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

2010

Philip Boucher

Manchester Business School

List of Contents

Word Count: 72, 823

List of Figures

List of Boxes

List of Tables

Abbreviations

BCTL	Biofuels Corporation Trading Limited
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
CDA	Critical Discourse Analysis
CITA	Controversies as Informal Technology Assessment
CTA	Constructive Technology Assessment
EC	European Commission
GHG	Greenhouse gases
GM	Genetically Modified / Genetic Modification
ID	Intransitive Dimension
LCA	Lifecycle Analysis / Assessment
MLP	Multi-Level Perspective
NFU	National Farmers' Union
NGO	Non-Governmental Organisation
REA	Renewable Energy Authority
RFA	Renewable Fuel Association
RSG	Relevant Social Group
RSPO	Roundtable on Sustainable Palm Oil
RTFO	Renewable Transport Fuel Order
SCOT	Social Construction of Technology
SNM	Strategic Niche Management
TD	Transitive Dimension
TF	Technical Frame
TMSA	Transformational Model of Social Activity
TMTA	Transformational Model of Technical Activity

Abstract

Philip Boucher, *Technology and Controversy: The Case of Biofuels.*
Doctor of Philosophy, University of Manchester, 12th November 2010.

In the past decade, biofuel development in the UK has been supported by regulations that were justified by government on the basis of their potential benefits for the environment, rural economies and fuel security. As concerns were raised about the negative impacts that biofuel development may have upon food prices and land use, particularly outside Europe, a controversy emerged. A number of technical and infrastructural responses to these concerns have led to the promise of as yet unrealised second, third and even fourth generation developments of the technology. Regulatory responses to concerns can already be identified and further responses, such as mandatory certification schemes, appear likely in the coming years. This relationship between the development of the technology and the controversy is subject to theoretical and empirical examination in the thesis.

A critical realist account of the technology-society has been forwarded recently but remains embryonic, unapplied to specific problems, and untested empirically. Here, this conceptualisation is developed to consider the dialectic, mutual conditioning relationship between technical artefacts and the controversies that surround them. This development includes an articulation of how semiotic processes can operate under realist conditions, emphasising the triad of objects, their names and the meanings that are associated with them. These semiotic processes are understood as the unfolding of technical reality. The resulting theoretical framework is developed into an analytical lens for the study of specific controversies about specific technical artefacts.

Material representing various positions from the biofuel controversy is analysed and discussed with reference to the theoretical framework, considering how the technology conditions the development of the controversy and vice versa. Biofuel technology is a collection of highly variable combinations of different feedstocks that are processed in different ways. These combinations have divergent relationships with various other environmental and economic realities and, as such, support the maintenance of a similarly variable collection of discourses about them. By supporting the relative endurance of discursive conflicts, the technology provides appropriate conditions for the emergence of a controversy. Some actors' discourse is engaged in the negotiation of the organisation of biofuels' internal variety by defining more specific subcategories and broadening the associated vocabulary. This activity may lead to the resolution of some conflicts within the controversy, as it emerges that some conflicts result from the insufficiency of the vocabulary to represent the internal variety of the technology. Furthermore, the controversy also provides the conditions under which the technology develops as engineers, regulators and others rise to new challenges. For example, certification schemes may follow the redistribution of language in selectively incentivising some feedstock-process combinations whilst restricting the development of others. Other conflicts in the controversy have emerged around biofuels produced by the same feedstock-process combination. These differ from conflicts resulting from a single name referring to many different objects, as a single object is understood and represented in different ways. Whilst other social and technical negotiations may still respond to such conflicts, they are unlikely to be resolved through expanding vocabularies.

Declaration

No portion of work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Statement

Acknowledgements

I would like to thank my supervisory team, Dr. Paul Upham and Dr. Sally Randles, and my sponsors, Supergen Bioenergy, for making this project possible. I would also like to thank everybody at Tyndall Manchester for providing such a wonderfully human research environment. I'm indebted to Manchester itself, and whatever it is about it that has provided me with everything I've ever needed. Finally, I'd also like to heartily thank my family and friends for their support and inspiration over the years. Dedicated to mum, who would probably have guessed that I'd still be at uni all these years later...

Nice one chaps.

Preface to the Author

After completing a BSc in Artificial Intelligence and an MSc in Pollution and Environmental Control, both at the University of Manchester, the author spent a year working on two projects at the Tyndall Centre for Climate Change Research. The first considered the measurement of environmental impacts in the cultural sector (see Upham *et al.*, 2007 and 2008) and the second undertook focus groups to consider public understandings of carbon capture and storage (see Reiner *et al.*, 2007).

Following this, the present PhD project was initiated, originally anticipated to identify indicators of the social and environmental sustainability of imported biofuels. During its first year, whilst working on sustainability and policy issues surrounding biofuels and their prospects for use as an aviation fuel (see Upham *et al.*, 2009a, 2009b), attention turned to the biofuel controversy and its relationship with the technology. Dissatisfied with existing frameworks' capacity to adequately support the exploration of this relationship, the author began considering the impacts that ontological assumptions have upon the research process and, particularly, the promise of critical realist philosophy of science (see Boucher, 2010). This led to the present thesis, which combines theoretical developments with applied empirical analysis of the relationship between biofuel technology and controversy.

During the forthcoming fellowship at Manchester Institute of Innovation Research, also at the University of Manchester, the author anticipates the further development, application and publication of the theoretical and empirical outputs of the thesis.

BOUCHER, P. 2010. What Next after Determinism in the Ontology of Technology? Distributing Responsibility in the Biofuel Debate. *Science and Engineering Ethics,* In Press

REINER, D. with **BOUCHER, P.**, SHACKLEY, S., UPHAM, P. & CHEN, J. 2007. Social Gaps Analysis: Communication and Public Perceptions of CO_2 Capture and Storage in the EU. *In:* ANDERSON, J., DE CONINCK, H., CURNOW, P., FLACH, T., GROENENBERG, H., NORTON, C., REINER, D., SHACKLEY, S., UPHAM, P., ELDEVIK, F. & SIGURTHORSSON, G. (eds.) *Multidisciplinary Analysis and Gap-Filling Strategies.* Det Norske Veritas, Hovik.

UPHAM, P., **BOUCHER, P.**, CONNOR, S., HEMMENT, D. & WATERMAN, H. 2007. *Futuresonic: Pilot Carbon Audit April 2007* [Online]. Tyndall Centre, The University of Manchester. http://www.futuresonic.com/07/eco2.html

UPHAM, P., **BOUCHER, P.** & HEMMENT, D. 2008. Piloting a Carbon Emissions Audit for an International Arts Festival under Tight Resource Constraints: Methods, Issues and Results. *In:* GÖSSLING, S., HALL, C. & WEAVER, D. (eds.) *Sustainable Tourism Futures: Perspectives on Systems, Restructuring and Innovations.* Routledge, London.

UPHAM, P., THORNLEY, P., TOMEI, J. & **BOUCHER, P.** 2009a. Substitutable Biodiesel Feedstocks for the UK: A Review of Sustainability Issues with Reference to the UK RTFO. *Journal of Cleaner Production,* 17**,** S37-S45.

UPHAM, P., TOMEI, J., **BOUCHER, P.** & ZAH, R. 2009b. Biofuels, Aviation and Sustainability: Prospects and Limits. *In:* UPHAM, P. & GÖSSLING, S. (eds.) *Aviation and Climate Change.* Earthscan, London.

Chapter 1: Introducing Biofuel Technology & Controversy

"As a matter of urgency, the Intergovernmental Panel on Climate Change needs to determine whether biofuels are good or bad" (New Scientist, 2007)

Biofuel technology has been around for as long as the motor engine although, compared to its fossil fuel counterpart, it has largely existed in a state of relative obscurity. The past decade, however, has seen a controversial period of development for biofuel technology, with legislation demanding its use increases across Europe despite concerns about the potential social and environmental effects.

Capturing the mood of the recent controversy surrounding biofuels, the opening quote from New Scientist, above, is also illustrative of a number of broader issues that are explored in the thesis. For example, what is it that *determines* the development of the technology; is it its interpretation in society by groups such as the Intergovernmental Panel of Climate Change (IPCC), or is it some inherent quality of the technology itself? Perhaps both play a role but, if this is the case, how can we differentiate the two and, more importantly, how does this affect the ways in which we can develop understandings of technology in society?

This introductory chapter presents an overview of biofuel technology from its inception over a century ago to its controversial resurgence over the past decade. It then briefly introduces the academic context of the research project before describing the aims, research questions and justifications that will guide its development. Finally, a map is provided to explain the approach to documenting the research process and the layout of the thesis.

1.1 Introducing Biofuel Technology and Controversy

Biofuels are defined as non-fossilised biological material processed for use in automotive engines, most notably cars, buses and other forms of road transport, although they could also be used in other automotive engines. The technology is differentiated from bioenergy, which also uses biological feedstocks but is associated with the production of energy for static applications such as heating. A wide variety of feedstocks have been used to produce biofuels, perhaps most notably wheat, corn, sugar cane and palm oil. Some waste products, such as used cooking oil and industrial outputs, can also be recycled as biofuel feedstocks.

Under exceptional market circumstances, surplus wine reserves have even been used to produce biofuels (Elena and Esther, 2010). The production of these feedstocks is associated with a variety of social and environmental impacts, some considered positive and others negative.

The breadth of feedstock options is matched in the breadth of processes that can be applied to produce the fuel product. This process includes the transportation of feedstocks to the processing facility, the chemical conversion and treatment process and the transportation of biofuels to the point of delivery. The infrastructures that are developed to support this process cross regional, national and continental scales. The processes themselves and the infrastructures that are developed to support them are, like feedstock production, also associated with a variety of social and environmental impacts. So, biofuels are an internally varied technology which can be produced by a great multitude of feedstock-process combinations with a wide spectrum of impacts.

Biofuel Technology in Relative Obscurity

Biofuels, like fossil fuels, were only consumed in relatively small quantities before the industrial revolution. In 1900, when Rudolf Diesel exhibited his engine for the first time at the World Exhibition in Paris, it was running on peanut oil. As motoring infrastructures developed through the 20th Century, petroleum became the dominant source of motor fuel, likely because of the simple and economical access to their abundant reserves (Agarwal, 2007). From the invention of the engine throughout its rapid diffusion, biofuels were seldom used outside of emergency situations (Ma and Hanna, 1999). Brazil provides a noteworthy exception to this rule as its government began promoting the use of biofuels in the 1940's, largely for geopolitical reasons, and has since then drawn on its substantial biotic resource to fuel its motor infrastructure (Pousa *et al.*, 2007). This remains an exceptional example, and certainly contrasts with the case of the UK where, like much of the rest of the world, biofuels faded to relative obscurity.

Perennial geopolitical, economic and physical concerns have been raised over the limitations of fossil oil supplies. The 1973 oil embargo, prompted by the Organisation of the Petroleum Exporting Countries, highlighted industrial societies' dependence upon potentially insecure supplies of fossil fuel (Salameh, 2000). This political insecurity was

coupled with emerging concerns regarding the physical finitude of oil supplies and the limits set by the prohibitive expense or energy intensiveness of the processes required for the extraction of some oils (Robert and Lennert, 2010).

It was these concerns about fuel insecurity that prompted the first significant doubts about industrial society's dependence upon fossil oils. Increasingly, and particularly over the last two decades, environmental objections to the use of fossil fuels have developed on the basis of a causal relationship between increasing greenhouse gas (GHG[1]) emissions into the atmosphere and climatic change. The most notable such changes involve an increase in the global average temperature and, as a result, rising sea levels and increased frequency of severe weather events (IPCC, 2007). Some have even suggested that the environmental impacts of using oil, rather than oil's scarcity, will define when and how its supply peaks in future (Verbruggen and Al Marchohi, 2010). According to the House of Commons' Environmental Audit Committee (2006), emissions from transportation within the UK accounted for 28% of the UK's total GHG emissions in 2004. More significant than the relative proportion of emissions is, perhaps, its growth. Transportation at this time was described as "the only sector [of the domestic economy] in which emissions have been rising consistently since 1990 and are projected to carry on rising" (p4). The context in which fossil fuels came to dominate biofuels in powering the industrial revolution during the early 20th Century had changed. In the new context, biofuels were becoming an increasingly attractive prospect for the avoidance some of the problems that were now associated with fossil fuels.

A New Political Context & a Second Look at Biofuels

Automotive technology has moved on somewhat since the early engines' fuel ambivalence. Various optimisations were made under the domination of fossil fuels which affected biofuels' suitability for use in modern engines. Nonetheless a broad compatibility was maintained and biofuels could be blended with fossil fuels to create a mix that can be used without requiring any changes to modern engines. The limits to the quantity of biofuels' that can be blended with fossil fuels depend upon a number of variables, most notably the

[1] GHGs are gases with warming potential via the greenhouse effect. The precise definition varies, though it often refers to a 'basket of six' gases used in the Kyoto Protocol; CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons and SF_6. These are often counted in terms of their global warming potential, expressed in their CO_2 equivalent.

engine's specification and local climatic conditions (Chiu *et al.*, 2004). Some specialist applications, such as biofuels as an aviation fuel, face stronger barriers as they operate in somewhat extreme environmental conditions, but substitution with biofuels remains within the realms of technical feasibility (see Upham *et al.*, 2009b).

The combination of biofuels' infrastructural compatibility and concerns about the continued use of fossil fuels led to the reconsideration of biofuels for automotive applications. Unlike fossil fuels, proponents forwarded that the burning of biofuels can be described as 'carbon neutral', because the CO_2 emitted during combustion is balanced against that taken from the atmosphere during the feedstock's production. Further, they could also leapfrog the issues surrounding fossil fuels' scarcity, expense and political sensitivity. Further still, proponents of biofuels have cited the potential benefits to struggling rural economies as farming activity increases to meet new demand for their agricultural produce.

For some (e.g. Demirbas, 2009), these theoretical advantages are not offset by any significant disadvantages, and biofuels are presented as something of a 'silver bullet' solution to global society's environment, economy and energy issues. In 2003, an EU Biofuel Directive (European Parliament, 2003) demanded that member states ensure that biofuels are blended into their fuel mix at a level of 5.75% by the end of 2010. As the UK announced its implementation of the Directive in its Renewable Transport Fuel Obligation (RTFO, see Secretary of State, 2007), it was justified on the basis of the silver bullet promises of carbon savings, diversity of energy supply and benefits to rural economies (Department for Transport., 2006).

The Emergence of the Controversy

Once these policy measures were introduced, biofuels' benefits were held against closer scrutiny and drew significant criticism in the UK and beyond. The GHG emission reductions that can be achieved may be neutralised or negated by other GHG emissions resulting from the production process, particularly the use of fertilisers and the transportation of feedstocks and/or fuels over long distances. Further, by increasing demand for agricultural land, biofuel development may encourage deforestation as environmentally productive land is cleared and replaced with industrial scale monocultures

to supply new biofuel production (de Vries *et al.*, 2010). The increased demand for agricultural produce can also have negative social impacts, such as inflating the price of food products, which may in turn push vulnerable people over the poverty line (Stein, 2007) and promoting large-scale industrialised agricultural practices which may exclude farmers that operate on a small scale (Hall *et al.*, 2009). This questioning of the very benefits used to justify policies to support increased biofuel development marks the beginning of the emergence of the contemporary biofuel controversy.

In response to some of these criticisms, attention also turned to a 2nd generation of the technology which could increase agricultural and economic efficiency by allowing a much greater variety of feedstocks to be used to produce biofuels. The promise of the 2nd generation is that, by using non-food crops, they will not directly affect food markets and that, by using material that would otherwise be wasted, they will improve upon the environmental and economic performance of the 1st generation of biofuel technology.

Whilst significant headway has been made with the 2nd generation, in 2010 the technology remains embryonic and faces ongoing barriers in reaching the requisite scale to surpass the 1st generation (Sims *et al.*, 2010). Their advantages are also qualified by some of the issues that are also faced by the 1st generation, albeit to a lesser extent. For example, increased demand for the land and agricultural activities that are required to grow non-food crops can also lead to rising food prices and may encourage land-use change as the capacity of existing agricultural land is reached. Even where biofuel policy demands that feedstocks are not grown on such land, food production may be relocated to environmentally sensitive areas to make agricultural land available for conversion to feedstock production (Searchinger *et al.*, 2008). Such indirect changes can be extremely difficult to measure but may effectively negate any GHG emissions reductions gained by substituting fossil fuels for biofuels.

In the meantime, the EU Biofuel Directive was not progressing as planned. A European Commission (2006) interim report conceded that only Germany and Sweden had met their intermediate target of reaching a 2% blend by the end of 2005 and that less than half of the 25 member states could report average blends above 0.1%. The UK's 2005 figure was 0.18%, exposed as particularly weak given that the national blend was actually 0.08% higher than this at 0.26% when the Directive was announced two years earlier. Three other member states reported a similar reductions in their biofuel use under the first two years of

the Directive. Given this lack of interim success, the commission concluded that "the biofuels directive's target for 2010 is not likely to be achieved" (p6).

More interesting than this failure, however, is that the Commission's report refers to the emergence of conflicting and inaccurate information about biofuels' social and environmental benefits. It even expresses internal doubts about the purported justification for their political support;

> "The Commission is aware that before taking the next step in the promotion of biofuels, Member States and members of the European Parliament will wish to be certain that the promotion of biofuels is indeed a desirable objective. Does biofuel use really lead to a reduction in greenhouse gas emissions? Will biofuels ever be commercially viable? Is biofuel promotion compatible with protection of the environment, including biodiversity, soil conservation, water quality and air quality?" (p8)

The Commission's report can be seen as a significant landmark in the development of the controversy as it marks the moment when these concerns entered the realm of high-level political thinking. Despite its doubts about the validity of the silver bullet justification, the report also signalled the Commission's motivation to continue its support for further biofuel development regardless of the potential costs. In doing so, the pressing motivation for this support, behind the silver bullet justification that was first cited, is exposed as reducing European dependence upon oil:

> "There is a pressing need for the Union to send a clear signal of its determination to reduce its dependence on oil use in transport. Biofuels are the only practical means of doing this today" (p7)

Rather than ceasing or delaying its support for biofuels, therefore, the approach to encouraging development was amended to appease some of the concerns raised in the controversy. As the European Parliament's Renewable Energy Directive (2009) made their previous Biofuel Directive obsolete, a minimum GHG emissions reduction target for biofuels was set at 35%, rising to 50% and 60% in 2017 for existing and new installations respectively. The Commission also said that by 2010 they would incorporate measurements of land-use change to their legislation and would act to restrict the use of biofuels produced from feedstocks grown on land high in carbon content or biodiversity.

In response to 'food Vs fuel' concerns, 2nd generation fuels were encouraged by counting the contribution of waste materials, residues and non-food materials twice in the meeting of targets. Nonetheless, production of 2nd generation feedstocks would be unlikely to reduce the extensive application of monocultural farming practices or the use of fertilisers and pesticides, all of which can be environmentally damaging. Whilst offering some environmental improvements upon 1st generation fuels, the 2nd generation has, to date, represented something of a second damp squib for biofuel development.

It has been suggested that a 3rd generation of biofuel technology, also in the development phase, may address some of these concerns. By using oceanic feedstocks such as algae, increased demand for feedstocks should not even indirectly promote land-use change (Nigam and Singh, 2010). By inputting liberal amounts of energy-intensive fertilisers and CO_2 to the production environment, rapid growth rates can be achieved which make algae an extremely attractive prospect. Unfortunately these same practices may also reduce their environmental credentials, although such difficulties can be mitigated to some extent by linking them to other industrial outputs by cultivating them in industrial or other waste water streams instead of open seawater and stimulating growth with inputs of CO_2 captured from industrial combustion (Clarens *et al.*, 2010). If this 3rd generation remains beyond current technical capabilities, the mooted 4th generation is little more than science fiction – involving the production of genetically modified biological material which can harvest solar energy to deliver hydrogen or electricity directly (Gressel, 2008).

The Renewable Fuel Agency (RFA), a non-departmental government body charged with overseeing the implementation of the RTFO, has introduced a reporting scheme (RFA, 2010) which requires biofuel suppliers to submit monthly performance indicators that may subsequently be made available to the public. The reportage process adopts a meta-standard approach, incorporating a number of other standards defined by various non-governmental organisations (NGOs) to benchmark social and environmental performance over the product's entire lifecycle, from the production of feedstocks to end usage and waste disposal. Whilst the approach could have significant power to shape biofuel development by ensuring that only those meeting strong environmental and social criteria are eligible to contribute towards suppliers' targets, legislatively it remains quite weak as suppliers are not obliged to meet any of the standards but are only required to report which ones they have met and which they have not. The meta-standard may become mandatory

in future but, whilst the public nature of reported information may encourage good practice, the meeting of social and environmental standards remains entirely voluntary.

The effects of biofuel developments are difficult to measure and even more difficult to predict and the variety of results that regularly emerge from lifecycle analyses does little to unify opinions on how (and, indeed, if) biofuels should be developed. During the emergence of the controversy, much debate was focussed upon questions of poverty and 'food Vs. fuel', although the latest studies of the early impacts of increased biofuel production over the past decade have failed to find evidence of any causal relationship between increased biofuel development and rising food prices (Ajanovic, 2010). Gallagher's (2008) review of the indirect effects of biofuel development suggested that that land-use change may be a more significant problem than the inflation of food prices. This issue has gradually superseded food prices as the central focus of concern about further biofuel development in the controversy. As for the future of the controversy, the practice of genetically modifying feedstocks for the 2nd generation of biofuels (Sticklen, 2008) and beyond (Gressel, 2008) may become a central arena of debate, although responses to this practice vary significantly over time and space, and specific predictions regarding the future direction of such controversies is not considered possible (Delshad *et al.*, 2010).

The Relationship between Biofuel Technology & Controversy

Since the resurgence of interest in biofuel technology during the past decade, various potential social and environmental effects have been predicted across positive and negative scales. As concerns developed, the technology responded, for example in the development of the 2nd generation and in altering which feedstock-process combinations are eligible to contribute towards legally binding targets. Similarly, the controversy responds to the development of the technology, as the dimensions and loci of conflict shift in response to changes in trajectory of technical development. Indeed, the controversy itself emerged as the technology was positioned in a new political context. It seems that there is some relationship between the technology and controversy, and the possibilities for the development of each remain very open indeed.

The present study will consider this interplay between technology and controversy with reference to recent developments in biofuel technology and relics of the controversy in the

form of media resources produced by domestic participants in the controversy[2]. The following section considers the academic context in which such a study would be positioned.

1.2 Academic Context

Academic interest in biofuels has generally focussed upon the environmental and economic impacts associated with various applications of the technology. Whilst these analyses are often justified by the controversy, and have certainly contributed to it, they tend to elide the controversy itself as a unit of analysis[3]. In a recent exception to this rule Landeweerd *et al.* (2009) drew out the implicit ontological positions held in debates amongst stakeholders in biofuel development. The article did not examine the relationship between the technology and the controversy, but instead focussed upon the inadequacy of the ontological frameworks that are applied to support positions within the controversy. They suggested that, in order to produce a complete account, it is necessary to draw upon two ontologies in parallel, one to consider the material reality of the technology and a second to consider its social construction. In response to this article (Boucher, 2010), I have suggested that it would be more elegant to resolve this problem at an ontological level by developing a framework which is suited to the examination of technical reality as a seamless fabric of socio-material reality, rather than attempting resolution at the level of debate by combining the insights that are developed under two frameworks that are considered inadequate and incommensurable.

The kind of history of technical development forwarded in the previous section, weaving political, technical and social developments to tell the story of a technology, has long been a curiosity of scientists and engineers working closely with technologies over a period of their development. The received understanding was of technical development being driven by the performance or features of the technologies that are available. As the contemporary sociology of technology emerged, however, it became apparent that technologies and their development are shaped as much, and perhaps entirely, by social interpretations and political activities. Approaches such as the social construction of technology and actor-

---

[2] More precise definitions of the technology and controversy, and discussions of their analytic treatment, are reserved for subsequent discussion.

[3] The present study sidesteps Byrant's (1976) consideration of an early 20th Century biofuel controversy, as this was not about the technology *per se* but, rather, its inventor's engineering credentials and the legitimacy of his patent on the engine.

network theory emerged, taking various technical histories as case studies to explore how power laden networks and social understandings play a crucial role in the shaping of technical development. This varied group of approaches grew in relevance and, by the late 1980s, were something of an academic vogue.

More recently, Lawson's (2007, 2008) account of technology has emerged with the support of critical realist theory, which may offer support for the resolution of the very issues identified by Landeweerd *et al.* (2009) in the biofuel debate. As recent scholarship, Lawson's work remains embryonic, requiring further engagement and, development towards the consideration of specific problems and empirical application. Thus, a gap in critical realist scholarship is identified which is approached in the present thesis to support the conceptualisation of the technology-controversy relationship and its empirical application to the case of biofuels. The following section considers the scope of the project in greater detail and also the justification, aims and the research questions which will guide the process.

1.3 The Project

Scope

It is necessary to define the scope of the project and to be clear about its limits. Empirically, the study is limited to the case of the development of biofuels and their controversy in the UK. Widening the scope to a global or even European level would not only have presented linguistic and cultural barriers to the researcher but, because the controversy is not ubiquitous and the issues vary from location to location, it would also have introduced an unwieldy level of geographic diversity. Restricting the study to a UK context also ensures that the results are maximally relevant to the sponsors and to the research environment in which the author is positioned.

As developments in biofuel technology and controversy remain ongoing, it is not possible to consider the development of each over a significantly longitudinal dimension. Similarly, as the future development of both technology and controversy remain open and difficult to predict, even in the short to medium term, it will not be possible to examine either from a retrospective position. Of course, undertaking the study during this period also offers some advantages, avoiding the illusion of linearity that hindsight can often bring and increasing

the political relevance of the implications of the study, since recommendations have the potential to feed in to the ongoing and open developments.

The theoretical scope of the study falls within the development of Lawson's critical realist account of technology and society to support the understanding the relationship between technologies and controversies, elaborating further upon the mechanisms through which technologies and controversies develop and supporting the empirical exploration of the case of biofuels.

Whilst these theoretical developments should also have a broader applicability to other case studies, their examination is only undertaken with reference to the case of biofuels. This limits the consideration of broader applicability to a theoretical and reflective excercise, untested with reference to alternative empirical case studies. The peculiarities of the case of biofuels, therefore, may emphasise some theoretical features at the expense of others or lead to a somewhat uneven examination or demonstration. The openness of the biofuel controversy provides an example of this limitation, as the theoretical conceptualisation of the process of reconciliation and resolution of technical controversies may not be as closely examined as may have been with another more mature case study and, certainly, such a process cannot be demonstrated with empirical examples.

Justification

The stipulations of the project's sponsor, Supergen, provides the most immediate justification for studying biofuels but the topic, as a salient contemporary problem with strong links to wider 'grand challenges' of climate change, development and energy also provides its own justification for academic attention. The project is also justified on academic grounds, contributing to the philosophy and sociology of technology by combining, developing and applying some concepts for the first time. This applies particularly to critical realist scholarship, although it is also anticipated to respond to more general appeals to vindicate realism whilst maintaining interpretivism in the sociological study of technology, for example, in the dualist school and in Winner's appeal to the importance of "what a thing is, what name it has, and how people judge its properties" (1993, p372).

Aims, Research Questions & Approach

Some aims and research questions have been devised to guide the research process and its documentation, also providing a point of reference for the concluding chapter's evaluation of the thesis. These aims and questions can be organised into three categories; empirical (Q_{Ex}), theoretical (Q_{Tx}) and reflective (Q_{Rx}). In this subsection, they are considered in turn.

The broad theoretical aim of the thesis is to develop the critical realist account of technology towards conceptualising the relationship between technologies and controversies. Critical realism's account of semiotic activity will also be drawn upon and applied to consider the mechanisms of the relationship in greater detail and also to consider analytical issues. The sum developments are then mobilised for empirical analysis with regards the case of biofuels. In meeting these aims, the thesis should articulate responses to the following questions;

Q_{T1}: How can the critical realist account of technology be developed to consider the relationship between technologies and controversies?

Lawson's account can be developed and specialised to the problem identified in conceptualising the technology-controversy relationship.

Q_{T2}: How can semiotic theory be developed to support the account?

In response to developments in the semiotic school of critical realism, semiotic processes may be developed to provide further support for the conceptualisation and its application to empirical problems.

Q_{T3}: How can the approach be applied empirically to explore the specific case of biofuel technology and controversy?

The theoretical framework should include an appropriate methodological approach to the empirical consideration of biofuel technology and controversy that demonstrates its own power whilst exposing new insights into the case study.

The broad empirical aim of the thesis is to explore the relationship between the development of biofuel technology and the biofuel controversy, demonstrating the working of the theoretical framework and its empirical applicability. Whilst these aims are considered to be relatively broad, there are also a number of more specific research questions for which responses are anticipated to emerge during the research process. These are listed and discussed below.

Q_{E1}: Why are biofuels controversial?

The examination of the biofuel controversy should provide some insights into the conditions under which, and reasons why, the controversy emerged.

Q_{E2}: How do biofuels affect the biofuel controversy?

Examining the case of biofuels with support from the theoretical framework should provide some insights into how biofuel technology shapes the development of the biofuel controversy.

Q_{E3}: How does the biofuel controversy affect biofuel development?

Examining the case of biofuels with support from the theoretical framework should provide some insights into how the biofuel controversy shapes the development of biofuel technology.

No overarching reflective aim of the thesis is defined. Rather, there is the anticipation that the thesis will offer scope for reflections upon some other questions, such as;

Q_{R1}: How might the controversy be resolved?

It should be possible to reflect upon the potential for resolution of the controversy, whether in terms of developments towards resolving specific conflicts or more general insights into how resolution might be achieved. It may be possible to draw some implications and recommendations as a result of this reflection.

Q_{R2}: How is power distributed?

The thesis should support reflection upon how power is distributed in the development of biofuels and the controversy. Again, this may take the form of specific power relations or more general observations on the broad dynamics of power, and may lead to the development of further insights and recommendations.

Q_{R3}: How transferrable are the insights of the biofuel case study?

It is anticipated that the theoretical framework may have a broader applicability than the case of biofuels, although it is not possible to consider alternative technologies in detail here. Nonetheless, it should be possible to reflect upon the potential scope for considering other technologies through the same theoretical framework. Ideally, these reflections should lead to the development of proposals for further analyses.

Approach

It is not considered appropriate to undertake a full theoretical development before considering the content of the empirical material or, indeed, vice versa. Instead, an iterative approach is adopted with theoretical developments being made in parallel to the empirical analysis. This allows the empirical case study and theoretical framework to each inform the development of the other, ensuring that the process leads to an empirically grounded and applicable theoretical framework, and also a theoretically informed analytical process. As progress is made, significant amounts of early work are subsequently rejected or made obsolete. These iterative developments continue until both the empirical and theoretical components are considered to provide a satisfactory and mutually compatible account of the relationship between biofuel technology and controversy that offers a constructive contribution to debate in the contemporary literature.

For all its benefits, the approach introduces something of a dilemma when it comes to presenting the research in the form of a thesis. Including all material in chronological order would require the inclusion of significant amounts of material that would subsequently be retracted or repeated, whilst including only the outputs of the final iterations would fail to capture the development of thinking that occurred during the research process. It can also be challenging to present full blown theoretical concepts clearly whilst referring to the lengthy empirical cases that led to their development. The adopted approach to documenting the research process lies somewhere between the two, and is described in the following subsection, which also provides something of a map to guide the reader through the remainder of the thesis.

Thesis Map

The following chapter presents a short pilot study which is included in the thesis as a vignette for two purposes. The first is to support an understanding of the foundations of the project and its progression from this embryonic state during the research process. The second is to present a concise set of empirical material that, while not considered representative of the controversy, can be drawn upon to provide an empirically grounded explication of the concepts which are subsequently presented. Chapter 3 presents Lawson's critical realist model and positions its approach to the study of technology in relation to other contemporary accounts. Chapter 4 presents the developments made to Lawson's

account, including the incorporation of semiotic theory. By presenting this with reference to the smaller empirical analysis of the pilot vignette (the first iteration of empirical analysis), rather than the larger data set (the final empirical iteration), the discussion can flow without the disruptions associated with the presentation of unwieldy chunks of empirical material. In this sense, the value of the pilot vignette lies in its capacity to support the telling of the story of the research, rather than as an empirical output in itself.

The theoretical development of Lawson's model towards the consideration the technology-controversy relationship with support from semiotic theory is presented in Chapter 4. A second vignette is introduced in Chapter 5, describing a school placement that was undertaken about half way through the research process. Like the pilot study, the placement itself is not considered of significant importance but is presented in the form of a vignette to support the consideration of some of the epistemological consequences of adopting the theoretical framework forwarded in the previous chapters. This Chapter 5 also includes an introduction to the empirical material and the method of its analysis before Chapter 6 presents a selection of outputs from the final iteration of the main empirical analysis. Whilst this analysis is heavily structured by the theoretical framework, the discussion remains focussed upon the empirical material. More substantive discussion of the case study with closer reference to the broader theoretical understanding is reserved for Chapter 7. Finally, a summary and concluding discussion of the thesis with reference to its associated implications and recommendations, and an evaluation of its intellectual contribution, are presented together in Chapter 8.

Chapter 2: Pilot Vignette

This short chapter describes a pilot study undertaken in January 2008 when the project was in the early stages of its development. It was the first iteration of empirical analysis and, at this time, the study had two objectives; first, to explore the potential of the controversy as a unit of analysis and, second, to consider the theoretical and methodological issues that would be involved in undertaking such an analysis. Here in the thesis, however, the pilot is not presented as an output in itself but, rather, as a vignette. As such, its inclusion serves two purposes. First, to document an early stage of the research process, supporting the 'telling of the story' of the research as a chronological process developing from an embryonic state. The approach and position adopted in the pilot and presented in this vignette is not, therefore, taken as consistent with the final approach and position forwarded in the thesis. The second motivation for presenting the pilot study in the thesis in the form of a vignette is to provide a concise glimpse of some empirical material from the controversy that can be drawn upon to illustrate some theoretical points that are presented in subsequent chapters. This allows theoretical discussion to flow without suffering from the distractions of lengthy empirical examples. The vignette is not considered part of the main empirical study, presentation of which is reserved for later chapters after the theoretical framework is fully presented.

Given that the original objectives of the study do not form the motivation for its presentation here as a vignette, some non-pertinent details have been edited out. In the following sections, after an introduction to the study, the empirical material is described and reproduced before a discussion of the research design, documentation of the analytic process and, finally, a brief review of the implications for the wider project and its development into a full scale analysis. Throughout the thesis, the pilot is referred to as a 'study' with reference to meeting its original objectives, and as a 'vignette' with reference to meeting its objectives in its presentation within the thesis.

2.1 Introduction to the Pilot Study

It appears that biofuel development could carry significant implications for a variety of social and environmental qualities both globally (e.g. carbon emissions, food prices) and locally (e.g. biodiversity, farming communities), although these vary wildly under different scenarios. A controversy has emerged around these potential impacts and gathered

increasing momentum in recent years. Whilst this controversy is frequently used as a justification for research into biofuel technology, there has been little academic attention to the controversy *per se* as a unit of analysis. The exploration of this possibility is the first objective of this pilot.

Controversy is described as a situation where there are multiple discourses, or ways of representing the same technology, which contradict each other visibly resulting in a broad and relatively enduring discursive conflict. A number of approaches to the study of discourse have emerged in the last few decades which could be drawn upon to support the analysis of the biofuel controversy. Some emphasise discursive processes at the expense of material and other contextual processes which may be important to the analysis or its implications. Critical discourse analysis (see Wodak and Kendall, 2007) is designed to position discourses within their wider political and material contexts and may provide a suitable framework for exploring the biofuel controversy. This possibility is explored in the study.

2.2 Empirical Material

The empirical material for the pilot was comprised of three short texts. This offered sufficient comparative scope to enjoy the benefits of a pilot without it suffering under the weight of excessive detail. Whilst, clearly, such a limited sample could not provide a fully representative microcosm of the material produced during the controversy, the three texts were selected from different positions in the debate and capture some typically divergent discourses. The texts are introduced in Table 1, below, and subsequently reproduced in full in Boxes 1, 2 and 3.

Reference	Text1-NFU (NFU, 2007b)	Text2-Ind (The Independent, 2007)	Text3-Bfw (Biofuelwatch, 2007a)
Actor	National Farmers' Union (NFU)	The Independent	Biofuelwatch
Description of Actor	A union representing UK farmers as prospective producers of domestic biofuel feedstocks (see NFU, 2009d).	A national newspaper with readership typified as upper-middle class, politically dissatisfied Liberal Democrat voters (see Ipsos Mori, 2005).	Volunteer-led, single-issue activists campaigning for a moratorium on biofuel development (see Personal Communication, 2009b).
Document Title	NFU welcomes proposals for the long awaited obligation on renewable transport fuel	Beet that! Britain's biofuel future takes off	New report calls for "reality check" on biofuels
Document Type	Journal Article	Newspaper Article	Press Release
Publication Date	6th July 2007	27th November 2007	3rd July 2007
Word Count	587 words	759 words	462 words
Reproduced In	Box 1	Box 2	Box 3

Table 1: Empirical Material Selected for the Pilot Study

BACKGROUND

The Renewable Transport Fuel Obligation (RTFO) will start in April 2008 and will apply to the whole of the UK. The main purpose of the RTFO will be to reduce greenhouse gas (GHG) emissions and provide a stable demand for renewable fuels. Under the obligation any road transport fuel supplier supplying more than 450,000 litres per annum will be required to supply a proportion of fuel derived from renewable sources.

The NFU has long campaigned for the introduction of an RTFO, which was eventually announced in November 2005. It will offer significant new opportunities to the UK's biofuel and farming industries, in particular by providing long term market certainty to justify investment in the sector.

In February 2007, the Department for Transport published a consultation paper on the draft RTFO Order and the future design of the obligation. This provided another valuable opportunity for the NFU to continue its representations on the development and implementation of the obligation.

NATURE OF THE OBLIGATION

The obligation will require road transport fuel suppliers to ensure that a specified percentage of their sales are made up of fuels from renewable sources. The level will be equivalent to 2.5% of total road transport fuel sales in 2008/9, rising to 3.75% in 2009/10 and 5% in 2010/11. Suppliers will be able to meet their obligation by supplying any combination of bioethanol, biodiesel, biogas or other accepted renewable road transport fuel.

An 'RTF certificate' can be claimed when renewable fuels are supplied and fuel duty is paid on them. At the end of the obligation period, these certificates may be redeemed to the RTFO Administrator to demonstrate compliance. RTF certificates may also be traded amongst suppliers or other persons who have an RTF account.

If suppliers don't have enough certificates to meet their obligation, they can purchase certificates from other suppliers. Alternatively, they must 'buy-out' the balance of their obligation by paying a buy-out price at the end of the obligation period. The draft Order confirms that the buy-out price will be 15 pence per litre in the first year. The intention is to keep the buy-out price under review to ensure that it remains an effective incentive to supply renewable transport fuels in accordance with targets.

SUSTAINABILITY CRITERIA

The RTFO will require fuel suppliers to report on sustainability and GHG savings of renewable fuels supplied to the market, covering the whole of the production chain. The Government is working with the European Commission, other member states and international bodies to develop a comprehensive sustainability and GHG savings assurance standard for biofuels. This will take time to develop, and in the absence of agreed standards, reporting rather than minimum standards will be introduced.

The NFU supports the development of such assurance schemes and believes that voluntary standards are the most appropriate way forward to allow systems to develop and become proven before mandatory minimum standards are implemented. UK farmers already meet many sustainability standards through existing legislation, cross-compliance requirements and assurance schemes. It is important that these existing schemes are used to avoid additional unnecessary costs being forced upon the industry and that any imported feedstock or biofuel can prove equivalent sustainable production standards have been met.

The NFU also states the importance of GHG-savings and sustainability standards of biofuels to be considered together, to ensure fuels satisfy both criteria. Providing incentives for high GHG-saving fuels without minimum sustainability standards could increase pressure to produce biofuels on environmentally sensitive land which could do more harm than good to both biodiversity and carbon emissions.

Box 1: Reproduction of Text1-NFU

Biofuels are here to stay in the UK whether we like it or not, after MPs voted last month in favour of the Government's Renewable Transport Fuel Obligation (RTFO). This legislation will require all petrol and diesel sold to come from renewable sources, ie bioethanol or biodiesel, by 2010.

The vast majority of drivers will notice no change. Supermarkets such as Tesco and Morrisons already blend 5 per cent ethanol into some of their supplies and sell it as standard unleaded petrol. The RTFO simply means that this will become standard practice, with all diesel sold also containing 5 per cent bio-matter.

The Government promises that a switch to 5 per cent biofuel blends across the board will deliver "significant and immediate" carbon savings, to the tune of 700,000 to 800,000 tonnes of carbon per year - the equivalent of between 2.6 million and 3 million tonnes of carbon dioxide (CO2). The RTFO also means that the UK will have the most sophisticated and robust biofuel reporting system in the world, forcing all suppliers to prove that their biofuels have been produced and sourced in a sustainable and CO2-efficient manner.

So everyone's happy, right? No hassle for the car driver, no expensive refuelling infrastructure changes for the fuel suppliers, considerable carbon savings for all, and at no threat to the rainforests?

Not quite. For some reason, in parts of the UK media, biofuels have changed from having the potential to make an important contribution to the reduction of greenhouse gas emissions to being single-handedly responsible for starving the world's poor, destroying its habitat and adding greatly to the problems of climate change.

Luckily, the UK's first commercial bioethanol plant, which was opened last week by Lord Rooker, Minister for Sustainable Food and Farming, in Wissington, Norfolk, addresses all of these concerns. Owned by British Sugar and built next to the world's largest and most efficient sugar beet factory, it will produce 70 million litres of ethanol each year from 700,000 tonnes of sugar beet, all of which is grown on 10,000 hectares of English countryside.

Far from destroying sensitive habitats and eco-systems or diverting valuable food crops into fuel, all of the beet that is turned into ethanol would have been grown anyway.

Previously, British Sugar used these supplies for its staple sugar business, but EU reforms put an end to this, leading the company to diversify into road transport fuel. Now, the site produces enough ethanol a year for one million cars to run on the Government's stipulated 5 per cent blend.

Another common criticism of biofuels is that their production is so energy-intensive that far more CO2 is created during their manufacture than is saved over the life of the fuel. Such statistics are usually based on outdated and inefficient US factories that use corn as their feedstock. Corn is notoriously difficult to extract energy from.

Thanks to state-of-the-art combined heat and power systems at Wissington, which utilise excess energy from the adjacent sugar factory, British Sugar's bioethanol boasts greenhouse gas savings of between 60 and 70 per cent on a life-cycle basis compared with fossil fuels. In addition, the site exports enough electricity back to the national grid to power 200,000 homes in Norfolk, and even uses excess CO2 to cultivate up to 100 million tomatoes each year, making it one of the UK's largest tomato producers.

If there's one downside to this story, it's that Wissington is a drop in the ocean, producing little more than 5 per cent of the one million tonnes needed by 2010 for the RTFO. However, British Sugar executives promise that this plant is just the start. The next step is a £200m ethanol factory being built in Hull by British Sugar's parent company, Associated British Foods (ABF), in a joint venture with oil giant BP and American chemical firm DuPont. The Hull factory will dip into the UK's 2 to 3 million tonne grain surplus to use as its raw material. (Grain is currently exported and dumped on world markets, thereby depressing prices to the detriment of emerging countries.) With an annual production capacity of 330,000 tonnes of ethanol, the Hull factory will supply one-third of the UK's biofuel needs.

Clare Wenner, head of transport biofuels at the Renewable Energy Association, says that with the opening of British Sugar's factory, the UK is leading Europe in mass biofuel production. "It's vital that the UK gets it right," she says, "otherwise how else can we expect other countries to meet the tough biofuel standards that we are imposing on them?"

Box 2: Reproduction of Text2-Ind

The rush for "biofuels" is already causing serious damage, according to a new report by 11 civil society organisations from around the world.

Agrofuels – towards a reality check in nine key areas sets out considerable evidence that the spread of what are more accurately called "agrofuels" – liquid fuels produced from biomass grown in large-scale monocultures, mostly in the global south – is compromising biodiversity and fuelling human rights violations.

The report finds that agrofuels threaten to greatly accelerate climate change through the destruction of ecosystems and carbon sinks on which we depend for a stable climate. The rush to agrofuels encourages intensive, industrial agriculture at the expense of sustainable food production.

"Monoculture plantations have been doing serious damage around the world for decades, but agrofuels represent a further intensification of the process, endangering what remains of global forest cover and climate. They also threaten the food sovereignty, cultural, human and land rights of indigenous peoples and local communities. The destructive impact of these agrofuels is already severe, while the pros and cons are being debated and certification initiatives are being devised. It is likely that by the time any real analysis has been completed, further irreversible damage will have been done to biodiversity and the climate" says Helena Paul of Econexus.

"Claims are being made that biofuels will mitigate climate change, yet the reality is very different. The rapid expansion of agrofuel monocultures is speeding up the destruction of peatlands, tropical forests and other ecosystems, leading to massive greenhouse gas emissions. In a worst case scenario, further deforestation for agrofuels could push the Amazon forest into rapid die-back, releasing up to 120 billion tonnes of carbon and disrupting rainfall patterns over much of the northern hemisphere" says Almuth Ernsting of Biofuelwatch.

