalgae for biodiesel production and other applications: A review. *Renewable and Sustainable Energy Reviews* 14, 217–232.

Mayer, S. (2003) Science out of step with the public: the need for public accountability of science in the UK. *Science and Public Policy* 30, 177–181.

McCarthy, E., Kelty, C. (2010) Responsibility and nanotechnology. *Social Studies of Science* 40, 405–432.

McCormick, J.B., Boyce, A.M. (2009) Biomedical scientists' perceptions of ethical and social implications: is there a role for research ethics consultation? *PLoS One* 4, e4659.

McGowan, F., Sauter, R. (2005) Public Opinion on Energy Research: A Desk Study for the Research Councils. Sussex Energy Group, SPRU, University of Sussex, Brighton.

McLachlan, G. (Ed.) (1978) Five Years After: A review of health care research management after Rothschild. Oxford University Press.

Meghani, Z. (2009) The US' Food and Drug Administration, Normativity of Risk Assessment, GMOs, and American Democracy. *Journal of Agricultural and Environmental Ethics* 22, 125–139.

Melo-Martin, I., Meghani, Z. (2008) Beyond risk. A more realistic risk–benefit analysis of agricultural biotechnologies. *EMBO reports* 9, 302–306.

Menon, V., Rao, M. (2012) Trends in bioconversion of lignocellulose: Biofuels, platform chemicals & biorefinery concept. *Progress in Energy and Combustion Science* 1–29.

Mepham, B. (2000) A framework for the ethical analysis of novel foods: the ethical matrix. *Journal of Agricultural and Environmental Ethics* 165–176.

Merton, R.K. (1968) *Social theory and social structures*. Macmillan, New York.

Merton, R.K. (1973) The Normative Structure of Science. In: *The Sociology of Science*. University of Chicago Press, pp. 223–267.

Meyer, M., Kearnes, M. (2013) Introduction to special section: Intermediaries between science, policy and the market. *Science and Public Policy* 40, 423–429.

Michael, M. (2000) Futures of the present: From performance to prehension. In: Brown, N., Rappert, B., Webster, A. (Eds.), *Contested Futures: A Sociology of Prospective Techno-Science*. Ashgate Press, Aldershot, pp. 21–39.

Michael, M. (2012) "What Are We Busy Doing?" Engaging the Idiot. *Science, Technology & Human Values* 37, 528–554.

Michael, M., Birke, L. (1994) Accounting for Animal Experiments: Identity and Disreputable "Others." *Science, Technology & Human Values* 19, 189–204.

Miles, M.B., Huberman, A.M. (1994*) Qualitative Data Analysis: An expanded Sourcebook*, 2nd ed. Sage Publications, Thousand Oaks.

Miller, C.A. (2001) Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime. *Science, Technology & Human Values* 26, 478–500.

Miller, C.A., Iles, A., Jones, C.F. (2013) The Social Dimensions of Energy Transitions. *Science as Culture* 22, 135–148.

Miller, S. (2001) *Public Understanding of Science* at the crossroads. *Public Understanding of Science* 10, 115–120.

Mirowski, P. (2011) The "Economics of Science" as Repeat Offender. In: *Science-Mart: Privatizing American Science*. Harvard University Press, Cambridge, MA, pp. 41–83.

Mohr, A. (2008) An independent evaluation of the BBSRC and the MRC Stem Cell Dialogue Project 2008.

Mohr, A., Busby, H., Hervey, T. (2012) Mapping the role of official bioethics advice in the governance of biotechnologies in the EU: The European Group on Ethics' Opinion on commercial cord blood banking. *Science and Public Policy* 39, 105-117.

Mohr, A., Raman, S. (2012) Representing the Public in Public Engagement: The Case of the 2008 UK Stem Cell Dialogue. *PLoS Biology* 10, e1001418.

Mohr, A., Raman, S. (2013) Lessons from first generation biofuels and implications for the sustainability appraisal of second generation biofuels. *Energy Policy* 63, 114–122.

Mohr, A., Raman, S., Gibbs, B. (2013) Which publics? When? Exploring the policy potential of involving different publics in dialogue around science and technology. ScienceWise ERC, Harwell.

Mol, A.P.J. (2007) Boundless biofuels? Between environmental sustainability and vulnerability. *Sociologia Ruralis*.

Mol, A.P.J. (2010) Environmental authorities and biofuel controversies. *Environmental Politics* 19, 61–79.

Monbiot, G. (2003) Guard dogs of perception: The corporate takeover of science. *Science and Engineering Ethics* 9, 49–57.

Moore, A. (2010) Public bioethics and public engagement: the politics of "proper talk." *Public Understanding of Science* 19, 197–211.

Morris, N. (2000) Science Policy in Action: Policy and the Researcher. *Minerva* 38, 425–451.

MRC, BBSRC, Sciencewise ERC (2008) Stem cell dialogue project - final report. Biotechnology and Biological Sciences Research Council, Swindon.

Murphy, E.A., Dingwall, R. (2003) Qualitative Methods and Health Policy Research. Aldine De Gruyer., New York.

Naik, S.N., Goud, V.V., Rout, P.K., Dalai, A.K. (2010) Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews* 14, 578–597.

National Audit Office (1994) The Renewable Energy Research, Development and Demostration Programme. National Audit Office, London.

Nelson, A. (2014) Wind power is cheapest energy, EU analysis finds. The Guardian 1–2.

New Economics Foundation, Edinethics Ltd. (2012) Bioenergy: A Democs game. Biotechnology and Biological Sciences Research Council, Swindon.

Nicholas, B. (1999) Molecular geneticists and moral responsibility: "maybe if we were working on the atom bomb I would have a different argument." *Science and Engineering Ethics* 5, 515–530.

Nill, J., Kemp, R. (2009) Evolutionary approaches for sustainable innovation policies: From niche to paradigm? *Research Policy* 38, 668–680.

Norman, W., MacDonald, C. (2004) Getting to the Bottom of "Triple Bottom Line." *Business Ethics Quarterley* 14, 243–262.

Nowotny, H. (2003) Democratising expertise and socially robust knowledge. *Science and Public Policy* 30, 151–156.

Nowotny, H., Scott, P., Gibbons, M. (2001) *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Polity Press, Cambridge.

Nuffield Council on Bioethics (2011) Biofuels: ethical issues. Nuffield Council on Bioethics, London.