The authors highlight how agrofuels are being used as a new promotional vehicle for GM technologies, in particular through the development of "second generation" crops. Agrofuel expansion also threatens to displace indigenous peoples from their lands.

"The whole agrofuel process is going far too fast, pushed by corporations and governments before any controls are in place. Massive investment in infrastructure is already taking place around the world that will set us on a path from which it will be difficult to escape," says Oscar Reyes of the Transnational Institute.

A call for a moratorium on EU incentives for agrofuels, EU imports of agrofuels and EU agroenergy monocultures was launched in Brussels last week by the same 11 organisations. It has already attracted the support of over 100 organisations worldwide.

Agrofuels – towards a reality check in nine key areas is co-published by: EcoNexus, Biofuelwatch, Carbon Trade Watch (Transnational Institute), Corporate Europe Observatory, Ecologistas en Acción, Ecoropa, Grupo de Reflexión Rural, Munlochy Vigil, NOAH (Friends of the Earth Denmark), Rettet Den Regenwald, Watch Indonesia.

Box 3: Reproduction of Text3-Bfw

2.3 Methodology

A bespoke method for the pilot study was designed to capture the process of analysing the three texts from first impressions through directed readings to contextual interpretation and critique.

In the first stage, before any of the texts were read at any significant level of detail, a surface reading was undertaken and some initial comparative and individual notes were taken. This process collected the most dominant or at least the most salient discursive features identified in the material, documenting them for reference.

In the second stage, drawing upon the outputs of the previous stage, a number of questions are developed to support the exploration of the biofuel controversy and its study. Then, in the third stage, a number of directed readings were undertaken for each text to produce an answer for each question. Some questions were unanswerable, or required some 'reading between the lines'. A significant level of researcher bias was inevitably introduced in the production of both the questions and the answers. Justifications for all claims made on behalf of the texts were made with support of direct quotations. The output of this third stage was three sets of answers to the set of questions produced in the second stage.

In the fourth and final stage, the previous analyses were discussed in terms of their wider contexts, paying particular attention to rhetorical devices in the discourse and the strategic positions of their authors.

2.4 Analysis

The following sections provide a stage-by-stage description of the analysis, illustrated by excerpts from the texts.

Stage One: Initial Observations

A surface reading of the texts was undertaken with early observations noted. Five of the most salient points from each are reproduced in Table 2, below. In the bottom row some general and comparative impressions are also reproduced.

Text1-NFU	Text2-Ind	Text3-Bfw
Appropriate governance can ensure biofuels' sustainability, although they should be developed slowly and with continual reviews.	Biofuels are already developing under government control and consumers are powerless to change this.	Biofuel developments carry international dangers, particularly for indigenous communities in the global South.
Further, biofuel developments will be to the benefit of both the economy and the environment.	Biofuels produced in the UK are not subject to the same criticisms as those that are sourced internationally	Biofuels are devastating for the environment and are linked to other controversies such as genetic modification (GM).
UK farmers already meet sustainability standards and no new mechanisms are required to ensure biofuels' sustainability.	The UK is world leader on environmental issues, including biofuel development as an environmental response.	The effects of biofuels' development are irreversible and they must be halted immediately.
Imported feedstocks must be able to prove that they meet equivalent standards as those produced domestically.	The development of biofuels will not affect consumers.	Biofuels' development is being driven by industry and government.
Ecological sustainability is as important as greenhouse gas savings.	Recent criticisms of biofuels in the media are unjustified.	Biofuel are a threat to food security.
Text3-Bfw opposes biofuel development, whilst Text2-Ind is supportive of it. Text1-NFU, in something of a middle ground, supports biofuel developments only where they are regulated in a certain way. Text3-Bfw was the only text which took an international view of the impacts developments, the other two were very much about domestic issues. Text1-NFU was the only text which did not discredit alternative accounts of biofuel technology and its impacts. Text2-Ind was particularly derisive of alternative perspectives.		

Table 2: Initial Observations from Surface Reading of the Texts

Stages Two & Three: Directed Readings

In the second stage, seven questions were devised and, in stage three, directed readings were undertaken to provide answers from the perspective of the texts. The results of these two stages are presented below in a combined Q&A format.

Q1- What is most concerning about recent biofuel developments?

Text1-NFU: That the regulatory framework will not support development of domestic feedstocks which would ensure that biofuels deliver genuine environmental improvements.

Text2-Ind: That the potential benefits of domestic biofuel developments are misrepresented by some actors who wrongly associate it with social and environmental problems.

Text3-Bfw: That biofuel development is spiralling out of control with devastating consequence for the environment and vulnerable social groups.

Q2- Who or what may benefit from further biofuel developments?

Text1-NFU: The environment can benefit from greenhouse gas emission reductions and the economy can benefit from a stabile demand for feedstocks, but only with the right regulation.

Text2-Ind: The domestic rural economy is the key beneficiary, although global markets may also benefit as some are currently saturated by produce that can be used as feedstocks for biofuel production. The UK's reputation as a world leader on environmental issues would also benefit from further biofuel development.

Text3-Bfw: There are no benefits from further biofuel developments.

Q3- Who or what may suffer from further biofuel developments?

Text1-NFU: Where regulation is insufficient, the environment may be negatively affected by international production of feedstocks by unsustainable methods. Domestic farmers may suffer from overregulation if new standards are too stringent. The right balance of regulation would avoid both problems.

Text2-Ind: Nobody will be disadvantaged by further biofuel development and, indeed, it is damaging to suggest otherwise.

Text3-Bfw: The developing world, particularly indigenous communities, would suffer greatly from further biofuel development. The global environment would also suffer from increased greenhouse gas emissions and climate change.

Q4- Which sources of knowledge are considered trustworthy?

Text1-NFU: The NFU's summary and analysis of biofuel development is a trustworthy source of expertise.

Text2-Ind: The government and industry provide expert knowledge. Other sources are not trustworthy and are subject to unjustified whim. e.g. "For some reason, in parts of the UK media, biofuels have changed..."

Text3-Bfw: Another report, which this press release is written to publicise, is a trustworthy source of expert knowledge. Other sources are not credible e.g. "[c]laims are being made that ... yet the reality is very different".

Q5- Who controls biofuels' future development?

Text1-NFU: The UK government, in partnership with the European Commission, other members of the EU and 'international bodies' control biofuel development, although the Department for Transport and the NFU also influence the development and implementation of the legal framework.

Text2-Ind: The domestic government is the key gatekeeper of development, particularly at a ministerial level, although markets also have some influence on biofuels' development.

Text3-Bfw: Corporations and governments are the key drivers of biofuel development, although others such as the GM lobby also have some influence.

Q6- Who or what need protection and what from?

Text1-NFU: Domestic farmers need to be protected from excessive regulation and the environment needs to be protected from the effects of biofuels without sufficient standards.

Text2-Ind: The biofuel industry needs to be nurtured and protected from unfair criticism which can stifle its growth.

Text3-Bfw: The environment and vulnerable social groups need to be protected from the social and environmental threats associated with biofuel development.

Q7- What should regulation be designed to do and what affect would this have on biofuel development?

Text1-NFU: Governance of domestic production should be minimal (e.g. on a voluntary basis) to avoid overregulation of farmers and driving up costs. This should be combined with strict standards for imported feedstocks to avoid unsustainable production methods.

Text2-Ind: Regulation should be designed to support the swift development of biofuels, particularly at a domestic scale.

Text3-Bfw: An EU level moratorium on all developments, incentives and imports should be imposed to quickly rein in the development of biofuels before it is too late to do so and their irreversible damage is done.

Stage Four: Critical Discussion

The NFU, as an organisation representing the UK farming industry, primarily lobbies for regulation that will strengthen and stabilise the domestic rural economy. It is interesting to recast their stance on the biofuel debate within this context. To recap, in Txt1-NFU, they suggest that, to ensure the sustainability of biofuels, the burden of proof should be placed upon the importers to demonstrate that their products are as sustainable as those that are produced domestically;

> "It is important that ... any imported feedstock or biofuel can prove equivalent sustainable production standards have been met."

Whilst the differences between imported and domestic feedstocks raise important questions, we must look at how this fits the strategy of the NFU as industry representatives. By lobbying for strong standards to be applied to feedstock importers, they raise their competitors' production costs, easing the competition for the sector they represent. Could it be that this argument is being made on environmental grounds instead of economic grounds to hide its self-interest and strengthen its rhetorical power? This is not an easy question to answer, although further examples can be drawn from the NFU treatment of domestic produce, which are described as sustainable by virtue of the existing standards already imposed upon farmers;

> "UK farmers already meet many sustainability standards."

This environmental position is used as a platform to lobby for a laissez faire approach to the regulation of domestically produced biofuels, which would also lead to a stronger competitive position for domestic farmers in the global market;

> "[V]oluntary standards are the most appropriate way forward."

It is not suggested that this means the NFU is only concerned with market protection and not with the sustainability of biofuels, but it is suggested that where regulatory approaches to meet environmental concerns is compatible with their economic interests, their

motivation to lobby for the environment is heightened. It is noted that elsewhere in the same document the NFU explicitly discuss regulation in economic terms;

> "[The RTFO] will offer significant new opportunities to the UK's biofuel and farming industries, in particular by providing long term market certainty to justify investment in the sector"

Biofuelwatch is an organisation with the central aim of lobbying against biofuel development on social and environmental grounds. It calls for an immediate EU level moratorium on their use. These aims are stated explicitly in Text3-Bfw which largely presents social and environmental reasons to curtail biofuel development, although subtler techniques are also used. For example, by associating biofuel development with that of GM technology, they 'piggyback' on the success of the anti-GM lobby;

> "[Biofuels] are being used as a new promotional vehicle for GM technologies."

Text3-Bfw's discursive approach is well aligned with their regulatory agenda. Further biofuel development is positioned as a devastating future for society and environment, its 'reality check' exposing biofuels as a threat to "food sovereignty, cultural, human and land rights of indigenous peoples and local communities" and to "greatly accelerate climate change through the destruction of ecosystems and carbon sinks on which we depend for a stable climate". These problems are presented as avoidable if action is taken now, but irreversible if development continues along the current trajectory. In doing so, they create a sense of urgency that supports their calls for an immediate moratorium;

> "By the time any real analysis has been completed, further irreversible damage will have been done... investment in infrastructure is already taking place around the world that will set us on a path from which it is difficult to escape."

As a company, The Independent is potentially different to the NFU as a union and Biofuelwatch as an activist organisation. Its financial stability is achieved by the delivery of news and advertisements to its readership, and it does not have a direct interest in the development of biofuels. Interestingly, in Txt2-Ind, the public are presented as powerless as both as citizen in the political process; "biofuels are here to stay in the UK whether we like it or not, after MPs voted last month in favour of the Government's [RTFO]" and as consumer; "the vast majority of drivers will notice no change. Supermarkets such as Tesco and Morrisons already blend 5% ethanol into some of their supplies".

The governmental and industrial actors in control of this development are positioned as the experts, with quotes from the Minister for Sustainable Food and Farming and the REA. The article is generally positive about biofuel developments with negative views framed as either inaccurate;

> "Another common criticism of biofuels is that their production is so energy-intensive that far more CO_2 is created during their manufacture than is saved over the life of the fuel. Such statistics are usually based on outdated and inefficient US factories that use corn as their feedstock".

Resolved;

> "[T]he UK's first commercial bioethanol plant... addresses all of these concerns."

Or derisory;

> "For some reason, in parts of the UK media, biofuels have changed from having the potential to make an important contribution to the reduction of greenhouse gas emissions to being single-handedly responsible for starving the world's poor, destroying its habitat and adding greatly to the problems of climate change."

The motive for this approach is unclear, but the article supports the further development of the biofuel sector as an environmental, economic and patriotic good by discrediting the accounts of biofuels' critics.

This analysis has largely drawn upon notional sketches of the organisations' strategies or motivations as the context for the discourse. Whilst the potential environmental impacts of biofuels have been considered in terms of their treatment in the material, and also as a framing justification for the study of the biofuel controversy, it has proved difficult to integrate this into the study. It appears that much more attention to the underlying concepts which support the analysis is required before a satisfactory analysis can be undertaken

2.5 Concluding Remarks

The original objectives of the pilot study are now revisited. The first was exploratory, and exposed significant scope for taking the biofuel controversy as a unit of analysis. Since many of the key actors in the debate are targeting the public, there is a great deal of material available for analysis spanning the breadth of perspectives forwarded in the controversy.

This material must be differentiated from the controversy itself, but provides an insight into perspectives within it which can be fruitfully analysed. As regards the second objective, how to go about such a study, it is clear that careful theoretical developments are required. The pilot study was considered a success as it confirmed the potential for further exploration of the biofuel controversy and highlighted some of the issues that required further attention.

Here, however, the pilot is presented as an empirical vignette and its inclusion is motivated by a different pair of objectives. Meeting the first, it provides an insight into the chronological development of the thesis, exposing the first iteration of the research process which ultimately resulted in the theoretical and empirical positions that are elucidated in the remainder of the thesis. Meeting the second, it provides a concise set of empirical materials to support the presentation of the theoretical developments in subsequent chapters.

Chapter 3: Critical Realism & the Study of Technology

As discussed in the introduction and pilot vignette, theoretical and methodological frameworks are required to support the analysis of the relationship between biofuels and the controversy. A critical realist approach recently initiated by Lawson may hold some potential in such a role but it remains embryonic, requiring further conceptual and empirical attention. This chapter opens with a discussion of some of the broad concepts of critical realism and the account of technical activity forwarded by Lawson. This approach to the study of technology and its broader critical realist philosophy of science are then briefly positioned within the wider literature concerning the study of technology.

3.1 Critical Realist Philosophy of Science

Critical realism, a movement in the philosophy of science, has alluded to its own reconciliatory powers both in general (Archer *et al.*, 1998, Bhaskar, 1979) and in the study of technology (Lawson, 2007a). This power is drawn from an acute distinction between ontology and epistemology which, it claims, positivism and social constructionism collapse into one, positivism by reducing what we experience to what *is*, social constructionism by reducing what *is* to what we experience (epistemic and ontic fallacies, see Hartwig, 2007d). The critical realist literature is large and burgeoning, its treatment here is limited to the provision of sufficient information on core concepts to explain the subsequent developments of its account of technology.

A transitive dimension (TD) is defined, which is restricted to "the epistemological process of any enquiry", including thoughts, understandings, experiences as they emerge and also praxis in the moment of its emergence. The intransitive dimension (ID) contains *everything*, including this TD. As a transitive reality such as a thought emerges, it unfolds from the TD to the ID, it becomes something that *has happened*, part of the fixtures of history. These dimensions do not form a dualism, they are not two sides of some metaphoric coin of reality, but rather the TD is contained 'constellationally' within the ID (Hartwig, 2007f). Take, for example, a transitive understanding of biofuels at a particular time. The distinction between the understanding itself and the object of understanding, mirroring the distinction between epistemology and ontology, is achieved by *referential detachment*. After the understanding has happened, new understandings can be made in referential detachment of either the object itself or of the understanding of it that was previously held.

So, the ID contains material reality and also social constructions that can never be retroactively changed, they will always *have occurred*, but they can be detached and engaged with by further social activity which, again, unfolds into the ID, rendering the ID transformed. All activity is, therefore, understood as a rather spectacular unfolding of being. This ID/TD concept will be revisited later.

Critical realism's 'powers based ontology' conceptualises reality in terms of mechanisms with causal power. The account of ontology is deep and stratified (Hartwig, 2007b). Its depth is understood in terms of three overlapping domains, the real (D_r), actual (D_a) and empirical (D_e) (Bhaskar, 1975). D_e is comprised of all semiotic or experiential reality. This is part of the broader D_a which, which is comprised of all phenomena and events, including D_e but also other actualities outside of experience. This D_a is, in turn, part of the broader D_r, which is comprised of all reality, including $D_{a\&e}$, but also the transcendental reality of causal mechanisms. As $D_r > D_a > D_e$, all experiences, phenomena and mechanisms are all real. Indeed, they are all mechanisms, but not all mechanisms actively generate events, and not all events are empirically experienced (Hartwig, 2007h).

The stratification of mechanisms in critical realism's ontology is derived from its concept of emergence (Morgan, 2007). Emergence is the process by which new mechanisms with distinctive causal powers egress from other mechanisms (Elder-Vass, 2005) The concept is reminiscent of the reductionism whereby the biological is seen as little more than the collective of the chemical (which is, in turn, of the physical, sub-atomic etc), but such reductionism is rejected here as chemical power, and thus chemical reality, does not exist at a sub-chemical level. Its ontological respectability lies *in situ*, at the strata of its emergence. This depth and stratification is a crucially intrinsic feature of critical realism's ontology.

Many objects, artefacts and systems are comprised of mechanisms operating at a number of different emergent strata. These are described as *laminated*, requiring equally laminated explanations that are designed to explore the various dimensions of a system *in situ*, usually espousing interdisciplinarity[4] (1989). Fleetwood has provided a critical realist definition of

[4] Multi-, cross-, trans-, post-, non- and anti- disciplinary varieties also feature in many literatures within and without critical realism, each providing a different response to the generally parochial and imperialist expressions of mono-disciplinarity (Hartwig, 2007e).

artefacts as laminated objects constituted by both social[5] *and* material realities (2005). The laminated technical reality of the artefact is emergent, it forms a new strata, so considering technologies as solely social or material, or even as aggregates of the two is a reductionist fallacy. The ontological respectability must be held *in situ* at the level of the artefact. In the biofuel system, therefore, we might consider the chemical mechanisms of the fuel being combusted in the engine, the biological mechanisms of the environment in which feedstocks are produced, the economic mechanisms of the markets in which they are sold and the social mechanisms of the discursive space in which the controversy emerges to name but a few.

The broad critical realist theory of society is described as the transformational model of social activity (TMSA). Following Bhaskar (1979), the TMSA's first movement is to adopt the classic dialectic position of simultaneously recognising the role of structure in conditioning the agent and the role of the agent in conditioning structure; they are mutually dependent upon each other. Society (structure) is made up a number of individuals (agents) without whom society simply would not exist, yet every individual is a product of its society; linguistically, normatively etc. So, to elaborate with the popular example of language, both positions hold – that an English speaking society produces anglophone individuals *and* that the collection of anglophone individuals produce an English speaking society. Structure and agency are also conceptualised as mutually irreducible to the other, so we cannot explain society only in terms of its members, and cannot explain individuals only in terms of their socialisation.

At this stage, the model is static, it fails to account for any chronological dimension and leaves the analyst in something of a 'chicken and egg' situation. This is rectified in the TMSA's second movement which provides a more marked distinction between structure and agency, defining them in parallel such that:

- Structure is the pre-condition of agency.

  Speech is an act of agency that is pre-existed by and contingent upon the structure provided by the syntax and semantics of the language in use. This is not

[5] Actually, contra Fleetwood's advice, we are conflating ideal reality into social reality. Here, the crucial point is that neither contains "one iota of materiality" (2005, p201). To strictly follow Fleetwood's definition of artefactual reality, it is constituted by all three of physical, social and ideal reality.

deterministic, so while the language structure is a necessary condition for speech acts, it is not a sufficient condition to determine speech acts as inevitabilities.

- Agency is the transformation of structure.

  Just as the speech act is conditioned by language, language is conditioned by individual speech acts. Speech transforms language, whether by developing new slang words, enunciations, acceptable contexts of use or simply in the reproduction and reinforcement of its rules. Transformation is not generally part of the speaker's intention, which is usually limited to the accomplishment of the speech act.

In these distinctions, the TMSA reveals two dualities. First, the duality of structure; since language forms the conditions for speech but is also reproduced by it, structure is shown to be not only the condition for agency, but also the outcome of agency. And second, the duality of praxis[6]; since the speech act is not only the accomplishment of speech, but also the *re*creation of linguistic structure, praxis is shown not only to be production itself, but also the reproduction of its own structural pre-conditions.

For critical realism, power is a necessary component of reality. Indeed, reality itself is defined by the possession of causal power. As a mechanism exists transcendentally, even if it is not exercised, actualised or experienced, this causal power remains real in D_r (Bhaskar, 1975). Power also permeates the understanding of social structure forwarded in Bhaskar's TMSA (1979); both in the potentially far reaching effects of an agent's transformation of structure and in the limitations placed upon individual agents. In later works, establishing his dialectical movement of critical realism (1993)[7] Bhaskar further defined two modes of power, differentiated as $power_1$ and $power_2$. $Power_1$ is the application of this causal power that is ascribed to human agents to transform structures. It is associated with ability and is usually understood in a positive sense. $Power_2$, on the other hand, is the negative application of an agent's capacity to dominate and control others. $Power_2$ is experienced as absence, which can be lifted by the emancipatory actualisation of $power_1$, and so the removal of $power_2$ is described as the 'absenting of absence' (Hartwig, 2007g). Following the duality of praxis, any such power may be expressed intentionally as praxis itself or, more often, unintentionally as the transformation or conservation of structure and, thus, the pre-

[6] A wide understanding of praxis is necessary here. In simplest terms, we might accept it as inclusive of all practice and also production, or take it to mean 'transformative agency' (see Hartwig, 2007a).
[7] Of course, original critical realism (as presented in Bhaskar's 1975 and 1979 works) is dialectical. Dialectical critical realism refers to a second wave of critical realist theory (*cf.* Bhaskar, 1993) which is not drawn upon substantially here.

conditions of future agency. In any case, following the social ontology of critical realism, specific power structures or hegemonies may come and go, but hegemony *per se* is a permanent feature that is inherent in any form of social structure (Joseph, 2000).

These core critical realist concepts have been applied to various specific enquiries and have, particularly in the past decade, begun to develop into a coherent empirical programme in the social sciences (see methodological texts such as Sayer, 1992, 2000, Danermark *et al.*, 2002, Carter and New, 2004). Its attention to technology is surprisingly limited, however, especially considering the centrality of its claims about scientific activity (see Bhaskar, 1979) and the closeness with which the study of technology has followed the study of science in contemporary scholarship. Lawson's embryonic developments of Bhaskar's work lack engagement from other scholars and remain unapplied. Nonetheless, it shows potential for developments beneficial to both critical realist scholarship and the study of technology. The work is summarised in the following section with particular reference to its suitability for further development and application to the study of biofuel technology and controversy.

3.2 The Transformational Model of Technical Activity

As discussed in the *Dictionary of Critical Realism's* (Hartwig, 2007c) entry for 'technology' (Lawson, 2007a), the literature has struggled to differentiate between technologies and other types of object. Following Fleetwood, the critical realist view would hold that technologies are artefacts, both socially and materially constituted but existing as emergent artefactual reality. Lawson's subsequent account of technology (2008) is more specific, saying that non-technical artefacts such as works of art, passports, money etc are more crucially social than material whilst for technical artefacts, such as biofuels, the material dimension is most crucial. Further, whilst technologies are generally considered to be things that are mobilised to some human end, Lawson is also more specific here saying that – unlike other things that are mobilised to human ends such as food, toys etc – technologies such as biofuels harness the material powers of artefacts to "extend human capabilities" (p59). This two-pass delineation still remains somewhat blurry and with some room for interpretation, the 'slippery' nature of artefacts makes the provision of a more specific definition difficult to provide.

Lawson (2008) has further commented upon how technologies can come to have a social dimension as well as a material dimension. The production of new technologies, he argues, is a social activity which is constrained and enabled by social structures, their norms, values etc. These are embodied, through the design process, into the technical artefact. Thus, a social reality which is dependent upon concepts, time and space is *concretized* into a material reality which is not dependent upon concepts, time and space. Through this, the "endurability and travel" (p55) of social reality is extended.

Lawson has also developed Bhaskar's (1979) TMSA into a Transformational Model of *Technical* Activity (TMTA, see 2007b, 2008). So, where the TMSA sketches the form of the relationship between social activity and social structure, the TMTA sketches that between technical activity and technical structure. In parallel to the TMSA's duality of structure, technical structure is considered as both the pre-condition and outcome of technical activities. In parallel to the TMSA's duality of praxis, technical activities are not only the intended use or design of technology but also, as an unintended consequence, the recreation of the technical structure.

At this stage, it becomes clear that 'technology' can be used to refer to specific technical artefacts or, more generally, to the technical sphere, as in the relationship between technical structure and social activities. To clarify, 'technology' will still be used for discussion of technology in general, whilst 'technical artefact' will be adopted as the standard term to indicate a particular artefact of technical reality.

Critical realism is well aligned with critical discourse and critical semiotic analysis, which supports the analysis of discourse and meaning production as processes situated within broader material, social and political contexts (see Fairclough *et al.* 2002). In its TMTA, it provides a conceptualisation of the technology-activity relationship which can be developed to consider the technology-controversy relationship. These features, coupled with the lack of scholarly engagement, make it an appropriate location for further development. Before discussing the developments undertaken in the thesis, Lawson's approach is briefly positioned in relation to other conceptualisations from the wider literature.

3.3 Positioning in the Wider Literature

Just as the critical realist philosophy of science is positioned within long running academic debates, its account of technology is also positioned within technology studies, a rich body of work which has grown in various directions, particularly in the past thirty years. This section locates the critical realist account in the wider literature, pointing out some of the key similarities and differences between it and other contemporary understandings of technology.

The Social Construction of Technology

The first approach considered here is the social construction of technology (SCOT), a literature associated with Pinch and Bijker's seminal study of 'facts and artefacts' (1984). Since then, it has developed into a school in its own right, with some internal diversity and continual development to the present day. These are all united by a set of organising concepts through which the practitioner comes to understand the development of technical artefacts as a result of socially constructive processes. The approach to the study of empirical cases is quite close to that adopted here. Before considering the differences and relative positioning of SCOT and Lawson's TMTA, these organising concepts are discussed with reference to how they could have been applied to consider biofuel technology and the social activity of the controversy.

The primary organising concept in SCOT is that of the *relevant social group* (RSG). These are defined as "institutions and organizations (such as the military or some specific industrial company), as well as organized and unorganized groups of individuals. The key requirement is that all members of a certain social group share the same set of meanings, attached to a specific artefact" (Ibid, p414). So, an RSG exists by virtue of its internally homogenous understanding or interpretation of the artefact. This understanding or interpretation is the second organising concept of SCOT and is referred to as the *technical frame* (TF) [8]. The TF is constitutive of the artefact itself; it defines its functionality, its content. Just as an RSG exists only by virtue of its internally homogenous TF, a TF exists only by virtue of its construction by RSGs, so the two are internally related. That different TFs are possible is testament to the *interpretive flexibility* of technologies, which is our third

[8] Whilst the concept was present in the 1984 text, the term was not (see Bijker, 1995).

organising concept. Simply put; "there is flexibility in how people think of, or interpret, artefacts" and "there is flexibility in how artefacts are designed" (Ibid, p421, emphasis removed). An irreducible part of what technical artefacts are exists, as it were, in the eye of the beholder.

TFs are dynamic and SCOT conceptualises their development in terms of problems and solutions which are negotiated by the RSGs. This negotiation can be understood as a process of defining and redefining part of the content of the artefact, and so, what the technical artefact actually *is*. A solution to a given problem could involve redesigning the artefact, finding a rhetorical response or redefining the problem. These are acts of *closure and stabilization*, the fourth and final organising concept of SCOT that will be considered here. These serve to reduce the interpretive flexibility of the technology as the RSGs settle upon a robust TF. Since a technology's previous development is always recast through the present milieu, closure is also, for RSGs, the *ex post facto* reconstruction of what the technology always was. Most studies sympathise with a Foucouldian understanding of the relationship between knowledge, power and discourse, referring to imbalances in the relative capabilities of different RSGs in the negotiation process. Closure, under this understanding, is presented as the domination of one TF over others at the cost of the scope for interpretive flexibility.

As regards biofuels, a SCOT study would undertake a thorough review of the available resources related to the technology in question. These vary from study to study but are usually comprised of publically available accounts from newspapers, adverts, reports etc. It may be limited to textual accounts but can be augmented by audio and visual material or interviews where available. Through the review, lists of RSGs and their TFs are compiled. Table 3, below, draws upon the pilot vignette to present three such RSGs and their corresponding TFs as an example of how this SCOT approach might work for biofuels. Clearly, it is not exhaustive. A SCOT study would recursively search the resources made available by any group referred to in their study adding them to their actor list until all avenues have been explored. So, for example, from the NFU text they would look at the government text, which might lead them to EU texts, and from the Biofuelwatch text they might look at industry actors' texts, etc.

Relevant Social Group	Technical Frame
NFU	Biofuels are an opportunity for the recovery of dwindling rural economies. With domestic standards, they are also beneficial to the environment.
UK Government (via The Independent)	Biofuels are an opportunity to demonstrate the UK's world leading capabilities, both environmentally and economically.
Biofuelwatch	Biofuels are a great threat to environment and society, particularly the developing world.

Table 3: Relevant Social Groups & their Technical Frames of Biofuels

Establishing the reasons why RSGs adopt particular TFs of biofuels is not straightforward. Staying with the example of biofuels, Thompson (2008) has shown how Americans' views on the war on terror can affect whether or not they support biofuel development. To expand; citizens may support a president on the basis of their foreign policy, and extend this support to their approval of the same leader's endorsement of biofuel development. Voices of dissent, perhaps opposing the leader on the basis of their foreign policy, may also oppose the biofuel development policy that is associated with the same president. Shifting to the UK context, in the material from The Independent newspaper that was considered in the pilot vignette, biofuels are presented as being under the control of the government and industry with individuals seen as powerless citizens, powerless consumers, powerless in the shaping of biofuel development. The government and industry were presented as 'safe hands' in the text and readers with a critical attitude to these actors may develop a similarly critical attitude to the biofuel developments that they promote. RSGs and TFs are not straightforward, and the relationship between them might not always be fully understood, but SCOT remains a useful framework for exposing how they develop over time and how that affects technical development.

An RSG's internal perspective may be different to its public facing one. The latter is often comprised of carefully sculpted rhetoric, particularly where the empirical material is developed for advertising or lobbying purposes. The pilot vignette unveiled an example of this situation. The NFU is primarily interested in biofuels' potential to stimulate the domestic rural economy, yet they generally present their arguments in environmental terms. So whilst their primary motivation to call for restrictions upon imported fuels must be the protection of their markets from global competition, their surface motive is ensuring that

sustainability standards are met (NFU, 2007b). Perhaps because the construction of biofuels' environmental value has a greater degree of interpretive flexibility than their economic value, it provides a more effective arena for the NFU to promote their arguments. By this understanding the NFU's environmentalist TF is a rhetorical facade, their *real* TF has much more to do with market protection.

It must be noted that SCOT never required technical development to be conceptualised as the constant reduction of interpretive flexibility until the process ceases when closure is achieved. Interpretive flexibility was always understood as in flux and closure as a *relatively* enduring phase of high stabilisation and low flexibility that may be reversed in a process of reopening. There has, however, been a tendency to overlook this, particularly in the earlier SCOT studies (Kline and Pinch, 1999).

Rip's (1986) understanding of 'controversies as informal technology assessment' (CITA) is relevant here, as it has demonstrated that controversy is one such example of the circumstances under which interpretive flexibility can be increased and 'closed' TFs can be reopened. The two programmes of SCOT and CITA have different aims, CITA being directed particularly towards identifying 'early warnings' about technology for assessment purposes, but it exhibits paradigmatic and thematic similarities with SCOT, adopting a similar historical style and conceptualisation of artefacts in terms of dynamic and flexible interpretations with one understanding coming to dominate others, gaining a 'robustness' that closes out debate. However, CITA does present a subtle but important difference of emphasis which, I suggest, can be seen as augmenting the SCOT programme. For CITA, after a robust understanding is developed and some closure is achieved, a controversy can emerge to interrupt closure and reopen interpretive flexibility. This interruption may arise from the actualisation of some feature of the technical artefact that is not dependent upon its social construction. This articulates a specific and empirically grounded mechanism of negotiation which does not reduce interpretive flexibility but increases it, opening and reopening debates at various stages of closure. CITA also emphasises that under this approach closure, like 'truth', is not conceptualised as *permanent* but, rather, as *relatively enduring*.

Some practitioners of SCOT have proactively engaged with the processes they study to attempt to shape the construction of technology in various ways (e.g. Elle *et al.*, 2010).

However, since most studies are of a historic nature and are undertaken during a period of closure, the level of interpretive flexibility required to achieve political efficacy tends to be restricted. More often, recommendations are made for the governance of technologies in general, usually advocating a broader participation, ensuring that technologies are shaped by a greater variety of social groups (Shin, 2008). The programme of constructive technology assessment (CTA) succeeded in assimilating insights from the new sociology of technology to various political arenas, particularly in the Netherlands but also elsewhere (Schot and Rip, 1997). Drawing on its understanding of technical development as a dynamic and power laden modulation of assessment and feedback, CTA is designed for active deployment during the process of technical development, its agents described as "intermediaries between a future better world and the present situation" (Ibid, p265).

The generally historical style of SCOT studies can leave the impression that technical development is conceptualised as mono-directional, strongly and inflexibly determined by the relative discursive powers of the RSGs at the time of study. Pinch and Bijker were cautious of this impression from the outset of the programme;

> "[A] multidirectional view is essential to any social constructivist account of technology. Of course, with historical hindsight, it is possible to collapse the multidirectional model on to a simpler linear model; but this misses the thrust of our argument that the "successful" stages in the development are not the only possible ones" (1984, p411)

SCOT would reject that a stable post-closure construct of the technical artefact could be an inevitable consequence of the set of RSGs and TFs involved in a negotiation. Pinch and Bijker's initiation of SCOT referred to the example of the bicycle, constructed as the 'speed machine' and 'unsafe machine' TFs by different RSGs. But the maintenance of these TFs must be conditioned by the physicality of human bodies, movement and other realities, and these are beyond the reach of rhetoric. There is an implicit appreciation for this kind of reality and, indeed, in approaches such as CITA this appreciation is formalised. This shaping, however, falls outside the focus of the study of the *social construction* of technology, marking a difference in the analytical scope of SCOT and the TMTA.

For SCOT, the possibility of truth is deemphasised in favour of a quality of closure or stabilisation, but there is certainly an implicit form of material realism to empirical studies within the programme. For example, in Shin's (2008) study of the development of a

community internet access infrastructure, SCOT's organising concepts are explicitly used to structure the analysis of the social processes by which the technology is constructed in different TFs and the power of various RSGs in the negotiation process. Yet the physical capabilities and spatial constraints of the technology also contribute to the provision of the conditions under which the technology develops.

Rip's CITA does something similar, but with a more direct articulation in the ontological domain. In it, an incongruence between the material properties of a technology and its understanding may emerge. This can lead to a failure of robustness and, subsequently, the emergence of a controversy, reopening of a 'closed' TF and prompting a process in which the technology is reconstructed. In this sense, materiality has a clearly articulated capability to shape technologies' trajectory. For tenability, this position requires that the reach of relativity is limited to the epistemological or methodological domain, rejecting ontological relativism. In CITA, Rip does this explicitly;

> "it is necessary to counteract the possible impression that everything is seen as socially constructed and "therefore" also relative in an ontological sense."
>
> (1986, p356)

In contrast with Lawson's approach, SCOT carefully avoids making any explicit ontological commitments, neither implying nor rejecting the possibility of ontological relativism. Indeed, SCOT co-founder Bijker has recently argued for the explicit adoption of an ontological agnosticism;

> "Constructivist technology studies are relativistic in only one sense: methodological. They are agnostic with respect to the ontology of technology." (2010, p63)

Kline and Pinch have criticised this programme's emphasis upon how social activities shape technology at the expense of also showing how technology shapes social activities (1999). Whilst differing from critical realism in not necessarily requiring any specific ontological commitments to realism, SCOT also holds some clear parallels with Lawson's approach, particularly in the transformative effect of social activity. Their *materialisation* is an account of how different social understandings lead to new versions of technologies which are existentially different – the social construction of 'the content of the artefact' (Pinch and Bijker, 1984). This is close to Lawson's *concretization*, whereby the social realities become embedded in technical artefacts. There is a subtle difference of emphasis, however, with Lawson adopting an explicit ontological realism which is left (deliberately) open in SCOT,

and also bringing into the conceptualisation the reverse conditioning of activities by technologies.

The Multi-Level Perspective & Strategic Niche Management

In the multi-level perspective (MLP), three scales of activity are identified in the niche, regime and landscape. The conceptualisation is designed to trace how emerging innovations, protected in niches and structurally conditioned by the regime and landscape, can break through to transform routines, beliefs, rules and roles at the regime level. The development of the regime is also pressured by the exogenous technical landscape. Developments at the regime level provide the conditions under which different niches are supported or restricted (Geels and Schot, 2007). Strategic niche management (SNM) is concerned with drawing insights from these understandings to improve technology policy and planning (Schot and Geels, 2008). A thorough review is neither possible nor pertinent here, but both MLP and SNM have received significant attention recently by European scholars drawing from and building upon a variety of traditions from the study of science, technology, innovation and economics.

The landscape is seen as exogenous, protected from developments at niche and regime level and itself developing over a longer timescale. The landscape is defined socially, with reference to the ongoing development of the conditioning influence of broad economic, cultural and political reality upon the regime (Schot and Geels, 2008). Materiality probably conditions developments at each of the levels identified in the MLP, but this is not brought in to the model explicitly, providing a key point of differentiation between it and the TMTA. This externalisation of materiality may be an effective means of capturing how social reality dominates the contemporary landscape, the human experience and technical development and how, through this domination, materiality is externalised, pushed out to the extent that it not longer falls within reach or reckoning (Reason *et al.*, 2009). Unlike the Lawson's work, the MLP is not designed to consider the nature of specific technical artefacts and holds some degree of ontological flexibility. Geels (2010), for example, has shown how MLP's ontology is best described as a crossover between evolutionary theory and 'interpretivism/constructivism' with various opportunities for further crossovers, particularly towards structuralism and conflict theory.

Sociology of Technical Practice

Another interesting direction in technology studies has emerged from the sociology of practice, which considers interactions at the scale of mundane everyday activities such as eating, cleaning and dressing and the social anthropology of the objects involved (Shove, 2003a). Whilst differing in many respects from MLP and SNM, and regularly positioning itself against it (see Shove, 2003b, Shove and Walker, 2007, 2010), it is similar inasmuch as it often considers material problems such as GHG emissions and climate change in terms of constructive social processes. The approach of the practice sociologists is designed to capture "that the re-specification of normal practice is of greater environmental significance than the ecological design of appliances and products" (Shove, 2003b, p193).

A central theme of this literature is identified in bringing "the materiality of practice firmly into view" (Shove *et al.*, 2007). They effectively show how materials used in the production of technical artefacts are also socially constructed. This is particularly supportive for their explorations of the relationship between technical materials and the items that they are used to make. 'Material' in this sense tallies with a critical realist understanding of *artefactual*, rather material reality. This distinction is crucial in understanding the relative positioning of the literatures and their epistemological projects. The key lesson for study here would be that the feedstocks, such as waste products from food production, are not straightforwardly material but are also socially constructed and negotiation in the same way as the biofuel products that they may be used to produce – the materials are also artefacts (Shove *et al.*, 2007).

The Dual Nature of Artefacts

A school has recently developed in the 'dual nature of artefacts' research group in the Netherlands (see Kroes and Meijers, 2006). Their dualism refers to two dimensions of artefacts which they label as the *structural* and the *functional*. The structural roughly corresponds to a material dimension of a technical artefact and the functional roughly corresponds to its social engagement. The dualists have, like critical realists, espoused the vindication ontological realism as a central theme of their project and consider the treatment of materiality as crucial part of this process;

> "Reinventing our ability to talk about the *substantive dimensions* of entities is, I believe, the next important project for an ontologically minded social theory".
>
> (McGrail, 2008, p79, original emphasis)

Houkes and Meijer (2006) assert that a new ontological framework will be required in pursuing this task, and that it must meet two adequacy conditions; first *underdetermination* and, second, r*ealizability constraints*. Underdetermination requires that artefacts with identical structural dimensions could have different functional dimensions and, vice versa, that the same functionality can be achieved by artefacts with different structural dimensions. Realizability constraints require that the functional dimension is conditioned by the structural dimension and, vice versa, that the structural dimension is conditioned by the functional dimension[9].

The mutual freedom (underdetermination) and mutual conditioning (realizability constraints) suggest a tension that may be well captured by a dialectical framework such as that presented in the TMTA, and lead to a useful point of comparison for positioning. Meeting the realizability constraints in the duality of structure, the technical structure (including functional capacities) is conditioned by technical activity, and technical activity (the processes of intentional use/design and unintentional reconstruction) is conditioned by technical structure. Meeting underdetermination, two different artefacts may hold a structural dimension in common, as a tennis ball can function as a tennis ball but also as a cricket ball without any physical change. Similarly, two different artefacts could have a functional dimension in common, as a chair and a coat hanger can each function as support for jackets. In performing favourably against their adequacy conditions, similarities are identified between the dualist project and Lawson's TMTA, that is, the requirement for technologies and technical activities to condition each other without determining each other. Further affinity is identified in their broad aim of vindicating explicitly realist ontological frameworks.

---

[9] They found analogy for the structure-function relation with questions of the mind-body connection and sought results in the *supervenience* and *constitution* approaches from this literature. Neither provided an appropriate approach and a suitable ontological framework to support the project was not found.

Actor-Network Theory

Actor-network theory (ANT) is usually credited as emerging from the strong school of empirical relativism and its application to the sociological study of science and, later, technology. It can be described as a conceptualisation of reality as emerging from networks of human and nonhuman 'actants'. The literature is extensive and a thorough treatment of it is not possible here. The ANT conceptualisations of material and social reality, as its stance on ontological realism, is subject to heated debate and frequent accusations of misunderstanding both internally (Latour, 2002) and extraneously (Bloor, 1999), particularly on the question of its accounts of materiality and realism. Its treatment here will inevitably fail to capture all of the subtlety and sophistication of the approach but, rather, seeks to indicate the relative positioning of ANT with regards to the critical realist conceptualisation.

Latour sees ANT as a movement to "associate reality and construction into one single dynamic with one single term" (2002, p1) and to avoid the defence against accusations of ontological relativism in more substantive ways than just 'denying that one denies external realism'. The approach may be understood, Latour suggests, as the elevation of all things to the status of text, or as the extension of text to encompass all things (1997). Their analyses consider relationships between all actants, human and nonhuman alike, bringing technical artefacts in to the negotiation processes that come to define what they *are* (see also Latour, 1992).

For the three actors in the pilot vignette, biofuels have different capabilities and their development is associated with very different impacts. Following the examples of Callon's scallops (1986) or Latour's microbes (1988), ANT might consider biofuels as an actant with some conditioning influence upon the development of the controversy. They participate in its construction. The human actants engaged with the technology negotiate with it to establish environmental performance, land-use impacts and compatibility with motor engines. Features such as these seem to lie between the human and nonhuman actants, co-constructed by their mediation.

As with critical realism, epistemic access to reality is always considered in terms of mediation and relationality. The approaches do have their differences, however, perhaps most notably the flatness that characterises ANT's organising concept of the network (an

epistemological, not ontological point), which contrasts with the depth that characterises those deployed in critical realist studies, such as lamination.

3.4 Concluding Remarks

The chapter opened with a discussion of critical realism in general, providing a concise overview of the core concepts that is sufficient for the explication of Lawson's account of technology and technical artefacts, presented in the second section, and to support the developments that will be presented later in the thesis. The remainder of this chapter briefly described some other contemporary approaches to understanding technology in society. These were considered from a critical realist perspective to highlight some of the similarities and differences of emphasis in each approach. The endeavour was limited, to some extent, by the embryonic nature of the critical realist account of technology.

Chapter 4: Developing an Unfolding Semiotic Account of Technology

"How can one who espouses social (linguistic) constructionism avoid slipping into relativism? How can a realist avoid slipping into essentialism? Surely the answer is 'By making enough distinctions'!" (Harré, 1998, xi)

In the opening quote, Harré succinctly captures the critical realist approach to handing socially constructive processes whilst maintaining a pervasive ontological realism. Lawson maintained these distinctions when developing Bhaskar's TMSA into his TMTA. As it stands, however, the TMTA is an unapplied concept pitched to the more general level of technical structure and social activity. Developments are required to conceptualise the relationship between technology and controversy and in preparation for its subsequent application to the empirical case of biofuels. Guided by Harré's wisdom in the opening quote, the requisite developments to the TMTA are presented in this chapter.

The first point of development is a specialisation of the TMTA's conceptualisation of the relationship between technical structure and technical activity into a conceptualisation of the relationship between a specific technical artefact and a controversy that surrounds it. This will include a conceptualisation of controversy as a specific formation of technical activity which is, at once, conditioned by and a condition for the technical artefact. As such, the activity of the controversy is seen as a transitive reality that unfolds into an intransitive technical reality. It is through the intransitive reality of technologies at the level of the emergent artefact that the seamlessness of technologies' social and material reality is captured. The second point of development draws upon critical realist semiotic theory to provide a 'close-up' understanding of this process of unfolding. This will also be presented as a methodological tool, allowing the theoretical framework to be mobilised into empirical analysis. Whilst the core relations identified in the TMTA are maintained, these developments are constitutive of a novel contribution to the literature.

These theoretical developments have been undertaken in an iterative process alongside a substantive empirical analysis. It is informed by features of the material from the biofuel controversy that has not yet been presented in the thesis. As with the discussion in Chapter

3, the illustrations used in support of this chapter refer to the pilot vignette, with insights from the full empirical analysis reserved for subsequent chapters.

4.1 Technology & Controversy

Figure 1, below, presents diagrammatic representations of two directions in the mutual conditioning of technology and controversy. Approaches to technology studies such as SCOT generally emphasise the social shaping of technology, which would err towards the model to the right of Figure 1, although others, such as lifecycle analysis (LCA), might be associated with the model to the left. In each case, the arrows would not represent causal, deterministic relationships or sufficiency conditions but, rather, shaping imperatives or necessary conditions; the direction of conditioning that is focussed upon in the study.

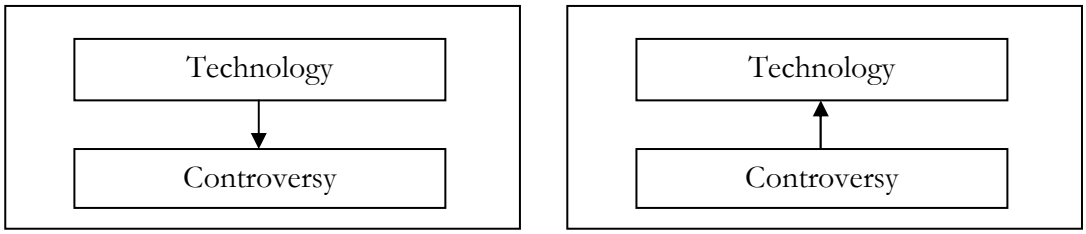

Figure 1: Imperative Emphases of Conditioning in the Technology-Controversy Relationship

In the TMTA, technical structure and technical activity are seen as mutually conditioning in a reflection of the mutual conditioning of structure and agency in Bhaskar's TMSA. Positioning specific technical artefacts within the technical structure and defining the controversy as a form of technical activity, the framework under development explicitly captures both directions presented in Figure 1. The technology itself is defined as an artefact (following Fleetwood, of both social and material constitution) which emerges within the broader domain of technical structure which was considered by Lawson in his TMTA. It is not determined but is conditioned by technical activities. Some activities, situated within the broader domain technical activity in the TMTA, are constitutive of a controversy; where there is a relatively enduring public conflict between different actors. The activities that are constitutive of the controversy are not limited to combative protest, broadcast accusations and advertised promises of biofuel technology, but are much broader, inclusive of refuelling vehicles, designing engineering solutions to problems and other more

mundane engagements which are undertaken during this broad phase of technical activity[10]. This understanding is presented diagrammatically in Figure 2, below, with Lawson's structure and activity used to label the domains which the artefact and activity occupy.

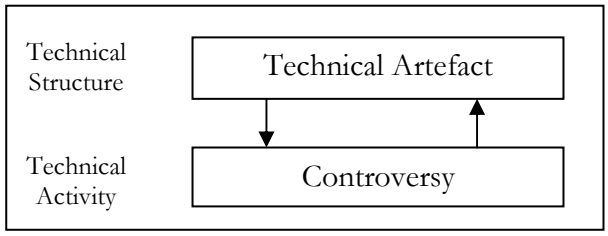

Figure 2: Development of the TMTA to Consider the Technology-Controversy Relationship

Now, some of the subtleties of the approach to the materiality of technical artefacts are not well captured by the relationship implied in Figure 2. To reflect the critical realist understanding of technology more accurately, the conditioning of the artefact must be limited to the extent to which it is socially constructed, i.e. only partially. There is a materiality within the technical artefact that, despite always being experienced through constructive mediation, is itself beyond the reach of socially constructive processes. This requires that the technical activity may only condition the technical artefact inasmuch as the technology has a social reality. An interim redevelopment of the model is presented in Figure 3, below, retaining the conditioning of the controversy by the technical artefact as a whole whilst limiting the conditioning of the technology to its social reality. This also begins to capture the concretisation of social reality that occurs during artefactualisation[11].

[10] The analysis of controversial activity is limited to discursive positions that can be traced through relics of the controversy, as discussed in subsequent chapters.
[11] Lawson describes an 'endurability and travel' that is gained by social reality as it is concretised in the technical artefact. This is precisely the process through which the technology emerges as an artefact of social and material constitution. Through social activity, the 'stuff' of technology is artefactualised.

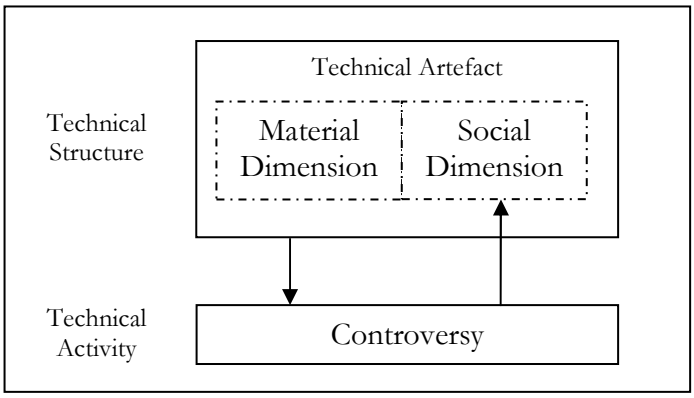

Figure 3: The Limits to the Conditioning of the Technical Artefact

The model presented in Figure 3 is a preliminary position, but the technology's artefactuality is not, now, well captured by the model. Instead, it appears as a social reality sitting alongside a material reality within the domain of technical structure. This does not reflect how social activity can transform the technical artefact as a whole, it does not capture the technical artefact's ontological respectability. To rectify this problem, we should revisit critical realism's TD and ID concepts. Recall that the ID captures all of reality, whilst the TD captures emerging thoughts, understandings and, importantly, praxis. In the moment of its becoming, the transitive reality passes over from the TD into the ID. Whilst distinct from each other, the ID and TD are not discrete. Rather, the TD is held 'constellationally' within the ID (Hartwig, 2007f). As technical artefacts are read, they are also written; the engagement takes on a historicity which is folded in to the fabric of the technical structure. Now, the controversy is a form of social activity which generates transitive realities which continually unfold into the intransitive reality of the technical artefact. Through this understanding, the emergent artefact and its continual transformation is correctly situated within the domain of technical structure of Lawson's TMTA. This understanding is illustrated in the model presented in Figure 4, below.

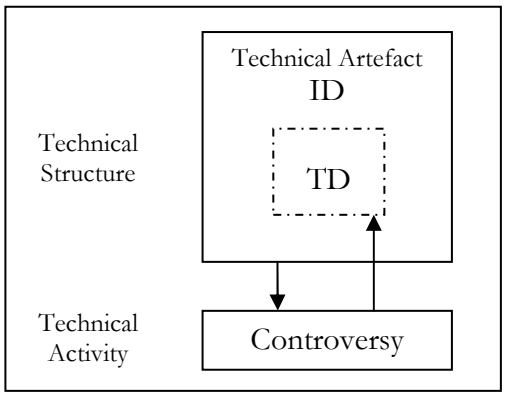

Figure 4: The Unfolding of Technical Reality

Building upon Figure 4, the final development of the model does not represent a significant conceptual change but recasts the existing understanding across a chronological landscape. Each of the TMTA, the unfolding of technical reality and the controversy as a phase of social activity emphasise temporality and are designed to capture a transformative process that is not well reflected in Figure 4, which presents the model as something of a feedback loop without a real sense of the history or development of the technology. It also fails to position the controversy as something which emerges and may come to be resolved because the future and past are obscured. Figure 5 recasts the same conceptualisation over a unidirectional temporal axis to illustrate this chronological dimension. Across t, the time axis, t_x is a moment of transitive technical activity; an understanding, experience, use or any such engagement with the technical artefact. It is conditioned by the technical artefact as it is presented to the actor at t_{x-1}, and then unfolds into the technical artefact, transforming it to its state at t_{x+1}. To emphasise that controversies emerge and dissipate, the technical activity at t_{x+1} and t_{x-1} are, in Figure 5, identified simply as 'activity' within the broader domain of technical activity. Thus, in all technical activity, including that as part of a controversy, the technical artefact is read and written in a transformative process.

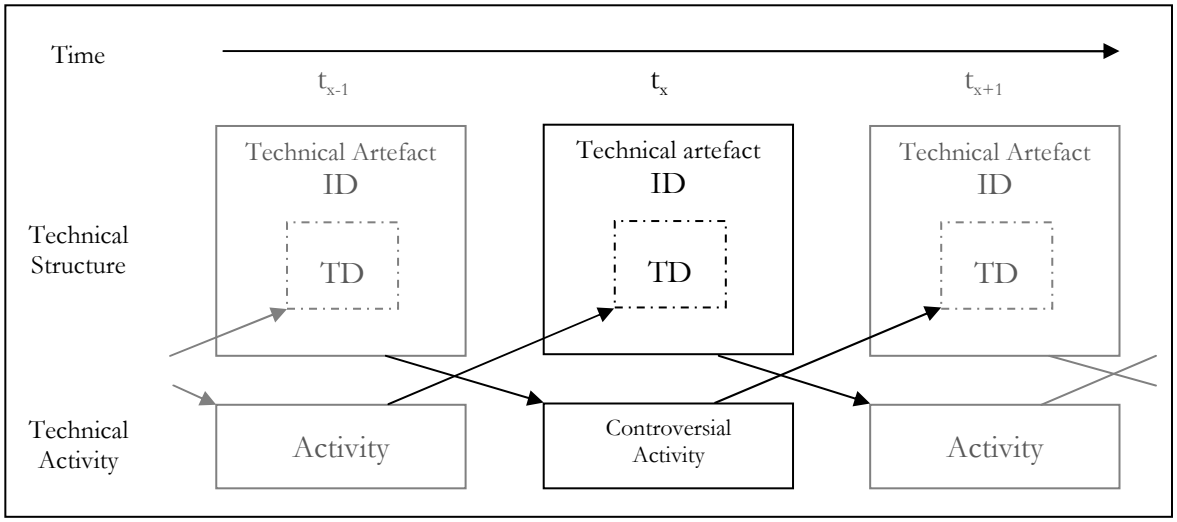

Figure 5: The Unfolding of Technical Reality Recast Chronologically

4.2 Realist Semiotics

The developments of the TMTA presented in the previous section used the concepts of TD and ID to develop Lawson's model of technology and technical activity. This introduces some difficulties which are addressed in this section. The first difficulty is that the relationship, described as a continual process of transitive creation unfolding into intransitive reality, is something of a black box. It fits with the wider model, it is plausible and ontologically consistent, yet the processes involved in this passing over is unclear and would benefit from a more detailed examination. The second difficulty is more practical, concerning how such an abstract conceptualisation can be mobilised for empirical studies. Semiotics (also, semiology) is the philosophy or study of signs, and has a rich history of deployment for both theoretical and empirical purposes. This section is given to the further development of critical realism's semiotic programme to expand upon the unfolding of technical reality and to provide a structure for the application of the theoretical framework to empirical material[12]. In drawing upon semiotics, attention also turns to the sign user and the differences between what the technical artefact *is* to different sign users.

After a brief introduction to the wide literature on semiotics, mobilised from a critical realist perspective, the critical realist conceptualisation of semiotics is described and situated within

[12] Recall that these theoretical advances are not developed *a priori*, but in parallel with the substantive empirical exercises which are presented in subsequent chapters.

it. This conceptualisation is then further developed with the intention of, first, further articulating the unfolding of technical reality from the TD to the ID and, second, supporting the empirical application of the framework.

Introducing Semiotics

Examples of the signs studied in semiotics include letters, words, colours, traffic lights, intonations and, indeed, anything that symbolises or acts as a sign for something else; anything that *represents*. Occasionally, signs are synecdochically referred to as language or discourse. Following Nellhaus' (1998) critical realist scholarship, the dominant terminology in the contemporary literature follows a Saussurean convention in calling the representation itself the *signifier* and that which it represents the *signified*, as illustrated by the sign schema presented in Figure 6, below. This understanding is defined as dyadic since it is characterised by a two-ness.

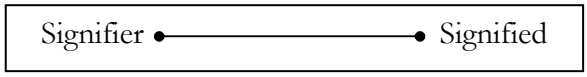

Figure 6: The Dyadic Saussurean Sign

An important concern for semioticians is how the signifier is related to the signified and, following this, they are also concerned with what the signified *is*. Most contemporary semiotics is associated with this Saussurean sign, conceptualising the signified as a unit of meaning. Within this conceptualisation, there is no articulated relationship between the sign and that which it is orientated around. There is only the meaning and that which acts as a signifier for this meaning. Because the signifier is nothing more than a mental construct, its relationship with the signifier is arbitrary (see de Saussure, 1986). Revisiting the pilot vignette, the NFU and Biofuelwatch use the signifiers 'biofuels' and 'agrofuels' respectively. The signifiers stand for very different meanings and understandings, so the signifier-signified pairing implies that the two signs are completely discrete. In emphasising the difference in what the technology means to the actors, the dyadic sign schema fails to articulate the relationship with the intransitive technical artefact to which their signifiers and signifieds refer.

The dyadic sign of Figure 6 eschews the articulation of how extra-semiotic structures are related to semiotic processes. As a result, it cannot conceptualise how materiality, as understood by critical realism, can provide the conditions under which semiotic processes take place nor how technical artefacts, as defined above, are themselves shaped by semiotic processes.

Fairclough *et al.* (2002) have made some effort to reposition semiotics within a broader ontologically realist framework. Describing Saussurean semiotics as focused upon the process of social construction whilst maintaining a kind of ontological agnosticism – neither rejecting nor requiring realism or relativism – they claim not only that semiotics can be undertaken from an explicitly realist perspective but, further, that realists must engage with this task much more enthusiastically if their ontology is to be vindicated. Critical realists Nellhaus (1998, 2007) and Cashell (2009) have engaged in this task, bringing the extra-semiotic explicitly into their conceptualisation. In doing so, they draw resource from an alternative semiotic tradition; that of Peirce.

A contemporary of de Saussure, Peirce included the object of meaning in his sign, creating a triadic schema alongside the meaning itself and its representation. Following Nellhaus (1998), Peirce's object was split into two, the 'dynamical object', which is understood as the referent as an independent object of the sign, and the 'immediate object', which is understood as the referent as it is presented by the sign. Peirce adopted a different terminology to the Saussurean signifier and signified, and for good reason. Whilst his 'interpretant' roughly equates to the signifier, its direct relationship with the referent introduces significant conceptual differences. Indeed, the interpretant is seen as a 'significate effect' or reaction to the dynamical object, and may (occasionally) be determined by the it alone. Similarly, whilst Peirce's 'representamen' roughly equates to the signified, its relationship with the referent also introduces some important conceptual differences. Not an arbitrary social convention like the signifier, the representamen can have a relationship with the dynamical object, perhaps a physical likeness or a geographic proximity. The compatibility of the Peircian sign, presented in Figure 7 below, with Bhaskar's brief musings on the subject, discussed in the following section, makes it the schema of choice for the limited critical realist engagement with semiotics.

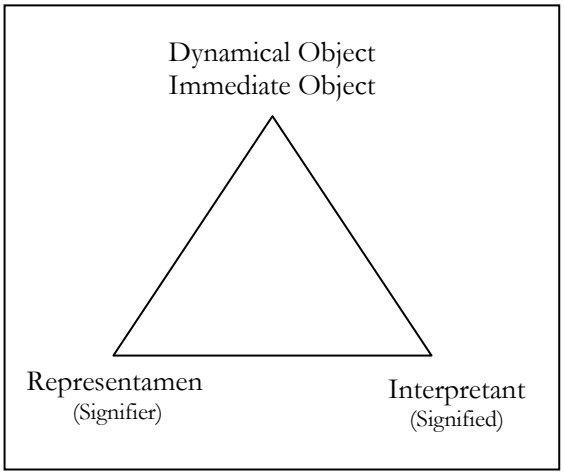

Figure 7: The Triangular Peircian Sign

In this subsection, I have provided a brief introduction to the two main traditions of Saussurean and Peircian semiotics through Nellhaus' critical realist perspective. Far from exhaustive, it has focused upon their capacity to support the development, presented in the following subsection, of an understanding of semiotics that is compatible with the unfolding model of technical development.

The Semiotic Programme of Critical Realism

The protagonist of critical realist development, Bhaskar, did briefly consider semiotics in 1993 (p222-224)[13], and there has been some, albeit limited, engagement from critical realist scholars since then, particularly since Fairclough *et al.'s* (2002) call for greater realist engagement with semiotics was reprinted alongside other contributions in Joseph and Roberts' (2004) edited collection. This engagement is not always primarily aimed at developing a critical realist understanding of semiotic structures. Rather, much of it is comprised of accommodations, incorporations and alternative readings of existing relativist literatures in the traditions of Derrida, Foucault, the Bahktin Circle etc. The developments offered here are closer to Fairclough *et al.'s* (2002) call for the development of a semiotics to support the realist understanding of 'reasons as causes'. Reasons, they argue, achieve their causal efficaciousness through semiotic processes which have either been left unexamined or are excessively simplified in the main body of critical realist literature. Here, the purpose is to examine how the unfolding of new semiotic reality conditions – that is, how it has

[13] It is noted that the passage is repeated in his Plato *Etc.* (1994).

some, albeit limited, causal power over – technical development. Further, it will also be used to examine the reverse of this process, how the emergence of transitive semiotic reality is conditioned by a pre-existing intransitive technical artefact.

Returning to Bhaskar's short discussion of semiotics, which cites neither Peirce nor de Saussure directly, he criticises what he calls the nominalist exclusion of the signified and the postmodernist exclusion of the referent from sign schemas, suggesting that a triad of signifier-signified-referent must form the "[t]he centrepiece of any adequate theory of meaning" (1993, p222). It is unfortunate that he does not explore this understanding of the triangle, presented in Figure 8 below, in greater detail. In little more than a page of text he introduces each of the components briefly, situating them within some wider critical realist concepts. The signified, highlighted in red below, is positioned within the TD and is described as a unit of meaning or a "conceptual distanciation" (p233). The referent, highlighted in blue, is positioned within the ID and is described as the 'chunk' of reality that is referentially detached by the signified. He also notes that, from any corner of the triangle, a number of other triangles may be attached.

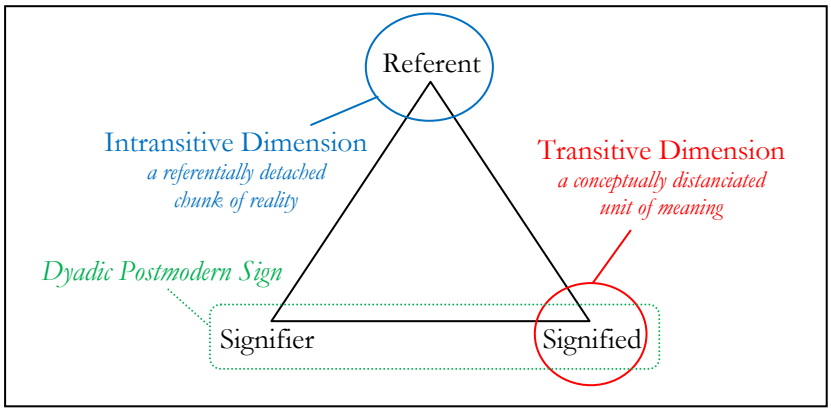

Figure 8: Bhaskar's Semiotic Triangle

Bhaskar follows the conventional Saussurean terminology in his signifier-signified pairing. In doing so, he positions the postmodern sign within the broader realist sign, as indicated in green in Figure 8, above. But there are significant conceptual differences between the concept in its Saussurean form and in its new realist context. The signifier is no longer

necessarily arbitrary, it can be more than mere social convention but can reflect, albeit interpretively, the dynamical object in the same way that a painting may bear some likeness to its subject (Nellhaus, 1998). The signified is a conceptual distanciation of the referent, so this referent must pre-exist the signified. Further still, if this referent has some causal power over the sign, shaping its emergence, then some causal power is being exercised within the sign process.

The similarities between Bhaskar's and Peirce's sign schemas are striking and well illustrated by comparison of Figures 7 and 8. Nellhaus (1998) has shown how the conceptual differences between de Saussure's and Bhaskar's signifier-signified pairing in the context of a relationship with a referent make Bhaskar's sign schema a much closer ally to the Peircian understanding of a representamen-interpretant pairing in the context of his dynamical and immediate objects. Fortifying the position, Nellhaus demonstrates how Peirce's dynamical and immediate objects are posthumously aligned with the critical realist concepts of the ID and TD. The dynamical object is not limited to material things but could be a dream dreamt, a feeling felt etc, i.e. it is *any* intransitive reality. The dynamical object is this intransitive object in a form that may be expressed by the sign, it is the transitive concept of itself, the part of the semiotic process that mediates a thing itself and its experience. Across the referent-signified axis of the triangle, the sign process is exposed as a single instance of a transitive reality emerging and immediately unfolding into the ID.

It appears that the Peircian terminology is much more compatible with the concepts presented in Bhaskar's sign, but they entail a number of further difficulties. First, they are associated with a number of wider Peircian concepts that are not routinely compatible with a critical realist ontological position[14], second, Peirce's terminology can be inconsistent, unintuitive and even deliberately ugly[15] and third, perhaps as a result of these two difficulties, his terms are capable of wide interpretation and have been taken in various directions within the wider Peircian tradition. Before further developments of the adopted

[14] Nellhaus accepts that Peirce flirted with empiricism and idealism, and is strongly associated with the pragmatist movement which is inconsistent with explicit realism and the demands of both objectivity and intransitivity.

[15] Still following Nellhaus, there are many examples of this across Peirce's work. Citing two, he uses 'sign' interchangeably for both the representamen and the whole sign and introduced the term 'pragmaticism' in response to his displeasure with directions in the pragmatist school, the origins of which he was strongly associated with.

understanding of the sign are presented, for clarity, the precise concepts and terminology of the adopted sign schema are defined.

For that which represents, in preference to de Saussure's signified or Peirce's representamen, I adopt the term *locution*, which captures its expressiveness, differentiates it from the meaning and referent and is associated with context sensitivity, allowing a single locution to have various meanings and referents. It also alludes to the critical realist understanding of the term, referencing Bhaskar's depiction of the signifier as the transmission of "locutionary force" (1993, p222).

A suitable term for the meaningful component of the sign, in place of Saussure's signified or Peirce's interpretant, must capture that it is an experience, differentiated from its locution and referent, and that it embodies the causal power of reasons, to reflect its importance within the critical realist project. I adopt the term *sense* which can imply both causal reasoning, 'the sense of a course of action', and also the essence of experience, i.e. the sensation itself as distinguished from both its referent and the locution as a force of expression.

The Peircian concepts of dynamical and immediate object are brought into the adopted sign with a focus upon the distinction between the intransitivity of the dynamical object and the transitivity of this object in its immediate form, as it is presented by the sign. These are existentially different and must not be collapsed into one. The terminology, suitably realigned, now defines Bhaskar's referent as a double identity, the *intransitive referent* and the *transitive referent*. This approach to the referent leads to a redefinition of the location of the ID within Bhaskar's sign. No longer encapsulating the entire referent, it is now set almost apart from the sign and is only related via its semiotic presentation in the transitive referent. The adopted sign schema is presented in Figure 9, below, alongside final definitions of each component.

Referent	The object of the sign, including the intransitive referent, independent of the sign and the transitive referent, as presented by the sign
Sense	A unit of experience, reasoning or other meaning, also inclusive of praxis.
Locution	Words, pictures and any other expression of meaning or reference

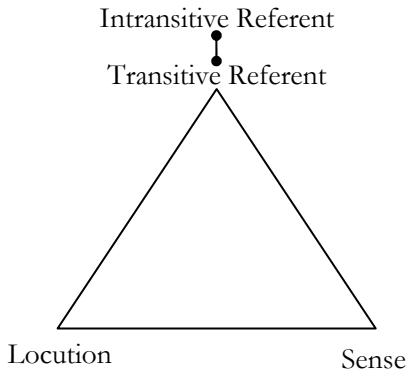

Figure 9: The Adopted Sign Schema

Developing a Semiotics of Technology

This sign schema can be mobilised to examine the mutual conditioning of the biofuel controversy and biofuel technology as conceptualised in the model of technology developed in the previous section and illustrated in Figure 5's chronologically recast presentation of the unfolding of technical reality (p62). This is supported by an understanding of the sign process in terms of two *moments*. Thus, the first moment of the sign process is the construction of new meaning, conditioned by the technology as captured in the downward arrows of Figure 5 – the technical conditioning of the controversy. The second moment of the sign process is the passing over of meaning into the ID, the sign becoming part of the fixtures of history and transforming technology as captured by the upward arrows in Figure 5 – the controversy conditioning the technology. These moments of the sign process are not sequential but immediate, they do not follow each other discretely but are alternative perspectives of the immediately mutual conditioning of the technical artefact and the activity of the controversy. Each moment is discussed in greater detail in the following paragraphs.

Remaining with Figure 5, above, the technical artefact at t_{x-1} is the intransitive referent of the sign at t_x. It pre-exists the semiotic process and provides *some* of the conditions under which signs may emerge from it. The intransitive referent does not, however, strongly determine the sense – indeed, to say that it does would be to imply that there is only one possible experience of the same thing. Rather, the intransitive referent is always mediated,

so the experience is never directly related to the technical artefact *per se*. The sign is personal to the sign user, and is also shaped by their prior understandings, their general attitude and current mood, their epistemological outlook, their prejudice and error – it is necessarily transitive. We say that the experience is not, therefore, of the intransitive referent but of the transitive referent, which is the intransitive referent *as it is presented by the sign*. Whilst it is invoked by the sign process and therefore does not pre-exist the sign, the conceptualisation is aided by positioning the transitive referent as that which is experienced by the sign user. This first moment of the sign process is represented diagrammatically in Figure 10, below.

Referring to the pilot vignette and generalising from single signs and sign users to broader semiotic structures (i.e. discourse) and groups of sign users (i.e. actors), the conflicting discourses that emerged are each semiotic structures that are shaped by the technology itself and mediated by the actors' perspectives and their interpretations of the technical artefact. When the NFU and Biofuelwatch consider biofuels, the transitive referent of their perspectives is the referent as presented by the sign – it is shaped by the intransitive technical artefact and their understanding of it.

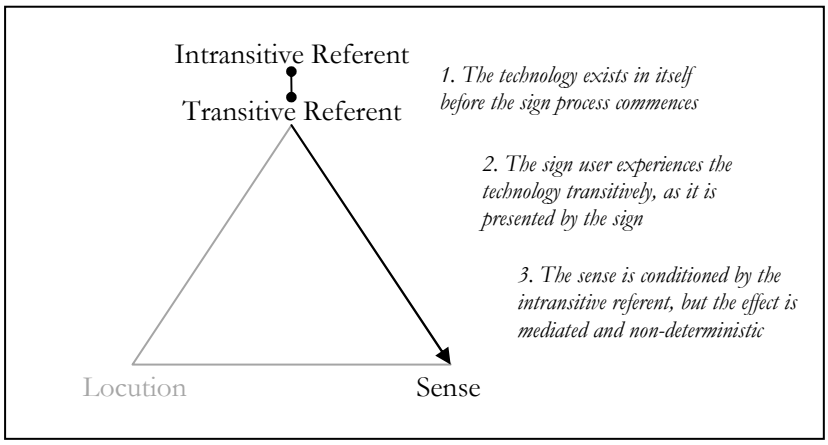

Figure 10: The Conditioning of the Sense by the Referent

Now, returning to Figure 5, above, the technical artefact *per se* is different at each increment of t_x. At t_{x+1}, a new sign has emerged and unfolded into the ID thus transforming the technical artefact. Even where the sign process serves only to recreate the artefact, as may be the case with many sign processes and particularly where the referent exhibits a low

degree of interpretive flexibility, it remains transformed. The sign processes of the discursive activity of the controversy, therefore, provide the conditions under which technology develops. This discursive conditioning of technology is not deterministic, because the technical artefact is not 'merely' semiotic, it has some intransitive and, indeed, material reality that is beyond the reach of discursive transformation. Referring once again to the pilot vignette, the conflicting discourses each transform the technical artefact through the invocation of a transitive referent which unfolds into the intransitive reality of the technical artefact. As the NFU engage with biofuels, they reaffirm its existence in terms of its relationship with the rural economy, and as The Independent engage with biofuels, they transform or reproduce its power to position the UK as environmental world leaders. This second moment of the sign process is represented diagrammatically in Figure 11, below.

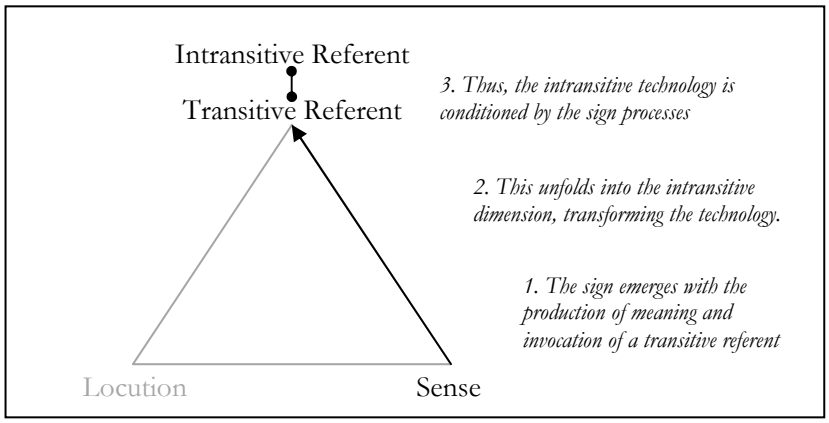

Figure 11: The Conditioning of the Referent by the Sense

This conceptualisation of the semiotic triangle is forwarded as the content of the black box of the mutual conditioning of technology and controversy. Most importantly, it presents an understanding that is consistent with unfolding of technology forwarded in Figure 5 that can also be deployed for empirical study. For the remainder of this chapter, the semiotic triangle is used to consider how controversy differs from other states of technical activity.

Consider the first two triangles in Figure 12, below. Drawing on the pilot vignette, they represent two directly conflicting senses of the same locution. This can be understood as one single locution with two triangles emerging from it, each with a different sense. This state of affairs is presented in the third triangle of Figure 12 as a locution-sense *dissonance*.

This term reflects the disharmony between signs more suitably than terms such as 'difference', which must apply to all signs, or 'conflict' which would detract from the potential for compatible or synergetic dissonances. These forms of dissonance are considered later. For now, the sufficiently enduring, significant or far reaching dissonance is demonstrated as a useful concept for disentangling the features of discourses constitutive of the controversy.

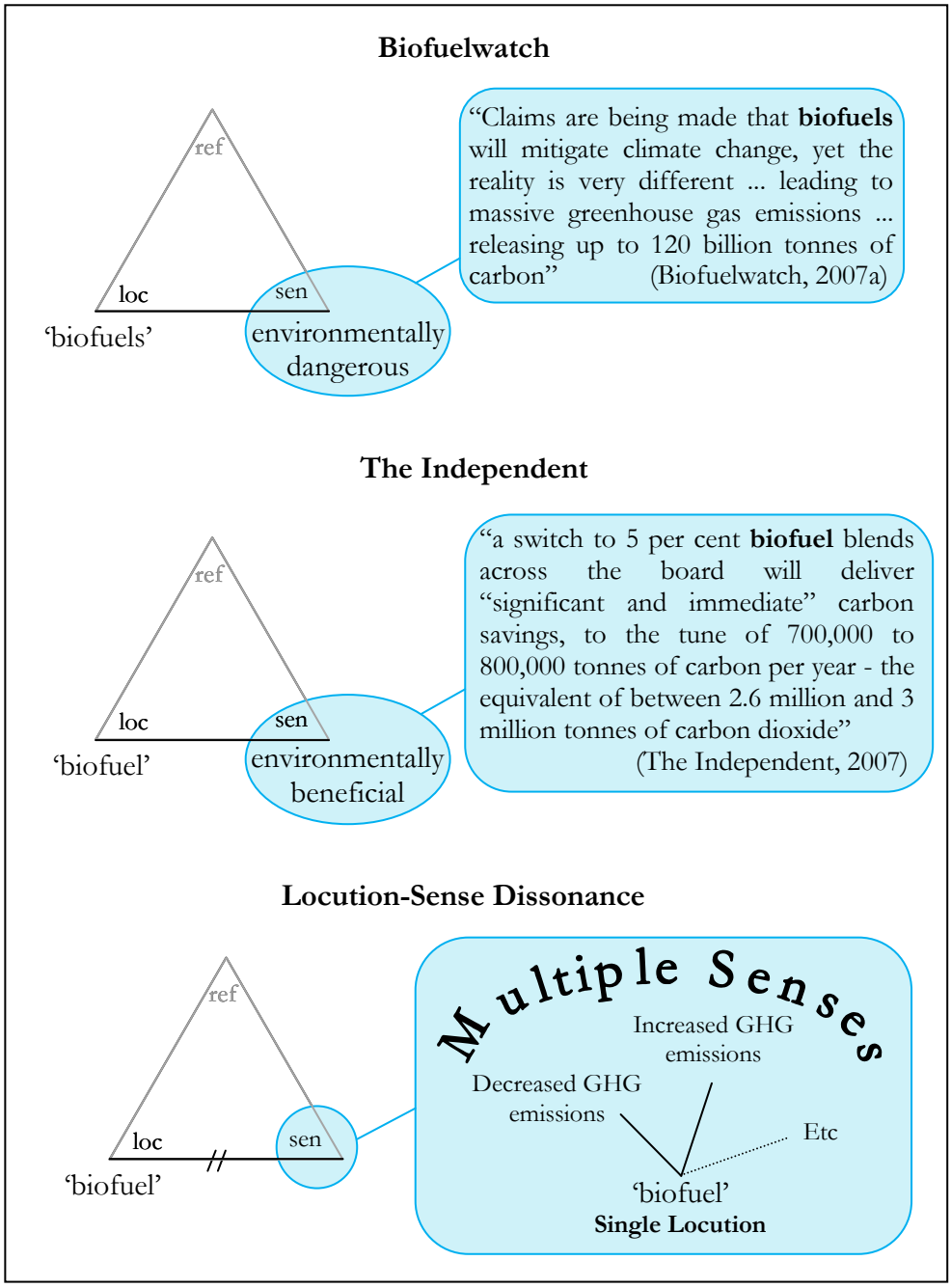

Figure 12: The Controversy as Locution-Sense Dissonance

In the pilot vignette, we observe each of the NFU, Biofuelwatch and Independent texts using the same locution 'biofuel' with very different senses. Under a dyadic conceptualisation of the sign, limited to a signifier-signified relationship, this kind of dissonance between the unit of meaning and that which represents the meaning is the only sort of dissonance that could ever be considered. Under the understanding forwarded here, however, the referent must also be considered. Back to the pilot vignette, the NFU, Biofuelwatch and Independent appear to be referring to different feedstock-process combinations, i.e., different referents. One focus of the discussion was how the NFU differentiate between imported feedstocks and those that are produced domestically. The Independent is particularly concerned with domestically produced biofuels from waste products and Biofuelwatch refer to feedstocks grown on Amazonian land and produced through damaging industrial processes. It becomes clear that the referent of each generalised sign, despite sharing the locution 'biofuels' in common, is actually variable and perhaps even discrete. This represents an alternative form of dissonance to the locution-sense dissonance discussed previously; it is a locution-referent dissonance, and is illustrated in Figure 13, below, in the form of a single locution with multiple triangles emerging from it, this time with a different referent.

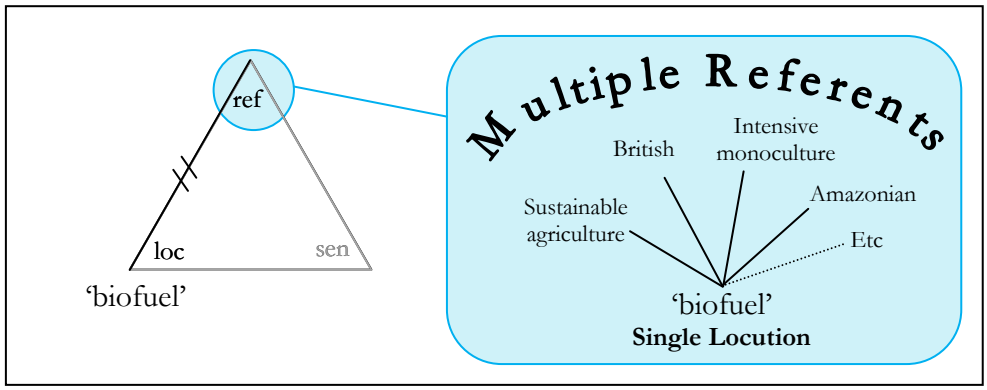

Figure 13: The Controversy as Locution-Referent Dissonance

So, locution-sense and locution-referent dissonance have each been defined and briefly illustrated, but what about referent-sense dissonance? Could it be that each locution-sense dissonance is equalled by a locution-referent dissonance? For example, the sense of biofuels as environmentally dangerous holds when the referent is imported biofuel produced in industrial scale monocultures on deforested land and the sense of biofuels as

environmentally beneficial holds when the referent is domestic biofuel produced by sustainable agricultural methods. If this were the case for all dissonances then the sole source of controversy would be the difficulty of referring to many different technical artefacts with the single term biofuels. From this, it would follow that resolution of this dissonance, and therefore the controversy, would require little more than the introduction of more locutions to handle to internal variety of the referent. Further discussion of this possibility is reserved for the full empirical analysis and discussion, for now it will suffice to suggest that there is evidence of precisely this kind of development in the pilot vignette. For example, Biofuelwatch have moved to expand the vocabulary that is used to specify a subset of the broadly accepted referent. They claim that the dangers to biodiversity and social justice are presented by a technical aretafct that is;

> "...more accurately called 'agrofuels' - liquid fuels produced from biomass grown in large-scale monocultures, mostly in the global south" (Biofuelwatch, 2007a)

I would suggest that whilst biofuels certainly suffer from an insufficient breadth of locution, perhaps more so than other controversial technologies, and that some points of controversy *may* be resolved by broadening this vocabulary, the controversy runs much deeper than this. For example, intensively produced Amazonian soya can be identified as a single referent for which multiple senses can be identified, so there must be a referent-sense dissonance of the sort illustrated in Figure 14, below. Such dissonance cannot be resolved by increasing the locutionary variety.

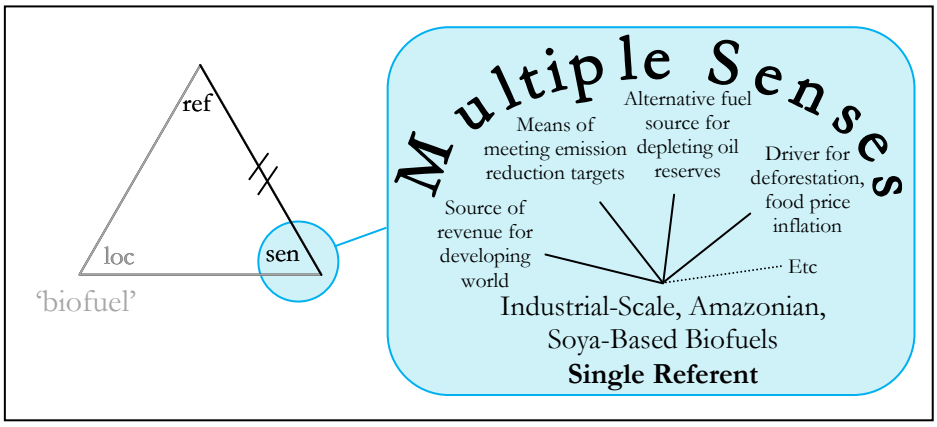

Figure 14: The Controversy as Referent-Sense Dissonance

Certainly it is the case that the same intransitive referent may have a number of different senses. To claim otherwise would imply that the referent determines the sense or that the sense may be reduced to the referent[16]. The power of the referent lies in its double identity, which serves to combine the pervasive ontological realism of the intransitive referent with the process of social construction in the emergence of a sense and its invocation of a new transitive referent. This also renders claims for referent-sense dissonance somewhat paradoxical, as two different senses necessarily invoke two different transitive referents – there cannot be multiple transitive referents for a single sense (nor, indeed, vice versa). Referent-sense dissonance is only, therefore, comprehensible with regards to a referent that is inclusive of its intransitivity.

The broad concept of dissonance between referent-locution-sense pairings in the semiotic triangle provides a powerful conceptualisation of the relationship between technology and controversy in terms of socially constructive processes positioned within a broader ontologically realist framework. It brings out the same questions of how and why different understandings emerge that made the constructionist approaches considered in the previous chapter so powerful whilst maintaining a credible and consistent variety of ontological realism.

4.3 Summary & Concluding Remarks

In the first part of this chapter, the TMTA was developed to show its specific relevance to understanding the relationship between technology and controversy and to consider the development of each as an unfolding of technical reality. In the second part of the chapter, Nellhaus' comparative analysis of the triangular sign schemas forwarded by Peirce and Bhaskar was developed. To ensure clarity, the terminology of the adopted schema was designed to distinguish it from preceding schemas which have been interpreted and mobilised variously in their respective traditions. Terms were chosen to closely reflect the concepts for which they stand and to position them within those literatures from which the concepts are drawn.

---

[16] The straw man positivist approaches discussed in the previous chapter may be guilty of this. Similarly, the rejection of referent-sense dissonance would imply that the referent is determined by or reducible to the sense, which straw man constructionist approaches are guilty of.

This sign schema was mobilised to provide a close up understanding of the unfolding of technical reality which presents a novel and empirically applicable method of disentangling technical controversies. The sign process in this context is correctly viewed as a single instance of technical activity. This activity can be traditionally discursive, i.e. of experience, interpretation and representation, but it is certainly also inclusive of praxis, of uses, designs, sales and productions. All of these are semiotic process which can be considered in terms of the adopted sign schema and can, in turn, be transposed upon the broader model of technology and controversy forwarded in Figure 5, above. Thus, the approach provides a strong theoretical framework for exploring the social construction of technology within a framework characterised by a pervasive ontological realism. By showing how interpretation and representation are causally efficacious, the mutual conditioning articulated in the approach and illustrated in terms of two moments in Figures 10 and 11 also responds well to Fairclough *et al.'s* (2002) call for a critical realist account of semiotics to elaborate at close range how semiotic processes mediate reasons as causes.

Chapter 5: School Vignette, Empirical Method & Material

"Sometimes it matters what a thing is, what name it has,
and how people judge its properties" (Winner, 1993, p372)

In this chapter's opening quote, Winner distinctly captures the three corners of the semiotic triangle; what a thing is (the referent), what name it has (the locution) and how people judge its properties (the sense). He continues with an example; "was the structure in Iraq photographed during the Gulf War of 1991 a baby food factory or a chemical weapons plant? It is true that some people claimed the building was one thing whilst others said it was something else. But noticing the diversity and flexibility of interpretations in such cases is of little help. Ultimately, one has to decide what one is dealing with and why it matters" (p372-373). The problem is that deciding upon 'what one is dealing with and why it matters' itself requires a number of methodological decisions, it adds a further layer of semiotic depth.

This chapter has the broad aim of defining the empirical method and introducing the empirical material in advance of the analysis and discussions which are presented in the subsequent chapters. First, as a bridge from the theoretical to empirical work, some methodological issues for realist analysis are considered, before a short empirical vignette is presented which draws upon some of the theoretical concepts to consider an exercise undertaken within a secondary school. This draws heavily upon the semiotic triangle to structure the consideration of objects, their names and judgements of them. Discussions of the method of analysis are then presented before the empirical landscape is mapped, introducing the actors and materials that will be studied in the main empirical analysis.

5.1 The Realist's Dilemma

There are difficulties involved in making absolute claims about the ontological state of things after emphasising the interpretive nature of all understanding. As ontology has attracted increasing attention across the contemporary social sciences, realists are faced with a dilemma – if, indeed, all knowledge is mediated interpretation, on what grounds can objectivist assertions be justified? This dilemma is considered in the present section. This 'realist's dilemma' was seminally levelled by Edwards *et al.* (1995) against 'bottom-line arguments for realism', particularly those which take the form of banging furniture to

demonstrate its objective limits (only doing so, of course, by mobilising a politicised interpretation of the furniture) and rather unfairly demanding the constructivist to either repent or to leave the building by the 5th floor window. As Edwards *et al.* put it;

> "All the pointings to, demonstrations of, and descriptions of brute reality are inevitably semiotically mediated and communicated. Rocks, trees and furniture are not *already* rebuttals of relativism, but become so precisely at the moment, and for the moment, of their invocation. We term this *the realist's dilemma*. The very act of producing a non-represented, unconstructed external world is inevitably representational, threatening, as soon as it is produced, to turn around upon and counter the very position it is meant to demonstrate."(1995, p27, original emphases)

This mode of reasoning is mobilised by the strong programme of relativism to counter the forwarding of truth claims, because as soon as knowledge is presented, it invokes a social, political or otherwise interpreted perspective of what the object of knowledge *is*. The practitioner cannot help but politicise these objects – they can do nothing *but* represent. The dilemma is subsequently mobilised by some, such as Edwards *et al.* (1995), to question the additional logic in presuming that a further reality is really *out there*, beyond experience?