Nuffield Council on Bioethics, Bioethics (1999) Genetically modified crops: the ethical and social issues. Nuffield Council on Bioethics, London.

Okken, P.A. (1991) A case for alternative transport fuels. *Energy Policy* 400–405.

Opdenakker, R. (2006) *Advantages and disadvantages of four interview techniques in qualitative research*. Forum: Qualitative Social Research.

Ostwald, M., Henders, S. (2014) Making two parallel land-use sector debates meet: Carbon leakage and indirect land-use change. *Land Use Policy* 36, 533–542.

OTA (1980) Energy from Biological Processes. Office of Technology Assessment, Washington DC.

Owen, R. (2014) The UK Engineering and Physical Sciences Research Council's commitment to a framework for responsible innovation. *Journal of Responsible Innovation* 1, 113–117.

Owen, R., Goldberg, N. (2010) Responsible Innovation: A Pilot Study with the U.K. Engineering and Physical Sciences Research Council. *Risk Analysis* 30, 1699–1707.

Owen, R., Macnaghten, P., Stilgoe, J. (2012) Responsible research and innovation: From science in society to science for society, with society. *Science and Public Policy* 39, 751–760.

Palmer, J. (2010) Stopping the unstoppable? A discursive-institutionalist analysis of renewable transport fuel policy. *Environment and Planning C: Government and Policy* 28, 992–1010.

Palmer, J. (2012) Risk governance in an age of wicked problems: lessons from the European approach to indirect land-use change. *Journal of Risk Research* 15, 495–513.

Palmer, J. (2014) Biofuels and the politics of land-use change: tracing the interactions of discourse and place in European policy making. *Environment and Planning A*.

Parry, S., Faulkner, W., Cunningham Burley, S., Marks, N.J. (2012) Heterogeneous agendas around public engagement in stem cell research: The case for maintaining plasticity. *Science and Technology Studies* 12, 61–80.

Penny Walker Consulting (2013) BBSRC Bioenergy Stakeholder Workshops 2013: Summary Report. Biotechnology and Biological Sciences Research Council, Swindon.

Performance and Innovation Unit (2002) The Energy Review. Performance and Innovation Unit, London.

Perrow, C. (1999) *Normal Accidents: Living with high-risk technologies*. Princeton University Press, Princeton, NJ.

Pestre, D. (2004) Thirty years of Science Studies: Knowledge, society and the political. *History and Technology* 20, 351-369

Petersen, A. (2009) The ethics of expectations: Biobanks and the promise of personalised medicine. *Monash Bioethics Review* 28, 1–12.

Petersen, A. (2013) From bioethics to a sociology of bio-knowledge. *Social Science & Medicine* 98, 264–270.

Phillips, R., Willis, R., Carty, T., Marsh, R. (2006) A new vision for energy. Green Alliance, London.

Pickering, A., Stephanides, A. (1992) Constructing Quaternions: On the Analysis of Conceptual Practice. In: Pickering, A. (Ed.), *Science as Practice and Culture*. University of Chicago Press, Chicago, pp. 139–168.

Pickersgill, M. (2012) The Co-production of Science, Ethics, and Emotion. *Science, Technology & Human Values* 37, 579–603.

Pickersgill, M. (2013) From 'Implications' to 'Dimensions': Science, Medicine and Ethics in Society. *Health Care Analysis* 21, 31–42.

Pidgeon, N., Parkhill, K., Corner, A., Vaughan, N. (2013) Deliberating stratospheric aerosols for climate geoengineering and the SPICE project. *Nature Climate Change* 3, 451–457.

Pielke, R.A., Jr. (2007) *The Honest Broker*. Cambridge University Press.

Pilgrim, S., Harvey, M. (2010) Battles over biofuels in Europe: NGOs and the politics of markets. *Sociological Research Online* 15.

Pimple, K.D. (2002) Six domains of research ethics. A heuristic framework for the responsible conduct of research. *Science and Engineering Ethics* 8, 191–205.

Pinch, T. (2001) Scientific Controversies. In: Smelser, N.J., Baltes, P.B. (Eds.), International Encyclopedia of the Social & Behavioral Sciences. Elsevier, pp. 13719–13724.

Pinch, T., Bijker, W.E. (1984) The Social Construction of Facts and Artefacts - or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science* 14, 399–441.

Popper, K. (1968) *The logic of scientific discovery*, 3rd ed. Hutchinson, London.

POST (1993) POSTnote 41: Biofuels for transport. Parliamentary Office of Science and Technology, London.

Potter, J. (2002) Two kinds of natural. *Discourse Studies* 4, 539–542.

Potter, J., Hepburn, A. (2005) Qualitative interviews in psychology: problems and possibilities. *Qualitative Research in Psychology* 2, 281–307.

Potter, V.R. (1971*) Bioethics: Bridge to the future*. Prentice Hall, Englewood Cliffs.

Potter, V.R. (1975) Humility with responsibility – A bioethic for oncologists: Presidential Address. *Cancer Research*. 35, 2297–2306.

Puig de la Bellacasa, M. (2012) "Nothing comes without its world": thinking with care. *The Sociological Review* 60, 197–216.

Rabinow, P., Bennett, G. (2012) *Designing Human Practices: An Experiment with Synthetic Biology*. University of Chicago Press, Chicago, IL.

Rabson, R., Rogers, P. (1981) The role of fundamental biological research in developing future biomass technologies. *Biomass* 1, 17–37.

Raman, S., Mohr, A. (2013) Biofuels and the role of space in sustainable innovation journeys. *Journal of Cleaner Production* 65, 224–233.

Raman, S., Mohr, A., Helliwell, R., Ribeiro, B., Shortall, O., Smith, R.D.J., Millar, K.M. (2015) Integrating social and value dimensions into sustainability assessment of lignocellulosic biofuels. *Biomass and Bioenergy* 82: 49–62.

Ramsay, W. (1985) Biomass energy in developing countries. *Energy Policy* 13, 326–329.

Ravetz, J. (2007) Post-Normal Science and the complexity of transitions towards sustainability. *Futures* 3, 275–284.

Ravetz, J., Funtowicz, S. (1993) Science for the Post-Normal Age. *Futures* 739–755.

RCEP (2000) Energy - The Changing Climate. HMSO, Norwich.

RCEP (2004) Biomass as a renewable energy source. Royal Commission on Environmental Pollution, London.