One response may be that, without ontological realism, our lives become something of a cosmic coincidence, or perhaps some dream or Creation. I suggest that whilst this dilemma may expose a weakness in realist rhetoric, it does not say much about realist ontology. It might illustrate a permanent fallibility of objectivist epistemology and demonstrate the limits of empiricism, but it says little more about realist ontology than 'it is difficult'. More crucially, it forces the scientist to devote serious consideration to what the object of knowledge is, how their methodology mediates results and how their knowledge is related to the object of study; i.e. interpretively. In this sense, so long as the dilemma does not push the scientist to reject realist ontology outright, it should drive them to adopt a sharper and more reflexive methodology, to think about what their object of study really *is*, and what their results really represent, and this certainly makes it a worthwhile thinking point.

Realists within the contemporary social sciences are aware of the difficulties posed by this dilemma and some have responded to it directly. Perhaps the most common response is to approach reality through the eyes of individuals in the proximity of the object under analysis. For example, Sims-Schouten *et al.* (2007) encountered a problem in identifying

extra-discursive realities after recognising that all their experience of it is unavoidably discursive. Their response drew upon the assumption that, just as knowledge is shaped by being, discourse is shaped by extra-discursive reality. 'Talk' about the conditions upon mothers' childcare arrangements is conceptualised as a discursive orientation around an extra-discursive reality. The conditions upon childcare arrangements, such as financial and biological needs, shape both the childcare arrangements themselves and also the discourses that emerge about the arrangements. Discourses amongst those arranging childcare may, therefore, be an appropriate channel for identifying the extra-discursive conditions under which actors act. The 'linguistic turn' and social constructionism in general has been particularly pervasive in their discipline of social psychology. There, such 'talk' would usually be more likely approached as a process of socially constructing not only discourse about constraints upon mothers' options, but also constructing the constraints themselves[17].

Sims-Schouten *et al.'s* approach is explicitly presented as a methodology which privileges one epistemic account of extra-discursive reality over another. This e*pistemic privileging* has also been deployed, albeit implicitly, in empirical studies of technology such as Kroes' (2010) study of the functionality of artefacts through consultation with engineer's patents and McGrail's (2008) study of a fabric used to make furniture through consultation with the designers who have worked with it. In each case, the engineer and designer are materialists by training, and the privileging of their account leads to a pro-material conceptualisation of technology.

Epistemic privileging is not compatible with the stronger varieties of relativism since it implies that one interpretation can provide a more accurate reflection of reality than another. If a deep reality is rejected, then one perspective cannot represent it more accurately than another. This strong approach is often criticised by critical realists for lacking judgemental rationality; it cannot criticise perspectives as wrong because there is no benchmark against which to establish rightness. Most social constructionists outside of the straw-man depiction, however, would roundly reject that all claims have an equal status. Indeed, they would assert the opposite. Instead of focusing on questions of truth or

[17] Sims-Schouten *et al.* have attracted some criticism for setting up a straw man version of relativism, not true to its tenants but built to be destroyed and replaced by their approach (see Speer (2007) and a rejoinder from Riley *et al.* (2007)). I suggest that a straw man version of relativism is neither fair nor necessary for the mobilisation of critique towards realist a social ontology.

discursive correspondence with extra-discursive reality, they would ask a different set of questions and, in doing so, demonstrate how and why some claims come to dominate others in a flexible discursive space. They claim a political edge by demonstrating the effects of this domination and highlighting how things could be different. The task of contemporary realism is to maintain this critical power whilst articulating a deep ontological realism. This methodological chapter continues in this vein in defining an analytical process consistent with the theoretical framework forwarded in the previous chapter.

5.2 School Placement Vignette

This short section documents a placement undertaken in a high school's science department. It was undertaken roughly half way through the PhD project, during a period when the iterative theoretical and empirical developments were beginning to take some shape. It provided an opportunity to consider some of the early theoretical ideas in an experimental, exploratory setting. Like the pilot vignette, its outputs are not considered to be of great empirical significance in themselves, but adopt a different role in the thesis as an empirical vignette which demonstrates the analytical power of the theoretical framework, how the framework is mobilised in an empirical setting and, importantly, how the interpretive process of research affects the analysis that is undertaken. In this sense, the crucial lesson of the school placement is the need for reflexivity. The following subsection describes the details of the placement and lesson delivery to provide a background for the discussion which is presented in the subsequent subsection.

Placement Background & Delivery

The placement was organised through Manchester University's Researcher in Residence programme, which promotes outreach and engagement by connecting academics with contacts in local secondary schools. I was placed with St. Gabriel's, a Roman Catholic comprehensive in North Manchester[18]. The Researcher in Residence programme has no further input to the process beyond establishing first contact. The broad lesson plan was developed with the school's director of science and aligned with an 'eco week', in which environmental issues were explored across the entire curriculum. The process took about six months from the placement's confirmation on the 30th September 2008, through the

[18] The school is familiar for a number of reasons; my sister teaches there, it is very close to where I grew up and it draws upon a similar demographic to my own school.

delivery of lessons on the 4th March 2009, to the submission of a completion report to the school and Researcher in Residence programme three weeks later.

The class was designed to explore the different perspectives on the environmental issues surrounding biofuels. The same 70 minute lesson was delivered to three different science classes, each with around 25 year nine (14-15 year old) students. After being introduced to the students by their regular teacher, I organised them into small groups and explained what would happen during the lesson. Each group was given a pack of images collected from material drawn from the biofuel controversy, thematically linked by the use of fuel pumps. Logos and other identifying text were removed before the session, as demonstrated in the reproductions in Figures 15, 16, 17 and 18, below. Without providing any detailed information on biofuels, the students looked through the images and discussed what they thought biofuels were, how they might affect the environment and how they felt about them.

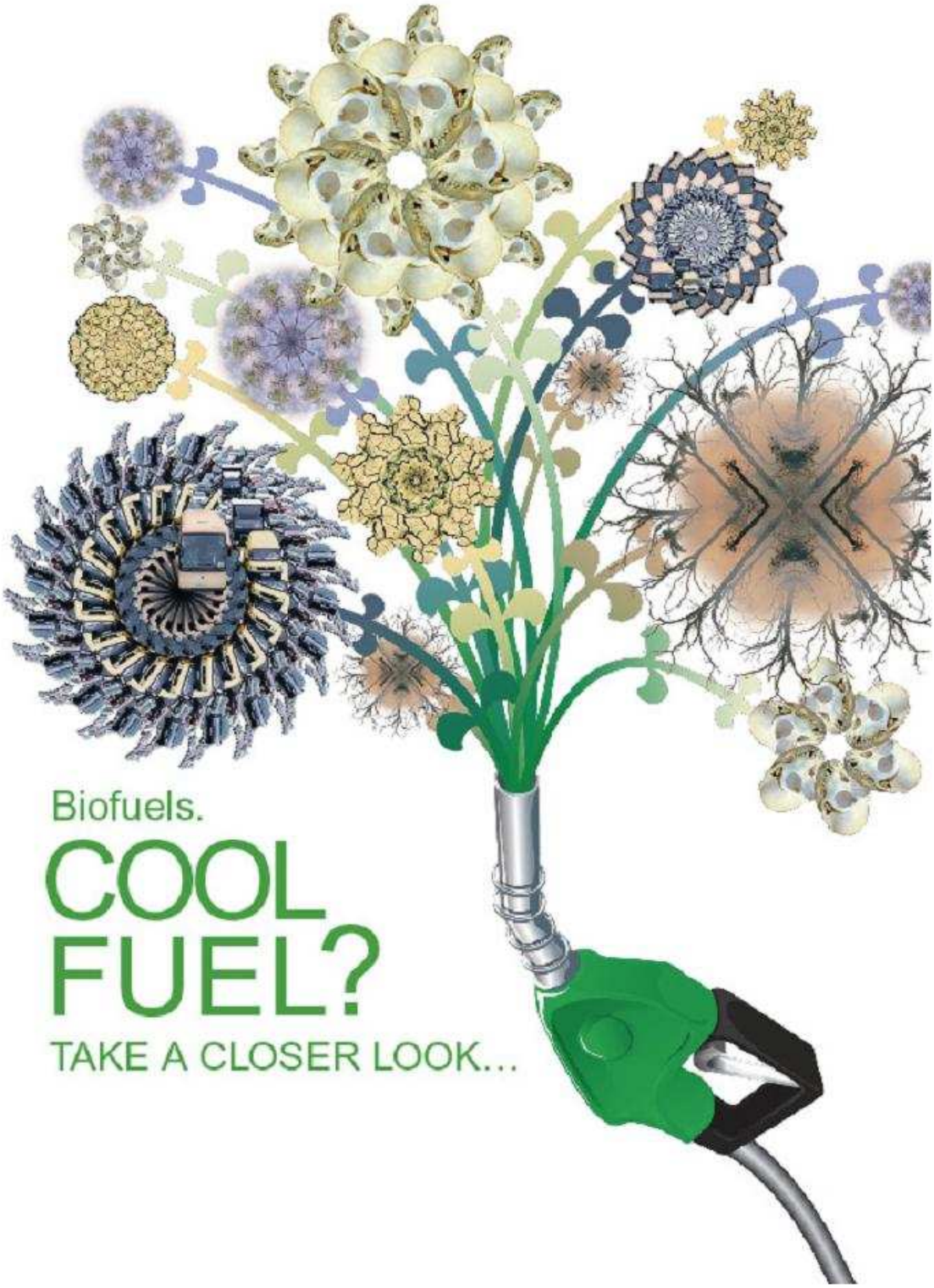

Figure 15: Greenpeace et al. Image Adapted for Use in Classroom Activity (2008)

Figure 16: Danish Center for Biofuels Image Adapted for Use in Classroom Activity (2009)

Figure 17: Greenpeace et al. Image Adapted for Use in Classroom Activity (2007c)

Figure 18: NFU Image Adapted for Use in Classroom Activity (2007a)

The students remained in their groups and selected an actor from a choice of biofuel exporting government, UK government, UK farmer, environmentalist group and biofuel retailer. The students were then provided with a corresponding information pack describing their chosen actor's main interests, particularly with regards biofuel development in the UK. The students were asked to identify which quote, from a selection drawn from material in the controversy, matched with their chosen actor. In a similar activity the students were asked to select an image from a collection provided which they felt appropriately represented their chosen identity's perspective on biofuels. Where time permitted, the students were to be invited to make their own image to represent their own perspective on biofuels, although this activity was only reached in one of the classes.

The activities served as a semi-structured yet flexible framework for discussions at individual, group and class scale. The use of quotes and images from different perspectives meant that the discussion remained well focussed on issues of perspective, rhetoric and imagery in the biofuel debate. Discussions were recorded by note-taking during and after the classes. These notes are used to inform the discussion that is presented in this section, which focuses upon how different interpretations can emerge from the same empirical material when considered by different analysts.

Generalised Signs & their Analysis

The first point which emerged from the analysis is the difficulty of assigning referents, locutions and senses to empirical material. During the activities, as may be expected, the students developed a number of interesting ideas about biofuels. To reorganise this

according to the semiotic triangle, the images can be defined as locutions and the students' ideas as senses. Assigning the referent is a little complicated. Perhaps it is biofuel technology *per se*, or perhaps the actors' presentation of it. Indeed, following the realist's dilemma, differentiating between the two will, in practice, always be problematic. Perhaps the image is acting as both locution and referent, in different capacities.

Conceptual help is provided by a reminder of the role of the transitive and intransitive dimensions of the referent. Biofuel technology may remain the intransitive referent whilst the perspective of biofuels forwarded is the referent as it is presented in the sign; the transitive referent, and so depends upon the locution and sense and thus also the sign user, their existing knowledge, experience and capabilities. If the sign user has relatively little exposure to other sources of information on biofuel technology, perhaps they are more readily influenced by the new locutions and senses presented to them in images such as those in Figures 15 to 18.

This problem illustrates a general and crucial point about semiotic studies in general; that semiotic processes cannot be stepped outside of for performing analysis. Following the realist's dilemma, semiotic studies are designed to consider, discuss and even demonstrate previous signs but they also necessarily involve the construction of more and more new signs by a different sign user. Escape is impossible, the unfolding and unfolding of new semiotic layers is like a slip noose; the stronger the protestations and claims for objectivity, the deeper the actor becomes embroiled in the semiotic web.

Nonetheless, analyses of relatively enduring discursive positions may be undertaken fruitfully with reference to *generalised signs*. Recognising the role of the analyst and justifying interpretations by continual reference to the text, generalised signs are understandings of discourses through the lens of the semiotic triangle. Reflecting the three moments of individual signs; the general referent is the object(s) to which an actor refers to. Importantly, since epistemic access is limited to the transitive presentation of the intransitive referent, when the referent is deployed in empirical analysis it must be limited to the transitive referent. The general locution is their approach to representation in the use of language, image, tone etc in their material. The general sense is the stated or implied understanding of and engagement with the general referent and locution. For the remainder of this section, these generalised signs are used to demonstrate the differences

between my own analysis of the images in Figures 15 to 18 and those of some of the students. This serves to illustrate an important point about the interpretive nature of semiotic analysis.

My understanding of the NFU image of the fuel pump in Figure 18 can be considered in terms of the triangular sign schema. Starting with the locution, i.e. the image itself, my understanding of it is a referent of biofuel technology being produced by a very simple and direct field to fuel process, obscuring some of the processes and side effects that are involved in the lifecycle. The sense would be one of environmental harmony. This analysis of the NFU sign can be organised in terms of the semiotic triangle, as presented to the top left of Figure 19, below. The discussion with the students about this image revealed a different understanding. The locution remained the same, the original NFU image. The sense also remained the same, the students certainly asserting the environmental value or harmony of biofuels. Interestingly, however, the students came up with a different referent to myself. Whilst I understood it to be a metaphor for a simple production process from feedstock to pump, the students took the locution as more literally related to the referent, suggesting that GHG is being emitted from the pump and fed directly into the sweetcorn to help it grow. The students' generalised sign for the NFU image is presented to the top right of Figure 19. The dissonance between my analysis of the referent and the students' analysis of the referent is described as a cross-referent dissonance. This is not suggested as an inconsistency in NFU understandings of biofuel technology, but serves to demonstrate that interpretations of the same empirical material can vary significantly, or even be very similar yet based upon fundamentally different assumptions about the referent.

A similar example is drawn from the image of the fuel pump presented in the Greenpeace *et al.* image in Figure 15. From the same locution, the students and I each considered a sense of biofuels as an extinction threat to orang-utans, but on the basis of different referents. I understood the referent as biofuel development affecting the ape's natural habitat, whereas the students' understanding of the referent was, once again, more literal; suggesting that orang-utans were being killed and used as a feedstock for biofuel production. These can be organised into generalised signs, as presented in the bottom row of Figure 19, to show a second example of the difference in generalised referent that results from a change in the analyst.

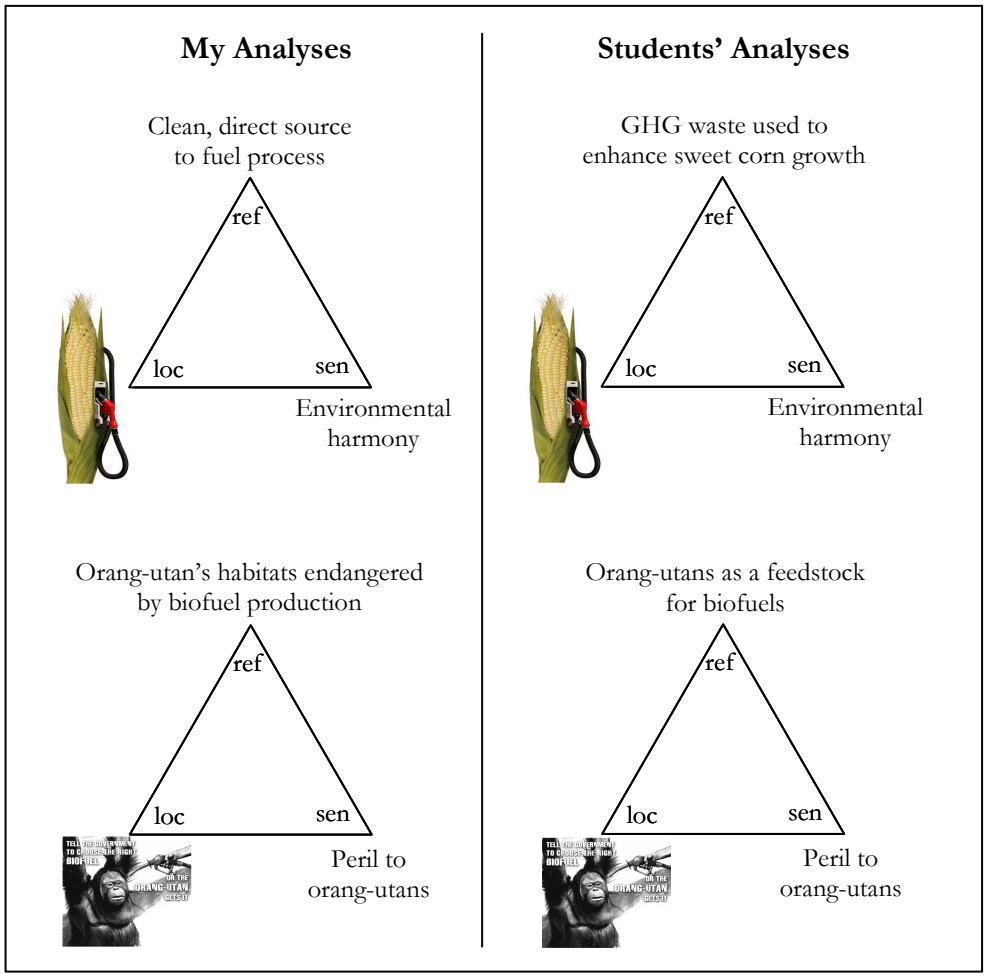

Figure 19: Cross-Referent Dissonance across Analyses

A second set of examples from the classroom discussion reveal, somewhat unsurprisingly, that the differences in my own analysis and that of the students also extend beyond the referent to different generalised senses. For example, the skulls and vehicles hidden within the Greenpeace *et al.* image in Figure 17, above, were interpreted by many students as suggesting that biofuels are made out of waste skulls and vehicles, regarded as a positive form of recycling. This generalised sign contrasted with my understanding of hidden dangers within biofuels (cross-referent dissonance) requiring that biofuels are treated cautiously (cross-sense dissonance). The two signs organised into the triangular schema are presented in the top row of Figure 20, below. I was similarly surprised to discover that one student understood the Danish Center for Biofuels image, presented above in Figure 16, as a negative presentation of biofuels as a driver of deforestation. By way of justification, the student pointed out that the trees in the background may once have covered the entire

scene and have since been cleared to produce crops to provide fuel. My own analysis, presented in sign form alongside the student's approach in the bottom row of Figure 20, was similar to that of the previously discussed NFU image, of biofuels being a product that is close to its source (cross-referent dissonance) and associated with environmental harmony (cross-sense dissonance).

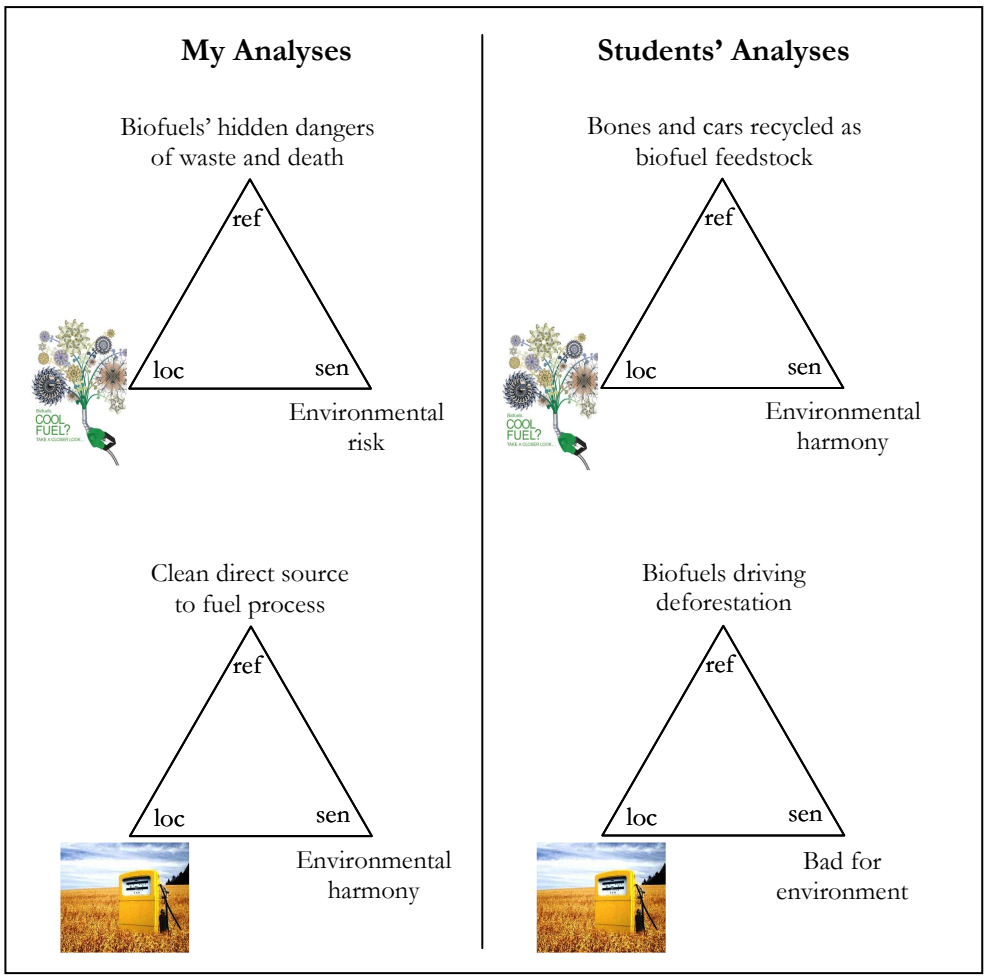

Figure 20: Cross-Referent & Cross-Sense Dissonance across Analyses

As stated above, the specific empirical outputs of the school placement are of limited value in themselves, but their consideration as an empirical vignette does hold some significance. The differences between my own analyses and those of the students was not only eye opening and refreshing, but also demonstrated an important point about the interpretive nature of semiotic analyses and reinforced the importance of developing a reflexive methodology. Whilst the contrast between my analyses and those of schoolchildren in a 70

minute session is likely to be more marked than a comparison of my analysis with that of another researcher who has also been immersed in the subject over a period of years, the inherently interpretive character of the approach must be recognised throughout. The vignette provided an introduction to how the semiotic triangle can be used as an empirical framework and also introduced the interesting use of fuel pump imagery by different actors in the biofuel controversy. Whilst peripheral to the wider argument of the thesis, the exercise serves as a valuable introduction to the application of the theoretical framework to the empirical material.

5.3 Empirical Method

In this section, the specifics of the method of empirical analysis are described. Broadly, the approach may be categorised as a variant of critical discourse analysis (CDA), itself a methodologically open approach with significant internal variety. Here, CDA is drawn upon for the purpose of the fruitful methodological application of the theoretical developments described in the previous chapter to the empirical material. The material to be analysed is a selection of conflicting discourses that are maintained in textual and visual relics of the controversy such as websites and leaflets. These reflect a variety of discursive positions that are forwarded during the controversy. Other activities that are also constituents of the controversy are not represented in the empirical material (for example the practice of engineering, refuelling and protesting). Thus, the unit of analysis used to explore the controversy cannot be described as the controversy itself but, rather, a variety of discursive positions that have been forwarded within it.

Semiotic Orders: Discourse, Genre & Style

So far, I have used terms such as 'discursive' and 'semiotic' to describe social realities, those that exist by virtue of human activity. Generally, the adjective 'semiotic' has been used to emphasise the involvement of signs (understood here as a triad of locution, referent and sense) whilst 'discursive' has been used to emphasise that something is a way of understanding or representing. Since discourses necessarily involve sign processes, discourse can be understood as a subset of a broader semiotic reality. Fairclough *et al.* (2002) have provided a definition of a 'semiotic order' which is in broad agreement with this usage. For them, semiotic orders are comprised of discourses, genres and styles, each of which are defined as follows (p33);

Discourses	Ways of representing social and material realities, e.g. environmentalist politics
Genres	Ways of acting in a semiotic context, e.g. behaviour in a ticket office
Styles	Ways of being in a semiotic context e.g. an approach to relationship problems

Genres and styles, therefore, refer to the format and norms of communication. The material under analysis here is organised into different media types (for example, the *genres* of video, press release, poster etc), and the reader is addressed in different ways (for example, the *styles* of communicating to a passive reader, an empowered citizen, a disgruntled farmer etc). The extent to which the term 'discourse' may be used to refer to non-linguistic representations varies in the literature, although it is not so much a matter of debate as a reflection upon the material that is analysed in different studies. For the remainder of this study, a broad and inclusive understanding is adopted whereby any expression capable of representing, including those that are non-linguistic such as gesture, tone etc, can be referred to and analysed as discourse. Largely, given the material to be studied, discourses are manifest in text and images.

The focus of the study here is discourse, i.e. the understandings, representations and presentations of what biofuel technology is. Yet, nonetheless, the genres and styles which accompany discourses in what Fairclough *et al.* (2004) called a semiotic order are also important and remain part of the discussion. Whilst there has been some movement towards developing CDA into CSA (i.e. 'critical semiotic analysis', see Wodak and Meyer, 2009), in this study I continue to use 'discourse' to refer to ways of representing and reserve 'semiotic' for emphasising the sign processes that are at play.

Critical Discourse Analysis

As mentioned, CDA is a broad school which contains a number of approaches such as functional systemic grammar, socio-cognitive approach etc. The crucial feature of CDA as far as this project is concerned is that discourse is analysed alongside other extra-discursive realities, often economic or material structures (Wodak and Kendall, 2007). Van Dijk (2009) describes CDA as an attitude to research involving self-reflexion, the inclusion of insights from a variety of non-discourse focussed disciplines and the resolution of social problems or an 'emancipatory impulse'.

The crucial point of convergence between critical realism and CDA in terms of this project is the explicit recognition of the importance of both discursive and extra-discursive reality. Since the critical realist researcher is compelled to consider the semiotic mediation – and thus the discursive reality – of experiences and understandings of extra-discursive reality, something broadly akin to CDA may be detectable in almost any empirical programme of critical realist research. Similarly, as CDA practitioners are concerned with discourse as a causally efficacious reality existing within a broader extra-discursive reality, a degree of compatibility with the critical realist approach to ontology is also implied. Whilst it would be excessive to imply that the adoption of a critical realist ontology necessitates a CDA methodology, or vice versa, there are strong paradigmatic links between the two.

Fairclough *et al.* (2004) describe two moments of the extra-discursive in semiotic processes. First, that the extra-discursive is *conditioned by* semiotic activity and, second, that extra discursive reality provides the *conditions for* semiotic activity. This position is well aligned with the dialectical understanding of technology and controversy developed in Chapter 4, whereby the controversy is described as a discursive activity which is both conditioned by and a condition for the extra-discursive technical reality of biofuels. This mutual conditioning in both CDA and the technology-controversy relationship is also reflected in the semiotic triangle, which is presented both as a theoretical close-up of the mutual conditioning of sense and referent and as a framework for the empirical study of generalised signs, as presented in the school vignette.

For the discourse analyst, the discursive conditioning of extra-discursive structures carries two significant consequences. The first is that others' discourses can have far reaching effects, including material effects, that the analyst is compelled to consider. The second is that the analyst's output, as discourse, can also have far reaching effects. Parker (2004) has illustrated how, in the commonly adopted approach of categorising discourses into competing frames, the analyst can fragment others' discourses, position them in competition with each other and grant them varying degrees of legitimacy which can affect their success. As a result of her critique of such analyses, she adopts a strategic discurse analytic stance which is sensitive to the discursive power of her analysis over those she analyses and also to the power that all discourse, including hers, can hold over extra-discursive structures;

> "[A]n aim of my discourse is to further the legitimation ... of progressive movements to increase their effectiveness" (Parker, 2004, p69)

CDA maintains an attention to power that it positions explicitly within a broader extra-discursive reality, forcing the consideration of the relationship between, for example, discourses and material changes to the climate. In establishing this relationship between discourse and extra-discursive reality, CDA attracts questions about the realist's dilemma. Previously discussed in terms of the tenability of ontological realism, here the questions take a methodological character; how can we find practical ways of identifying and understanding extra-discursive realities when these processes are inevitably discursive? How can we be sure that what we deem to be extra-discursive is not 'merely' discourse? The short answer to each question is that we quite simply can't, but this does not mean we can not or should not continue.

Epistemic privileging, discussed previously as an abstract response, is mobilised to this end. A number of studies were identified as bearing an implicit commitment to epistemic privileging, including some from the field of technology studies (e.g. Kroes, 2010, McGrail, 2008). Sims-Schouten *et al.* (2007), however, commit to the position explicitly with a focus upon identifying the ways in which extra-discursive reality provides the conditions under which discourses are adopted. They focus upon instances in their empirical material where an actor's discourse is orientated around an extra-discursive reality. An example from their study, which focussed upon mothers' childcare arrangements, involves an actor's discourse being orientated around financial constraints upon their capability to remain out of work to look after their children. They argue that that the experience of financial pressure to return to work is a sign process and its manifestation in their talk is discursive, but also that this does not mean that the financial pressure is 'merely' a social construction. They identify the discourse as an orientation around an extra-discursive condition upon both her childcare arrangements and also upon the discourses she adopts. It is worth noting that Sims-Schouten *et al.'s* (2007) empirical material consisted of transcripts from spoken word interviews with individuals, whilst in this study the materials are carefully planned text, images, video and sound produced by organisations. These differences do not affect the broad applicability of their approach to the developing understandings of the conditioning of the biofuel controversy by biofuel technology.

Analysing Discourse in the Biofuel Controversy

The empirical analysis here also considers how actors' discourses are orientated around extra-discursive realities. To this end, the semiotic triangle is used as a framework for considering how a sense may be conditioned by its referent, as illustrated in Figure 21, below. Subsequently, the results of this analysis are discussed in terms of how the technical structure of biofuels may act as a condition upon the development of the controversy and the discourses that are adopted therein.

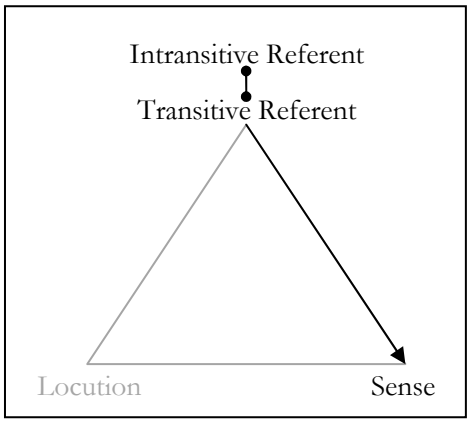

Figure 21: The Conditioning of Sense by the Referent

This represents the first moment in the mutual conditioning of technology and controversy. It is necessary to develop the approach to consider the second; the conditioning of biofuel technology by the biofuel controversy. How do the discourses identified in the analysis affect biofuels and their development, and how can the transformation of such technologies be analysed? Again, there is no straightforward answer; certainly it is not possible to take some measurement of what biofuel technology *is* before and after the occurrence of the sign processes. A more innovative approach must be developed.

Sims-Schouten *et al.* (2007) did not consider this direction of the conditioning relationship. As discussed, the linguistic turn exposed the importance of power in discursive activity. The affordance and restriction of discourses to different actors is an expression of power, and the deployment of discourses to transform structure is also an expression of power, but it is not shared equally amongst different actors. Not all discursive activity in the controversy has the same potential to transform biofuel technology. The participants in

Sims-Schouten *et al.'s* (2007) study are characterised by a lack of power to transform their structural context. The strong restrictions upon the discursive agency of the participants may be the reason why the authors did not develop a method for tracing the discursive conditioning of extra-discursive reality. In this study, however, the selection process has dictated that only those actors with a significant role in the development of the biofuel controversy are included. All actors in this study have achieved some discursive agency and, for this reason, the discursive transformation of extra-discursive structures adopts a prominent role.

The analytical approach is similar to that for the extra-discursive conditioning of discourse. The extra-discursive orientations that are identified in actors' discourses are considered as potential recreations of facets of technical artefacts with some transformative potential. The semiotic triangle is used as a framework for considering how senses and locutions are mobilised to condition the transitive referent, as demonstrated in Figure 22, below. Subsequently, the results of this analysis are discussed in terms of how the technical structure of biofuels may be conditioned by the controversy and the discourses that are adopted therein.

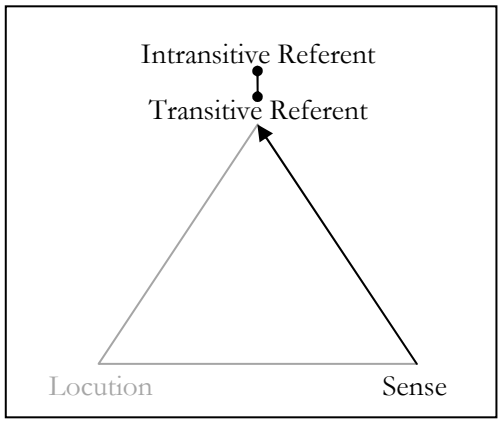

Figure 22: The Conditioning of the Referent by the Sense

In each direction of conditioning captured by this conceptualisation of the sign, the intransitive and transitive referents are sharply distinguished. The intransitive referent is the technical artefact itself and the transitive referent is the mediated representation of itself to which experience is limited. In empirical analyses such as that presented in the school

vignette, only the general term 'referent' is used. To be clear, here the referent does not stand for the intransitive technical artefact itself, which lies beyond the analysis but is, rather, the transitive referent; the referent as conceived and interpreted by the sign user in the sign.

Now, the approaches described above can lead to a bias towards positive accounts. That is to say, there is a danger that the focus upon *adopted* discourses as conditions for and conditioned by the *presence* of extra-discursive structures may come at the expense of the consideration of discourses that are *not* adopted or extra-discursive structures that are *not* present. Certain discourses may *not* be available to some actors because of extra-discursive constraints. The same may also be true of the absence of discourses to condition (the absence of) extra-discursive structures. The approach must, therefore, be sensitive to the concept of positive absence which, in short, recognises the impact and importance of both presence and absence[19]. This means that the effect that Tesco's discursive silence may have upon biofuel technology can be considered alongside the presence of, say, NFU and Biofuelwatch discourse. Other examples of absence will also feature in the discussion. This positive consideration of absence inevitably implies the consideration of latent possibilities for biofuel technology and controversy in general. How might the controversy be resolved? What would the effect be? What technical futures for biofuels are possible? What human activities would lead to the development of such a technology? These kinds of questions are not considered beyond speculation.

To conclude, semiotic systems are incredibly complicated and permeate all human activities, entailing processes and relationships of an intractable subtlety and size. The networks of referents, locutions and senses grow constantly in a spectacular unfolding of being. The intractability of studying semiosis at the sign level should not dissuade the analyst from recognising it in their analyses. Rather, its thoroughgoing significance should compel further engagement and discussion. Indeed, as Fairclough *et al.* put it;

---

[19] Absence is an important part of critical realism's second movement (see Bhaskar, 1993, 1994) which, as discussed previously (see footnote 7, above), is not the focus here. Further work on absence, specifically the absenting of absence, also features in critical realism's third or 'spiritual' turn (see Bhaskar, 2000), although this is contentious and not considered here at all. For our purposes, the absence of discourse is better understood as an unexcercised (and, thus, not actualised or experienced) power, existing in D_r but not the subsets of $D_{a\&e}$. Note that this transcendental reality provides a further point of differentiation from ANT.

> "Given the prolific nature of semiosis[20] with its infinity of possible meaningful communications, understandings, and (mis)understandings, it is important to explore the various extra-semiotic mechanisms that contribute to the variation, selection, and retention of semiosis as well as the contribution of semiosis to the reproduction and transformation of social structures" (2004, p38)

It is anticipated that the mobilisation of the semiotic understanding of the unfolding of technical reality will support just this kind of exploration.

5.4 Empirical Material

In this subsection, before moving on to discussion of the analytic method, the process of selecting material for the substantive empirical analysis is documented. The empirical analysis consists of a desk study of publicly available material from the debate about biofuel technology in the UK. The corpus of empirical material used in the project is described as forming a landscape of positions which is designed to reflect the variety of actors and perspectives that form the biofuel controversy in the UK. Whilst there has been some degree of personal communication with most of the actors involved, and more besides, and this has supported the analysis, they do not comprise a significant portion of the empirical landscape. Such private and personal communication does not represent the biofuel controversy as it develops in the UK and are not as useful or interesting to study as those discourses that are present in public facing advertisements, campaigns and information portals.

Media outputs have been excluded from this study on the basis that they differ significantly from other actors producing significant public facing material in the controversy in that they are not stakeholders in the development of the technology. This was a difficult decision to make, particularly as the media is clearly an important actor in the development of the controversy and maintains a high penetration of various publics. Indeed, this power combined with the accessibility of their material is a key reason why so many discursive studies are limited to news and media outputs alone (e.g. Doulton and Brown, 2009). Further, material is often used to represent (e.g. Bell, 1994) or partially explain and justify (e.g. McComas and Shanahan, 1999) tides of public opinions – perhaps misguidedly. Limiting the study to media alone would omit much of the breadth of the controversy.

---

[20] Their *semiosis* can be read here as *sign process*.

Including them together would risk obscuring the differences between their motivations to produce material, and smaller stakeholder's voices may be drowned out despite being engaged with the development of biofuel policy (see DfT (2008c) consultation report).

The focus upon this scale of institutional actors is a methodological decision considered apposite for the study at hand. It is recognised that each actor is comprised of a number of other actors operating under certain conditions. They are not assumed to be internally homogenous, and how they come to be grouped together within an organisation is not considered unimportant. A different study could have been dedicated to understanding how an organisational discourse emerges from a group, a process that is effectively black-boxed here. A similar approach is adopted in ANT studies, for example, where the "complexity of the network remains, but for heuristic purposes of analysis it can be moved to the background" (Williams-Jones and Graham, 2003).

Before selecting actors for the project's landscape, some conditions of inclusion are defined. First, the actor must be involved in the biofuel controversy. Thus, the actors must have a relatively prominent public perspective on biofuels, particularly on their relationship with social and environmental qualities at local and global scales that is contested by other perspectives in the debate. It is recognised that this is a difficult definition of involvement as it depends upon the positions of other actors and whether they, too, are considered part of the controversy. Relative prominence is also a non-absolute quality. For an actor to be included they must have sufficient material available for analysis, preferably covering a variety of media. Linguistic material must be in English and, whilst some material may be international in scope, it must be part of the controversy in the UK[21], for example, a domestic perspective on international issues would be suitable, whilst an international perspective on UK activity would not. Clearly the selection of actors is an interpretive process, although it is considered possible to provide a selection that can reflect the vast majority of significant positions adopted in the controversy as it unfolds in the UK.

The empirical analysis expands significantly upon the pilot study and the practicalities of the selection procedure are familiar to that advised by SCOT. Recall that these studies are

[21] Anecdotal evidence suggests that there are differences between the controversy here and elsewhere. In France, for example, there are said to be few environmental questions and the debate is orientated around fuel security and economic development.

initialised by the production of an exhaustive list of all actors engaged with the technology, which is then collapsed into a set of RSGs by conflating those with the same TFs. The result is a collection of actors which the analyst deems to have a sufficiently uniform perspective on the technology to be able to reduce them to a collective. Here a similar approach is adopted but, instead of conflating actors into RSGs, the actors are identified with reference to groups that they have organised themselves into, most frequently a company or other such organisation. The suitability of an actor is not, therefore, made solely on their perspective and available material, but also how they relate to other actors and how they fit into the wider controversy. Naturally, this leads to the exclusion of some actors, but it also ensures that the full breadth and depth of the UK biofuel controversy is represented without overemphasising certain discourses that dominate the public facing corpus of the controversy. In the following subsections, each selected actor is introduced individually with reference to the material that they have made available for analysis before a brief summary description of the group as a whole.

The National Farmers' Union

As an industry representative for UK farmers, the prospective producers of domestic biofuel feedstocks, the NFU have become actively involved in the biofuels controversy. Their inclusion in the pilot study will be carried over with the addition of a larger set of analytic material. The NFU website (NFU, 2009b) hosts downloadable versions of many of their press releases and public reports, some hard copies have also been collected through contact with their press office (Personal Communication., 2009).

Biofuelwatch

Biofuelwatch are single-issue campaigners dedicated to active opposition to biofuel development. As with the NFU, their inclusion in the pilot study will be carried over, supplemented by a greater breadth of material. Press releases, reports and material from their many public campaigns have been obtained through contact with their office (Personal Communication, 2009b) and their online archives which contains press releases (Biofuelwatch, 2009e) and other resources (Biofuelwatch, 2009f).

Greenpeace et al.

These mainstream environmental NGOs are concerned about the potential sustainability issues that may be associated with some biofuel developments (see Greenpeace *et al.*,

2007b). In something of an exception to the rule regarding group actors, it represents a self-organised joint campaign by Greenpeace, Friends of the Earth (FoE), Royal Society for the Protection of Birds (RSPB), World Wide Fund for Nature (WWF) and Enough's Enough. Henceforth referred to as Greenpeace *et al.*, this is not a conflation into a 'relevant social group' for the purpose of analysis, but reflects a coalition built by the actors for a unified and high-profile public campaign. Much of the campaign is freely available for download, including a TV advert, posters, flyers and press releases from the group. Only material produced and disseminated as part of this joint campaign is included.

Oxfam

Oxfam are a mainstream NGO which generally oppose biofuel developments although, unlike the other campaign groups which tend to prioritise environmental issues, Oxfam foregrounds social issues, particularly poverty in less developed countries. They have made a modest array of publications available on their online biofuel archive (Oxfam, 2009c), including an 'easy guide to biofuels' (Oxfam, 2009a) a number of press releases (Oxfam, 2008c, Oxfam, 2008b, Oxfam, 2008d, Oxfam, 2009b) and a more comprehensive 58-page briefing paper 'another inconvenient truth' (Oxfam, 2008a).

Supergen

Supergen is a cross-centre institute which conducts academic research, largely based in the applied sciences, into biofuel technology. Much of their research involves the development and study of processes, installations and infrastructures. Its caption, "advancing UK bioenergy", is a telling indicator of its positive and proactive approach to the development of biofuel technology (Supergen Bioenergy, 2009a). Hard copies of their nine public facing newsletters have been obtained for analysis.

Government

As discussed in the introductory discussion, a number of government departments are involved in the public debate and governance of biofuels in the UK, most notably the DfT, the Department for Environment, Food and Rural Affairs (DEFRA) and the Department of Energy and Climate Change (DECC). Whilst they are certainly an important actor in the development of biofuel technology, and the material they produce is publicly available, it is of a political genre that is not really intended for public consumption. Directgov, the government's interface with its citizens (NIDirect, 2009) has produced a number of articles

directed specifically to the public on the topic of biofuels. These articles have been replicated in other governmental websites such as NIDirect (2009), a citizens' portal for Northern Ireland, and the RFA (2009c), which is charged with overseeing the implementation of government legislation. This more publicly orientated material is much better suited to this analysis, and communications from each of these groups are analysed as representative of the government's contribution to the public biofuels controversy.

Greenergy

Greenergy lead the domestic biofuel market, having supplied over a third of all biofuels sold in the UK since 2005. It positions itself as an independent 'green energy' company, although it should be noted that it is also a major supplier of conventional automotive fuels and significant shares of the company are owned by Tesco and Barclays (Greenergy, 2009e). In their public facing material, particular attention is given to social and environmental issues. Their website includes a number of information packs, described as 'Greenergy Perspectives' for the public to learn about its biofuel products (Greenergy, 2009l). They have also made a number of press releases since early-2007 available on their website (Greenergy, 2009o, 2009m), although these are not always relevant to the biofuel controversy.

Saab

Saab is typical of the motor industry in many respects, which is generally positive about biofuels and their potential for achieving GHG emission reductions without requiring significantly disruptive infrastructural transformation. They manufacture a range of 'biopower' cars which are explicitly designed for the dual use of biofuels and fossil fuel sourced petrol. They have produced a dedicated website to promote this biopower range (Saab, 2009d), focussing upon technical performance more than environmental issues. A significant amount of material has been made available on this biopower website across various media, including documentary style video clips.

Tesco

Tesco are an interesting actor in the context of this analysis. As a major retailer, they began using biofuels in their distribution fleet voluntarily and significantly before the legal demands of the RTFO. They did not, however, communicate their decision to do so directly to their customers or to the public. Whilst brief references could be found though

searching their farming (Tesco, 2006) and investment (Tesco, 2009a) websites, a search of their consumer front end (at Tesco, 2009b) yields just one result, ironically for a book, *'The Biofuel Delusion'* (2012), by Andrew Boswell – a Biofuelwatch affiliated campaigner who fervently opposes biofuels and those that support its development. The lack of public engagement on the introduction of biofuels to their fuel mix has been confirmed privately as a conscious discursive strategy related to uncertainty in the outcome of the emerging biofuel controversy (Personal Communication, 2009a). Since there is no material to apply analysis to, they are excluded from the following chapter on empirical analysis, although their lack of communication is considered a 'positive absence', and is drawn upon in the subsequent discussion. It is noted that Morrisons supermarket also introduced biofuels to their fuel mix at around the same time and, like Tesco, did not communicate this to their customers.

Summary of Actors

The process of analytic screening was described and justified and the actors selected for the empirical analysis were introduced alongside a summary of the material they have made available. The material covers a broad range of media genres and perspectives within the public biofuel controversy. Without undertaking analyses of every single group with material of relevance to the controversy, it is not possible to claim that all distinctive perspectives are included in the analysis. Indeed, even if this were the case, it would be naïve to reduce all dimensions of the controversy to all those that are documented in an accessible format. No such claim is made here. Rather, it is forwarded that the actors, perspectives and materials included are sufficient to allow empirical insights that fairly represent the broad dimensions of the biofuel controversy in the UK and to demonstrate the workings of the theoretical framework described in the previous chapter.

To summarise, as presented in Table 4, below, there are four industrial actors, three NGO actors, one academic actor and one governmental actor. The industry and NGO categories have a greater internal variety of perspectives in the biofuel controversy than government and academic actors. This is likely due to the greater variety of sectors and interests they represent, which are provided in brackets alongside the organisation type in Table 4.

Actor	Organisation Type
NFU	Industry (farming)
Saab	Industry (motoring)
Greenergy	Industry (fuel)
Tesco	Industry (commerce)
Oxfam	NGO (development)
Biofuelwatch	NGO (single issue, biofuels)
Greenpeace *et al*	NGO (environment)
Directgov	Government
Supergen	Academic

Table 4: Actors Selected for Empirical Analysis

Chapter 6: Discourse in the Biofuel Controversy

This chapter presents some of the outputs of the empirical analysis that was prepared in the previous chapter. Since the empirical work was undertaken in iterative steps alongside the development of the theoretical framework, some 'dead ends' were faced and much material was reappraised and analysis repeated in light of new theoretical developments such as the semiotic triangle. An exhaustive presentation of all of the analytic avenues traversed during the empirical process would be unduly long as much of the analyses would be rendered obsolete by subsequent iterations. Instead, only the most salient results are presented, and the analysis is provided in a concise format with empirical material fully referenced but not reproduced. Short quotes and images are used to illustrate, support and justify the analysis where appropriate. Whilst not all actors have made equally rich data available, there is some attempt to balance the presentation of the analysis of each.

Each actor is considered in turn. They are briefly introduced in terms of their broad position in the debate. Key discursive orientations around the extra-discursive reality of biofuel technology are then presented in **Bold Orange** alongside further description, justification and illustrations from the material. There is an emphasis upon how actors' discourse is orientated around biofuels' inherent powers, e.g. to provide social and environmental benefit, and upon who or what controls biofuel development, i.e. which groups have the power to shape the technology. An analysis of the material through the lens of the semiotic triangle is then presented. The presentation adopts a familiar format to that which was used to illustrate findings in the empirical vignette from the school placement in the previous chapter, using the template presented in Figure 23, below. Following the lessons of the same vignette, the results are seen as a construction that reflects both the discourses studied and the method of their study. The former is seen as conditioned by the extra-discursive reality of biofuels, and the latter as inclusive of the interpretive bias of the author. It is anticipated that the provision of quotes and excerpts will provide some legitimation for the results in demonstrating how they were constructed. The chapter concludes with a brief summary of the empirical findings, but further discussion of the analysis in terms the technology-controversy relationship described in the theoretical framework and the implications and recommendations that result from it are reserved for the subsequent chapter. The analysis provides a novel contribution to the understanding of biofuels and also marks the first empirical application of the TMTA

discussed in Chapter 3 in the guise of the developments to it that were presented in Chapters 4 and 5.

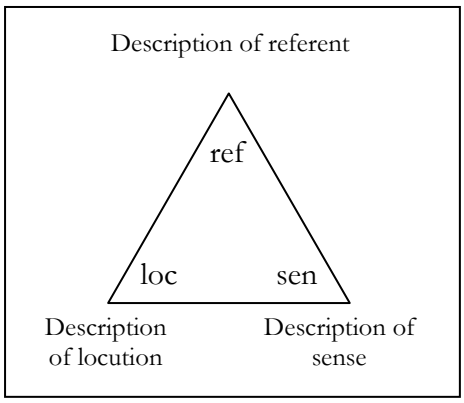

Figure 23: Format of Generalised Sign Analysis

6.1 Supergen

Supergen is an academic research group comprised largely, though not exclusively, of engineers. It has a motto of "advancing UK bioenergy" (Supergen Bioenergy, 2009a), which frames the content of all of their communications and suggests a default position of support for bioenergy developments, inclusive of biofuels. This position of advancement is repeatedly confirmed in their newsletters, which are the subject of analysis here. Entitled 'British Bio-Energy News' (henceforth BBEN), the newsletter is distributed amongst academic and industrial partners, made available to the public at events featuring representatives of the group and can also be downloaded or ordered through their website (Supergen Bioenergy, 2009c).

By autumn 2009, nine issues of BBEN have been produced and disseminated, containing about a dozen articles that are focussed upon biofuels, rather than bioenergy more generally. Table 5, below describes the referencing system which will be used to present the remainder of the analysis. The first five issues are not precisely dated, so estimates are provided based upon the content of the newsletters.

Issue	Date	Full Reference	Reference
1	~Early 2004	(Supergen Bioenergy, 2004)	BBEN-1
2	~Early 2005	(Supergen Bioenergy, 2005a)	BBEN-2
3	~Late 2005	(Supergen Bioenergy, 2005b)	BBEN-3
4	~Mid 2006	(Supergen Bioenergy, 2006a)	BBEN-4
5	~Late 2006	(Supergen Bioenergy, 2006b)	BBEN-5
6	June 2007	(Supergen Bioenergy, 2007)	BBEN-6
7	February 2008	(Supergen Bioenergy, 2008a)	BBEN-7
8	April 2008	(Supergen Bioenergy, 2008b)	BBEN-8
9	August 2009	(Supergen Bioenergy, 2009b)	BBEN-9

Table 5: Supergen Newsletters

Discursive Orientations

Supergen discourse is consistently orientated around a number of extra-discursive realities regarding biofuels. Three such realities have been selected and are presented below, each with illustrative examples from the text which are considered representative of the wider corpus.

Biofuels are good for society and environment

The discursive orientation around biofuels as a green technology is consistently visible in Supergen material. Illustratively, the newsletter's watermark features 'techy' shapes highlighting a green backdrop (see Figure 24, right), perhaps a straightforward semiotic indicator for green technology. More substantive claims in support of this discourse are made in the text, where biofuels' technical features are identified as having a positive effect on the environment;

> "The closed carbon cycle makes biodiesel an environmentally friendly product" (BBEN-5, p11)

And also on economies;

> "Given that 70 billion litres of [biofuel] production has a market value in excess of £15 billion, there is also a strong financial incentive for the UK to take a lead in this area" (BBEN-9, p24)

Figure 24: Supergen Newsletter Watermark

That biofuels *per se* are good for environment and society acts as the justification for Supergen's broad support for its advancement, as discussed with reference to their motto. That biofuels should be advanced is consistently assumed throughout the newsletters. In the article 'Establishing the Future of the UK Biofuels Industry' (BBEN-6, p19-21), for example, the starting position is not whether or not a UK biofuel industry should be established, the positive answer is assumed from the outset clearing the ground for the body text to consider the next steps;

> "The issue is how to expand this production capacity" (BBEN-6, p19)

It is surprising that an academic actor such as Supergen does not engage with the biofuels as a technology of questionable or internally variable suitability for advancement in the UK. The closest Supergen come to this position is in their occasional use of qualifiers, e.g. that biofuels can provide *a degree* of environmental and economic benefits, that they may not be the *only* appropriate technology and that other actions are required *before* they become suitable for a large scale roll out. Implicit pressure from their industrial partners and the need for continued funding income may limit the opportunity for Supergen to adopt a critical, let alone questioning position on biofuel advancement.

Partnerships are a mechanism for biofuel development, particularly in their capacity to promote environmental and economic good

Supergen's links with other industrial and academic institutions are enthusiastically demonstrated throughout the articles. There are a number of examples where Supergen go beyond the declaration of an institutional link and present partnerships and cross-institute coalitions as beneficial for biofuel development and particularly its positive economic and environmental effects. In the following excerpt, for example, it is observed that the industrial partnership is positioned as the active agent (as developer, producer, marketer) in a process which benefits the economy, as it meets a global demand, and the environment, through the renewability of the product.

> "BP and DuPont have announced the creation of a partnership to develop, produce and market a next generation of biofuels to help meet the increasing global demand for renewable transport fuels" (BBEN-4, p4)

Similarly, Supergen discourse is also orientated around the environmental advantages of BCTL's (Biofuels Corporation Trading Limited, a biodiesel production company) wider partnerships and affiliations.

> "BCTL is actively involved in this [environmental] area and is a member of the Roundtable on Sustainable Palm Oil (RSPO). The company is committed to the criteria and principles agreed with the RSPO and is working very closely with industrial stakeholders on appropriate standards to ensure sustainable production. BCTL is also a member of the Low Carbon Vehicles Partnership, a UK action and advisory group promoting the shift to clean low-carbon vehicles and fuels" (BBEN-5, p11)

Government support is required to ensure the future of biofuels

Despite their discursive orientation around biofuels' inherent environmental and economic good, Supergen discourse is not orientated around this being sufficient to secure its further development. They continually refer to the need for governmental support in this area, often in addressing "non-technical barriers" (BBEN-4, p9), but also in overcoming economic barriers, to ensure that biofuels are economically competitive with fossil fuels;

> "Alternative transport fuels have to compete with cheaper fossil fuels in today's marketplace, and therefore require government legislation or other incentives to become established" (BBEN-6, p20)

Furthermore, governmental agency is consistently positioned by Supergen as an active agent, frequently deploying their power to shape biofuel development. The following excerpt is illustrative of their discursive orientation around direct legislation as a shaper, a determinant even, of biofuels;

> "The direction for renewable transport fuels is set by two new European laws." (BBEN-9, p22)

And the following excerpt shows their orientation around government funding initiatives as a key shaper of biofuel development;

> "With an investment of over £25m over 5 years in sustainable power generation, [biofuels] have the potential to make a very important contribution to the achievement of Britain's energy goals." (BBEN-1, p2)

Supergen's discursive orientation around the agency of industrial partnerships and government in shaping biofuels' trajectory is not matched in their consideration of individuals. There is no discursive orientation around the power of consumers in commercial processes or citizens in political processes to shape biofuel development. Whilst it is noted that there is some unspecified references to "the increasing global demand for renewable transport fuels" (BBEN-4, p4), where elaboration is provided Supergen are not orientating around consumer agency but changes in the physical supply of competing fuels (see BBEN-6, p19) and legislative drivers, indeed;

> "Demand for renewable fuel is, in the main, driven by government incentives."
>
> (BBEN-5, p11)

Semiotic Analysis

Supergen discourse is now considered in terms of the semiotic triangle. In line with the definitions of biofuel and bioenergy provided in the opening section of the thesis, the locution 'bioenergy' is most frequently used to refer to a category of technical artefacts inclusive of biofuels and other technologies, i.e. the feedstocks which are not only used for producing transport fuel but also to provide heat and electricity. Occasionally, however, it is noted that the locutions 'bioenergy' and 'biofuels' refer to a discrete set of technical artefacts, e.g. "[s]ustainable bioenergy and biofuels" (BBEN-9, p2-3). Whilst the locution 'bioenergy' may or may not include biofuels, the locution 'biofuels' is used exclusively for transport fuels and is associated with a positive environmental performance. Even where the text is specifically about the differences between objects within the category of biofuels, the single locution 'biofuel' is applied (e.g. BBEN-9, p2-4). The use of locutions more specific than 'biofuels' is reserved for exceptional cases where a biofuel is seen to have a poor environmental performance, such as palm oil as illustrated in the excerpts below.

> "...the case of palm oil, where there is some concern that not all plantations are environmentally sound." (BBEN-5, p11)

This has the effect of differentiating negative palm oil from the generally positive group referred to as biofuels and to which palm oil feedstocks readily belong. This is interesting when considered in terms of the triangle as illustrated by the three generalised signs presented in Figure 25, below. The first generalised sign, to the left of Figure 25, is for the locution biofuels referring to all transport fuels. Supergen material demonstrates a sense of environmental value for these biofuels and a positive attitude to their advancement. The

second generalised sign, presented to the centre of Figure 25, is for the locution 'palm oil' and refers to biofuels produced from a specific feedstock, for which Supergen demonstrates a sense of concern for environmental degradation. This second triangle implies a third generalised sign, presented to the right of Figure 25, because those biofuels with a negative sense are not referred to as biofuels and, instead, are given more specific locutions.

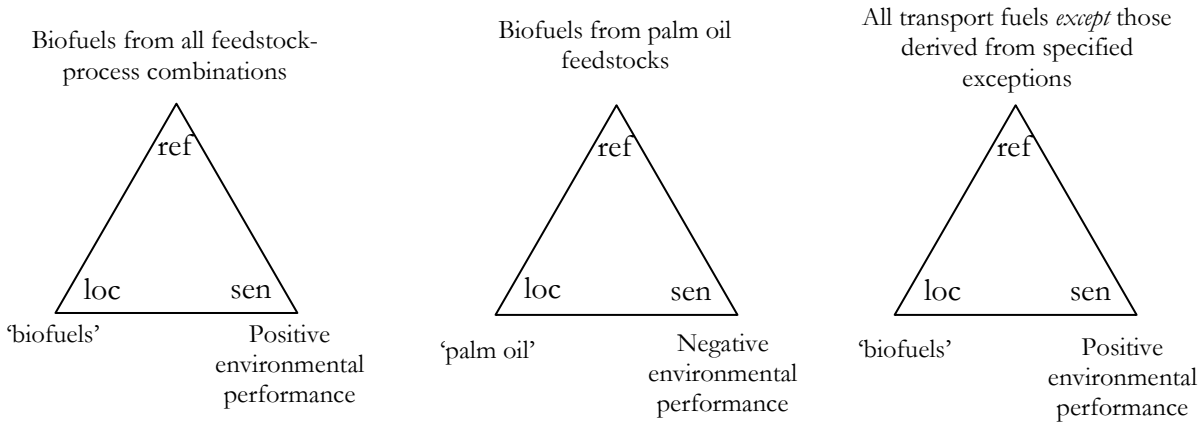

Figure 25: Supergen Signs for Biofuels & Palm Oil.
From left: Generalised signs for 'biofuels', 'palm oil' and 'biofuels' drawn from analysis of Supergen discourse

6.2 Government

Directgov is a government run information portal for citizens of Great Britain, "working closely with ministerial departments and non-departmental public bodies to collate key information all in one place" (Directgov, 2009a). Directgov and NIDirect, for citizens of Northern Ireland, present much of the same content in an almost identical format (see NIDirect, 2009). The RFA, a government body which oversees the implementation of the RTFO, also has a public facing website which presents more material from a similar governmental perspective. The style of communication across all three government actors is short text-only articles written in simplistic language, i.e. with short declarative statements which avoid jargon and acronyms. The UK government frames their legislative support for biofuel production in terms of three key benefits; improving fuel security, mitigating climate change and supporting rural economies (Department for Transport., 2006). These benefits also frame the discourse of the public facing government material, although it is noted that it tends to be presented in global terms rather than simply as regards the UK, for example;

> "[C]oncerns about fuel security, climate change, and the wish to support rural economies has led to plans for significant expansion in biofuel production across the globe" (RFA, 2009a)

Discursive Orientations

Three key orientations are found in the governmental discourse, each of relevance to their important role in shaping biofuel trajectories.

Biofuels can be good and bad for society and environment in different ways

The government discourse is most notably orientated around biofuels' physical power for environmental good, as illustrated in the following excerpt;

> "Biofuels can offer the potential to reduce greenhouse gas emissions because the carbon in the plant matter from which biofuels are produced comes from the carbon dioxide absorbed by the plants from the atmosphere during their lifetime" (RFA, 2009d)

Their discourse is certainly also sensitive to variability in the environmental and social effects of expanding biofuel development, making liberal use of qualifiers in their statements and listing a number of varied statements about how biofuels "can help improve energy security" but can also "lead to pollution and soil erosion" (Directgov, 2009b).

Industry shapes biofuels with agency afforded by government

The governmental discourse also reveals an orientation around these material powers of biofuels being shaped by industrial actors' agency, and this in turn being shaped by the government's control. So the government affords some agency to industry so that the inherent qualities of biofuels are controlled in desirable ways. The following excerpt concisely illustrates this hierarchy of control quite effectively, as the policy instrument restricts the agency of industry in a way that is intended to bring out the inherent environmental benefits of biofuel use;

> "Under the RTFO suppliers are required to report on the carbon emission savings and sustainability of the biofuels they have supplied" (RFA, 2009b)

The following excerpt from Directgov demonstrates their similar orientation;

> "The government has said that no more than 5 per cent fuel in the UK will be biofuel until it can be sure that it is supplied in a way that avoids negative side effects" (Directgov, 2009b)

Individuals shape biofuels with agency afforded by government

The government discourse also reveals an orientation around the material powers of biofuels being shaped by individual actors. It is also orientated around this agency being ultimately afforded by the greater power of government. As the performance of biofuels and their suppliers is monitored by the government, for example, it is suggested that this can be used by the government as a lever of consumer action;

> "The RFA publishes reports comparing the performance of different suppliers and the biofuels they have supplied, and expect consumers to be interested in using these comparisons to inform purchasing choices." (RFA, 2009b)

Semiotic Analysis

Considering the government discourse in terms of the semiotic triangle reveals that, despite their simplistic approach to language, they succeed in providing a relatively high level of locutionary specificity. That is to say, the material shows that it is possible to differentiate between the many types of biofuels without resorting to complicated or inaccessible language. For example;

> "Biofuels are fossil fuel substitutes that can be made from a range of agricultural crops including oilseeds, wheat and sugar, and from wastes like used cooking oil and tallow. The two most common current biofuels are bioethanol, which can be blended into petrol, and biodiesel, which can be blended into diesel." (RFA, 2009a)

And;

> "Two common biofuels are:
> biodiesel: made from vegetable oil crops like palm or soya, and waste vegetable oil. it can be mixed with standard diesel and used in normal diesel engines
> bioethanol: made by fermenting starchy and sugary crops such as sugar beet and wheat. It is mixed with petrol" (Directgov, 2009b)

They also discuss how social and environmental impacts can also vary according to choices about managing and processing this variety of feedstocks;

> "Some biofuels can lead to loss of important habitats and wildlife, and can have negative social impacts such as rising food prices." (Directgov, 2009b)

And also how this variation is exacerbated by the approach to processing;

> "[I]f biofuel production is not carried out with care, it can have serious side effects, like destruction of wildlife habitats and increased food prices ... impacts from producing and transporting biofuels can reduce, or even cancel out, the benefits of the resulting biofuel" (Directgov, 2009b)

They also effectively communicate the potential for indirect impacts;

> "Secondly, there may be carbon emissions associated with changing the usage of land to biofuel crop cultivation." (RFA, 2009d)

This leads to an internally varied set of referents for the single locution 'biofuel' and significant flexibility in the senses which are associated with them. This can be illustrated with a single triangle, as presented in Figure 26 below, or in the format presented in Figure 27 which shows that the locution biofuels explicitly refers to a number of different referents.

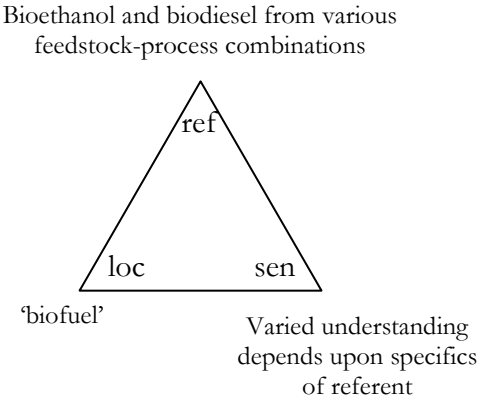

Figure 26: Government Signs for Biofuels
The single locution 'biofuels' refers to an internally varied set of referents and the sense depends upon the specifics of the referent.

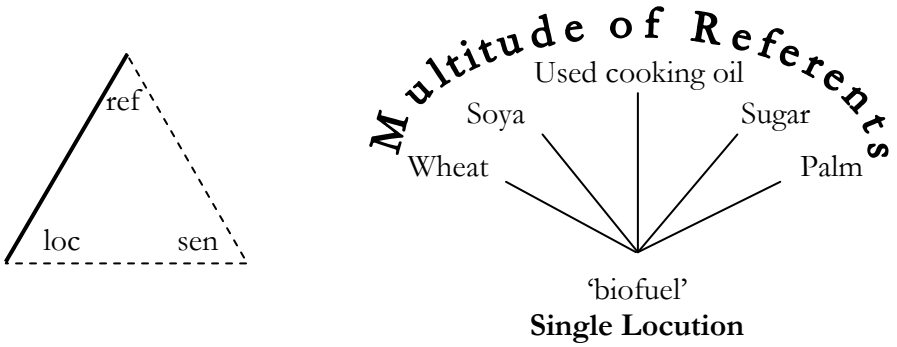

Figure 27: Multitude of Referents in Government's Locution of Biofuels
Each line in the diagram represents an edge of a semiotic triangle between the locution and referent, as indicated in bold to the left. The locution 'biofuel' also has many associated senses, which depends upon the specifics of the referent.

Figure 27 exhibits similarities with Figure 13 of Chapter 4, which was used to demonstrate the theoretical point that a single locution may refer to a multitude of referents. That theoretical point was developed significantly with reference to this analysis of government discourse. Also crucial, here, is that the governmental discourse succeeds in reflecting the variety of referents in the generalised sense. Whilst using a single locution 'biofuels' they do not conflate the internal variety within the referent. Further discussion of this success is reserved for the subsequent chapter.

6.3 Biofuelwatch

Biofuelwatch are a single issue campaign group which focuses upon the potential social and environmental problems with biofuels, lobbying for a moratorium on their development. Despite their relatively low resource base, they are probably the most vocal biofuel campaigners in the UK. They communicate directly to the public with leafleting campaigns, often associated with banner protests and other forms of direct action. Some such leaflets' content is tailored for specific events, e.g. picketing retailers such as Tesco or industry events, whilst others are of a more general character, e.g. awareness raising outside parliament.

Table 6, below, provides an index of the leaflets used in this analysis. Some were collected from their website (Biofuelwatch, 2009f) whilst others were collected in person at Biofuelwatch events attended as background research. The material contains a fairly balanced combination of text and images, some of which is reused from item to item with only minor modification, so there is some duplication within the data set. Most of the

material is undated, and those provided below refer to the date on which they were distributed.

Title	Date	Purpose	Reference
Protest Outside Biofuel Finance and Investment World Conference	November 2007	To promote a forthcoming protest	(Biofuelwatch, 2007b)
Greenergy and Tesco, Stop Trashing the Planet for Biofuels!!	January 2008	For distribution at a protest	(Biofuelwatch, 2008b)
Monocultures for Biofuels: Stop a Climate, Ecological and Social Catastrophe!	July 2008	General information	(Biofuelwatch, 2008c)
Biofuels – A New Threat to Climate and Climate Justice	July 2008	General information	(Biofuelwatch, 2008a)
Newark Exposé	October 2008	For distribution at a protest	(Biofuelwatch, 2008d)
Biofuels: Help to Stop Another Quick Way of Heating the Planet	March 2009	General information	(Biofuelwatch, 2009b)
Help us Stop Deforestation and Hunger due to Biofuels	March 2009	General information	(Biofuelwatch, 2009d)
Blue NG's Agrofuel Power Plant Makes Them an Entrepreneur Without Conscience	March 2009	For distribution at a protest	(Biofuelwatch, 2009c)
Biofuels East Launch Exposé	April 2009	For distribution at a protest	(Biofuelwatch, 2009a)

Table 6: Details of Biofuelwatch Material

Discursive Orientations

Biofuels have negative social and environmental consequences, particularly in the global South

Biofuelwatch discourse is consistently orientated around biofuels' negative social and environmental effects, for example;

> "[Biofuels are] causing serious harm to the climate, to communities, food sovereignty and food security and to biodiversity" (Biofuelwatch, 2008a)

The strongest orientation is around the global climate change potential of GHG emissions associated with biofuel grown in Europe, well illustrated by the following excerpt;

> "It is now clear that the greenhouse gas emissions from Northern grown biofuels such as corn ethanol and oil seed rape (...) have been underestimated by the EU and UK governments." (Biofuelwatch, 2007b)

A particular focus upon global inequity is maintained throughout their campaign as Biofuelwatch claim that most of the social and environmental problems affect the poorest people in the world, particularly those in the southern hemisphere. The following excerpts are representative of much of their material, as are the images in Figure 28, and each are presented to demonstrate the typical expression of this orientation which spans social, economic and environmental devastation;

> "Up to 60 million indigenous peoples [sic] are at risk of becoming 'biofuel refugees'" (Biofuelwatch, 2009c)
>
> "Food prices are rising due to biofuels, causing the poor to suffer more malnutrition" (Biofuelwatch, 2008b)
>
> "Biofuels are becoming the main reason for rainforest destruction" (Biofuelwatch, 2008b)

Figure 28: Biofuelwatch Images of Biofuels' Impacts in the Global South (left to right, Biofuelwatch, 2008d, 2009c)

Whilst Biofuelwatch discourse is primarily orientated around impacts in the southern hemisphere, there are some orientations around biofuels' negative northern impacts on social and environmental qualities, particularly in their immediate context of the UK and Europe. This focuses upon the people's ability to afford healthy food;

> "Even in the UK, poorer people are struggling ever more to afford a healthy diet. Agfrofuels are one of the main driver [sic] of this" (Biofuelwatch, 2008c)

And to maintain dwindling bird species;

> "'set-asides' of cropland have been scrapped following strong lobbying from the biofuel industry. Our well loved birds such as the sky lark and lapwing are at risk." (Biofuelwatch, 2009b)

Demand from the global North derives from governmental support for industrial activity

Complementing Biofuelwatch's previous discursive orientation, that biofuels affect global social and environmental qualities regardless of where they are produced, Biofuelwatch discourse is also orientated around the global North and its industrial interests as the active agent of biofuel development. This discourse of an unfair global division is well illustrated by the following excerpt which features in three of their items;

> "While Europeans maintain their lifestyle based on automobile culture, the population of Southern countries will have less and less land for food crops and will loose [sic] its food sovereignty" (Biofuelwatch, 2008b, reproduced in 2009d, 2009b)

And;

> "The South fuels the North. Most agrofuels expansion is planned in global South, but most of the demand comes from global North. Tens and perhaps hundreds of millions of hectares ... are to be converted to monocultures, largely to grow fuel for car drivers in the North" (Biofuelwatch, 2008a)

In is worth noting that support for this biofuel development, as with some of the other actors considered so far, is positioned as being fostered by proactive governmental support, the agency is ultimately afforded by government;

> "Agrofuel policies support a new corporate alliance which includes big agri-business, oil companies, the biotech industry, car manufacturers and venture capitalists" (Biofuelwatch, 2008c)

This orientation is frequently combined with the north-south divide and inequity in control over biofuel development;

> "The agrofuel market is being driven by government targets and obligations in the US, Europe and elsewhere, which have been imposed without taking account of the views of communities in the global south" (Biofuelwatch, 2008a)

Individuals have some democratic power but no consumer power

As indicated in the previous discussion, Biofuelwatch discourse is not orientated around the agency of individual consumers to shape development. This is occasionally backed up explicitly in the text with statements directed at the reader, such as "You cannot avoid using biofuels" (Biofuelwatch, 2009b). Unlike some of the other actors, however, Biofuelwatch discourse is orientated around the civilian power of individuals to shape biofuel development. Thus, they encourage members of the public to lobby the government to encourage legislation which will control the big businesses and curb their drive for biofuel expansion. The following illustrative example is taken from a section of a leaflet entitled 'What you can do to help';

> "Write to your MP demanding that the government stops promoting biofuels and suspends the Renewable Transport Fuel Obligation" (Biofuelwatch, 2008b)

Elsewhere, the appeal to civilian power is orientated around a different kind of relationship between individuals and industry, where the individual is not seen as a consumer but as a lobbyist or activit. The following illustrative example is taken from a section entitled 'What you can do to help';

> "Write to Terry Leahy, CEO of Tesco ... asking Tesco to pull investment out of Greenergy and to stop promoting biofuels" (Biofuelwatch, 2008b)

The following excerpt is provided to demonstrate the activist style of Biofuelwatch discourse – they promote the development of individuals political lobbying power into a united front against the governmental-industrial interests which drive biofuel development;

> "Stopping agrofuel monocultures means taking on one of the biggest corporate alliances and a government still commited to supporting them. Only a strong and diverse grassroots campaign can achieve this." (Biofuelwatch, 2009d)

Semiotic Analysis

Turning, now, to the consideration of Biofuelwatch discourse through the lens of the semiotic triangle, they have introduced a new locution, 'agrofuels'. This is used interchangeably with 'biofuels' in most of the text and it is difficult to distinguish between their meanings, particularly as they are often used in the same sentence, for example;

> "Take part in regular email actions against forest destruction and communities being evicted for *agrofuels*, and against the policies of promoting *biofuel* expansion"
>
> (Biofuelwatch, 2009b, emphases added)

In one of their pamphlets an explanation of how they differentiate between the two terms is provided, agrofuels are defined as those biofuels that are produced from feedstocks that were always intended to be used for biofuel production;

> "Most biofuels are agrofuels – made from crops and trees grown specifically for that purpose, such as sugar cane, palm oil, soya, jatropha or maize"
>
> (Biofuelwatch, 2008a)

Elsewhere, they define agrofuels in terms of the scale of their growth;

> "...more accurately called 'agrofuels' - liquid fuels produced from biomass grown in large-scale monocultures, mostly in the global south" (Biofuelwatch, 2007a)

So, it seems that for Biofuelwatch, 'biofuels' is a locution which refers to all biofuels, some of which, those that are grown on an industrial scale for the purpose of becoming biofuels, are also referred to by the locution 'agrofuels', as illustrated in the semiotic triangles presented in Figure 29, below.

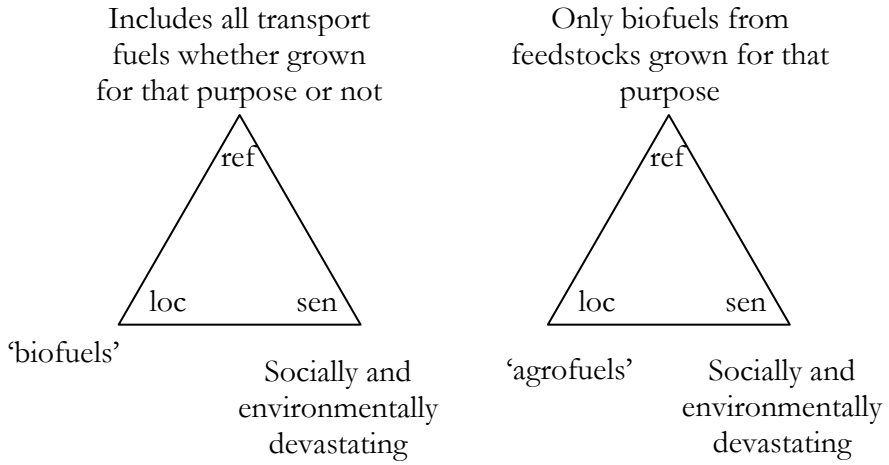

Figure 29: Biofuelwatch Signs for Biofuels & Agrofuels.

That 'most biofuels are agrofuels' implies that there is a sense in which non-agrofuel biofuels are insignificant in scope. Perhaps they are insignificant to the extent that the

category biofuels may be reduced to the almost-identical sub-category agrofuels – supported by the generally interchangeable use of locutions 'agrofuels' and 'biofuels'. Elsewhere in the material, there is evidence that there is a sense in which the benefits non-agrofuel biofuels are also insignificant;

> "We can get a very small amount of energy from waste-vegetable oil, biogas from landfill or manure – and that's something to be supported. But it's not enough to reduce our carbon emissions by much" (Biofuelwatch, 2008c)

Thus, we can draw out a semiotic triangle for the second category of biofuel; non-agrofuel biofuels, illustrated in Figure 30, below. This provision of specific positive exceptions to the rule is similar to Supergen's treatment of 'palm oil' as a negative performing exception to their generally positive discourse.

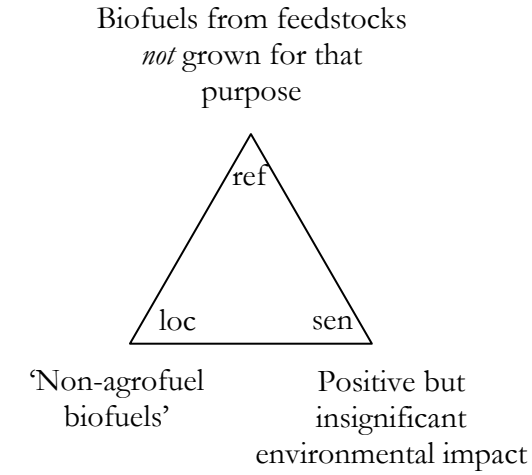

Figure 30: Biofuelwatch Sign for Non-Agrofuel Biofuels.

This difference between the referent of the locutions 'biofuels' and 'agrofuels' does not seem to offer a satisfactory explanation of why they are used interchangeably in their communications. The deliberate introduction of a new locution is quite interesting and, in pursuing further information, a channel of personal communication with the Biofuelwatch team was opened (Personal Communication, 2009b). In it, it was suggested that Biofuelwatch avoid using the term biofuels in a deliberate attempt to avoid the environmentally friendly associations which, they feel, is suggested by the inclusion of the lexeme 'bio'. This represents a significant engagement with the discursive structure of

biofuels. This development will be considered further in the discussion presented in the following chapter.

6.4 Oxfam

Oxfam are a non-governmental organisation with a focus upon social issues, particularly poverty and development. They are generally opposed to biofuel development on the grounds of the social impact in less developed countries but, as shall be demonstrated, their position is somewhat unsophisticated, particularly when compared to other key actors' positions.

Discursive Orientations

Biofuel development causes increased poverty

Oxfam discourse is consistently orientated around biofuels' negative social impacts. In a reflection of Oxfam's particular interests, they focus on poverty and its effects on the poorest people. The discourse is consistently orientated around a relatively simplistic relationship between biofuel development and increased poverty. This is well demonstrated by the image presented in Figure 31 and the statements in text that biofuels "may already be responsible for dragging 30 million people into poverty" (Oxfam, 2009a) and that its production "continues to negatively impact on poor people's lives" (Oxfam, 2009b).

Figure 31: Oxfam Image 'Biofuels Fuel Poverty' (from Oxfam, 2008c)

Oxfam discourse occasionally elaborates upon the mechanisms of biofuels' social impacts. This is a combination of a contribution to rising food prices;

> "The cost of basic foods are at record levels, and biofuels are in part to blame"
>
> (Oxfam, 2009a)

And more direct mechanisms such as removing people's capability to use land.

> "There are many examples of biofuels production leading to 'land-grabs', where poor people are forcibly removed or denied access to land essential to their

> livelihood. Once people lose their land, they lose their livelihoods – driving them even deeper into poverty." (Oxfam, 2009a)

Oxfam discourse echoes Biofuelwatch's orientation around biofuels' development being driven to meet the demands of richer people, although the orientation is not, as with Biofuelwatch, around the excess of individuals' lifestyles, but the meeting of legislative targets;

> "As rich nations scramble to meet targets for biofuel production, the rights of poor people are getting trampled on." (Oxfam, 2009a)

The similarity with Biofuelwatch discourse does not end there. Further parallels are identified in Oxfam's critical discursive orientation around the government's role in supporting biofuel development and the lack of consumer agency of individuals. Oxfam's discourse is orientated firmly around government support for biofuel development. Unlike Biofuelwatch, criticism is focused primarily at the Euroepean level, with member states positioned under the control of their directives;

> "[T]he European Union voted on legislation that will decide how member states use biofuels for the next decade." (Oxfam, 2009b)

This European level government control is also orientated as extended beyond member states to industry;

> "[T]he European Union is considering introducing laws forcing fuel suppliers to meet targets for blending biofuels with petrol and diesel." (Oxfam, 2009a)

Individuals have some democratic power but no consumer power

Also evocative of Biofuelwatch discourse, Oxfam reject individual's power to shape biofuel development through their purchasing choices, as illustrated by the following excerpt;

> "The legislation means that motorists would have no choice but to fill their cars with fuel that is harming poor people and making climate change worse." (Oxfam, 2009a)

And also in terms of the knowledge consumers have of the process, as illustrated by the following excerpt;

> "[S]cots motorists unwittingly drawn into biofuels fallacy" (Oxfam, 2008c)

Still, a number of differences remain between Biofuelwatch and Oxfam's discursive orientations, particularly regarding individuals' power to shape biofuel development through their lobbying activities. Whilst applauding the lobbying activities of themselves and their members, its power to shape development is rejected, as illustrated in the following excerpt;

> "Throughout last year, Oxfam supporters relentlessly badgered European politicians for the former. Emails were sent, letters written, meetings had and giant maize costumes worn. Sadly, when the EU announced its final decision a few weeks ago, much of what we'd hoped for was ignored." (Oxfam, 2009b)

Semiotic Analysis

Considered through the analytical lens of the semiotic triangle, Oxfam discourse is relatively unsophisticated. They do not use any other locutions aside from 'biofuels', nor do they orientate their discourse around any internal variety to this referent. The black and white understanding that 'biofuels drive poverty', well illustrated by the image in Figure 31, provides a fair reflection of their generalised sense. This is illustrated by the single triangle presented in Figure 32, below.

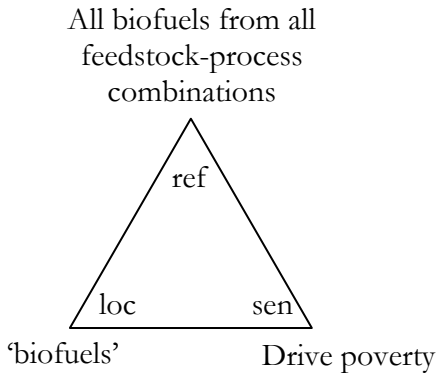

Figure 32: Oxfam Sign for Biofuels

6.5 Greenpeace *et al.*

As discussed, this actor refers to the material produced under a joint campaign by four environmental NGOs. Their discourse focuses upon the environmental costs associated with further development of 'the wrong biofuels' and they have produced campaign

material in support of this joint policy both individually and as a coalition. Only material produced explicitly as part of this particular joint campaign is considered.

> "As you may have already seen, along with WWF, the RSPB, Friends of the Earth and enoughsenough.org, we've placed an advert in several of today's papers warning the government about the environmental risks of biofuels as an alternative to petrol and diesel" (Greenpeace *et al.*, 2007b)

The material is internally consistent, exhibiting quite high discursive coherence and clarity, bearing the hallmarks of a well planned campaign.

Discursive Orientations

Biofuels are potentially environmentally dangerous

Greenpeace *et al.'s* discourse is orientated around biofuels as a potential cause of environmental devastation. Environmental dangers are understood broadly, including not only global issues such as climate change, but also local sustainability and wildlife conservation issues. They are careful to provide qualifiers, as illustrated by the following excerpts.

> "[I]t *could* spell disaster for rainforests, our own food and water supplies and even climate change ... the irony is that instead of reducing emissions, this supposedly 'green' alternative *could* actually be increasing them by an order of magnitude. (Greenpeace *et al.*, 2007b, emphasis added)

Greenpeace *et al.* have published a video (2007b) on the dangers posed to wildlife by *some* biofuels. Stills from the video are provided in Figure 33, below. The video is split into two parts, the first part is a rapid juxtaposition of two clips, one depicting a motorist filling their car with biofuels, and another showing orang-utans struggling to cope with the recent deforestation of their habitat. They are depicted as exposed and vulnerable. The images to the top left and right of Figure 33 are representative of these alternating streams that are presented during the first part of the video. The second part of the video is blacked out with text appearing in white. This text is reproduced from left to right in the bottom two rows of Figure 33. Note, again, the use of the qualifier 'could' in linking increased biofuel use with deforestation in the context of habitat destruction and species endangerment.

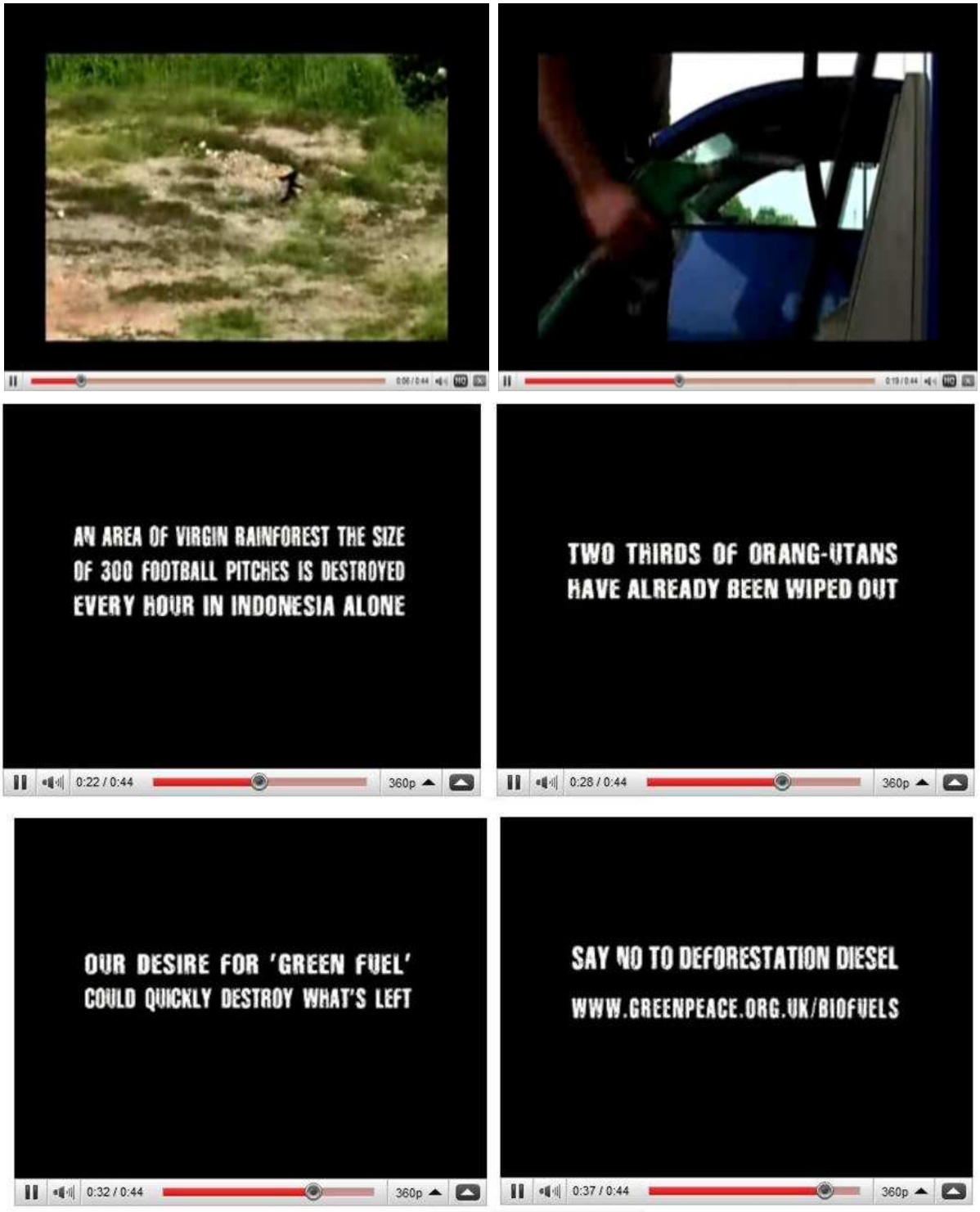

Figure 33: Stills from Greenpeace et al. Video of Orang-Utans & Biofuel Use

The qualifiers that Greenpeace *et al.* spread liberally through their material are a telling indicator of their discourse's orientation around an internally varied understanding of

biofuels. They are careful to point out that whilst *some* biofuels pose risks, others do not. Indeed;

> "[T]hey could form part of the solution to climate change, at least if it doesn't take a huge amount of energy to actually make them which is sometimes the case"
>
> (Greenpeace *et al.*, 2007b)

In another interesting visual example, also used to structure the discussion in the school placement, Greenpeace *et al.* present the potential negative effects of biofuels as a threat which may or may not be realised, depending on whether the right or wrong biofuels are chosen for development. Part of the poster, which the group published as part of a relatively high profile campaign including full page broadsheet advertisements, is reproduced in Figure 34, below. Here the fuel pump is used as though it were a gun to the head of the orang-utan which will be triggered if the government chooses the wrong biofuels. This use of the fuel pump is considered a genre of communication in the biofuel controversy and is revisited in the discussion presented in the following chapter.