Reading, A.H., Norris, J.O.W., Feest, E.A., Payne, E.L. (2002) Ethanol Emissions Testing. Final report to DTLR. AEA Technology, Didcot, UK.

Reich, W.T. (1995a) Introduction. In: Reich, W.T. (Ed.), *The Encyclopedia of Bioethics*. Simon & Schuster Macmillan, New York.

Reich, W.T. (1995b) The word "bioethics": the struggle over its earliest meanings. *Kennedy Institute of Ethics journal* 5, 19–34.

Resnik, D.B. (1996) Social epistemology and the ethics of research. *Studies in the History and Philosophy of Science* 27, 565–586.

Resnik, D.B. (2014) Editorial: Does RCR education make students more ethical, and is this the right question to ask? *Accountability Resesearch* 21, 211–217.

RFA (2008) The Gallagher Review of the indirect effects of biofuels production. Renewable Fuels Agency, St. Leonards-on-Sea.

Rip, A. (1986) Controversies as Informal Technology Assessment. *Knowledge* 8, 349–371.

Rip, A. (1998) The Dancer and the Dance: Steering in / of science and technology. In: Rip, A. (Ed.), *Steering and Effectiveness in a Developing Knowledge Society*. Proceedings of a Workshop at the University of Twente. pp. 27–49.

Rollin, B.E. (2006) *Science and Ethics*. Cambridge University Press, New York.

Rosenberg, C.E. (1999) Meanings, policies, and medicine: On the bioethical enterprise and history. *Daedalus* 128, 27–46.

Rosillo-Calle, F., Hall, D.O. (1992) Biomass energy, forests and global warming. *Energy Policy* 20, 124–136.

Ross, L.F. (2010) Forty years later: the scope of bioethics revisited. *Perspectives in Biology and Medicine* 53, 452–457.

Rowe, G. (2012) Evaluation of a BBSRC Public Dialogue on Health. Biotechnology and Biological Sciences Research Council, Swindon.

Rubin, E.M. (2008) Genomics of cellulosic biofuels. *Nature* 454, 841–845.

Ryan, L., Convery, F., Ferreira, S. (2006) Stimulating the use of biofuels in the European Union: Implications for climate change policy. *Energy Policy* 34, 3184–3194.

Salter, B., Harvey, A. (2014) Creating problems in the governance of science: Bioethics and human/animal chimeras. *Science and Public Policy* 41, sct063–696.

Salter, B., Jones, M. (2005) Biobanks and bioethics: the politics of legitimation. *Journal of European Public Policy*.

Sarewitz, D.R. (2000) Science and environmental policy: An excess of objectivity. In: Frodeman, R. (Ed.), *Earth Matters: The Earth Sciences, Philosophy and the Claims of Community*. Prentice-Hall., London, pp. 79–98.

Sarewitz, D.R. (2004) How science makes environmental controversies worse.

Environmental Science & Policy 7, 385–403.

Sánchez, O.J., Cardona, C.A. (2008) Trends in biotechnological production of fuel ethanol from different feedstocks. *Bioresource Technology* 99, 5270–5295.

Schaffer, S. (2013) 2: How disciplines look. In: Barry, A., Born, G. (Eds.), *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*. Routledge, Abingdon, Oxon, pp. 57–81.

Schomberg, von, R. (2013) A vision of responsible research and innovation. In: Owen, R., Bessant, J., Heintz, M. (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*. Wiley, Chichester, UK, pp. 51–74.

Schuurbiers, D. (2011) What happens in the Lab: Applying Midstream Modulation to Enhance Critical Reflection in the Laboratory. *Science and Engineering Ethics* 17, 769–788.

Schyfter, P. (2011) Technological biology? Things and kinds in synthetic biology. *Biology and Philosophy* 27, 29–48.

Schyfter, P. (2013) How a "drive to make" shapes synthetic biology. *Studies in History and Philosophy of Biology & Biomedical Science* 44, 632–640.

Scott, W.R. (2013) *Institutions and Organizations: Foundations for organisational science*. SAGE.

Searchinger, T., Heimlich, R., Houghton, R.A., Dong, F., Elobeid, A., Fabiosa, J., Tokgoz, S., Hayes, D., Yu, T.-H. (2008) Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science* 319, 1238–1240.

Secretary of State for Transport (2009) Statutory Instrument No. 843: The Renewable Transport Fuel Obligations (Amendment) Order 2009. HMSO, London.

Secretary of State for Transport (2011) Statutory Instrument 2937: The Renewable Transport Fuel Obligations (Amendment) Order 2011. HMSO.

Selin, C. (2007) Expectations and the Emergence of Nanotechnology. *Science, Technology & Human Values* 32, 196–220.

Selin, C. (2008) The Sociology of the Future: Tracing Stories of Technology and Time. *Sociology Compass* 2, 1878–1895.

Sharp, M., Rees, D.A., Williamson, A.R., Fairtlough, G.T. (1989) The Management and Coordination of Biotechnology in the U.K. 1980-88 [and Discussion]. *Philosophical Transactions of the Royal Society B: Biological Sciences* 324, 509–523.

Silverman, D. (2006a) Interviews. In: *Interpreting Qualitative Data: Methods for Analyzing Talk, Text and Interaction*. Sage Publications, Thousand Oaks, pp. 109–152.

Silverman, D. (2006b) Naturally Occurring Talk. In: *Interpreting Qualitative Data: Methods for Analyzing Talk, Text and Interaction*. Sage Publications, Thousand Oaks, pp. 201–240.

Silverman, D. (2013) *Doing qualitative research*. SAGE, London.

Simons, H. (1996) *The Paradox of Case Study.* Cambridge Journal of Education 26, 225–240.

Sims, R.E.H., Mabee, W., Saddler, J.N., Taylor, M. (2010) An overview of second generation biofuel technologies. *Bioresource Technology* 101, 1570–1580.

Singer, P. (2009) *Animal Liberation.* Harper Collins.

Singh, A., Nigam, P.S., Murphy, J.D. (2011) Renewable fuels from algae: an answer to debatable land based fuels. *Bioresource Technology* 102, 10–16.

Sismondo, S. (1993) Some Social Constructions. *Social Studies of Science* 23, 515–553.

Slade, R., Panoutsou, C., Bauen, A. (2009) Reconciling bio-*Energy Policy* and delivery in the UK: Will UK policy initiatives lead to increased deployment? *Biomass and Bioenergy* 33, 679–688.

Smedley, T. (2014) Waste coffee grounds set to fuel London with biodiesel and biomass pellets. The Guardian.

Smith, A., Stirling, A., Berkhout, F. (2005) The governance of sustainable socio-technical transitions. *Research Policy* 34, 1491–1510.

Smith, R.D.J. (2013) Examining the potential for bridging public and stakeholder engagement activities in BBSRC's bioenergy programme. The University of Nottingham, Nottingham.

Spalding Today (2014) Call for public inquiry over biomass plant.

Speer, S.A. (2002) Transcending the 'natural' / 'contrived' distinction: a rejoinder to ten Have, Lynch and Potter. *Discourse Studies* 4, 543–548.

Stahl, B.C. (2012) Responsible research and innovation in information systems. *European Journal of Information Systems* 21, 207–211.

Star, S.L. (2010) This is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology & Human Values* 35, 601–617.

Stein, K. (2007) Food vs Biofuel. *Journal of the American Dietetic Association* 107, 1870–1878.

Stengel, K., Taylor, J., Waterton, C., Wynne, B. (2009) Plant Sciences and the Public Good. *Science, Technology & Human Values* 34, 289–312.

Stephens, N. (2007) Collecting data from elites and ultra elites: telephone and face-to-face interviews with macroeconomists. *Qualitative Research* 7, 203–216.

Stern, N. (2006) Stern Review on the Economics of Climate Change. HM Treasury, London.

Stilgoe, J., Owen, R., Macnaghten, P. (2013) Developing a framework for responsible innovation. *Research Policy* 42, 1568–1580.

Stirling, A. (2008) "Opening Up" and 'Closing Down' Power, Participation, and Pluralism in the Social Appraisal of Technology. *Science, Technology & Human Values* 33, 262–294.

Stirling, A. (2012) Opening up the politics of knowledge and power in bioscience.

PLoS Biology 10, e1001233.

Straughan, R., Reiss, M. (1996) Ethics, morality and crop biotechnology. Biotechnology and Biological Sciences Research Council, Swindon.

Sturges, J.E., Hanrahan, K.J. (2004) Comparing Telephone and Face-to-Face Qualitative Interviewing: A Research Note. *Qualitative Research* 4, 107–118.

Swinbank, A. (2009) EU Policies on Bioenergy and their Potential Clash with the WTO. *Journal of Agricultural Economics* 60, 485–503.

Tait, J. (2012) Adaptive governance of synthetic biology. *EMBO reports* 13, 579–579.

Taleb, N.N. (2007*) The Black Swan: The Impact of the Highly Improbable*. Penguin, London.

Tallacchini, M. (2009) Governing by values. EU ethics: soft tool, hard effects. *Minerva* 47, 281-306

Taylor, G. (2007) DEVELOPING A BIOENERGY ROADMAP FOR THE UK - Bioenergy research roadmap workshop, April 2007 - Working Paper. UKERC.

Taylor, G. (2008) Biofuels and the biorefinery concept. *Energy Policy* 36, 4406–4409.

Taylor-Alexander, S. (2014) Bioethics in the Making: "Ideal Patients" and the Beginnings of Face Transplant Surgery in Mexico. *Science as Culture* 23, 27–50.

Thaemlitz, T. (2009) Midtown 120 Blues [WWW Document]. http://www.comatonse.com/writings/2008_midtown120blues.html (accessed 6.10.15).

Thompson, G., Joseph, S., Juniper, T., Napier, R., Wynne, G. (2004) Brown should stand firm on rising fuel prices (04/06/2004). The Guardian.

Thompson, P.B. (2008) The Agricultural Ethics of Biofuels: A First Look. *Journal of Agricultural and Environmental Ethics* 21, 183–198.

Thompson, P.B. (2012) The agricultural ethics of biofuels: climate ethics and mitigation arguments. *Poiesis and Praxis* 8, 169–189.

Thornley, P., Cooper, D. (2008) The effectiveness of policy instruments in promoting bioenergy. *Biomass and Bioenergy* 32, 903–913.

Tilman, D., Socolow, R., Foley, J.A., Hill, J., Larson, E., Lynd, L. (2009) Beneficial biofuels—the food, energy, and environment trilemma. *Science*.

Todd, R.W., Alty, C.J.N., Hall, D.O., McVeigh, J.C., Musgrove, P.J., Platts, M.J., Schumacher, P. C. (1977) An alternative energy strategy for the United Kingdom. Centre for Alternative Technology, Macynlleth.

Turner, L. (2008a) Anthropological and Sociological Critiques of Bioethics. *Journal of Bioethical Inquiry* 6, 83–98.

Turner, L. (2008b*) Bioethics* and Social Studies of Medicine: Overlapping Concerns. *Cambridge Quarterly of Healthcare Ethics* 18, 36.

UK Research Integrity Office (2009) Code of practice for research: Promoting good practice and preventing misconduct. UK Research Integrity Office, London.

Undheim, T.A. (2003) Getting Connected: How Sociologists Can Access The High

Tech Elite. *The Qualitative Report* 8, 104–128.

Upham, P., Dendler, L. (2015) Scientists as policy actors: A study of the language of biofuel research. *Environmental Science & Policy* 47, 137–147.

Upham, P., Shackley, S., Waterman, H. (2007) Public and stakeholder perceptions of 2030 bioenergy scenarios for the Yorkshire and Humber region. *Energy Policy* 35, 4403–4412.

Upham, P., Thornley, P., Tomei, J., Boucher, P. (2009) Substitutable biodiesel feedstocks for the UK: a review of sustainability issues with reference to the UK RTFO. *Journal of Cleaner Production* 17, S37–S45.

Upreti, B.R. (2004) Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales. *Energy Policy* 32, 785–800.