Figure 34: Greenpeace et al.'s 'Orang-Utan' Poster

Government legislated industrial activity is the key driver of biofuels

Greenpeace *et al.'s* discourse is consistently orientated around the government's power to shape the development of biofuels. For example, as demonstrated in the poster in Figure 34, above, it is the government that makes decisions between choosing 'the right biofuel' or some other biofuels which will cause the elimination of the orang-utan. Indeed, there is a consistent emphasis upon the government's role in shaping the ways in which biofuel development can affect other environmental issues, most notably GHG emissions, as illustrated in the following excerpt;

> "Conservative estimates show the biofuels obligation, which came into force in April 2008, could have caused 1.3 million tonnes of extra carbon dioxide emissions."
>
> (Greenpeace *et al.*, 2009a)

Occasionally, these problems caused by biofuels are described as driven by industry;

> "[B]iofuel developments are firmly controlled by northern companies which are taking over our [Swazi] land at an incredible pace, and are bringing about serious socio-economic and environmental impacts on our communities, food security, forests and water resources." (Greenpeace *et al.*, 2009b)

However, such presentations are not maintained consistently and industrial powers are certainly positioned as under the control of government. Indeed, the excerpt above continues with a call for governments to be mindful of the power they have to control the industrial development of biofuels;

> Our governments urgently need to stop and think before delivering our continent [Africa] to the fuel demand of foreign investors" (Greenpeace *et al.*, 2009b)

Elsewhere, Greenpeace *et al.*'s discursive orientation around government control of biofuel developments via its control of industry is presented in even clearer terms;

> "[T]he government has grabbed onto biofuels like a drowning sailor and in the proposed Renewable Transport Fuel Obligation (RTFO) is insisting that all fuel companies increase the amount of biofuels they supply." (Greenpeace *et al.*, 2007b)

Individuals have some lobbying power but no consumer power

This broad orientation is recurrent, with some variation, amongst the NGO actors. Like Oxfam and Biofuelwatch, Greenpeace *et al.'s* discourse is also orientated around the lobbying power of both their own organisation and individual supporters and sympathisers. The reader is compelled to join in with the organised lobbying activity directed towards government, which is presented as a "small group making big, bad decisions" (Greenpeace *et al.*, 2007a). To an extent, this individual agency is clouded by the power of the lobbying group. The following typical excerpt, for example, positions the individual with some power to shape biofuel development, before compelling them to effectively cede this power to the group, repeating how Greenpeace *et al.* would deploy their power of biofuel development;

> "The government wants to know what you think about biofuels. Tell them we need strict and compulsory controls to make sure they really are green fuels. Hurry – you need to do it before 17th May." (Greenpeace *et al.*, 2007b)

Whilst comparable in its orientation around the lobbying power of individuals, Greenpeace *et al.'s* discourse is closer to that of Oxfam than Biofuelwatch in that, despite applauding such activity and calling for more of this kind of activity, they are not orientated around any degree of optimism with regards to its efficaciousness. For example, in discussing the details of new government legislation on biofuel development, Greenpeace *et al.* note that the government "ignored nearly 3000 submissions from Greenpeace supporters" (2007a).

Semiotic Analysis

Greenpeace *et al.* discourse is now considered in terms of the framework of the semiotic triangle. The analysis so far has already shown that Greenpeace *et al.* are sensitive to the internal variety of the referent and take care in how they refer to it. Whilst almost all of the time they use the locution 'biofuels', at the end of their video they refer to the biofuels that they are critical of as 'deforestation diesel'. This can be seen in the stills from the video presented in Figure 33, above, and has also been used in some of their press features. The following excerpt shows Greenpeace *et al.'s* support for some biofuels and rejection of others, each on environmental grounds, before compelling the reader to lobby for 'green fuel' instead of 'deforestation diesel'.

> "While [biofuels] could make a small contribution in the battle against climate change, it could in fact do more harm than good. Because without setting standards, there is a danger even more rainforests will be cut down to grow 'green fuels' ... The government is asking for people's views about biofuels. Say no to 'deforestation diesel' and yes to real 'green fuels'" (Greenpeace *et al.*, 2007c)

This implies three different generalised signs. The first stems from the locution 'biofuels' referring to an internally varied referent and approached with discursive caution about their potential threat, particularly to the orang-utan. This is presented in the triangle at the left of Figure 35, below. The second, presented in the triangle in the centre of the Figure, stems from the locution 'deforestation diesel' and refers to the subset of biofuels which are produced on deforested land and strongly criticised for their environmental impact. The third, presented in the triangle to the right, stems from the locution 'real green fuels' and refers to those biofuels that offer genuine GHG emission savings and avoid the environmental threats associated with other biofuels. There is significantly less discursive attention to this third triangle, although where it is present, the orientation remains strong.

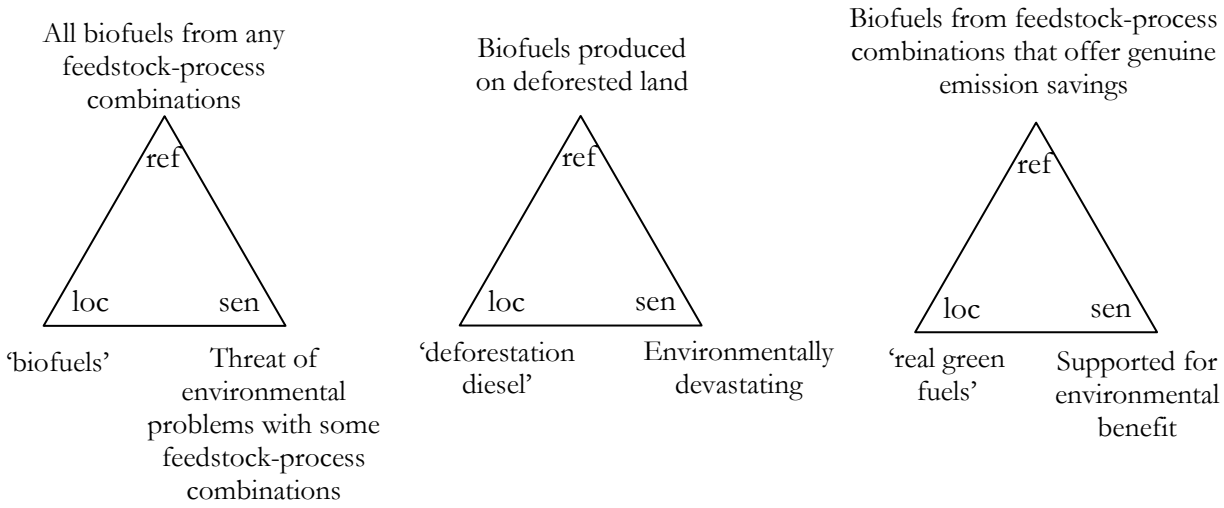

Figure 35: Greenpeace et al.'s Signs for 'Biofuels', 'Deforestation Diesel' & 'Real Green Fuels'

6.6 National Farmers' Union

The National Farmers' Union (NFU) are representatives of the farming industry in the UK. They are broadly supportive of biofuels and have made some information publicly available. Four articles are analysed. More are available to members but these are out of the public domain and access to them was not sought (Personal Communication., 2009). This is not considered a significant barrier as the focus here is on the controversy as it plays out in the public sphere. The first item of NFU material, Biofuels: Some Myths and Misconceptions' (NFU, 2007a), is a 16 page full colour leaflet distributed for public information and available on their website under the link 'Biofuels explained' (see NFU, 2009a). The remaining three documents are shorter text-only articles; 'NFU Welcomes Proposals for Long awaited Renewable Fuels Order' (NFU, 2007b), 'World Biofuels Markets 'More Upbeat' This Year' (NFU, 2009e) and 'RTFO – One Year On' (NFU, 2009c). These articles are slightly different to the 'Myths and Misconceptions' leaflet, as they adopt a news format, featuring columns of short paragraphs with major and minor headlines.

Discursive Orientations

Biofuel development has a positive impact on society and environment

NFU discourse is strongly orientated around the social and environmental benefits of biofuel development in general, which is positioned as reducing GHG emissions (NFU, 2007b) and as "a major driver for sustainable development" (NFU, 2007a). Their visual material also reinforces this orientation, for example, the front cover of their leaflet reproduced in Figure 36, below, presents a bright day and healthy image of nature within a field of rapeseed plants in bloom with the fields beyond bearing the marks of recent agricultural activity. This is a clear visual orientation around biofuel agriculture being in harmony with the environment. Another interesting example is provided in the 'corn pump' image reproduced in Figure 37, below. As discussed in the school placement vignette, this image is interpreted as an orientation around the a fairly clean and direct process of extracting biofuels from feedstocks, in this case the fuel is seemingly provided directly from an oversized corn. Of course, this metaphoric simplification obscures many processes required to deliver biofuels from a raw feedstock, and fails to capture other impacts along the way. Further examples of positive, clean imagery abound in the material,

including images of fresh food, butterflies, chameleons and even a somewhat perplexing photograph of a police car being refuelled by a uniformed officer.

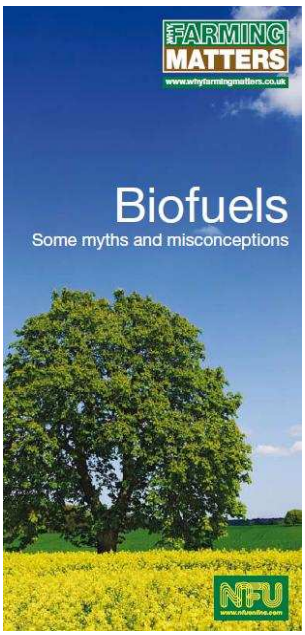

Figure 36: Front Cover of NFU Pamphlet (NFU, 2007a, p1)

Figure 37: NFU 'Corn Pump' Image (NFU, 2007a, p10)

The NFU discourse is more guarded when considering the environmental performance of imported biofuels, and present an understanding of these as requiring regulation to protect environmental qualities. The following excerpt, which was also considered in the pilot vignette, is illustrative of this orientation and will be considered further in the following chapter's discussion;

> "[It is important that] any imported feedstock or biofuel can prove equivalent sustainable production standards have been met." (NFU, 2007b)

Government policy controls the development of biofuels in the UK

Like that of many of the actor actors discussed, the NFU's discourse is orientated around the government as the active agent of further biofuel development through its imposition of legislation upon industry. This governmental agency is referred to consistently in NFU material in statements of the form that "[the] obligation will require road transport fuel

suppliers to..." and "[the] Energy Act 2004 requires that..." (NFU, 2007b). There are no references to the lobbying power of individuals, NGOs or industry groups to shape biofuel development – only this governmental power – although they do position themselves in support of the government legislation;

> "The NFU has long campaigned for the introduction of an RTFO" (NFU, 2007b)

Partnerships support the environmental benefits of biofuel development

This discursive orientation has also been observed in Supergen discourse. Here in the NFU discourse, however, it is orientated around a need for, rather than existing establishment of, cross-industry collaborations to ensure the environmental benefits of biofuel development. In the following illustrative example this involves a partnership between the biofuel and farming industries;

> "...the need for the biofuels industry to work in partnership with farmers to deliver on sustainability" (NFU, 2009e)

Semiotic Analysis

Now, considering the NFU material through the semiotic triangle, it generally presents an understanding of biofuels as an opportunity for social and environmental good, as presented in the sign in Figure 38, below.

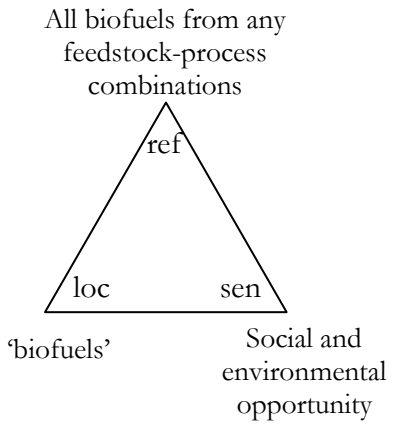

Figure 38: NFU Generalised Sign for Biofuels

However, as discussed previously, the NFU do not treat biofuels as a homogenous category and they distinguish between the various referents mostly on the basis of whether they are domestically produced or imported. When considered in the form of generalised signs, these two different biofuels, imported and UK, are associated with very different understandings. For biofuels produced from domestic feedstocks, it is one of a positive environmental performance, and for those from imported feedstocks they are of questionable value and require regulation.

This is a somewhat predictable position for the NFU, as the industrial representative of UK farmers, since they benefit from increased demand for their products and suffer where competition is increased. Occasionally their discourse is orientated around the economic advantages of domestic feedstocks over imported ones, for example in stating that biofuel from domestic wheat supplies will "boost the market and provide opportunities for both arable and livestock farmers" (NFU, 2009c), More usually, however, the discourse is orientated around the environmental benefits of domestic products. The following excerpt is illustrative;

> "99% of biofuels from *UK feedstocks* meet environmental sustainability standards. *UK biofuels* are also meeting, and in some cases significantly exceeding, the government's target for greenhouse gas savings for the first year of the RTFO."
>
> (NFU, 2009c, emphasis added)

And the following example, orientated around the regulatory caution required to ensure the environmental performance of imported products;

> "[It is important that] any imported feedstock or biofuel can prove equivalent sustainable production standards have been met." (NFU, 2007b)

Occasionally, though less often, the discourse is more strongly orientated around specific environmental problems associated with imported feedstocks, although it maintains a discourse of danger rather than the more deterministic causation that is observed in, for example, Biofuelwatch discourse;

> "There is a danger of biofuel production causing environmental damage elsewhere in the world through the destruction of rain forest and other natural habitat to make way for crops" (NFU, 2007a)

This distinction can be distilled into the form of generalised signs. The first, presented to the left of Figure 39, below, considers UK products and the second, presented to the right

of the Figure, considers imported products. When compared to the generalised sign for all biofuels presented in Figure 38, above, the sense is not only stronger, particularly for UK biofuels, but also captures a shift in focus to the environmental benefits (or otherwise) of biofuels.

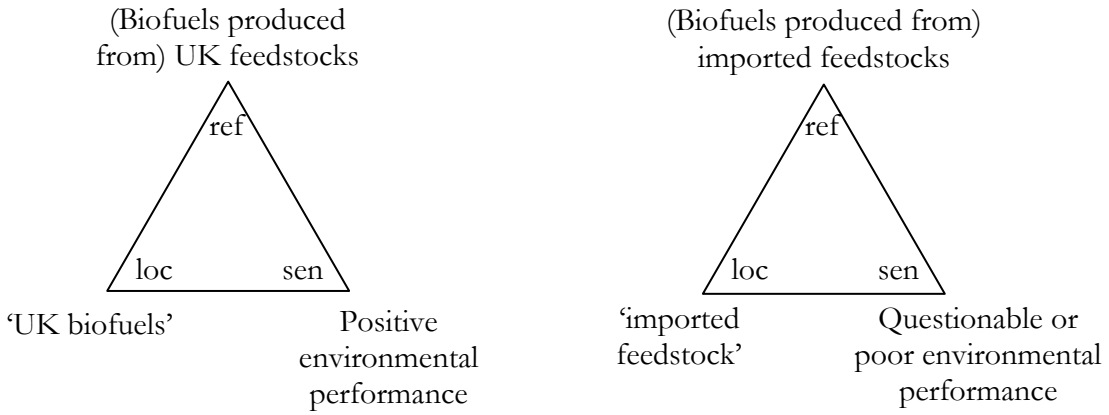

Figure 39: NFU Signs for UK and Imported Biofuels

6.7 Saab

Saab are an automobile manufacturer with a specialism in 'biopower' cars made especially for running on petrol, biofuels and blends of any proportion. They have a separate website (Saab, 2009d) dedicated to this technology. Aside from information on the vehicular technology, which is interesting but considered somewhat out of scope in this study, the website also includes a substantial amount of information on biofuels. Its front page contains an 'FAQ' with links to pages providing information on production (2009b) and operation (2009c), global usage statistics (2009h) and sustainability (2009g), in addition to a substantial library of video files on the subject (2009f).

Discursive Orientations

Biofuels benefit the environment

There is a strong defence of biofuels' environmental performance in Saab's discourse. In their FAQ, for example, the following Q and A sequence is found;

> Q: "Is it true that the rainforest is being sacrificed to grow sugar cane for bioethanol production?"
>
> A: "Not at all. In fact, heavy rainfall makes the rainforest soil unsuitable for growing sugar cane, Brazil's source of bioethanol" (Saab, 2009e)

Whilst the above statement is certainly contestable (indeed, many would say that it is simply untrue), the point here is that it evidences a discursive orientation around biofuels as beneficial to the environment. This is reinforced repeatedly in text, as illustrated in the following excerpt;

> "CO_2 which is released during the burning of the fuel is counter-balanced by that which is removed from the environment by photosynthesis when growing crops and trees for ethanol production. This, in effect, stabilises the atmospheric CO_2." (Saab, 2009g)

This discursive orientation is maintained in the video clips presented on the website. For example, in one titled 'Future of Biofuels' (Saab, 2009f), they emphasise the use of waste products as a feedstock for the production of ethanol biofuels. The video shows waste spinning around, a car tyre eventually being superimposed onto the cyclic movement. A still from this point in the video is presented in Figure 40, below. The narrator is, at this stage, saying that "your household waste could power your car instead of polluting a landfill". This juxtaposition of the raw feedstock against its end use exhibits similarities with the NFU 'corn pump' image discussed previously, as each obscures a number of steps involved in the production of useable fuel. Here, Saab also obscure the many other feedstock production methods that are used to make fuel for their cars. There is also a more significant discursive difference between Saab and NFU in that, for the NFU, the corn to pump process was presented in a harmonious environmental setting, whereas here the atmosphere is equally harmonious but with a much more technical feeling, replacing the green fields with a sterile and gravity-free laboratory setting.

Figure 40: Still from Saab Video- 'Household Waste'

In an interesting twist on this recurring theme, Saab's discursive orientation around the environmental benefits of biofuels, particularly the GHG balance, is accompanied by a cautious treatment of the legitimacy of claims about the climatic impacts of GHG emissions. This is illustrated by the following excerpt, with emphasis added to indicate the cautious treatment of the legitimacy of the claim;

> "The key environmental benefit of bioethanol is that, unlike petroleum, its consumption does not significantly raise atmospheric levels of CO_2, which *some scientific research suggests* is a major contributor to global warming"
>
> (Saab, 2009c, emphasis added)

This may have something to do with the actor's positioning within the motor industry, although it is difficult to show precisely how. It may, however, be one explanation for their preference for technical atmosphere over environmental atmosphere. This leads discussion to the next discursive orientation found in Saab material.

Biofuels are a traditional technology under continued development

The second of Saab's discursive orientations is unique amongst the actors analysed in this study. It is around biofuels as a traditional technology which is under continuing development. This is a fairly dominant discourse in the Saab material. Biofuels, they say, are part of a continual tide of general technical development and has its roots in traditional, tried and tested technologies. For example, continual emphases are placed upon the technology's parallels with the production of alcoholic drinks, as illustrated in the following quote;

> "Traditional production of this alternative fuel is a well-known, easy fermentation process of the sugar, similar to those used to make whisky or vodka." (Saab, 2009b)

This discourse is also maintained in video clips on their media library. One such video, titled 'Sustainable Fuel', features TV personality Kevin McCloud testing out a Biopower car and extolling the virtues of biofuel technology, again, emphasising its parallels with the process of producing alcohol. A still from the point of the video from which the following quote is drawn is provided in Figure 41, below;

> "You could run it purely on bioethanol which is the stuff that's in whisky and gin. Good alcohol." (Saab, 2009g)

Figure 41: Still from Saab Video- 'Good Alcohol'

Saab's discourse of biofuel development and, indeed, technical development in general is not about meeting government legislation, improving environmental standards or rural economies. Rather, it is about improving technical performance. The development of biofuels is orientated in the same way as other technical developments such as aerodynamics and safety systems. Their use is justified on the grounds of performance such as "[brake horse power] increases by 20% Torque increases by 16%" (Saab, 2009e). The following excerpt illustrates the same discourse whilst also reinforcing the orientation around biofuels as a traditional technology;

> "Replacing petrol and diesel fuel with bioethanol as motor fuel is by no means a new idea. Bioethanol has been used as a petrol additive to increase octane ratings (and therefore fuel potency) for almost a century" (Saab, 2009h)

Saab's discursive orientation around biofuels as an opportunity for automotive technical development operates at a level more specific than just biofuels. It cuts through the internal variety of biofuels in terms of their first and second generations of their development. As previously discussed, the production of first generation fuels is presented as a traditional and simple process that is, again illustrating the alcohol analogy, "not dissimilar from that of wine or beer-making fermentation" (Saab, 2009a). The second generation is much more advanced, it is "a breakthrough in ethanol technology that produces fuel from practically any renewable energy source" (Saab, 2009a). Whilst declaring them to be more economical (Saab, 2009b) and having a "favourable" GHG balance (Saab, 2009a), the primary orientation is around the technical performance of the second generation, which offers "a better quality of fuel than first generation biofuels" (Saab, 2009a).

Political processes can affect biofuel developments

At just two points in the Saab material, the discourse is orientated around the social shaping of biofuel technology. In the first, they refer generally to the need for government support to ensure development;

> "The availability of bioethanol in any given country often depends on government support" (Saab, 2009d)

And, in the second, they refer to the power of voluntary schemes to guarantee about the fuel's environmental benefits. This, to an extent, echoes the NFU orientation around the sufficiency of voluntary schemes and, thus, the lack of necessity for mandatory regulation;

> "Certain biofuel suppliers have already adopted voluntary auditing and certification schemes to guarantee the CO_2 emission savings generated by the biofuels they supply" (Saab, 2009g)

Semiotic Analysis

Turning to the consideration of Saab discourse in terms of the semiotic triangle, there are two features of their semiotic treatment of biofuels. The first is relatively insignificant, that they use the locutions 'bioethanol' and 'biofuel' interchangeably. The terms do not appear to refer to different referents or senses, probably because Saab's biofuel range are bioethanol only. There is little interesting that can be said about this feature of Saab discourse. The second is much more interesting, as Saab refer to a subset of all biofuels as 'second generation' biofuels. As discussed above, biofuels are engaged with as a development of previous 'traditional' technologies that afford improvements to automotive technical performance whilst providing some environmental and economic benefits. This is captured by the triangle presented to the left of Figure 42, below. Second generation fuels are an advanced subset of these biofuels which afford even further technical, environmental and economic benefits. This is captured by the triangle to the right of Figure 42. Their approach is revisited in the discussion presented in the following chapter.

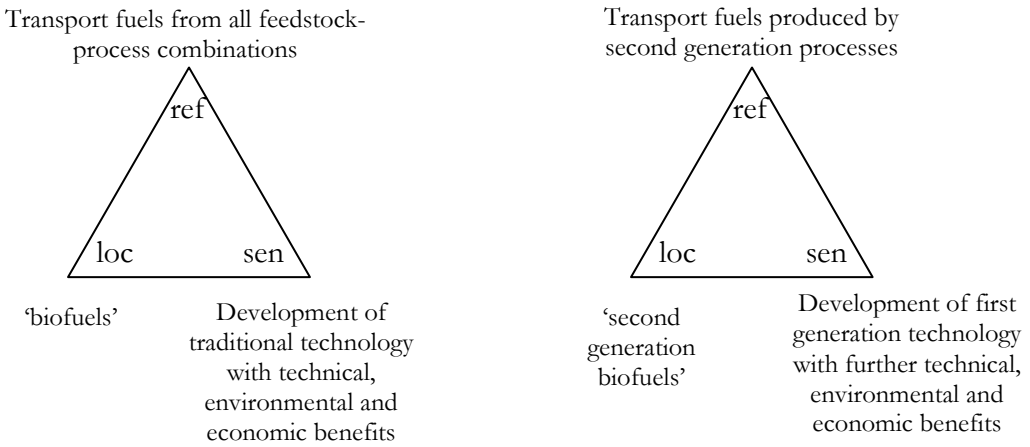

Figure 42: Saab's Signs for First & Second Generation Biofuels

6.8 Greenergy

Greenergy are the leading biofuel supplier in the UK. Their name, combining the locutions green and energy, provides an immediate semiotic indicator of their position on the environmental benefits of biofuels. They also have a wealth of material on their website, including press releases (Greenergy, 2009m, Greenergy, 2009o) a photo library (Greenergy, 2009n) information on their sourcing (Greenergy, 2009c) and production (Greenergy, 2009a). Whilst these provide some useful information and are included in the analysis, their series of public facing 'Greenergy Perspectives', detailed in Table 7, below, are better suited to the analysis undertaken here.

Title	Reference
Bioethanol	(Greenergy, 2009b)
Carbon Benefits of Biofuels	(Greenergy, 2009d)
Palm Oil in Biodiesel	(Greenergy, 2009k)
Deforestation	(Greenergy, 2009f)
Soy Oil in Biodiesel	(Greenergy, 2009s)
Jatropha	(Greenergy, 2009h)
Second Generation Biofuels	(Greenergy, 2009r)
Meeting Future Demand for Oil – Considering Alternatives to Biofuels	(Greenergy, 2009j)
The Relationship Between Biofuels and Consumer Fuel Prices	(Greenergy, 2009p)
RTFO	(Greenergy, 2009q)
Making Biodiesel from By-Products	(Greenergy, 2009i)
Food Vs Fuel?	(Greenergy, 2009g)

Table 7: Greenergy Perspectives
(Hosted at Greenergy, 2009l)

Discursive Orientations

Biofuels have positive environmental impacts

The first of Greenergy's discursive orientations is around biofuels providing environmental benefits. This is well illustrated by some the images presented in Figure 43, below, (Greenergy, 2009n). The first, to the left of Figure 43 shows Greenergy's CEO Andrew Owens presenting a finished biofuel product against a backdrop of oilseed rape. This

juxtaposition of feedstock and biofuel, like the previously discussed NFU image of the 'corn pump' in Figure 37, obscures the intermediary processes and wider impacts involved in the production of biofuels. The second image, to the right of Figure 43, is similar and adds another example to the growing set of images reflecting interpretations of the fuel pump. Both images present biofuels in a healthy environmental-agricultural setting, and support Greenergy's discursive orientation of biofuels' environmental benefits.

Figure 43: Greenergy's 'Field to Fuel' Imagery

Despite this overall positive focus, they certainly recognise the significant variation in impacts resulting from different fuels within the spectrum of available feedstocks and production processes. They use careful language to avoid the impression that any such impacts can be generalised across all biofuels. Nonetheless, the variability of impacts is presented across a range that remains broadly positive. For example, in the excerpt below, lower performing biofuels are framed as having 'little carbon benefit', rather than having no carbon benefit at all, or even a negative carbon benefit. Thus, Greenergy maintain a generalised sense of biofuels as environmentally beneficial.

> "Many biofuels have much lower emissions that [sic] their fossil alternatives but the range of emissions savings varies widely and some biofuels have little carbon benefit" (Greenergy, 2009d)

Similarly, in their comparison of first and second generation biofuels, reproduced in Table 8, below, the carbon benefit ranges from poor to excellent and is never described as negative. The overall understanding is still positive because a poor carbon benefit is better than a negative balance or no benefit at all;

Issue	First Generation	Second Generation
Carbon benefit per ton	Variable (poor to excellent)	Variable (poor to excellent)
Carbon benefit per hectare	Variable (poor to excellent)	Good to best

Table 8: Carbon Benefits of First and Second Generation Biofuels (from Greenergy, 2009r)

Industrial agency affects biofuels' environmental benefits, encouraged by government

That industry has some control over the extent to which biofuels can provide environmental benefits is a clearly present discursive orientation within Greenergy material. This discourse is deployed most frequently in demonstrating the responsibility of their own particular approach to biofuel production, e.g. forwarding that they "only supply biofuel that makes a real contribution to cutting greenhouse gas emissions" (Greenergy, 2009c). This discourse is generally framed by an orientation around the need for appropriate regulation to ensure the environmental benefits of biofuel development, well illustrated by the following excerpt;

> "Government policy measures that encourage the use of biofuels are therefore to be welcomed, as long as the biofuels offer a genuine carbon benefit and are derived from sustainable sources" (Greenergy, 2009q)

And, similarly;

> "The carbon benefits of sustainably produced biofuels should be the basis on which government promotes their use" (Greenergy, 2009d)

As with many of the other non-NGO actors considered in this analysis, there is an absence of any discursive orientation around the power of individuals, either as consumers or citizens.

The association of biofuels with many social and environmental problems is unfounded

The final discursive orientation in Greenergy material discussed here is strongly related the first, that biofuel development is broadly beneficial. It focuses upon the ways in which the biofuel controversy has already affected biofuels has led to an unfair association of biofuels

with various social and environmental problems. Occasionally the existence of an association between biofuels and social and environmental problems is rejected outright, for example in the following excerpt regarding food prices;

> "There is little evidence that biofuel production was a significant contributor to rising food prices. Commodity crop prices are continuing to fall in spite of a continued increase in world biofuel production." (Greenergy, 2009g)

Elsewhere, it is claimed that biofuel development actually alleviates the very problems it is accused of causing, as illustrated in the following excerpt from a Greenergy press release, also focussing on food prices;

> "[B]iofuels are also playing a major role in the reduction of fuel prices which in turn reduces the cost of food production - energy, from fertilisers to tractors to transport to processing being a significant cost in food production... Without biofuels, fuel prices will continue to rise to levels that put them out of reach of the many in developing nations who need fuel to produce food." (Greenergy, 2008)

In other corners of Greenergy material, these defences are accompanied by accusations that other industries are the real cause of the social and environmental problems that are wrongly blamed upon biofuel development. The following excerpt demonstrates this point with reference to rising agricultural prices;

> "A combination of factors contributed to the rising agricultural prices during 2007 and early 2008. These included speculative trading activity, rising fertilizer and other agricultural production input costs" (Greenergy, 2009g)

The following excerpt demonstrates a similar discursive orientation, this time considering the environmental issue of deforestation as an effect of the development of other industries;

> "Food production, logging and the removal of wood for fuel remain the key drivers of global deforestation" (Greenergy, 2009f)

Finally, the following excerpt defends Greenergy from criticisms on the grounds of unsustainable practices in the production of biofuels from palm oil, forwarding that increased demand for this feedstock is not associated with biofuel development, but the food industry which is not subject to the same legislative standards;

> "The main driver of palm oil demand is the food industry which is not subject to the sustainability standards that apply to biodiesel" (Greenergy, 2009k)

Semiotic Analysis

The consideration of Greenergy material through the analytic lens of the semiotic triangle reveals their relatively sophisticated understanding of biofuels. Their locution 'biofuels' refers to a category of significant internal variety where, although there is a broad understanding of biofuels as environmentally and economically beneficial, no specific understanding can be generalised across the different use of feedstocks, production regions or even specific plantations (see Greenergy, 2009k). Their discourse also moves beyond other actors' in recognising that biofuels are not produced from single feedstock-process combinations, but are blends incorporating a variety of different methods "to get the best balance of quality, carbon and environmental impact" (Greenergy, 2009a). The blend can also depend upon "customers' requirements, on season as well as on quality, availability and price" (Greenergy, 2009s). The climate in which the fuel will be used can also make a difference. In colder climates, for example, biofuels from waste products are "best blended with other biodiesels to achieve an acceptable cloud filter plugging point" (Greenergy, 2009i).

Indeed, Greenergy discourse exhibits such a rare caution in its treatment of the locution 'biofuels' that the triangle exposes very little. Like the government's generalised sign for biofuels, the locution refers to a variety of different referents, although Greenergy surpass the government in the extent to which this variety is recognised. Unlike the government discourse, however, the multitude of senses associated with biofuels all fall within a positive range. This is presented in the format of the semiotic triangle in Figure 44, below.

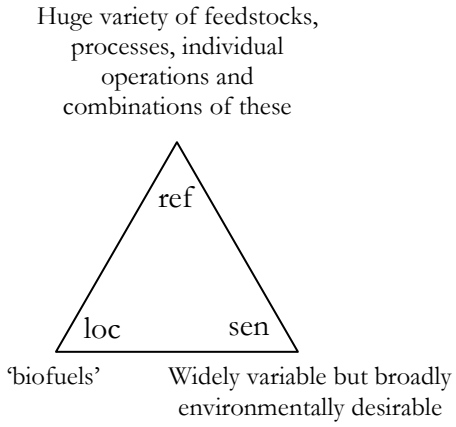

Figure 44: Greenergy Sign for 'Biofuels'

6.9 Summary & Compendium of Analysis

This chapter has presented and illustrated the most pertinent results of the empirical analysis on an actor-by actor basis. It was non-exhaustive, concisely demonstrating the application of the theoretical framework in an empirical setting. This final section summarises these results into a more comparative format in preparation for the discussion of the study that is presented in the following chapter.

Summary & Compendium of Discursive Orientations

In the analysis of discursive orientations around extra-discursive realities, there was a focus upon orientations around what biofuels are and the powers they have, particularly with regards to social and environmental impacts, and also upon how their development is controlled by different actors. With the exception of Oxfam's two, three pertinent orientations were presented for each actor. These are brought together into the compendium presented in Table 9, below.

Actor	Discursive Orientation
Supergen	Biofuels are good for society and environment
	Partnerships are a mechanism for biofuel development, particularly in their capability to promote environmental and economic good
	Government support is required to ensure the future of biofuels
Government	Biofuels can be good and bad for society and environment in different ways
	Industry shapes biofuels with agency afforded by government
	Individuals shape biofuels with agency afforded by government
Biofuelwatch	Biofuels have negative social and environmental consequences, particularly in the global South
	Demand from the global North derives from governmental support for industrial activity
	Individuals have some democratic power but no consumer power
Oxfam	Biofuel development causes increased poverty
	Individuals have some democratic power but no consumer power
Greenpeace *et al.*	Biofuels are potentially environmentally dangerous
	Government legislated industrial activity is the key driver of biofuels
	Individuals have some lobbying power but no consumer power
NFU	Biofuel development has a positive impact on society and environment
	Government policy controls the development of biofuels in the UK
	Partnerships support the environmental benefits of biofuel development
Saab	Biofuels benefit the environment
	Biofuels are a traditional technology under continued development
	Political processes can affect biofuel developments

Greenergy	Biofuels have positive environmental impacts
	Industrial agency affects biofuels' environmental benefits, encouraged by government
	The association of biofuels with many social and environmental problems is unfounded

Table 9: Compilation of Discursive Orientations and Actors

Summary & Compendium of Semiotic Analysis

In the analysis structured by the semiotic triangle, actors' discourses were interpreted in terms of the triad of referent, sense and locution. The triangle was deployed to consider how actors involved in the controversy use the term 'biofuels' and other related terms to refer to different technical artefacts, and demonstrating the broad sets of meanings associated with them. This usually captures their sense of support or opposition on the basis of their interpretation of the technology's impacts on social and environmental qualities. Where actors make distinctions between different types of biofuels these were also explored, leading in some cases to the analysis of multiple triangles.

Organising the analysis into the triangular structure of locution, sense and referent helps to maintain the distinctions set out in the theoretical framework, and will be particularly useful in the discussion presented in the following chapter. It suffers, however, from being something of a cumbersome format. Table 10, below, presents a compendium of all of the semiotic triangles for each of the actors in a condensed format. In drawing upon these triangles, the contextual support of the analysis of each actor's discourse, presented throughout this chapter, remains of significant importance – the analysis cannot be reduced to the triangle alone.

Actor	**Locution**	**Referent**	**Sense**
Supergen	'biofuels'	Biofuels from all feedstock-process combinations	Positive environmental performance
	'palm oil'	Those biofuels from palm oil feedstocks	Negative environmental performance
	'biofuels'	All transport fuels *except* those derived from specified exceptions	Positive environmental performance
Government	'biofuel'	Bioethanol and biodiesel from various feedstock-process combinations	Varied understanding depends upon specifics of referent

Biofuelwatch	'biofuels'	Includes all transport fuels whether grown for that purpose or not	Socially and environmentally devastating
	'agrofuels'	Only biofuels from feedstocks grown for that purpose	Socially and environmentally devastating
	'non-agrofuel biofuels'	Only biofuels from feedstocks *not* grown for that purpose	Positive but insignificant environmental impact
Oxfam	'biofuels'	All biofuels from all feedstock-process combinations	Drive poverty
Greenpeace *et al.*	'biofuels'	All biofuels from any feedstock-process combinations	Threat of environmental problems with some feedstock-process combinations
	'deforestation diesel'	Biofuels produced on deforested land	Environmentally devastating
	'real green fuels'	Biofuels from feedstock-process combinations that offer genuine emission savings	Supported for environmental benefit
NFU	'biofuels'	All biofuels from any feedstock-process combinations	Social and environmental opportunity
	'UK biofuels'	(Biofuels produced from) UK feedstocks	Positive environmental performance
	'imported feedstock'	(Biofuels produced from) imported feedstocks	Questionable or poor environmental performance
Saab	'biofuels'	Transport fuels from all feedstock-process combinations	Development of traditional technology with technical, environmental and economic benefits
	'second generation biofuels'	Transport fuels produced by second generation processes	Development of first generation technology with further technical, environmental and economic benefits
Greenergy	'biofuels'	Huge variety of feedstocks, processes, individual operations and combinations of these	Widely variable but broadly environmentally desirable

Table 10: Compilation of Triangular Analyses

Concluding Remarks

Now, the discursive orientations are to be understood as the researcher's interpretation of actors' material. Just as the interpretations emerge under the conditions of the material, which afford and restrict my ability to maintain the interpretations presented, the material

also emerged under a set of extra-discursive technical conditions, which afford and restrict the actors' ability to maintain the discourses mobilised in their material. Following the discussion of semiotics presented in Chapter 4, this conditioned interpretation has a crucial role in shaping technology *per se*, discourse about technology and also the analysis of discourse about technology.

A similar understanding of the analyses structured by the semiotic triangle is also adopted, whilst recognising that we cannot have a direct epistemic access to the referent or, indeed, anything, the analysis is seen as having been conditioned by the discourses presented by the material which is, in turn, conditioned by an intransitive technical reality. These moments of 'reading technology' in the emergence of conditioned units of meaning also, we have asserted, involve the writing of technical reality, as the transitive sign unfolds into intransitive technical reality, it has a transformative power, it conditions the technical future. It is this mutual conditioning, as defined in Chapter 4, which forms the backbone of the relationship between biofuel technology and the controversy about it. This relationship is considered in the discussion presented in the following chapter.

Chapter 7: The Mutual Conditioning of Biofuel Technology & Controversy

Whilst the empirical and theoretical work presented in the previous chapters were developed in an iterative process, so far they have been discussed in relative isolation. First, the theoretical framework was presented in detail but with reference only to the pilot vignette which could not provide a complete account of the biofuel controversy nor fully demonstrate its explanatory power and empirical applicability to the case of biofuels. Subsequent chapters presented the main empirical study which, whilst heavily structured by the theoretical framework, remained focussed upon the presentation of material from the controversy on an actor-by-actor basis. More substantive discussion was reserved for the dedicated chapter, which is presented here.

This chapter draws upon the theoretical framework together with the full empirical analysis for a synergetic discussion organised into three sections. The first two consider each of the conditioning directions of the transformative unfolding dialectic of technology and controversy; first how the extra-discursive reality of biofuel technology acts as a condition for the development of the controversy and, second, how the controversy acts as a condition for the development of the technology. The aim of these is to further demonstrate the explanatory power of the theoretical framework for understanding the relationship between technology and controversy and to draw out specific features of the relationship between biofuel technology and the biofuel controversy. In the absence of space constraints the discussion could consider other points that are also illustrative of the conditioning process, but here it is necessary to provide a concise demonstration of each direction. Finally, a third section draws upon some wider scholarship in the philosophy of technology to reflect upon a few points about the transformation of technology and controversy with particular reference the distribution of power and responsibility, and potential avenues for resolution.

7.1 The Technical Conditioning of Discourse

The understanding of technology as a condition for discourse in the biofuel controversy is captured in Figure 45, below. This draws upon one direction of the wider transformative dialectic relationship set out in Chapter 4; that which articulates the conditioning of the controversy, and the discourses therein, by the technical artefact. This is presented to the

left of Figure 45. This direction of conditioning was also considered as a moment of the triangular sign process whereby the referent conditions the senses that are experienced by the sign user, as presented to the right of Figure 45. In each case, the direction of conditioning under consideration is highlighted in red, to emphasise this section's focus upon how technologies provide the conditions under which they are experienced, understood and ultimately represented in discourse.

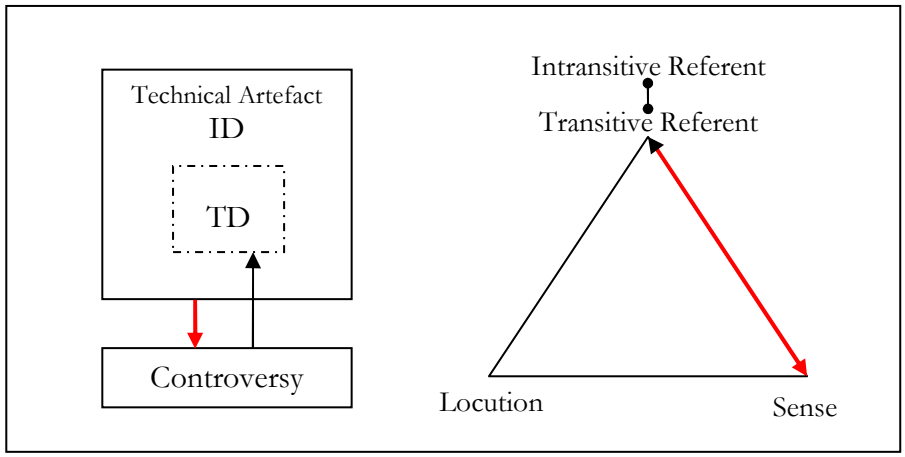

Figure 45: The Technical Conditioning of Discourse

It must be emphasised that this technical conditioning is from the seamless intransitive fabric of the social and material reality of the technology, not just its material intransitivity. Indeed, the collectivisation of various feedstock-process combinations under the banner of biofuel technology is an accomplishment of social activity. As we shall see, it is this intransitive combination of socio-material reality through which the artefact emerges is crucial in the development of the controversy. The remainder of the section is split into three sections, considering in turn how each of the three elements of Fairclough *et al.'s* (2004) semiotic orders, i.e. discourse, genre and style, are conditioned by their technical context. The purpose is to demonstrate the totality of this conditioning, that it is not limited to discourse but also the genre and style in which it is mobilised.

The Conditioning of Biofuels' Performance as Discourse

The biofuel controversy is understood as a particular phase of technical activity in which there is a broad conflict within the corpus of discursive orientations around biofuels, particularly their social and environmental performance. The empirical analysis was

designed to draw out from the material how various discourses in the controversy are orientated around different extra-discursive technical realities, particularly with regards to their social and environmental performance. Following Sims-Schouten *et al.'s* (2007) approach, these orientations are used as a starting point for considering how the extra-discursive reality of biofuels conditions the emergence of the various discourses in the controversy.

Each actor's broad discursive orientation around biofuels' social and environmental performance is collated from Chapter 6 and reorganised into Table 11, below. They are categorised by colour into three groups; blue for NGO, red for industry and green for both government and academic actors. The table demonstrates that NGO discourse tends to be orientated around the negative social and environmental performance of biofuels. Whilst Greenpeace *et al.'s* discourse is orientated around a mixed performance, this is not considered a significant exception as their discourse places a particular emphasis upon the potential threats of negative performing biofuels over the potential benefits of positive performing biofuels. For this reason, Greenpeace *et al.* have been positioned to the right of the central column in Table 11. In contrast, the industrial actors' discourse tends to be orientated around the positive social and environmental performance of biofuels. Greenergy discourse is certainly similar to Greenpeace *et al.* inasmuch as it is orientated around the mixed social and environmental performance of biofuels, but this variety is spread across a positive scale from slightly positive to very positive and for this reason they are grouped in the leftmost column of Table 11. Saab also orientated their discourse around the more or less positive, but not negative, impacts associated with biofuel development. The NFU are a slight exception to the industry group, as they are orientated around both the potentially positive and negative environmental impacts of biofuels. They have been justified towards the left of the middle column of the table to reflect their strong emphasis on the potential positives. The academic actor Supergen, which has strong industry links, adopts a similar discursive position. The government's discourse is also orientated around mixed performance but, unlike Greenergy, this spans both positive and negative impacts leading to its grouping in the central column of Table 11. In contrast with Greenpeace *et al.*, however, it maintains an emphasis upon the potential benefits of positive performing biofuels over and above the potential threats of negative performing biofuels, as reflected in their alignment to the left of the central column of Table 11.

Positive Performance	Mixed performance	Negative Performance
Supergen	Government	Biofuelwatch
Saab	NFU	
Greenergy	Greenpeace *et al.*	Oxfam

Table 11: Discursive Orientations around Biofuels Social and Environmental Impacts

The variety of representations that are present in the debate is testament to the lack of absolute determinism in the conditioning of discourses by the technical artefact. But the different understandings are not unbounded; they do not *merely* reflect processes of social construction because the intransitive technical artefact has a crucial conditioning influence upon the development of discourses. The method devised in Chapter 5 draws upon Sims-Schouten *et al.'s* (2007) approach to retroductively consider how technology may have conditioned discourse based upon the observations of the empirical analysis; it asks questions of the form 'what must the world be like in order for these discourses to emerge?'.