Van Den Ende, J., Mulder, K., Knot, M., Moors, E., Vergragt, P. (1998) Traditional and Modern Technology Assessment: Toward a Toolkit. *Technological Forecasting and Social Change* 58, 5–21.

van der Burg, S. (2009) Taking the "Soft Impacts" of Technology into Account: Broadening the Discourse in Research Practice. *Social Epistemology* 23, 301–316.

van der Horst, D. (2005) UK biomass energy since 1990: the mismatch between project types and policy objectives. *Energy Policy* 33, 705–716.

van der Horst, D. (2007) NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy* 35, 2705–2714.

van der Horst, D., Vermeylen, S. (2011) Spatial scale and social impacts of biofuel production. *Biomass and Bioenergy* 35, 2435–2443.

van der Meulen, B. (2003) New roles and strategies of a research council: intermediation of the principal-agent relationship. *Science and Public Policy* 30, 323–336.

van Egmond, S., Bal, R. (2011) Boundary Configurations in Science Policy: Modeling Practices in Health Care. *Science, Technology & Human Values* 36, 108–130.

van Lente, H. (2012) Navigating foresight in a sea of expectations: lessons from the sociology of expectations. *Technology Analysis & Strategic Management* 24, 769–782.

van Lente, H., Rip, A. (1998) Expectations in technological developments: an example of prospective structures to be filled by agency. In: Disco, C., van der Meulen, B. (Eds.), Getting New Technologies Together. Studies in Making Sociotechnical Order. De Gruyter, Berlin, pp. 195–220.

van Oudheusden, M. (2014) Where are the politics in responsible innovation? European governance, technology assessments, and beyond. *Journal of Responsible Innovation* 1, 67–86.

Vonnegut, K. (1985) *Galapagos*, 1st ed. Delacorte Press, New York.

Wainwright, S.P., Williams, C., Michael, M., Farsides, B., Cribb, A. (2006) Ethical boundary-work in the embryonic stem cell laboratory. *Sociology of Health & Illness* 28, 732–748.

Walker, G.P. (1995) Energy, land use and renewables: a changing agenda. *Land Use Policy* 12, 3–6.

Waterton, C. (2005) Scientists' conceptions of the boundaries between their own research and policy. *Science and Public Policy*.

Webster, A. (2007) Reflections on Reflexive Engagement: Response to Nowotny and Wynne. *Science, Technology & Human Values* 32, 608–615.

Webster, A., Eriksson, L. (2008) Governance-by-standards in the field of stem cells: managing uncertainty in the world of "basic innovation." *New Genetics and Society* 27, 99–111.

Weil, V. (2002) Making sense of scientists' responsibilities at the interface of science and society. *Science and Engineering Ethics* 8, 223–227.

Weinberg, A.M. (1990) Technology and democracy. *Minerva* 28, 81–90.

Weiner, C. (2006) Patient and Professional Constructions of Familial Hypercholesterolaemia and Heart Disease: Testing the Limits of the Geneticisation Thesis.

Weiner, M., Slatko, B. (2008) Kits and their unique role in molecular biology: a brief retrospective. *Biotech.* 44 Supplement, 701–704.

Weingart, P. (1999) Scientific expertise and political accountability: paradoxes of science in politics. *Science and Public Policy* 26, 151–161.

Whitehead, J.M., Sokol, D.K., Bowman, D., Sedgwick, P. (2009) Consultation activities of clinical ethics committees in the United Kingdom: an empirical study and wake-up call. *Postgraduate Medical Journal* 85, 451–454.

Wickson, F., Delgado, A., Kjolberg, K.L. (2010) Who or what is "the public ?" *Nature nanotechnology* 5, 757–758.

Wickson, F., Forsberg, E.-M. (2014) Standardising Responsibility? The Significance of Interstitial Spaces. *Science and Engineering Ethics* 1–22.

Wickson, F., Wynne, B. (2012) The anglerfish deception. The light of proposed reform in the regulation of GM crops hides underlying problems in EU science and governance. *EMBO reports* 13, 100–105.

Wilsdon, J., Wynne, B., Stilgoe, J. (2005) The Public Value of Science: Or how to ensure that science really matters, Demos. Demos, London.

Wilson, J.C. (2012) *A history of the UK renewable energy programme, 1974-88: some social, political, and economic aspects.* University of Glasgow.

Winner, L. (1986a) *The whale and the reactor: A search for limits in an age of high technology*. University of Chicago Press, Chicago.

Winner, L. (1986b) Do artifacts have politics? In: *The Whale and the Reactor: a Search for Limits in an Age of High Technology*. University of Chicago Press, Chicago, pp. 19–39.

Wolpe, P.R. (2006) Reasons Scientists Avoid Thinking about Ethics. *Cell* 125, 1023–1025.

Woods, J., Bauen, A. (2003) Technology status review and carbon abatement potential of renewable transport fuels in the UK. Department of Trade and Industry, London.

Woolgar, S. (1988) *Knowledge and reflexivity: New frontiers in the sociology of knowledge*. SAGE, London and Beverly Hills.

Woolgar, S., Lezaun, J., Lezaun, J. (2013) The wrong bin bag: A turn to ontology in science and technology studies? *Social Studies of Science* 43, 321–340.

Wright, S. (1994) *Molecular Politics*. The University of Chicago Press, Chicago.

WWF (2002) Oil palm plantations and deforestation in indonesia. What role do Europe and Germany play? www.panda.org/downloads/forests/oilpalmindonesia.prf (accessed 4.24.14).

WWF (2011) The energy report: 100% renewable energy by 2050. WWF, Gland, Switzerland.

Wyatt, S., Balmer, B. (2007) Home on the Range: What and Where is the Middle in Science and Technology Studies? *Science, Technology & Human Values* 32, 619–626.

Wynne, B. (1991) Knowledges in Context. *Science, Technology & Human Values*.

Wynne, B. (1992) Uncertainty and environmental learning: Reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, 111–127.

Wynne, B. (1993) Public uptake of science: a case for institutional reflexivity. *Public Understanding of Science* 2, 321–337.

Wynne, B. (1998) May the sheep safely graze? A reflexive view of the expert–lay knowledge divide. In: Lash, S., Szerszynski, B., Wynne, B. (Eds.), *Theory, Culture & Society: Risk, Environment and Modernity: Towards a New Ecology*. Sage Publications, London, pp. 44–84.

Wynne, B. (2001) Creating public alienation: expert cultures of risk and ethics on GMOs. *Science as Culture* 10, 445–481.

Wynne, B. (2002) Risk and Environment as Legitimatory Discourses of Technology: reflexivity inside-out. *Current Sociology* 50, 459–477.

Wynne, B. (2006) Public engagement as a means of restoring public trust in science--hitting the notes, but missing the music? *Community Genet*ics 9, 211–220.

Wynne, B. (2007a) Public Participation in Science and Technology: Performing and Obscuring a Political–Conceptual Category Mistake. *East Asian Science, Technology and Society: an International Journal* 1, 99–110.

Wynne, B. (2007b) Dazzled by the Mirage of Influence?: STS-SSK in Multivalent Registers of Relevance. *Science, Technology & Human Values* 32, 491–503.

Wynne, B. (2008) Elephants in the rooms where publics encounter "science?": A response to Darrin Durant, 'Accounting for expertise: Wynne and the autonomy of the lay public'. *Public Understanding of Science*.

Wynne, B. (2011) Lab Work Goes Social, and Vice Versa: Strategising Public Engagement Processes. *Science and Engineering Ethics* 17, 791–800.

Wynne, B. (2014) Further disorientation in the hall of mirrors. *Public Understanding of Science* 23, 60–70.

Yearley, S. (1989) Bog Standards: Science and Conservation at a Public Inquiry. *Social Studies of Science* 19, 421–438.

Yearley, S. (1992) Skills, Deals and Impartiality: The Sale of Environmental Consultancy Skills and Public Perceptions of Scientific Neutrality. *Social Studies of Science* 22, 435–453.

Yearley, S. (1996) *Sociology, Environmentalism, Globalization.* Sage, London.

Yin, R.K. (2009a) Introduction: How to know whether and when to use case studies as a research method. In: *Case Study Research: Design and Methods*. SAGE, Thousand Oaks, California, pp. 3–24.

Yin, R.K. (2009b) *Case study research: Design and methods*, 4 ed. SAGE, Thousand Oaks, California.

Zhang, Y.-H.P. (2008) Reviving the carbohydrate economy via multi-product lignocellulose biorefineries. *Journal of industrial microbiology & biotechnology* 35, 367–375.

Zhu, J.Y., Pan, X., Zalesny, R.S., Jr (2010) Pre-treatment of woody biomass for biofuel production: energy efficiency, technologies, and recalcitrance. *Applied Microbiolology and Biotechnology* 87, 847–857.

Ziman, J. (1998) Why must scientists become more ethically sensitive than they used to be? *Science* 282, 1813–1814.

Zussman, R. (2000) The Contributions of Sociology to Medical Ethics. *The Hastings Center Report* 30, 7–11.

Appendices

Appendix 1: Participant information sheet

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Responding to Ethical and Social Concerns in the Bioscience Research Process: Examining Stakeholders' Construction of Engagement.

INFORMATION FOR PARTICIPANTS

1. Who is carrying out the study?
The Study is being conducted by Robert Smith as part of his PhD in the School of Biosciences, University of Nottingham. The primary supervisor is Dr Kate Millar (Director, Centre for Applied Bioethics, School of Biosciences and School of Veterinary Medicine and Science) and the co-supervisors are Professor Paul Martin (School of Sociology, University of Sheffield) and Dr John Harris (Lecturer in Neurophysiology, School of Biosciences).

The individual project is linked to two other research projects within the University: Lignocellulosic Conversion to Ethanol (LACE), funded through BSBEC (http://www.nottingham.ac.uk/bioenergy/lace/index.htm) and EST-frame, which explores emerging science and technology assessment methods and is funded by the EU FP7 program.

2. What the study is about?
The project is a qualitative research project investigating institutional, individual, organisational, and policy responses to social and ethical issues by a range of stakeholders in the biosciences. It uses the case study of biofuels research in the UK to provide a practical context to the work.

3. What are the research objectives?

i. Review institutional policy for references to ethics and public engagement in the scientific process, using BBSRC as a case study.
ii. Interview scientists and other stakeholders about their experiences of ethical reflection, public engagement and the procedural translation of any related policies into practice.
iii. Compare the stakeholders' definitions of, motivating factors for, and barriers to ethical reflection and public engagement in the scientific environment.
iv. Compare data gathered from interviews and documentary analysis to discussions of responsibility in the fields of science and technology studies / bioethics and civil society.
v. Make recommendations for the improvement of current institutional governance mechanisms in the biosciences.

4. What will participation involve?
The interviews will explore different responses to ethical and social concerns. As such, the participant will be asked a series of questions that aim to explore key issues of interest for the project including:

- Ethical and social concerns with biofuels;
- Varying responses from institutions, organisations and individuals;
- Different strategies for considering ethical and social issues;
- Rationales for and barriers to engagement

Interviews will take approximately one hour.

5. What are the benefits of participating in the study?
The participant will be contributing to the PhD project. Despite a general sense that consideration of ethical and social aspects of research should be integrated into the research process, an assessment of the different means and value – independent of and in relation to institutional initiatives – has yet to emerge. This study will contribute to the current gap in knowledge in this area and provide policy recommendations to BBSRC and RCUK.

6. Are there any foreseeable risks as a result of participation and are there any costs or inducements involved in the research?

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No

7. What happens to the collected data?
Interview data will be anonymised, coded by key themes, and used to structure the analysis of how different actors in the research process assess the need to and the means by which it is possible to address ethical and social concerns in the biosciences.

8. What are the research outputs?
Ultimately the project will inform the way that ethics and public engagement is embedded into research projects.

The data collected in the interviews will also contribute to a range of scholarly articles for publication in international peer-reviewed journals, as well as briefings and presentations targeted at a wider audience of interested parties within the bioethics / social science and the science communities.

9. Who else has been identified?
Comprehensive documentary analysis has helped to identify a core list of stakeholders within the scientific process. A sample group of potential interviewees will focus on those within BBSRC / government departments and scientists working in the selected case studies but selected representatives for NGOs will also be interviewed.

10. What should you do if you do/do not want to participate?
Participation in the interview process is voluntary. Individuals will initially be contacted by email/letter asking them if they would be willing to be interviewed. Any of the involved individuals can be contacted at any time using the details on the following page.

Main contact point:

PhD Student and interviewer:

Robert Smith
Tel: 07792590623
Email: stxrdjs@nottingham.ac.uk

Centre for Applied Bioethics
School of Biosciences
South Lab Building
Sutton Bonington Campus
Nr. Loughborough
LE12 5RD

Additional Contact Details:

PhD Primary Supervisor:

Dr Kate Millar
Tel: 01159516303
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Centre for Applied Bioethics
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Complaint Procedure
If you wish to complain about the way in which the research is being conducted or have any concerns about the research then in the first instance please contact the *Principal Investigator*.

If this does not resolve the matter to your satisfaction then please contact the School's Research Ethics Officer, Professor Brigitte Nerlich
(tel. 0115 84 67065, email brigitte.nerlich@nottingham.ac.uk).