A supportive underpinning for this approach is provided in Rip's (1986) concept of robustness. Revisiting its use in CITA, as discussed in Chapter 3, 'truth' as some kind of discursive correspondence with extra-discursive reality is deemphasised in favour of a concept of robustness, which is understood as the relative durability of a discourse through its interrelated dominance in "arguments, evidence, social alignments, interests, and cultural values" (p353). The lesson, here, is that discursive representations of extra-discursive reality are things of a different ontological category to extra-discursive reality itself. The concept of ontological truth in the controversy is somewhat irrelevant – what matters is the extent to which a discourse provides an adequate or durable interpretation within a given context, and how such a discourse may come to dominate its competitors. The role of the extra-discursive technology enters the picture in providing an important part of this context. Consider a technology with the latent power to explode causing injury. A discursive orientation around the safety of the technical artefact may be maintained until such an explosion occurs, after which its robustness will likely be interrupted. Thus, whilst the role of extra-discursive technical reality as the corroborator of truth is rejected, technology does condition technical discourses by providing the context in which they must be maintained.

'Biofuels' is a locution that has multiple referents which vary significantly in terms of both the feedstocks and the processes from which they are produced. This single locution to multiple referent relationship was previously discussed in Chapter 4's Figure 13, formulated into the diagram that is reproduced in Figure 46, below.

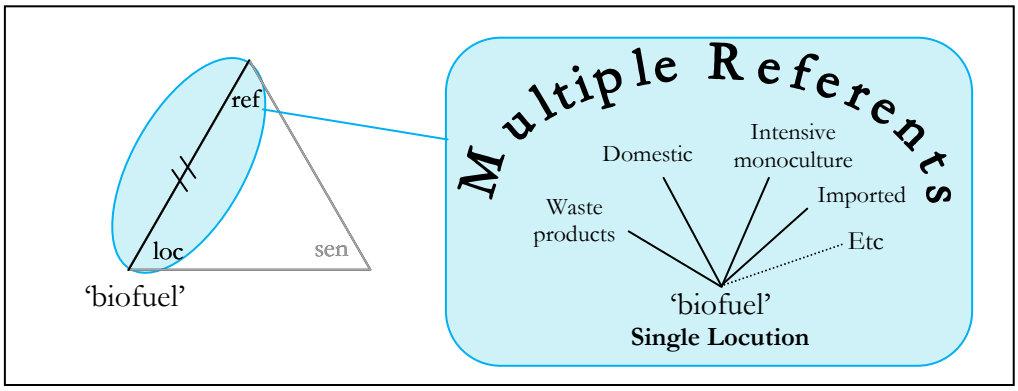

Figure 46: Single Locution & Multiple Discrete Referents

Considered in terms of the technical conditioning of discourse, the biofuels produced from domestic waste products, for example, provide very different conditions for discourse to those provided by biofuels produced from imported feedstocks. Despite the final products being chemically indistinguishable as C_2H_5OH, they support the maintenance of contradictory discourses and there is evidence in the empirical analysis of discourse frequently being provided with qualifiers and exceptions, rather than being applied across all biofuel technologies. For example, whilst the NFU generally applaud biofuels for their environmental benefits, they recognise that some biofuels can be environmentally destructive;

> "There is a danger of biofuel production causing environmental damage elsewhere in the world through the destruction of rain forest and other natural habitat to make way for crops like palm oil and sugar cane. But this is an avoidable danger."
>
> (NFU, 2007a, p9)

Similarly, Biofuelwatch condemn biofuels for the environmental destruction they cause, whilst occasionally recognising that some biofuels can provide some environmental benefits in the form of, albeit limited, GHG emission reductions;

> "We can get a very small amount of energy from waste-vegetable oil, biogas from landfill or manure – and that's something to be supported. But it's not enough to reduce our carbon emissions by much." (Biofuelwatch, 2008c)

In the absence of the internal variety of the technology to which these discourses are orientated, such qualifiers might not be necessary. As it stands, however, the environmental problems posed by palm oil and sugar cane could interrupt NFU's discourse of environmentally beneficial biofuels if they did not provide qualifiers. Similarly, the environmental benefits of using waste products for biofuel production could interrupt Biofuelwatch's discourse of environmentally devastating biofuels if they did not provide caveats to their position. In providing contrary examples to interrupt the maintenance or robustness of unqualified discourses, the internal variety of the referent provides suitable conditions for the emergence of multiple conflicting and qualified discourses.

Expanding the example to the full spectrum of feedstock-process combinations commonly referred to with the locution 'biofuels', their varied social and environmental performance provides the appropriate conditions for the adoption of a variety of different discursive orientations around the social and environmental performance of biofuels. The result of such a variety of discourses is significant conflict amongst senses of the same locution. Table 12, below, illustrates the point by presenting four technical scenarios of feedstock-process combinations that are referred to as 'biofuels'. They are positioned in the grid according to their provision of the appropriate conditions for the emergence of four distinct combinations of positive and negative discursive orientations around biofuels' social and environmental performance.

	Negative environmental performance	**Positive environmental performance**
Negative social performance	Land use change to meet increased agricultural demand involving deforestation and forced eviction.	Genuine GHG savings achieved by substituting fossil fuels for biofuels from edible feedstocks, raising food prices pushing vulnerable groups into poverty.
Positive social performance	Increased agricultural activity boosts rural economies and also fertiliser use, affecting ecosystems and increasing GHG emissions.	Genuine GHG savings achieved by substituting fossil fuels for biofuels from waste products and non-edible domestic feedstocks, also boosting rural economies.

Table 12: The Provision of Appropriate Conditions for the Emergence of Conflicting Discourses

The technical conditioning of discourse in the controversy is not only a question of the presence of technology and the presence of discourse, but also absence; absence in the technical referent and absence in discourses adopted. Tesco can be considered to illustrate this point. Recall that they began blending biofuels into their fuel mix before the legal obligation of the RTFO was introduced, yet they held off from engaging publicly with the development of the technology and controversy. Moreover, an anonymous Tesco employee has explained that the decision not to launch a public campaign was based upon concerns about the uncertainty of how the controversy would develop (Personal Communication, 2009a). This illustrates that the conditions set by the technology may not only favour the presence of certain discourses but also the absence of others. If biofuels were non-controversial or stability was achieved, Tesco's discourse would, most probably, be present[22]. It is more difficult to provide empirical examples of how the absence of technical reality can condition discourse, although the concept can be demonstrated by considering how discourse would be affected if some technical feature that *is* present were, in fact, absent during the development of the biofuel controversy. If, for example, food products such as corn could never be used for producing biofuels, then a number of discourses that are now present could not be maintained. Similarly, the presence of some

[22] Interestingly, we can catch a glimpse of what the presence of Tesco discourse may have been like by inspecting the Greenergy image to the mid-bottom row of Figure 47 in the subsection on fuel pump imagery, below.

currently non-existent technical feature would also have a number of conditioning effects on the discourses that could (and, indeed, could not) be maintained in the controversy. Just as technical presence provides the conditions for discourse, so too does technical absence. Between them, they define the boundaries of the technical conditions under which discourses emerge and are maintained.

This section has shown how technology conditions discourse and, more specifically, how biofuel technology in particular provides the appropriate conditions for the simultaneous maintenance of multiple conflicting discourses about biofuels' performance and, thus, the emergence of a controversy. The following two subsections consider how, furthermore, the technology conditions the two other moments of semiotic orders; genre and style.

The Conditioning of Fuel Pump Imagery as a Genre

This subsection considers how biofuel technology conditions the ways in which a particular visual genre is deployed in the biofuel controversy. Recalling Fairclough *et al.'s* (2002) semiotic orders and its concept of genre, it is defined as a 'way of acting' in a semiotic context, capturing the protocols of how communication takes place. Images of the fuel pump are frequently used by actors involved in the biofuel controversy as a genre for the structure and communication of discourse. Six examples are reproduced in Figure 47, below, having been considered in previous chapters for various reasons, in most cases to support the discussion of the actor's discursive orientations.

Half of the six images in Figure 47 are reproduced from Greenpeace *et al.* material. Their discourse is orientated around the mixed social and environmental performance of biofuels but, as discussed, they tend to emphasise the threat of poor performance over the opportunity of positive performance. This is well reflected in each of their images of the fuel pump. The first, to the top left of Figure 47, features a pump emitting visually pleasant plant-like structures which, on closer inspection[23], are seen to be comprised of primate skulls, cars and burnt trees, implying that the biofuels' benefits may not stand under rigorous inspection. Moving clockwise, the second image features two stills from a video which presents a more directly critical discourse, juxtaposing images of the fuel pump in use against images of orang-utan habitat destruction, presumably suggesting a causal link

[23] A larger copy of the same image is provided in Figure 15 (p96).

between the two. Further clockwise, the third Greenpeace *et al.* image emphasises the potential threats associated with biofuels, as the fuel pump is positioned as though it were a gun to an orang-utan's head. The remaining three images are from other actors. Moving clockwise, Oxfam use the pump to make a simple and direct causal link between biofuels and poverty. The final two images are more positive. To the centre of the bottom row, Greenergy position the fuel pump in a clean, green setting, obscuring the many intermediary steps which are associated with a number of social and environmental consequences. Finally, the NFU image performs a similar obscuration, depicting the fuel product as though it were delivered directly from the corn, all within a clean, almost clinical setting.

Figure 47: Images of the Fuel Pump
Clockwise from top left, Greenpeace et al. image from information pack (2008), Greenpeace et al. video stills (2007b), Greenpeace et al. image from newspaper campaign (2007c), Oxfam image from 'Easy Guide to Biofuels' (2009a), Greenergy press image (2009n) and NFU image from biofuel pamphlet (2007a).

The genre remains the same throughout the suite of images with the fuel pump imagery being used as a vessel or protocol for a discursive orientation around biofuels which is in keeping with wider material from each actor, most of which is deployed in a textual genre. The point here is that the technology provided the conditions under which the genre emerged. For example, the robustness of the discourse deployed through the NFU's use of the fuel pump genre depends upon the use of corn as a feedstock for biofuels and that there is some fuelling process which uses a pump that is familiar to the reader, pre-exists the image and can be visually simplified in the way that the image does. Even the robustness of relatively simple uses of the genre, such as that of Oxfam where a text label is applied to the fuel pump, relies upon a pre-existing intransitive technology whereby vehicles are refuelled in this way. Thus, its is not only the discourses of the controversy that are conditioned by the technology, as shown in the previous section, but also the genre through which the discourses are mobilised.

The Conditioning of Truth & Falsity as a Style

Recalling now Fairclough *et al.'s* (2002) concept of styles as a third moment of a semiotic order, it is defined as 'ways of being' in a semiotic context, capturing the conduct or general approach to an actor's discourse. Here, a 'truth and falsity' style is drawn upon to demonstrate how styles are conditioned by technologies. Truth and falsity, here, do not refer to some degree of absolute ontological accuracy but, rather, to the practice of orientating discourse around the falsity of other actors' discourse and around the truth of their own discourses. Examples of the style are provided before a discussion of how they are conditioned by the technology.

The falsity part of the discursive style is reminiscent of the defensive discourses identified in the empirical analysis and presented in the previous chapter. For example, in Greenergy's defence against claims that biofuel development has negative social and environmental impacts and, similarly, the rejection in Saab's FAQ that biofuel development contributes to deforestation. The truth part of the style refers to explicit orientations around the truth or integrity of an actor's own discourse. Truth and falsity are often found together. For example, in the title of the NFU's pamphlet 'Biofuels: Some Myths and Misconceptions' (NFU, 2007a), which emphasises the falsity side of the style. The immediate discursive

effect is an orientation around the falsity of some other actors' discursive orientations around biofuels. Within the pamphlet's introduction, the truth part is then reinforced;

> "This leaflet attempts to answer the key questions about biofuels with the minimum of spin and the maximum of objectivity ... if the "food vs fuel" debate is to continue, it can at least be based on facts, rather than misinformation and myth." (p3)

In Biofuelwatch material, a falsity style is identified in their orientation around others' material as "sophisticated biofuels greenwash" (Biofuelwatch, 2008d), and a truth style identified in their orientation around their own material as a "reality check" (Biofuelwatch, 2007a). Reinforcing the message, they describe a process of "exposing the lie of 'good biofuels'" (Biofuelwatch, 2009a). Another example of the truth and falsity style is found in Oxfam material which dismisses opposing discourses in a falsity style as a "green con" (Oxfam, 2009a) whilst using a truth style for their own material, which they describe as an "inconvenient truth" (Oxfam, 2008a). The two images presented in Figure 48, below, further highlight the use of this truth and falsity style in combination with images in support of their broader discursive orientations around biofuels' environmental performance.

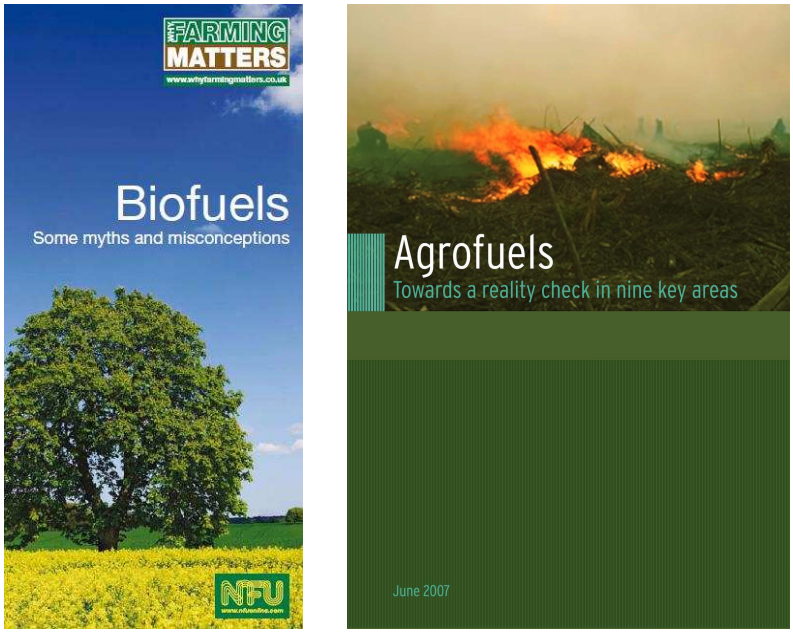

Figure 48: The Truth & Falsity Style with Imagery
Left to Right; NFU (2007a) and Biofuelwatch (2007)

The technical conditioning of the truth and falsity style of delivering discourse is difficult to demonstrate with reference to single instances amongst actors in the empirical material. Treated as a corpus, however, including contrasting uses of the style by different actors, such as that demonstrated in Figure 48, the internal variety of the relative endurance of multiple conflicting discourses, in turn supported by the internal variety of the technical referent can be seen to provide the appropriate conditions for a number of different truth and falsity styles of discourse to emerge.

This section has considered how biofuel technology conditions the controversy by reference to its shaping of entire semiotic orders of biofuel discourse and the genres and styles through which it is deployed. The controversy, understood as a group of conflicting discourses, can also be considered in terms of its conditioning influence upon the technology. This direction in the mutual conditioning of technology and controversy are considered in the following section.

7.2 The Discursive Conditioning of Technology

The understanding of discourse in the biofuel controversy as a condition for technology is captured in Figure 49, below. Moving on from the previous section, it draws upon the other direction of the wider transformative dialectic relationship forwarded in Chapter 4. To the left of Figure 49, the technical artefact is subject to the continual unfolding of transitive technical praxis (usage, discourse etc), thus the seamless fabric of social and material reality is continually woven. To the right of Figure 49, the semiotic triangle presents a conceptualisation of the process of social construction which results in the construction of the transitive referent (the referent as it is presented by the sign). In each case, this section's focus upon how discourses shape the technologies they are orientated around is highlighted in red.

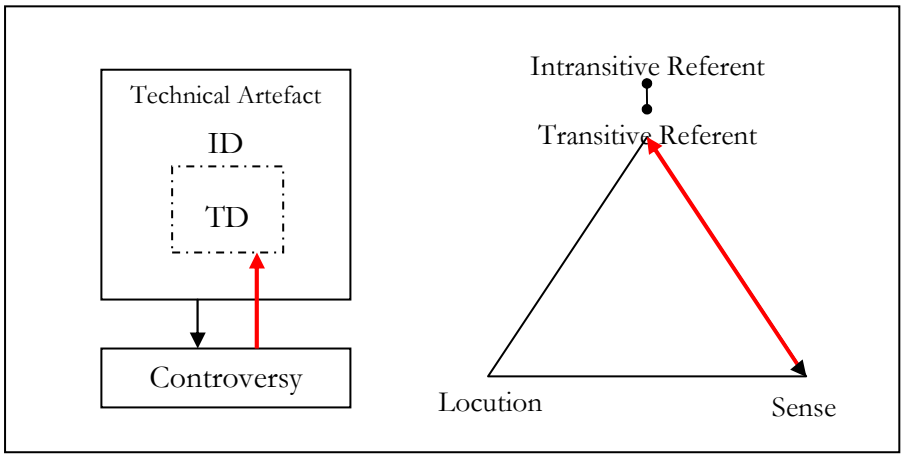

Figure 49: The Discursive Conditioning of Technology

The following subsections illustrate two specific ways in which the discourse of the controversy conditions the development of the technology; first in establishing a controversial status of the technology and, second, in constructing organisations of the internal variety of the technology.

The Discursive Conditioning of Biofuels' Controversial Status

This subsection considers how discursive activity provides the conditions under which biofuel technology is transformed into a controversial technology, first in the construction of biofuels as a controversial technology and second in the continued maintenance of conflicting discourses.

Discourses which maintain the controversial state of the technology are well documented in the empirical analysis of the controversy and the discussion of the truth and falsity discursive style, which illustrated how actors engage directly with the contestation of claims about biofuels' social and environmental performance. An illustrative example is provided in the following NFU excerpt; following the duality of praxis, they are making a point about how biofuel discourse has changed in recent years (production itself) but, in doing so, they also recreate the controversial status of the technology (the re-production of the preconditions of their discourse);

> "until recently [biofuel] was seen as non-controversial ... before long, the technology stood accused of laying waste to vast areas of rainforest, as trees were felled to make way for palm oil plantations in countries like Brazil and Malaysia, and of threatening

> to create a monocultural desert, devoid of biodiversity, across the British countryside." (2007a, p2-3)

Given the level of consistency in this orientation across the material, it is as though the technology's controversy is the only point on which the actors in the study agree. A technology's controversial status is also maintained indirectly, by the relatively enduring maintenance of conflicting discourses. This has been documented extensively in the empirical analysis of the controversy and the variety of orientations around biofuels' social and environmental performance that are maintained within it. Conflicting discursive orientations around a technology form the appropriate conditions under which the technology may become controversial. Furthermore, conflict about specific features of a technology shape the specific content and boundaries of the technology's controversy.

This discursive activity is conditioned by the technology itself. Recall that, in the previous section's discussion, the internal variety of the technology was seen to create the appropriate conditions under which a number of discursive positions could be simultaneously maintained. Now, the maintenance of this combination of discourses, coupled with direct engagement with the controversial state of the technology, constitutes the construction and definition of biofuels' controversy. This development is captured in Figure 50, below; at t_{x-1} the internally varied technology provides the appropriate conditions for multiple conflicting discourses to emerge at t_x. These provide the appropriate conditions for the technology to emerge as a controversy at t_{x+1}. Whilst emphasising this process of structure providing conditions for agency providing conditions for structure in Figure 50, the constant development of each in parallel is not completely obscured, but backgrounded in grey. The purpose is to avoid the impression of some turn taking development. Rather, the process of mutual conditioning is conceptualised as ongoing dialectical tension with the technical structure and technical activity in continual flux.

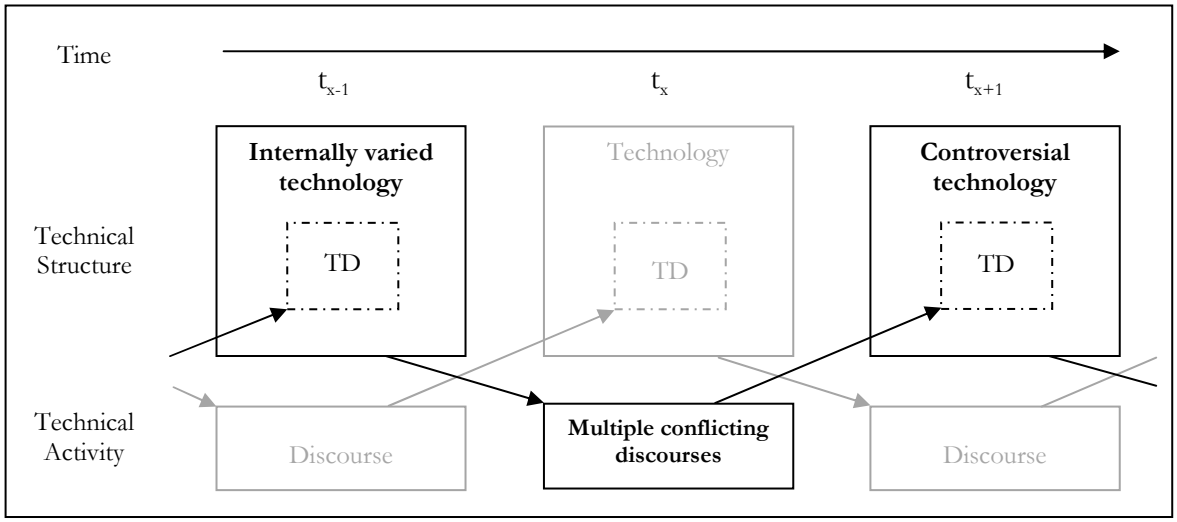

Figure 50: The Mutual Conditioning of Technology & Discourse

This is illustrative of a more crucial point about the model; that in technical activity such as the controversy, the actors have some, albeit limited and conditioned, agency within which they may transform features of the technical structure and thus the conditions of future technical activities. The transformed conditions for future activity are likely to affect different actors in different ways, adjust power balances and degrees of interpretive flexibility. The following section presents a more specific and empirically grounded demonstration of the discursive conditioning of biofuel technology, as it considers how actors' agency to transform and construct biofuel's internal variety is afforded and restricted by the technology itself but also the transformative effect that these orientations may have upon future technical activities, inclusive of future discourses.

The Discursive Conditioning of the Organisation of Biofuels' Internal Variety

This subsection draws upon the analyses structured by the semiotic triangle to introduce a new concept; the 'semiotic cut'. Somehow straddling the definitions of discursive genres and styles, it is understood as a function or method in the deployment of discourse that is deployed by actors to organise the broad and internally varied referent into more specific subsets, occasionally introducing other, more specific locutions. It offers actors the opportunity to direct their discourse to subsets of the unwieldily broad category referred to by the single locution 'biofuels', whilst also being constitutive of the negotiation of how biofuels' internal variety is organised. Therefore, the outcome of this negotiation has a

transformative effect and the semiotic cut can be understood as a pre-conditioned moment of the discursive conditioning of technology.

In the first example of a semiotic cut, Supergen discourse is orientated around biofuels' environmental benefits but, occasionally, it is also orientated around the potential environmental threats of certain feedstock-process combinations. It was observed in the empirical analysis that, when these exceptions are introduced, a more specific locution such as 'palm oil' is used in place of 'biofuels'. This has the effect of organising the internal variety of the referent by introducing alternative locutions in parallel to 'biofuels' to refer to a specific subset of the technology. By deploying this cut as a qualifier, Supergen improve the robustness of their wider discourse by isolating a specific subset of the wider category and orientating negative performance discourses around it. Thus they do not reject the potential problems with biofuel development that could otherwise interrupt the maintenance of their broadly positive discourse. This semiotic cut is demonstrated in Figure 51, below, drawn from the empirical analysis of Chapter 6. The triangle to the left presents the general discourse for the wider category biofuels, whilst the triangle to the right presents the exception to the category and the alternative locution. Should each triangle feature the locution biofuels, there would be a locution-sense dissonance within the Supergen discourse which may have detracted from its effectiveness.

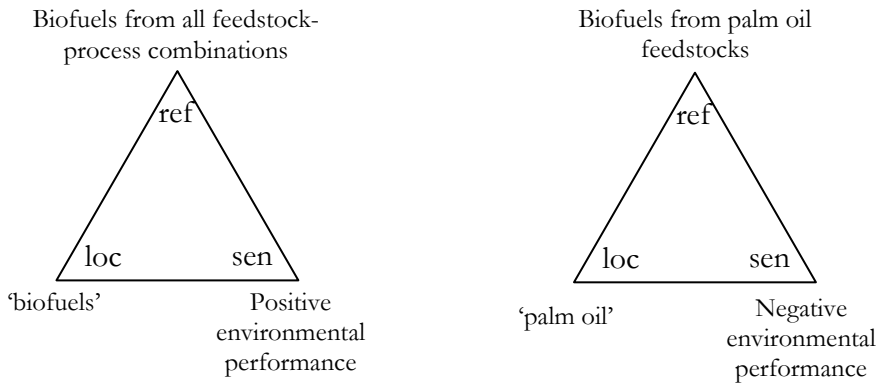

Figure 51: Semiotic Cut in Supergen Discourse

Similarly, Biofuelwatch deploy a semiotic cut to qualify a broader position although, interestingly, they introduce a new locution, 'agrofuels' which includes the majority of all biofuels, defined as biofuels that are "made from crops and trees grown specifically for that purpose" (Biofuelwatch, 2008a). Non-agrofuel biofuels from waste products are defined as 'sustainable biofuels', although they say that only "a very small amount of energy" can be gained from these and "not enough to reduce our carbon emissions by much" (Biofuelwatch, 2008c). The semiotic triangles for the locutions 'biofuels' and the subsets of 'agrofuels' and 'sustainable biofuels' are presented in triangular form in Figure 52, below. In the first triangle, to the top of Figure 52, we see that the sense of the broad array of technical artefacts referred to as biofuels is orientated around their devastating social and environmental performance. In the two triangles to the bottom of Figure 52, we see that biofuels are split into two mutually exclusive categories. To the left, the locution 'agrofuels' refers to the great majority of biofuels and maintains the socially and environmentally devastating sense whilst, to the right, the locution 'sustainable biofuels' refers to a minority subset of biofuels and concedes their limited environmental benefits. It is noted that the concept of sustainable biofuels is frequently referred to as a myth, as discussed in the 'truth and lies' section and in dedicated sections of their material such as "exposing the lie of 'good biofuels'" (Biofuelwatch, 2008d). In this case, by allowing the possibility of environmentally beneficial biofuels, Biofuelwatch's semiotic cut provides a qualifier which strengthens their broader discursive orientation around the technology.

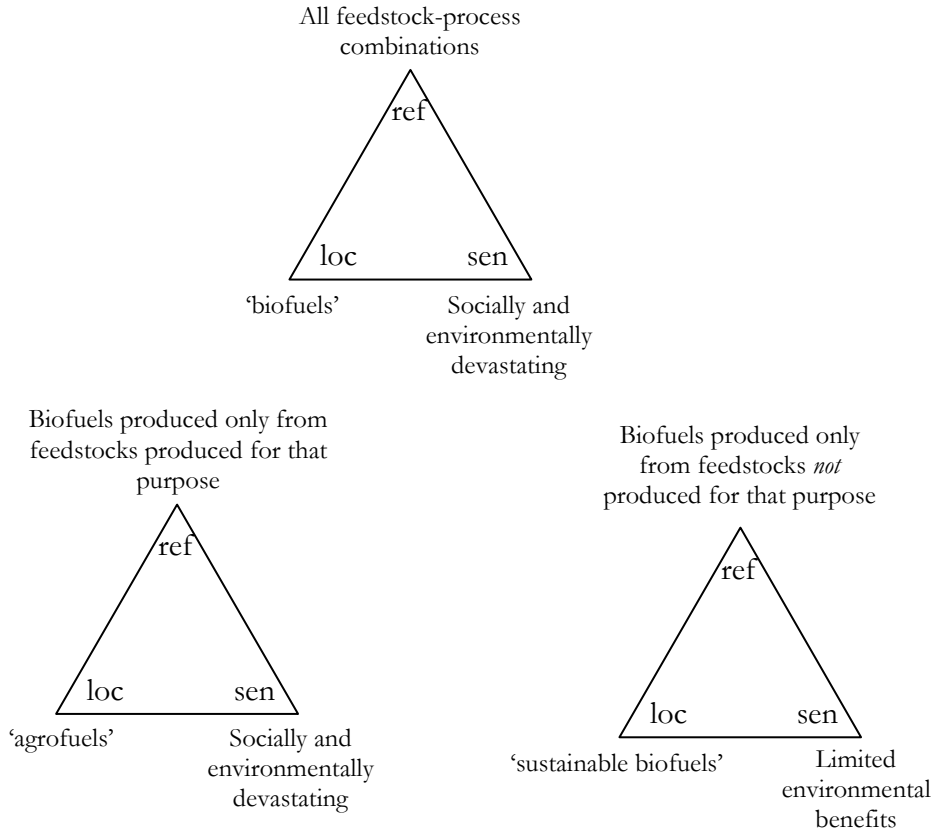

Figure 52: Semiotic Cut in Biofuelwatch Discourse

Instead of providing qualifiers to a generalised understanding of biofuels, the third example of the semiotic cut demonstrates their deployment as an exceptionally enhanced subset of the technology that does not run counter to but, rather, supports the generalised sense. As illustrated by the triangles in Figure 53 below, Saab's discourse is orientated around biofuels as one of many developments of a traditional technology, which has some environmental benefits. They make a semiotic cut through the referent to isolate second generation biofuels as a subset of these which are a further development of the first generation, offering even further environmental benefits. Such a semiotic cut does not protect Saab's discourse from conflicting discourses or the kind of extra-discursive interruptions discussed in the previous section. Nonetheless, in positioning the exceptions as a stronger example than the rule, the approach does bolster their broad discursive orientation.

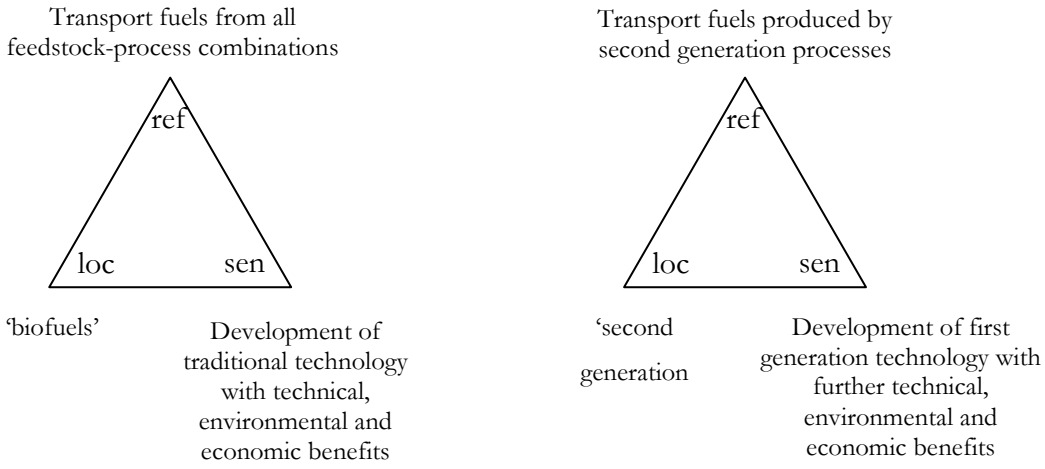

Figure 53: Semiotic Cut in Saab Discourse

In each of these cases, the semiotic cut has been used in support of the broader discursive position, although it is noted that not all actors deploy semiotic cuts in their discourse. For example, in Table 11 above, it was noted that Greenpeace *et al.* and government discourse is orientated around biofuels' mixed social and environmental performance. In each case, their discourse is already orientated around the many feedstock-process alternatives that can be used to produce biofuels having different social and environmental effects. This complexity that they recognise makes it difficult for them to construct specific subcategories to which their orientations would remain internally consistent. Greenergy discourse is similarly positioned and also does not deploy semiotic cuts, as illustrated by the three actors' generalised signs for biofuels that are reproduced in Figure 54, below.

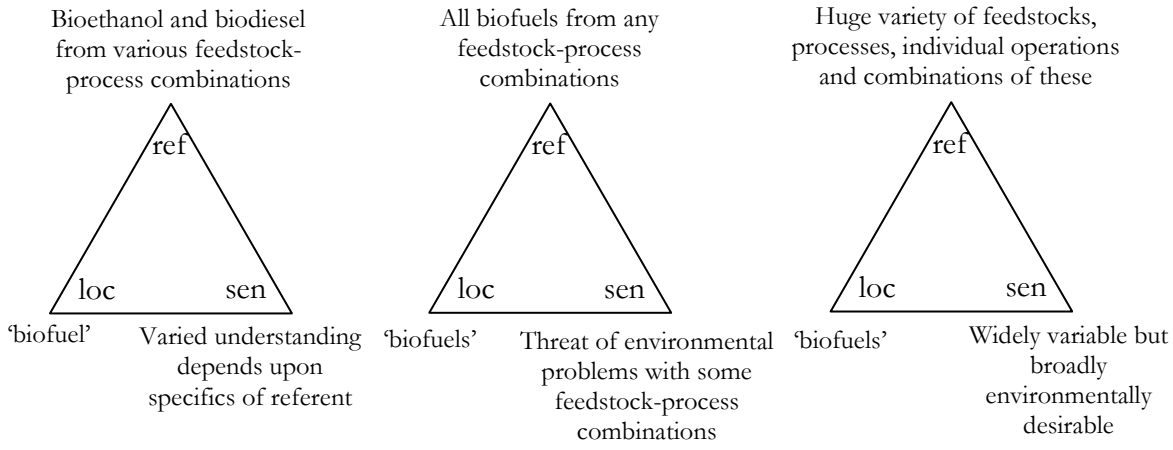

Figure 54: Actors' Discourses without Semiotic Cuts
(Left to Right) Government, Greenpeace et al. & Greenergy Discourse

Semiotic cuts such as those discussed can be seen as a response to the insufficiency of the single locution 'biofuels' in reference to the multitude of referents. As discussed in the previous section, this insufficiency is a condition under which discursive activity must take place. Here, we are concerned with the transformative power of this conditioned discourse and the crucial point is that they are constitutive of the social construction of biofuels. To demonstrate this, the remainder of the subsection shows how managing what is and is not referred to by the locution 'biofuels' has a significant impact upon what biofuel technology *is*.

Recalling the summary of policy developments around biofuel technology presented in Chapter 1, how the great variety of different types of biofuels are organised through ongoing social negotiation has a significant effect upon their development. Take the example of a certification scheme which defines those biofuels that are eligible for subsidy and those that are not, those that contribute to RTFO quotas and those that do not. Such a certification scheme must entail a certain approach to the organisation of the internal variety of biofuel technology, and it might be expected that the approach will draw upon a robust construction of this organisation and indeed, in it affording this discursive legitimacy, will further establish its robustness. Now, returning to our example, as yet the way of organising the internal variety of biofuels appears to be a relatively flexible point of interpretation, as illustrated by the variety of discourses that are present in the debate. For

example, Supergen's discursive success may lead to a broad support for biofuel development with some restrictions upon specific feedstock-process combinations. For Biofuelwatch it may lead to a future where biofuel production is restricted to the use of waste products. For the NFU, the organisation would increase support for domestic feedstocks and regulation of imported ones. The government is yet to indicate how the organisation will proceed. This is reflected both in their discourse and in their policy, which draws upon a variety of different certification schemes and asks industry to report upon which standards they meet without requiring that they meet any of them on more than a voluntary basis. The success and relatively enduring dominance of different actors' discourses present alternative futures for the organisation of biofuels' internal variety and, further, for the technology's development.

The consequence of this discursive conditioning is the transformation of technology and, thus, the transformation of the conditions of future technical activity. Continuing with the example of certification schemes, they are conditioned by discursive activity but, once they are in operation, they provide the conditions for all kinds of technical activity, including fuel production, supply and use and also, of particular interest here, discursive activity and the future of the controversy. Under a future scenario of discursive success for Biofuelwatch, a redistribution of discursive agency may lead to response from actors such as the NFU and Greenergy who support some visions of biofuel development as their robustness would be interrupted.

A stable organisation of biofuels' internal variety may even provide the conditions for the partial resolution of the controversy. This would be a further example of the technical conditioning of discourse, and is a possibility that is revisited in the following section's discussion. Thus far, the discussion has considered how technology provides the conditions for the emergence of discourse which, in turn, provides the conditions for the transformation of technology. Revisiting the model forwarded in Figure 50, above, and developing it towards the conceptualisation presented in Figure 55, below, the three semiotic cuts at t_x are competing discourses all supported by the internally varied technical referent at t_{x-1}, included in Figure 50 but off to the left of Figure 55. Each offer alternative constructions of the technology at t_{x+1}. This vying for discursive dominance is being played out at the moment, but discourse that succeeds, for example by transforming some future

mandatory certification scheme, will certainly shape future technical activity, including future discursive activity.

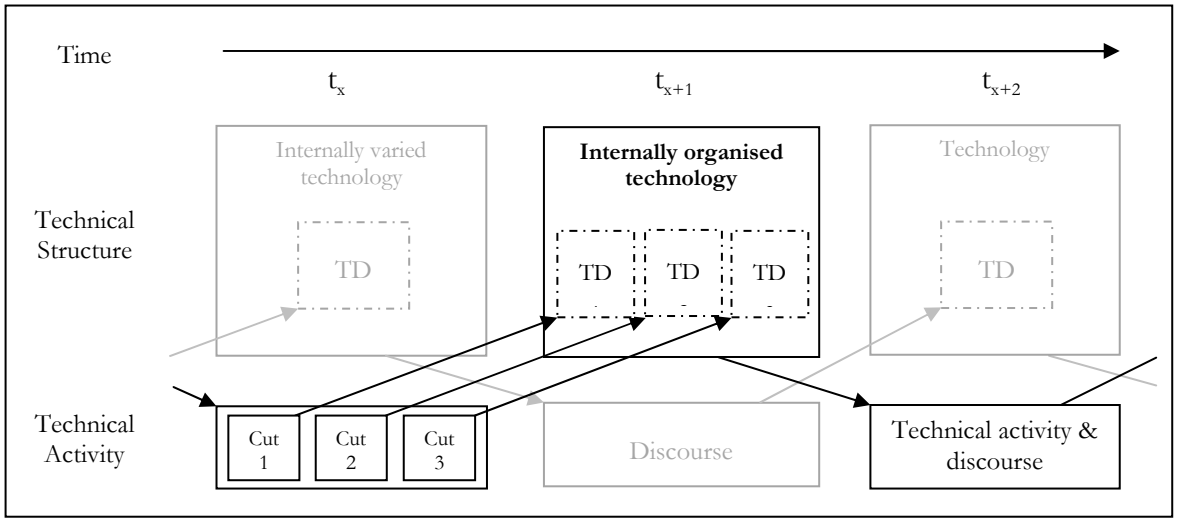

Figure 55: Full Circle in the Mutual Conditioning of Technology & Discourse

To summarise, the first two sections of this chapter have drawn upon the empirical analysis to demonstrate the working of the theoretical framework and its prescription for the relationship between biofuel technology and controversy. Building upon the comparatively isolated theoretical and empirical chapters presented previously, it describes how technology conditions the full semiotic orders of discourse, genre and style in the biofuel controversy. The discursive conditioning of technology was then described with the introduction of the concept of semiotic cuts as the negotiation of the organisation of biofuels' internal variety. In examining the working of the theoretical framework across a chronological dimension, as illustrated in Figure 55, above, the open character of future transformations of both biofuel technology and the controversy is highlighted. The potential of this transformative openness is the central theme of the following section, which considers power, responsibility and the potential resolution of the controversy.

7.3 Transforming Technology, Transforming Controversy

The theoretical framework considers biofuel technology and controversy in terms of continual dialectical transformation over time. All technical activity, including the discursive activity of the controversy, comes to be understood as actors using their

conditioned agency to transform the technical structure. As this transformation takes place, the conditions upon each actor's future discursive agency is also transformed. Just as this may present barriers to the ongoing maintenance of some actors' current discursive activities, it may also open the potential for new actors and new discourses. This final section of the substantive analysis reflects upon three topics in light of this understanding of transformation; technical bias and hegemony, responsibility for technical development and the potential resolution of the controversy.

Power in the Technology-Controversy Relationship

Power has a presence in each moment of the mutual conditioning forwarded in Chapter 4. Actors' discursive agency to transform the technology is distributed unevenly amongst the actors, so they have different degrees of transformative agency. This understanding of power could be considered in terms of Bhaskar's (1993) $power_1$ and $power_2$ although, whilst considered with reference to this concept, a more fruitful alignment is identified in Feenberg's (2002) concepts of technical bias and manoeuvrability.

Derived from his Marxian critique of technology in society, the bias of technology refers to how a technology reflects the hegemony under which it is produced and serves this hegemony's interests. On these grounds, Feenberg offered a critique of the direct adoption of the capitalist mode of production by socialist movements, particularly in those of the Soviet bloc. He argues that doing so ignores Marx's critique of the alienation of the workers and withdrawal of their agency via their craft. As the technology was not transformed in its new social context, it continued to oppress the worker and would continue to reflect the previous hegemony's interests until it is actively transformed to reflect the workers' values. Thus, suggests Feenberg, the new social order must develop or transform technology unto its own image in order to overturn the bias to the previous hegemony. Only this, he argues, can lead to the liberation of the workers and the flourishing of their craft. His margins of manoeuvre refer to the power of any actor to transform technology, even where this power is highly constrained. The transformation of a technology is, necessarily, the transformation of all actors' future margins of manoeuvre. This brings an optimistic $power_1$ flavour to Feenberg's understanding of power, emphasising the future prospects for technology and its potential for social good.

At first glance, transposing this technical bias to the framework forwarded here presents a few challenges. If this class-based understanding of technical bias to the hegemony applies, the diagnosis appears fairly static, reducing the negotiation of the technology to an ongoing process of bourgeois domination. If technical development serves the interest of the hegemony under which it is produced, how does the emergence of the controversy serve these interests? If it does not, then why did it emerge? There are a few possible responses to these questions. Two considered here challenge the definition of hegemony and the scale over which transformation occurs. It may be that, regardless of the specific outcome of the controversy, the technology will always eventually come to serve the interests of the hegemony in one way or another given a long enough time scale. Thus, the controversy is a relatively insignificant moment of longer term development of a technology that will ultimately reflect the interests of the elite class. Various alternative futures are possible but only those that serve the interests of this hegemony will succeed. Alternatively, as a second response, it may be that the hegemony itself is not always the elite class but, rather, is a *technical hegemony* that is defined through the negotiation process – the technology reflects the group which succeed in defining it and, thus, that actors that form the technical hegemony are not automatically the pre-existing hegemonic class, but they emerge *ex post*. This hegemony may be unexpected – not limited to the elite class nor, necessarily, reflecting its interests – although the discourse of the elite class and those whose interests are aligned with it may be more likely to succeed as they are afforded a greater degree of discursive power.

This second reading of Feenberg is fair and fits in with the theoretical framework much more comfortably, emphasising his concept of manoeuvrability as the, albeit limited, opportunity for any actor, whether part of the elite class or not, to appropriate control of technical development. A further welcome implication is that power and technical bias are not drawn exclusively across class boundaries, around tension between the bourgeoisie and proletariat, but are open to gender biases, environmental biases, commercial biases or, indeed, any kind of technical bias. Indeed, Feenberg's vision for technology draws heavily upon the potential manoeuvrability of actors outside the elite class at any stage of technical development, however small their 'margin of manoeuvre';

> "Struggles over control of technical activities can now be reconceptualized as tactical responses in the margin of manoeuvre of the dominated." (2002, p87)

Following critical realism's TMSA and the maintenance of this dialectic in the TMTA and the unfolding account forwarded here, some form of hegemony is an inevitability of social reality that should not always be considered as an unwelcome form of domination. Joseph (2000) has identified a parallel in the critical realist understanding of power with that of hegemony; hegemony$_1$ as the causal power of dominant structures generally, and hegemony$_2$ as the negative forms of control and domination which, particularly in Marxian analyses such as Feenberg's, is perhaps most often associated with the term.

Feenberg's concepts of technical bias and margins of manoeuvrability – technology reflecting the groups that shape it and technical activities as the transformation of conditions for future technical activity – fit the forwarded understanding of the unfolding of technical reality as a transformative process remarkably well. Yet there is an important ontological point of difference in his understanding of the *ambivalence of technology*. With this concept, Feenberg emphasises the openness of technical futures; that a technology can serve the interests of any group, creating an opportunity for liberation as much as it does for hegemonic domination. Indeed;

> "any given technical order is a potential starting point for divergent developments depending on the cultural environment that shapes it" (2002, p131)

In the present model, however, there are explicit and absolute limits to the reaches of socially constructive processes. A given technical artefact may have some material quality that restricts or, equally, supports its capacity to be transformed to reflect the interests of a particular group. These limits evoke the story of King Canute, who demonstrated the limits to his regal power in his futile demand for the ocean to cease its tide – the key point here is that some technical artefacts may reflect specific actor's interests more readily than others. Whilst it may not be possible to identify these material and otherwise intransitive limits empirically, the ambivalence of a technology and the possibilities for its transformation are not unbounded.