Appendix 2: Sample interview guide

Interview Guide - Scientists

Background & Introductory Questions

I know a little about your research group. Could you just briefly introduce yourself and tell a bit about your main interests and give me an idea of the range of projects, funders and professional societies that you work with?

1.Can you tell me a little about your background?

2.How does your work fit into the bioenergy sector as a whole?

3.Can you give me an idea of the kinds of funders that you work with? Are you a member of any societies?

---

1. Do any of your Funders have any specific requirements in relation to ethical / social aspects of research?

   a.This could also be codes of practice

   1.What role should funding bodies play in managing the ethical and social concerns of the research that they fund?

Move this to later

   a. What role do they play at the moment?
   b. In your opinion, which are the most effective ways of doing this?
   c. Can you think of any good or bad examples (this doesn't have to be BBSRC)?

Ethics and social responsibility: General thoughts

Scientists are often asked by research funders, governing bodies, universities, and arguably society to consider and manage the ethical and social aspects of their work. There are lots of different ideas about what this could mean but there really hasn't been much research that asks scientists what this means to them so I'd like to explore that first.

1.I want to ask you a broad question to start off with: What does ethics as part of the research process mean to you?

   a. Does this extend to social responsibility? [e.g. a responsibility for the outcomes of your research in society]

2.What is the value of ethics in science?

3.Is there anything special about research in the field of bioenergy / biofuels that would differentiate it from other areas?

a. (Does sustainable = ethical?)

Not main section!

Discussion of implications around a specific topic: biofuels

I'd like to focus now on bioenergy as a field. There are a wide range of ethical and social issues that have been raised in relation to bioenergy technologies (for example the competition of bioenergy crops with food crops and the issues of water availability in the places where many of these crops are grown). These have obviously been discussed in the literature of organizations like the FAO, reference to them is included in policy and they're increasingly referred to in the policy of BBSRC. I'd like to explore your perception of these issues and whether or not they link to any of your research.

1.For you, what are the most important impacts, implications and issues to consider when doing research in this area? (This doesn't have to be the 'standard set' of controversial aspects)

2.Do any of the broader ethical and social issues with Biofuels relate to your research?

a. Does your research aim to address any of these issues? (E.g. Does 2G deals with 1G?)

3. Are there any specific responsibilities or difficulties to think about with your research – e.g. miscanthus?

Are there tensions between attracting funding and managing expectations? (E.g. Of 2G in light of 1G)

- Speculation
- Hype
- Building expectations

Responsibilities for addressing issues?

- Who? You?
- Funders?
- Are there any difficulties?

Specific ways of managing ethical and social aspects

There are a number of established and emerging methods for considering and managing the ethical and social aspects of research. I'm interested in what your experience of them is, so what you've had experience with and what your actual experience of those processes was, or is. (for me, some examples would be things like ERP, potentially public engagement, potentially sitting on policy committees or review boards, reviewing impact statements or any informal activity or interaction that I haven't thought of – for example I would even say that lab meetings could potentially be points where these issues, on a broad level are considered).

1. Can you explain the **kinds of activities** that you're involved in that allow you to consider and manage ESI?
    a. Do you see any tensions when trying to fit them into your day-to-day role as a scientist?
    b. Are these formal and required, or are they optional?

   c. Who else is involved in them? (I.e. other scientists, communications people, sociologists, ethicists…etc.)

2. Have there **been any changes** in the way that ethical and social aspects of research are considered within your areas of research?
   a. What are the pros and cons of this?
   b. What changes can you envisage for the future?
3. Something that is becoming increasingly prominent is a notion of '**reflection**', for example BBSRC talk about it.
   a. How would you interpret something like 'reflecting on the social and ethical implications of research'?
   b. Are there any points that you reflect? (Formal or informal.)
      i. on 'ethics'
      ii. or your methods
      iii. or wider values
4. One of the things that many ethically and socially reflective tools talk about is trying and **shape the research as it progresses**. In your opinion, what ability is there to do that, firstly with your research and secondly with research in general?
   a. Do you have any role in **research agenda** setting?
5. One of the things I'm interested in, and something relevant for biofuels, is the **interactions between different disciplines**. Do you have any interaction with social scientists or ethicists?
   a. What are the benefits and challenges that this raises?
6. What are the most **appropriate assessments** for biofuels (e.g. TA / Economic Assessments / Sustainability Assessments) and are they being done at the moment?
   a. Can you think of any notable examples?
7. Have you been involved in any **assessments** of biofuels / bioenergy?
   a. Are you aware of any sustainability assessments that have been conducted around biofuels?
8. As a bioenergy researcher you're probably aware of the policy debate around biofuel use.
   a. Have you ever thought about the role of science in this debate?
   b. And have you thought about the role of assessments in this debate?
9. Biofuels can be seen as controversial by some & as a response to this, a common response is for more **integrated** forms of **policy** and assessments. What is your view of this?

10. Do you take part in any **public engagement** activities? What's your experience of this? What are the advantages and disadvantages of engaging the public?
    a. What are the benefits and what are the barriers?
    b. Could you tell me about them and what you do?
    c. Is this encouraged by BBSRC or by your institution? (i.e. WHY)
    d. What are the main topics that you talk about? i.e. do you mainly present science?
    e. What have been the main issues raised and how can the scientific community respond to them?

- ERP
- Policy Committees
- Advisory Bodies for government / Funders.

11. Finally, I'd like to ask you what the major **barriers to engagement** are.
    What are the major difficulties in considering the ethical and social aspect of research in your day-to-day practice?
12. Do scientists have a **responsibility** to extend their view to consider what the implications and potential uses of their research might be in the future? (TB)
    a. What are the difficulties of doing this?

Closing Questions

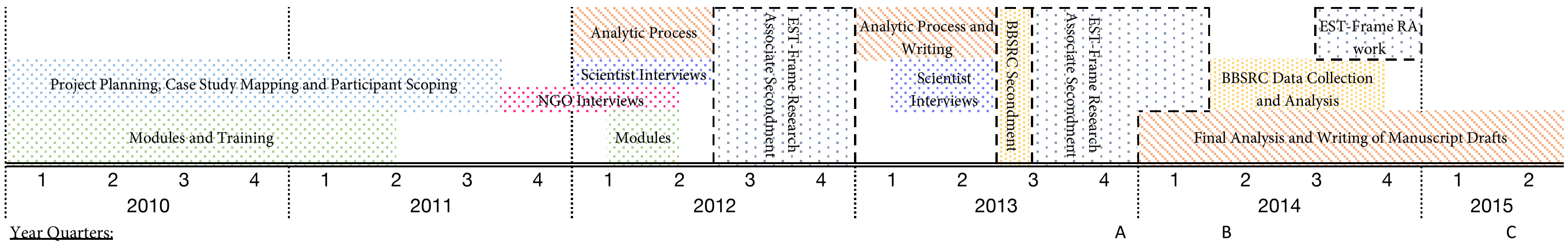
- Is there anything else that you'd like to add?

Before we finish, I'd just like to get your view of who you think the major players are in this field to make sure we're not missing people.

1. Who would you highlight as the major research groups working within bioenergy in the UK?

THANK YOU I RECONFIRM CONSENT I CONFIRM PROCESS, if any, i.e. comment on the transcript, etc. I UPDATED ON PROJECT?

Appendix 3: Timeline of project work, secondments and publications



<u>Year Quarters:</u>

1 Jan, Feb, March
2 April, May, June
3 July, August, September
4 October, November, December

<u>Publication dates</u>

A - December 2013 Smith, R.D.J., 2013. Examining the potential for bridging public and stakeholder engagement activities in BBSRC's bioenergy programme, Nottingham: The University of Nottingham.

B - May 2014 Boucher, P., Smith, R.D.J. & Millar, K.M., 2014. Biofuels under the spotlight: The state of assessment and potential for integration. *Science and Public Policy,* 41(3), pp.283–293.

C - May 2015 Raman, S., Helliwell, R., Mohr, A., Ribeiro, B., Shortall, O., Smith, R. & Millar, K., 2015. Integrating social and value dimensions into sustainability assessment of lignocellulosic biofuels. *Biomass and Bioenergy* (RCUK Bioenergy Manchester special issue). DOI: 10.1016/j.biombioe.2015.04.022.

Appendix 4: Summary of BBSRC Secondment Report

Examining the potential for bridging public and stakeholder engagement activities in BBSRC's bioenergy programme

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(Submitted to BBSRC for circulation and review from relevant parties in December 2013)

Preface

This report is the product of a one-month placement working as part of the External Relations Unit (ERU) of BBSRC between June and July 2013. During this time, I was embedded as a member of ERU. The main focus of my time within ERU was on conducting the work that underpins this report. I also participated, in a small way, to the running of engagement activities: travelling to York and acting as a facilitator at a BBSRC bioenergy stakeholder workshop and subsequently travelling to Falmouth to oversee one of the BBSRC bioenergy dialogue events.

Members of staff at BBSRC have expressed that there is often a lack of time to review and reflect on the processes of engagement. By providing the perspective of an outsider coming into the organisation, the report aims to provide an opportunity to reflect on the practices currently in place, and to provide a starting point to think about and discuss the goals, motivations and practices of public and stakeholder engagement at BBSRC: What should engagement be trying to achieve? Which practices could achieve these ends? Who should engagement include? How can stakeholder and public engagement be integrated into a 'spectrum of communication, engagement and dialogue'?

Report Summary

BBSRC has had a longstanding interest in public and stakeholder engagement. Despite an interchangeable history within the research council, stakeholder engagement and public engagement are currently clearly demarcated on paper and to an extent in practice. Two trends identifiable in the 2012 Corporate Strategy for Communications, Engagement and Dialogue are likely to drive future approaches to engagement policy and practice:

1. A desire to integrate public and stakeholder engagement practices more tightly, and;
2. A general desire to approach decision making in evermore consistent and strategic ways.

The report initially maps engagement activities in BBSRC. It identifies that several different teams are responsible for conducting various forms of stakeholder and public engagement at BBSRC. The actual engagement practices are similarly diverse. Public engagement is more consistently contained within ERU than stakeholder engagement to the extent that ERU could be said to have 'ownership' over public engagement. One danger here could be a tendency for other teams to defer to ERU whilst still maintaining personal conceptions about the goals and aims of public engagement. Given that the multiple and often vague meanings attached to public engagement have produced conflicts in the past, it is important to be explicit and clear regarding questions about: who a stakeholder is; what should be achieved by engaging with them, and; how engagement with different stakeholder types should be prioritised. ERU have begun to make steps in this direction by thinking about taking a 'motivations-led' approach to engagement. It may be useful to develop and expand this across BBSRC as a whole.

The latter half of the report focuses a number of key issues and interesting points that BBSRC may wish to consider in more detail in light of the desire for an integrated approach to engagement. Here, discussion is centred on questions such as the organisational place of engagement, different rationales for engagement, and the potential for building on common understandings for a more integrated and strategic approach. These categories represent key points that have arisen from the previous mapping and conversations with individuals in the three teams covered by the report.

Using Daniel Fiorino's 'normative', 'substantive' and 'instrumental' categories to question the different motivations for engagement in BBSRC, the report demonstrates that in the Corporate Strategy for Communications, Engagement and Dialogue there is a clear instrumental logic and rationale. Motivations in practice are more diverse with individuals drawing on both normative and substantive rationales.

An instrumental logic assumes that engagement will help to maintain BBSRC and bioscience's 'licence to operate'. However, it may be valuable to move towards a process where supporting engagement (as a whole) is part of BBSRC's responsibility as a distributor of public funds. Engagement would be seen as part of ensuring that these funds were distributed in 'the public interest' by helping to provide BBSRC and the people involved in the work it funds with a space to consider and reflect on what the implications of research in a specific field might be, asking questions like 'who might benefit and who may pay', 'what might the risks and benefits be', and importantly 'are there any specific topical (bioscientific or otherwise) aspects that are understudied which should be funded'? To move in this direction may require a renegotiation of BBSRC's position and broader responsibilities, which to an extent is already happening. Questions about balancing different interests, for example, should be explicitly addressed.

In the final section, the report suggests that if desired, integration could be achieved in one of two ways: by unifying outputs (e.g. the findings or evaluations of 'engagements') or by unifying approaches to engagement across BBSRC. Each requires a number of similar steps: A way to judge the role that the different methods of engagement aim to play; Ways to evaluate those methods against their goals; An explicit analysis of the broader political, technological and social context of the relevant research fields, and the ways and points at which engagement might fit into these. Consequently, integrating engagement is a daunting task but focusing on cross-membership of advisory and planning committees may provide a useful first step.