As the controversy unfolds, a relatively enduring period of stability may be achieved. At this point, the technology will reflect the interests of those actors whose discursive success shaped the technology into what it is. Nonetheless, margins of manoeuvre would remain and continue to be adjusted by various developments within and without the discourse-technology relationship. Any relatively enduring period of stability in the technical structure

can be interrupted, and power can be rapidly redistributed by specific events and manoeuvres.

The mobilisation of Feenberg's conceptualisation of power within the understanding of technology and controversy adopted here can be drawn upon to consider how discourse in the controversy can transform biofuel technology, intentionally or otherwise, to reflect their interests. Returning to the empirical material – both the NFU and Biofuelwatch adopted a style of purporting to present discourse from a perspective that represents the global South. Somewhat unsurprisingly, these 'Southern perspectives' conflict with each other and match those of the actor forwarding them. The NFU provide a quote from the Southern African Confederation of Agriculture Unions which says that biofuel technology is "a huge opportunity for our farmers to augment their incomes" (NFU, 2007a), whilst Biofuelwatch dedicate a section of one of their leaflets to 'voices from the global South' which are critical of biofuels as "a push by industry to make another scramble for Africa... an effort at extending frontiers of neo-colonialism" (Biofuelwatch, 2008c). The style may be seen as an attempt to legitimate or otherwise validate the actor's discourse by showing that it is supported by those in the global South. Returning to Feenberg, however, the voices from the global South do not enjoy an empowered position in the transformation of biofuel technology in the UK, the power remains in the hands of Biofuelwatch, the NFU or whichever actor it is that selectively mobilises the discourse – the actor mobilising their margin of manoeuvre in undertaking the technical activity. Until Southern actors enlarge their margins of manoeuvre to a point where they can engage with the development of biofuel technology directly, it technology will never be transformed to genuinely reflect their interests (unless these interests so happen to coincide with those of the hegemony). This may, for example, be the case for the NFU's discursive allies in Africa, but not for Biofuelwatch's.

To summarise the understanding of power in the relationship between technology and controversy, drawing upon Feenberg's technical bias and manoeuvrability, technical development is understood as actors drawing upon their limited power to transform the distribution of power and, in doing so, transforming the future conditions of their own activity. As all actors operate under slightly different conditions and with different aims, the margins of manoeuvre are never equal and there is a necessary power imbalance amongst

actors engaged in technical activity. There are also intransitive and absolute limits to these margins of manoeuvre.

The Transformation of Technology & the Distribution of Responsibility

Questions of power are often followed by questions of responsibility. Landerweerd *et al.'s* (2009) discussion of the utility of different philosophical traditions in explaining the development of biofuel technology also considered how these different traditions offer accounts of how responsibility in the biofuel controversy may be distributed. They suggest that technical determinism, and positivism more generally, positions scientists and engineers at the centre of questions of responsibility for biofuel technology as they are conceptualised, more or less, as 'midwives' to the technology. Social determinism and constructionist positions, they continue, position society at the centre of questions about responsibility as it is considered the active agent of technical change. Their analysis of these unidirectional approaches to the technology-controversy relationship (as illustrated in Figure 1, above) exposes how responsibility for outcomes follows power in the shaping of developments. Interestingly, both points are well illustrated by revisiting the New Scientist quote;

> "As a matter of urgency, the Intergovernmental Panel on Climate Change needs to determine whether biofuels are good or bad" (New Scientist, 2007)

A technical determinist reading would position the scientists at the IPCC as the passive measurers of the impacts of biofuels but, as the adage 'knowledge is power' takes on a Foucauldian twist, a social determinist reading would position the IPCC as a social group with high discursive power whose construction of biofuels is likely to dominate others and shape what the technology *is*.

I would suggest that there are some difficulties with Landeweerd *et al's* assignments. Since technical determinism positions the broad technology itself as the agent of its development, the scientists and engineers do not have much intentional control over biofuel development, which seems to be important in the assignment of responsibility. Since social determinism emphasises the inequity amongst actors in their power to shape developments, responsibility cannot lie with society as a whole but must be with the specific social group that defines the technical artefact. This could be the scientist and engineers or, perhaps, venture capitalists, unions, industry groups – whichever actors emerge as the technical hegemony.

Further discussion of the distribution of responsibility under social or technical determinisms is somewhat futile, since a dialectical approach is adopted. Mitcham (2003) has provided some guidance on the distribution of responsibility within dialectical models, suggesting that it can be traced through the agency of individuals or social groups. Following the understanding of power discussed in the previous subsection, actors have varying degrees of transformative agency over a technology which can be understood as manoeuvres within margins to manipulate the future distribution of their own transformative agency. Through this understanding of power, actors are not only responsible for the direct outcomes of their activity, but also for the ways in which these activities affect the future distribution of power. Returning to the running example, the IPCC scientists are responsible for the deployment of their discursive power to shape biofuel technology but they would, alongside other actors, also be responsible for their maintenance of a wider social structure which affords the IPCC its discursive power.

Whilst the focus here has remained upon the technology-controversy relationship, and so the technical conditioning of the controversy, the conditioning of technical activity is deeply structured. Part of the conditioning influence is social, such as the norms and politics of technology and society in general, the economic system and even the language system. The weight of this conditioning influence makes it difficult to assign responsibility to actors for their reproduction of power structures that pre-exist them. Another part of the conditioning influence is material. The biology and chemistry of the technical artefact and the wider world it inhabits exists beyond the reach of discursive activity and also affects the maintenance of actors' discursive positions.

Responsibility for outcomes must also, to some extent, be balanced against degrees of intentionality, so actors are not always held as responsible for the unintended consequences of the deployment of their agency. As Waelbers (2009) points out, the increasing complexity of technical systems dissociates agents from their actions and the consequences of these actions. This dissociation is often considered in various contemporary understandings of technology, such as Rip's (2008) reflection upon the distance between the 'impactors' and 'impactees' of technical activity. Certainly, it forms part of Feenberg's understanding of power in the transformation of technology as he considers the "unintended cultural consequences of technology" (2002, p7), describing how this

dissociation is exaggerated in a technology laden society. The interests of the hegemonic agent take on an intransitivity in the technical artefact from which their power can be exerted, remotely in time and space from the agent, upon those that are impacted by the technology. Thus, the hegemony achieves a God-like external omnipotence whilst also dissociating themselves from responsibility for the outcomes (see p181).

Now, returning to the understanding forwarded in Chapter 4, this dissociation between technical activity and the production of the conditions for future activities can be considered in terms of the duality of praxis. This duality is rooted in Bhaskar's TMSA, and demands that technical activity is not only understood as production itself, i.e. the intentional deployment of agency but also, and not usually intentionally, the reproduction and transformation of the conditions for future activity. This brings the dissociation of actions and consequences to the centre of the dialectic of technical structure and agency, presenting serious difficulties in following Micham's advice to 'follow the agent'. First, all actors past and present would be held responsible for all subsequent outcomes, as all necessarily participate in the production and transformation of society. Second, if intentionality matters for the distribution of responsibility then, since the reproduction and transformation of the ways in which power is distributed is not usually the intended outcome of a technical activity, actors may not usually be held responsible for the ways in which the technology, which they reproduce and transform, distributes agency.

The distribution of responsibility across dialectical relationships is found to be problematic at best, with significant questions surrounding the dissociation of activity and outcome and the intentionality of (re)producing the conditions for future activity. Short of all individuals being held as responsible for all outcomes, including those resulting from conditioning influences that pre-exist their birth, Micham's approach of tracing responsibility through the agent is somewhat fruitless.

The Transformation of Technology & the Resolution of the Controversy

In this final subsection, the possibility of resolution of the controversy is reflected upon. Previous discussion has considered how the broad variety of different referents for the single locution 'biofuels' provides the appropriate conditions for the emergence of multiple simultaneous conflicting discourses. Thus the technology, and specifically the insufficiency

of its associated locutions, provides appropriate conditions for engagement with the biofuels as a controversial technical artefact. This would suggest that diversification of the locution would reduce discursive conflict as the technology, thus transformed, would no longer provide the same conditions for the maintenance of conflicting discourses. Elsewhere, the concept of the semiotic cut was introduced to consider some actors' attempts to organise the internal variety of the technology, often introducing new locutions such as Biofuelwatch's 'agrofuels'. Here, the limited capacity for this discursive activity to transform the technology towards the resolution of the controversy is examined.

Considering semiotic cuts in terms of the three forms of dissonance introduced in Chapter 4, it can reduce locution-referent dissonance, where there is a single locution which refers to multiple different referents. Where the same semiotic cut also corresponds to some boundary within the variety of senses associated with the same locution, this also serves to reduce locution-sense dissonance, where there is a single locution and a multitude of senses. If all locution-referent dissonance were resolved in this way, by the addition of new locutions deployed as semiotic cuts which correspond with each instance of locution-sense dissonance, then the extent to which the internal variety of the technology provides the appropriate conditions for the maintenance of multiple conflicting discourses would be reduced and some resolution of the controversy could be expected.

For example, a substantial amount of Biofuelwatch discourse is orientated around biofuels driving rainforest destruction and leading to forced evictions of indigenous people, yet a substantial amount of NFU discourse is orientated around the advantages of producing biofuels domestically, within the existing environmental regulations, to revive the rural economy. Clearly, the specific referents for each discourse are discrete feedstock-process combinations; for the NFU, the locution 'biofuels' here refers to domestically produced grasses and, for Biofuelwatch, the same locution is referring to imported tropical produce. There are multiple referents for the single locution. Were there to be distinct locutions to match these referents, not only would the locution-referent dissonance be removed, but the locution-sense dissonance would also be removed. The two signs would be exposed as referring to different things. This is illustrated by the semiotic triangles presented in Figure 56, below. The top row of triangles in Figure 56 shows the current state of conflicting discourses with locution-referent and locution-sense dissonance, whilst the bottom row

shows the same discourse with a diversified set of locutions[24] to match the internal variety of the referent. In this bottom row, the locution, referent and sense are all different so, in this particular example, it does not provide the appropriate conditions for the emergence of a controversy.

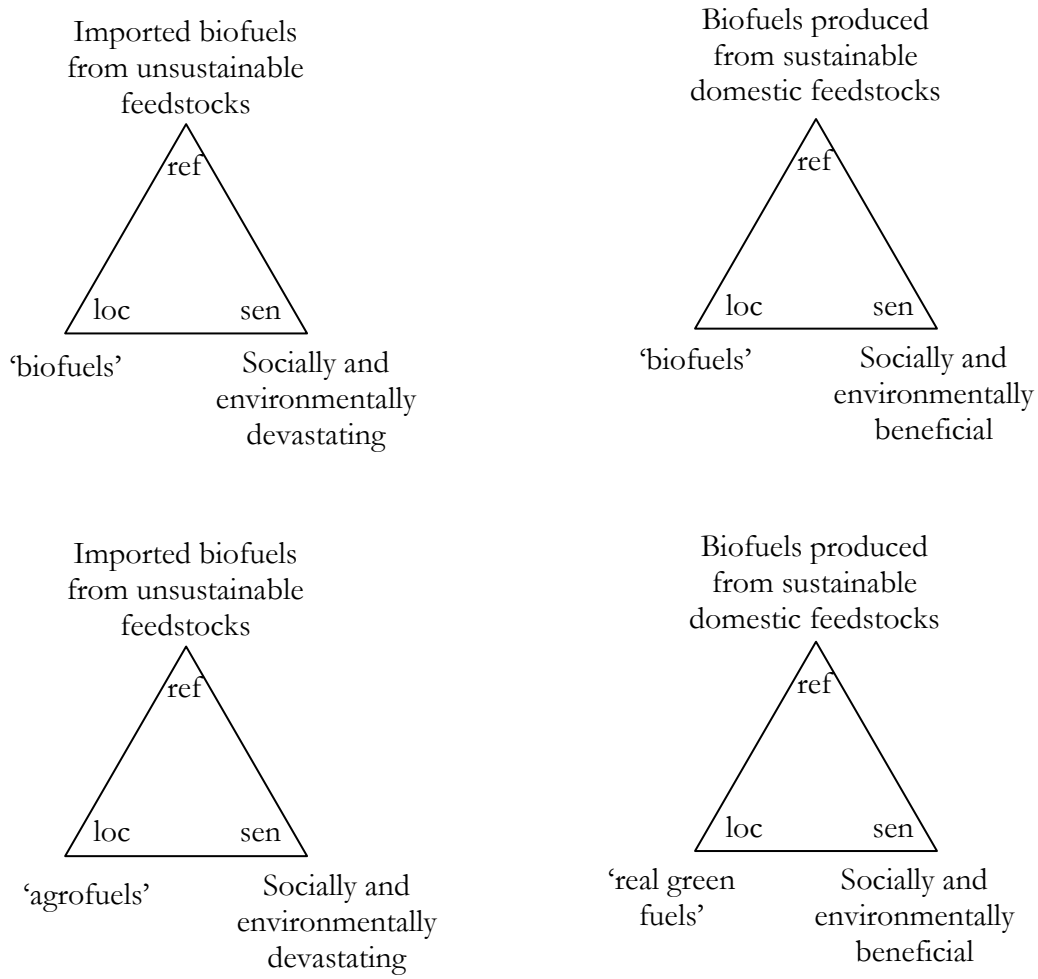

Figure 56: Imagining Locutionary Variety & its Easing Effect on the Controversy

[24] The selected locutions for these imagined triangles are borrowed from other corners of the controversy, Greenpeace *et al.'s* locution 'real green fuels' is used to refer to those fuels that offer genuine sustainability advantages over fossil fuels, particularly emphasising the use of waste products but also including sustainably produced feedstocks. Biofuelwatch's locution 'agrofuels' is used to deliberately counteract the impression of environmental harmony denoted by the lexeme 'bio' (Personal Communication, 2009b).

This difference between the NFU and Biofuelwtach discourse was strongly evident at a live debate between an activist representative of Biofuelwatch and a unionised farmer representing the NFU (Biofuelwatch and NFU, 2007). The Biofuelwatch perspective of biofuels' potential effect on the rainforest and indigenous people was quite successful in this arena, dominating the local farmer's perspective which described the potential to produce feedstocks locally and benefit the rural economy. The NFU representative was accused of promoting the problems described by the Biofuelwatch representative, with one audience member asking 'how he could sleep at night', despite the farmer's repeated criticisms of the use of imported feedstocks, in line with wider NFU rhetoric. The only source of dissonance here was that a single locution was used to refer to the two discrete referents – each actor maintained broadly compatible senses with regards each referent. The adoption of discrete locutions for these referents would, in this case, have avoided contestation in the debate.

As discussed, some actors have made some attempt to introduce new locutions, but none are found to be demonstrably successful as yet. The extent to which locutionary variety can be introduced, however, will depend upon the actors seeking to establish a broader vocabulary achieving sufficient discursive agency for such a transformation. Further than limits in the margins of manoeuvrability, there are also more substantive barriers to the extent to which increasing locutionary variety can reduce the biofuel controversy. Whilst it may mitigate some locution-sense dissonances, this can only occur where the dissonance correlates with a locution-referent dissonance, i.e. when the contradictory discourses are actually referring to different things yet the actors use the same terminology. Regardless of the extent to which locutions can be expanded to better reflect the internal variety of 'biofuels" referent, there is still room for locution-sense dissonance regarding the same referent, i.e. different senses of the same referent. Such dissonance cannot be reduced by increasing locutionary variety.

The point can be demonstrated with the empirical material from the biofuel controversy, observing conflicting senses within the same specific referential category. For example, the discourse of actors such as Saab and Supergen are orientated around the added social and environmental benefits offered by second generation biofuels. Biofuelwatch discourse is also orientated around the second generation of the technology as a special case of the first although, for them, it has an enhanced capacity for environmental destruction. This is a

locution-sense dissonance with a shared referent and referent-sense dissonance that cannot be resolved by introducing locutions.

Similar contrasts were found in the NFU-Biofuelwatch debate (Biofuelwatch and NFU, 2007) with reference to certified and non-certified biofuels. As discussed previously, certified biofuels are a subset of all biofuels that are differentiated by means that remain undefined. In their material, NFU discourse is orientated around the social and environmental benefits of certified fuels as "a major driver for sustainable development" (NFU, 2007a) whilst Biofuelwatch's dismiss the (as yet undefined) process as "dangerous greenwash" that "will not save a single tree, nor prevent a single eviction" (Biofuelwatch, 2008c). These positions were maintained by each actor's representative in the debate, and present an example of locution-sense dissonance that is not derived from locutionary insufficiency, but a referent-sense dissonance that provides yet another example of how not all contestation can be resolved by the introduction of new locutions.

Other technical activities outside of the discourses mobilised in the controversy may respond to these referent-sense dissonances leading to transformations towards some resolution. Engineers, as discussed in the introduction, have continually developed new technical capabilities for the production of fuels in response, directly or otherwise, to the development of the controversy. Two examples are second generation fuels which may mitigate some of the problems associated with food price inflation and third generation fuels which promise to mitigate some of the problems associated with land-use change. As such, the technical activities undertaken by engineers is defined as part of the controversial phase of technical activity identified, and may lead to the transformation of the technical artefact to provide the appropriate conditions for the resolution of some discursive conflicts. These are not explored in significant in the present study, which uses discourses mobilised within the controversy as its empirical entry point, but are flagged as a potential path to resolution that would fit within the model presented in Figure 5, above.

To summarise, increasing the breadth of vocabulary that is used to refer to different biofuel technologies may ease the presence of conflicting discourses to some extent, but is limited to those conflicts rooted in a locution-referent dissonance and by the extent to which actors can achieve sufficient margins of manoeuvrability. Referent-sense dissonance, i.e.

conflicting understandings of the same precise referent, cannot be resolved by increasing locutionary variety.

Finally, it must be noted that any closure of the controversy, however partial, is not understood as final. Whilst both the technology and controversy are understood as developing in irreversible time sequences, so developments emerge and become part of history, there is always the possibility of subsequent re-opening of controversy. Indeed, as discussed in the introduction, during biofuels' period of relative obscurity from the introduction of the engine until the turn of the century it was an uncontroversial technology. The controversy emerged not as a result of developments of the technology *per se*, but of developments around the technology, its political context and changes in the development of its dominant counterpart fossil fuels. As new developments further transform the technology, the controversy and wider arenas, new discursive conflicts may emerge invoking both referent-sense and locution-sense dissonances. Whilst any resolution will always have happened and, in that sense, is not reversible, a state of closure can only be described as relatively enduring and subject to subsequent transformation.

7.4 Summary & Conclusions

This chapter has drawn upon Chapter 4's theoretical developments and Chapter 6's empirical analysis to present a discussion of the mutual conditioning of biofuel technology and controversy, before considering issues of power, responsibility and resolution.

The first section focussed upon how biofuel technology conditions the development of the controversy. As controversy is understood as a particular state of social engagement with technical artefacts, i.e. technical activity, and this activity is understood in terms of semiotic processes, the section considered the three moments of semiotic orders; discourse genre and style. Taking each in turn, the section demonstrated how biofuel technology conditions the discourse of performance, the genre of the fuel pump and the style of truth and falsity.

The second section focused upon the reverse conditioning relationship; how the biofuel controversy conditions the development of the technology, both in developing its controversial status and in negotiating the organisation of its internal variety. Building upon the technology's provision of the appropriate conditions for the emergence of multiple

conflicting discourses, these discourses are shown to condition the development of the controversy around the technology. The approach to organising biofuels' internal variety was shown to have a significant potential impact upon how biofuels are regulated in future certification schemes.

The final section of the chapter reflected upon broader issues of how power fits into the conceptualisation, how responsibility may be distributed and how some partial resolution may be achieved. Feenberg's conceptualisation of power in technical development as actors' margins of manoeuvre to transform the conditions of their future activity, was considered compatible with the present understanding. Issues of intentionality and dissociation between actor's activities and their consequences clouded the discussion of how responsibility may be distributed. The potential for resolving the controversy by increasing locutionary variety is limited to those conflicts based upon locution-sense dissonance where sufficient margins of manoeuvre are achieved and effectively deployed. Conflicts resulting from referent-sense dissonance, it was shown, cannot be resolved by these means.

The analysis balances the development of insights specific to the case of biofuels with the demonstration of the power of the theoretical framework. The empirical and theoretical work developed in parallel and in mutual support. Without the addition of a referent to the dyadic sign schema, for example, the difference between locution-sense and referent-sense dissonance could not have been established. It is difficult to disentangle this from the possibility that, without such a feature of the biofuel controversy, the theoretical framework may have developed in a different way. Whilst the empirical analysis presented here is considered sufficient to represent the breadth of the biofuel controversy in the UK, it also presents certain limits in demonstrating the full power of the framework, particularly in terms of its capacity for longer term longitudinal studies and for considering the closure of controversies as the empirical material did not allow for the exploration of these in significant detail. These issues are considered, amongst others, in the following chapter which presents the conclusions, recommendations, and summary of contributions of the thesis.

Chapter 8: Conclusions, Implications & Contributions

This chapter provides a brief summary of the entire thesis before compiling its conclusions and discussing some of the implications and recommendations that emerge from its findings. Following this, the intellectual contributions of the research are summarised before the final concluding remarks are made.

8.1 Summary of the Thesis

The thesis opened with a discussion of the development of biofuel technology from its introduction alongside the diesel engine to its controversial resurgence amid political support. The theoretical challenges involved in studying the relationship between a technology and a controversy were set out in terms of the potential of critical realism's embryonic account of technology in society. A set of aims and specific research questions were defined to guide the research process.

A short pilot study of three articles from the Independent, NFU and Biofuelwatch, pivotal in defining the scope and aims of the research but not leading to substantive outputs, was presented in Chapter 2 of the thesis as a vignette. The purpose of its presentation was as a storytelling aide – to illustrate the thinking that shaped the early stages of the research process and to provide a concise set of empirical material which could be drawn upon to illustrate the subsequent theoretical developments.

In Chapter 3, after a brief account of critical realist theory, Lawson's account of the relationship between technical structure and technical activity was described. Following, this, it was positioned with reference to some other contemporary approaches to the social study of technology. The developments of Lawson's model into the unfolding account of technology were presented in Chapter 4. First, his transformative dialectic, which was designed to consider the relationship between a broadly defined technical structure and technical activity, was adapted to consider the relationship between a technical artefact as part of a technical structure, and controversy as specific state of technical activity. Then, drawing upon the broader ontological resources of critical realist philosophy, the process of interpretation and construction of technology was articulated as an unfolding from the TD to ID, the latter forming a seamless socio-material reality that is at once singularly material and extra-discursive, yet continually transformed by social activity. Finally, the embryonic

critical realist understanding of semiotics was developed to bolster this account of technology whilst also providing a useful analytical device for structuring the study of empirical material.

Chapter 5 was something of a bridging chapter. A discussion of the realist's dilemma opened the chapter whilst highlighting an epistemological and methodological challenge for contemporary realism. A second short empirical piece was presented in the form of a vignette, this time drawing on a school placement undertaken in the midst of the thesis' development. It was presented to illustrate some points regarding the empirical application of the theoretical framework. The semiotic triangle was then used to demonstrate the inevitability with which the analyst shapes the results of the analysis. The same discussion also served to introduce the use of the semiotic triangle as an analytic lens for material from the controversy. This fifth chapter also documented the selection process and its outcome, introducing the set of actors and materials that were selected for use in the main empirical analysis.

Selected outputs of the main empirical analysis were presented in Chapter 6. Taking each actor in turn, the analysis focussed upon their discursive orientations around biofuels' social and environmental performance, which varied wildly, and around the loci of power in shaping the development of the technology, most often identifying the power of government and industry and combinations of the two. These analyses were accompanied by discussion of their material through the analytical lens of the semiotic triangle, drawing out the ways in which actors represent different understandings of different technical artefacts within the internally varied category of biofuels.

The penultimate chapter considered the empirical material in terms of the theoretical framework and its conceptualisation of the mutual conditioning relationship between biofuel technology and controversy. First, it demonstrated how the technology shapes the emergence of the controversy in terms of each aspect of the semiotic order – discourse, genre and style – before considering how the activity of the controversy shapes the development of the technology, with particular reference to how debate about the organisation of biofuels' internal variety may shape technical development via regulations such as certification schemes. The final subsection briefly reflected upon the implications of the analysis upon power, responsibility and resolution. Feenberg's understanding of

power in terms of margins of manoeuvre in the transformation of technology was found to be fruitful and compatible, but the distribution of responsibility for activities suffered significant difficulties. A broadening of the vocabulary associated with biofuel technology was found to offer the potential for resolution of some corners of the controversy without much compromise between understandings, but some conflicts about specific biofuels would still remain. The remainder of this final chapter of the thesis is comprised of three sections presenting compendia and discussions of its conclusions, implications, recommendations and contributions.

8.2 Conclusions

This section revisits the initial theoretical and empirical aims of the thesis set out in Chapter 1 to frame a summary of the conclusions of the thesis before considering the responses to the specific research questions and, finally, the potential and limits that are identified.

The broad theoretical aim of the thesis was described as the development of Lawson's critical realist account of technology towards conceptualising the relationship between specific technologies and controversies with the support of critical realism's account of semiotic activity. These were then to be mobilised for empirical analysis with regards the case of biofuels. This theoretical aim was met in the developments forwarded in Chapter 4, conceptualising the technology-controversy relationship in terms of an unfolding of technical reality, with further support in the development of the semiotic triangle which also provided an empirical lens for the model's application to empirical case studies. During this process of theoretical development, a number of more specific conclusions emerged. These are compiled and presented in Table 13, below.

Theoretical Conclusions

Lawson's TMTA can be built upon, with the support of broader critical realist concepts, to consider the relationship between specific technical artefacts and the controversies that occasionally surround them.
The development of the semiotic triangle and its two 'moments' as both interpretation and construction can be drawn upon to structure empirical analyses with close reference to the conceptualisation of the unfolding of technical reality.
Feenberg's account of power in technology-society relations is compatible with the approach and can be drawn upon to consider actors' power as margins of manoeuvre to transform the conditions for their future activity.
The level of dissociation and lack of intentionality in the relationship between technical activities and their consequences makes it difficult to meaningfully assign responsibility to actors for the ways in which technologies develop.

Table 13: Theoretical Conclusions

The empirical aim of the thesis was defined, broadly, in the exploration of the relationship between biofuel technology and the biofuel controversy. As the empirical and theoretical work were undertaken in parallel, feeding into each other, it is somewhat unsurprising that the mutual conditioning of technology and controversy described in the theoretical framework was also exhibited in the empirical material. The analysis showed how the technical reality of biofuels provides the appropriate conditions for the simultaneous maintenance of multiple conflicting understandings of biofuels which, in turn, provides the appropriate conditions for a controversy to emerge. In considering how the construction of the organisation of biofuels' internal variety can affect biofuel development through future regulations, it also showed how the outcome of current arenas of conflict within the controversy can shape future technical development. A second aim of the empirical research was to examine and demonstrate the functionality and applicability of the theoretical framework. The development of the semiotic triangle allowed the empirical analysis to be permeated with the framework's influence whilst demonstrating some of its features. It is noted that the empirical study also presented some limitations to the research process, which are considered in a forthcoming subsection. A compendium of more specific empirical conclusions is provided in Table 14, below.

Empirical Conclusions

As biofuel technology's internal variety supports the maintenance of multiple conflicting discursive orientations, it provides the appropriate conditions for the emergence of a controversy.
The controversy also shapes the development of biofuels, driving the emphasis that is placed upon different feedstock-process combinations and providing alternative visions for the organisation of their internal variety – for example by feedstock, location, production method etc – which can feed into the development of new regulations.
Where discursive conflicts within the controversy emerge from understandings of different feedstock-process combinations, this is described as a locution-sense dissonance which would be resolved by broadening the vocabulary to reduce locution-referent dissonance. There are many examples of such conflicts in the controversy, so significant resolution may be achieved by increasing the locutionary variety and developing the vocabulary. There is some evidence of this broadening taking place, considered as 'semiotic cuts'. Other discursive conflicts in the controversy emerge from referent-sense dissonances – differences in understandings of the same feedstock-process combination. These cannot be resolved by introducing locutions to widen the vocabulary.
Biofuel development will reflect the interests of those who succeed in its shaping. This process remains open in many respects, for example the criteria for differentiating between feedstock-process combinations that qualify for regulatory support. Despite this, it appears that industrial and governmental discourses are outperforming those of NGOs (discussed further amongst recommendations).
Significant margins of manoeuvre remain with which *all* actors have some (albeit different) level of power to shape biofuel technology to reflect their perspective.

Table 14: Empirical Conclusions

Revisiting the Research Questions

Referring back once again to Chapter 1, a number of research questions were defined to guide the research process. The questions were separated into theoretical (Q_{Tx}), empirical (Q_{Ex}) and reflective (Q_{Rx}) categories which are revisited in this subsection. Summarising a brief response to each question from the perspective of the thesis, this subsection contributes to the evaluation of the success, limitations and further potential of the thesis.

Q_{T1}: How can the critical realist account of technology be developed to consider the relationship between technologies and controversies?

By positioning a technical artefact within Lawson's technical structure and a controversy within his technical activity before drawing upon the TD-ID distinction to refine how the constructive process fits with the realist account of technology.

Q_{T2}: How can semiotic theory be developed to support the account?

With some development, the critical realist account of semiotics can be used to support the account of technical artefacts emerging through transitive activity unfolding to the ID and also how all technical activities, including controversy, are related to the artefact as a pre-existing referent.

Q_{T3}: How can the approach be applied empirically to explore the specific case of biofuel technology and controversy?

The process of exploring the case of biofuels with the theoretical framework is necessarily interpretive, qualitative and exploratory. Following a methodological approach of epistemic privileging, material from the controversy is considered in terms of how its discourse is orientated around extra-discursive realities and also analysed through the analytical lens of the semiotic triangle. Discussion of the analysis is then structured by the understanding of the mutual conditioning of technology and controversy.

$Q_{E1\&2}$: Why are biofuels controversial and how do biofuels affect the biofuel controversy?

The biofuel controversy and the controversial status of biofuel technology appears to have emerged only as it was positioned in a new context of political support for its development, prompting renewed attention to its performance. One significant cause of the emergence of the controversy is that, as an internally varied technology, biofuels support the simultaneous maintenance of multiple conflicting interpretations of it. This, however, is not the only cause, as demonstrated by the referent-sense dissonance also identified within the controversy. Such dissonance emerges from the interpretive flexibility of an intransitive referent amongst different actors.

Q_{E3}: How does the biofuel controversy affect biofuel development?

One particularly salient example of how the controversy affects biofuel development is identified in the construction of the organisation of biofuels' internal variety. This is shown to have a significant effect upon how regulation develops to differentially support and restrict various feedstock-process combinations. These may be based upon the generation of the technology (Saab), its location (NFU) the intentionality of the feedstocks production (Biofuelwatch) or various other means. There remains significant interpretive flexibility with

regards to this organisation, as reflected in both the discourse present in the material from the controversy and current legislation.

Q_{R1}: How might the controversy be resolved?

The partial resolution of discursive conflict may be achieved without actors compromising on their understandings of a specific referent, as some referent-sense dissonances are derived from locution-referent dissonance – two different feedstock-process combinations being referred to by the same term. Introducing a broader vocabulary for the technology could be enough to consolidate some of the discourses that remain in apparent competition, although the semiotic cuts required to increase vocabulary in this way would also be subject to significant negotiation and it is not likely to be something that can be achieved by the activities of any one actor. Referent-sense dissonances are also evident in the controversy, where the conflict surrounds understandings of the same feedstock-process combination. These may not be resolved by the introduction or adaptation of locutions and will require negotiation.

Q_{R2}: How is power distributed?

All negotiations around biofuels' internal organisation or environmental performance are subject to the differential power of actors participating in the controversy, understood in terms of margins of manoeuvre. Most actor's discourse is orientated around the government and industry holding much of the power over biofuel development, although all actors have some capacity to transform the conditions of their future activity. The technology is expected to develop in ways which will serve the interests of those actors who successfully deploy their margins of manoeuvre to shape the development of the technology.

Q_{R3}: How transferrable are the insights of the biofuel case study?

It is not considered appropriate to respond directly to this question, although it is worth reflecting upon the reasons why this is the case. Whilst the theoretical framework is anticipated to hold some broader applicability to the study of other technologies and controversies, and such an application would be seen as a beneficial to the development of the approach, it has simply not been tested. The absence of further case studies may have negatively affected the development of the framework, perhaps overemphasising some features at the expense of others. Certainly, it has led to the uneven examination and demonstration of the powers

of the framework. On the other hand, the applicability may be broader than technologies in controversy – it may be possible to consider other artefacts such as art, climate change or economies and it may be possible to consider activities other than controversy, such as mass appeal or disinterest. The praxis of technical activity could also be considered, using the framework engage, for example, with the sorts of mundane technical activities that Shove and Southerton (2000) have studied with the support of theories of practice.

Successes, Limitations & Further Potential

Spreading the limited resource of time and space across theoretical, methodological and empirical developments presented some barriers to the depth that could be achieved in each. This section considers more specific successes, limitations and further potentials of the thesis.

The project's initial aim was to explore biofuel technology and its relationship with the biofuel controversy. A further aim was then defined in the development the embryonic critical realist account of technology to support the empirical work. The research process is considered successful in each respect; certainly the empirical analysis has benefited significantly from the specific features of the theoretical framework which set it apart from other approaches. Yet, whilst the empirical conclusions remain valuable in themselves, their second function as a means of examining and demonstrating the theoretical framework was difficult to fulfil without the support of other case studies alongside it. In this sense, the intellectual contributions of the theoretical outputs have dominated those of the empirical outputs.

Aside from the initial justification for using the single case of biofuels, the capacity of any single case study to examine and demonstrate theoretical functionality would inevitably reach its limits before straining the furthest reaches of the framework. Certainly, the consideration of other empirical case studies would not only highlight currently under-examined features but would also do more to expose its limitations and drawbacks. Further to this drawback of using any single case study, the specific characteristics of the case of biofuels in particular present their own drawbacks to the examination, demonstration and support for the development of the theoretical framework. Most notably, there is a lack of

significant longitudinal depth to the material which restricted the capacity of the example to trace the long term development of dynamic groups of actors, how their discourses change over time, how actors within the actor groups come to converge and diverge and how new collectives of actors emerge as others dissipate. Similarly, since resolution of the controversy and closure of the technology has not been achieved, these processes cannot be examined with reference to empirical examples. Whilst this lack of post-closure hindsight limits the potential for evaluating the framework's capacity for the retrospective analysis of the resolution of controversies, there are also advantages to undertaking the analysis during a period of heightened interpretive flexibility, as it permits insights into the process that might not have been achieved *ex post*.

Now, these are not necessarily limitations of the framework itself, but of the capacity of the empirical case study to examine and demonstrate its working. Further research applying the framework to other empirical examples is already scheduled[25], anticipated not only to provide case specific insights but also to support further examination, demonstration and, crucially, development of the theoretical framework. These will be selected to complement the case of biofuels, and will include newer technologies at the point of emergence and others that have reached a degree of maturity and relative stability. Maintaining a theme of energy technologies that have been identified as 'low-carbon' and are subject in some way or another to controversy, nanotechnology and wind energy may be suitable cases, also each carrying the advantage of having received some attention from the sociology of technology literature. It is also considered desirable to explore technical or engineering responses to the controversy and their conditioning influence upon technical activity in greater detail.

At first glance, it would appear that nanotechnology may, like biofuels, exhibit a significant degree of internal variety. The difference is that, whilst for biofuels this variety is limited to the material-process combinations used to produce the same product, here it extends to how different technologies-of-the-very-small can be differently applied to produce different products with different applications. The tenuousness of grouping such utterly *different* nanotechnologies together just because they capture some sense of *nanoness*[26] already

---

[25] To be undertaken during a two year postdoctoral fellowship commencing immediately.
[26] The discursive achievement of the organisation of different technologies under the nano banner is well concealed, often to the extent that it would seem as though the nano scale simply does not exist in other technologies.

appears to be causing difficulty (see Swierstra and Rip, 2007). It may be the case that conflicts (or phobias about conflicts (Rip, 2006)) emerge from the internal variety of the technology's organisation (locution-referent dissonance) as much as they do from understandings of the technology *per se* (referent-sense dissonance). This might also support some increased engagement with shove's understanding of materiality as a socio-material artefact, as discussed in Chapter 3. This may, in turn, support further engagement with praxis as a sign process.

8.3 Implications & Recommendations

The thesis carries implications for actors participating in the controversy and their transformative conditioning of the development of biofuel technology. This section considers some of these implications to make recommendations, particularly in terms of participation in technical development and the resolution of the controversy.

Participation in Technical Development

Landeweerd *et al.* (2009) have recommended that biofuel debates should be organised with sensitivity to the variety of ontological approaches to technology that are adopted by different actors. Whilst they were critical of deterministic approaches, they suggested that NGO and policy actors adopt a constructionist position whilst scientists and engineers take a positivist stance, and were unoptimistic about achieving any kind of resolution of these determinisms at an ontological level. This led them to suggest that development may be democratised by taking "into account societal, economic and technological determinants, without reverting to either of these as a 'true' base of the reality" (p542).

Elsewhere (see Boucher, 2010), I have criticised this approach for attempting to resolve an ontological problem at the level of debate. Technical and socially deterministic insights are not ontologically commensurable nor, I suggest, are they adopted outside of straw man understandings. To combine determinisms without articulating the way they are related to each other could exacerbate problems by formalising the dichotomy of social vs technical determination. Instead, I suggested, effort should be expended in developing an approach which ensures that, as insights draw on combinations of social and technical shapings of technology, the effect is synergetic rather than antagonistic. This may be achieved by building upon the present framework.

Other recommendations of Landeweerd *et al.* are less problematic. For example, in the practice of holding debates, they suggest that "one creates a platform where as many stakeholders as possible are offered the possibility to speak out" (2009, p540-541). A similar recommendation is made by Thompson following his philosophical exploration of biofuels: "[A] democratic version of biofuels will require that the construction of pasts and futures for biofuels be done in forums that are open to all and where participants are willing to take each other's ideas seriously" (2008, p196). These echo broader appeals in the contemporary technology literature to develop more participatory methods of technical development integrating more actors to the shaping process (Rowe and Frewer, 2000).

The UK's DfT undertook a consultation during the development of their policy to implement the EU Biofuel Directive (DfT, 2008c, 2008b). Whilst this included a specific carbon and sustainability consultation (see 2008a), Upham and Tomei, (2010) have shown that many of the perspectives expressed by environmental groups during the process did not have any discernible impact upon the resulting policies, leading to the development of weak environmental standards. It seems that, in the consultation, many stakeholders were invited to voice their perspectives but their voices were not then taken seriously and, therefore, cannot be readily described as a genuinely participating in the process.

Drawing on Feenberg's approach, the understanding of power forwarded in the thesis carries some implications for the possibility of the emergence of a truly participatory development process. Recalling his concept of technical bias always reflecting the technical hegemony, recent developments in biofuel technology appear to be serving the interests of the governmental and industrial hegemony. If an approach that increases the participation of environmentalist actors – currently blocked from participation – is considered desirable in fostering a technology that serves the interests of the environment, environmentalist actors must "transform technology through enlarging the margin of manoeuvre they already enjoy in the technical networks in which they are enrolled" (Feenberg, 2002, p174). By transforming the future distribution of power over technical development, they may provide the conditions for the technology to reflect their environmental interests[27].

[27] A further level of difficulty may be identified in the disjoint between the environment and environmentalists.

Until this kind of shaping occurs, the participatory approach in the development of biofuel technology, such as the DfT consultation, may remain little more than an illusory lip service – inclusion only permitted where the widening of participation would reflect the interests of the prospective hegemony. Considering this with reference to the European level political support for biofuels discussed in the introductory chapter, where the support for biofuels was not justified environmentally but for reducing dependence upon the unstable supplies of fossil oil, environmental concessions may be made in order to overcome opposition to the development of the technology.

The research does not present specific recommendations for achieving a desirable level of participation, not least because it is difficult to see through the dissociation between actions and their consequences and to identify specific activities in the present which would lead to the desirable future outcomes. Indeed, even if such predictions were possible, the answers would depend upon a number of other questions; desirable for whom, when and on what scale? It is, however, possible to suggest that actors can make use of even the smallest margins of manoeuvre to shift the future distribution of power.

Returning to the interpretive flexibility of the organisation of biofuels' internal variety and the effect this may have upon future developments, their existing engagement with subsets of biofuels as 'agrofuels' (Biofuelwatch) or 'deforestation diesel' (Greenpeace *et al.*) may in time prove worthwhile for actors seeking more participation. Actors from the global South, which both the NFU and Biofuelwatch purport to represent in very different ways, may find that they cannot participate in the development process effectively via these Northern proxies, as the discursive power is held by the NGO and union, any resulting discursive success will lead to transformations which reflect the interests of these groups. It may be recommended, therefore, that would-be Southern participants in the shaping of biofuel technology in the UK should deploy their margins of manoeuvre in an attempt to participate themselves in the shaping of technology, rather than 'being participated' by Northern actors who will only present selective snippets of their discourse when it matches those of their own.

Of course, since the flux in actors' margins of manoeuvre is conditioned by the technical artefact, there are certain limits to the transformation of the technology and the conditions

of future activity. Technical artefacts such as biofuels (and atomic bombs) are not merely discursive achievement and they may more readily reflect the interests of some actors, such as governments, than others, such as environmentalists. However, the specifics of how technologies can come to serve these interests, and the specific activities that can be undertaken to achieve the requisite transformation, cannot be crystallised *ex ante*.

Engaging with the Controversy & its Resolution

Biofuel technology's inclusion of such a variety of different feedstock-process combinations and their association with significantly variable social and environmental impacts is described as providing the appropriate conditions for the emergence of multiple conflicting discourses. This, in turn, provides the appropriate conditions for the emergence of a controversy which can therefore, to an extent, be considered in terms of the inability of the vocabulary to handle the internal variety of the technology. This was shown to offer some potential for resolution, particularly as actors appear to be currently engaged in negotiation over the organisation of biofuels' internal variety, including the generation and application of a broader vocabulary. This potential for resolution is limited because some of the conflicting discourses refer to the same feedstock-process combination and, therefore, would remain in conflict regardless of how the vocabulary is transformed.

It is one thing to show the, albeit bounded, potential for resolution of the controversy by increasing the associated vocabulary, but it is quite another to make specific recommendations for speeding this resolution path or steering it in a specific direction. Analogous to Shove and Walker's (2007) concerns regarding the development of the transitions literature into a transitions *management* discipline, such a deliberate engagement with the complex process of the transformation of technology in an attempt to achieve a specific set of outcomes entails the crucial and problematic assumption that such activity could possibly be efficacious. This does not mean that we cannot make broad recommendations for the prospects and limits of transformative activity to foster technical futures that may be considered desirable, but it serves as a warning against claims that specific and identifiable technical activities will have specific and identifiable consequences that will be limited to that which was intended and expected in the first place. The ongoing negotiations around the organisation of biofuels' internal variety are important loci of construction which may have far reaching effects on the future of the technology via policy

schemes such as certification. Active and careful participation in this negotiation process is, therefore, recommended for all individual actors seeking to participate, as it is identified as an area with significant potential for the future shaping of the technology. This may be particularly pertinent advice for peripheral actors. For those that appear to be forming the technical hegemony, i.e. government and industry groups, it may also be beneficial to attempt to broaden the vocabulary associated with the technology to defer opposition.

8.4 Contributions of the Thesis

This section considers the intellectual contributions of the thesis, and is organised into theoretical and empirical subsections.

Theoretical

The development of a dialectical understanding of technology and society is frequently cited as the next substantial step for the development of a suitable framework for approaching environmental problems. Thompson concluded his study of biofuels with the identification of such a dialectic understanding as "the fundamental challenge for environmental philosophy in the twenty first century" (2008, p194) and, ten years earlier, Rip and Kemp described it as "vital if deliberate technological change is to be part of the solution to climate change problems" (1998, p328). This sentiment has been accompanied by a shift in broad dualist and critical realist movements towards the adoption of an explicit ontological realism, rather than the agnosticism or unarticulated ontology of weak constructionism which dominated scholarship in the 1980s and 90s. The intellectual contributions of the theoretical developments presented in the thesis are well positioned in response to these developments.

The broad theoretical contribution of the thesis is in Chapter 4's development of Lawson's TMTA, which has not before been subject to significant attention in the literature. The developments shifted the focus of study to consider the relationship between specific technologies and controversies, rather than the broader technology-society relation originally conceived in the TMTA. It then drew upon the broader ontological concepts from critical realism to consider the dialectic relation as an unfolding of technical reality from the activity of the controversy to the seamless fabric of the socio-material reality of the technical artefact whilst maintaining a singular account of materiality that is beyond the

constructive reach of discursive activity. The thesis also contains the first empirical application of Lawson's TMTA in the literature, which was also supported by further developments of the model.

Fairclough *et al.'s* (2002) call for critical realist engagement with semiotics was justified on the basis of the causal power of semiotic processes and their permeation of all human activity. In the thesis, critical realism's limited semiotic programme was mobilised and further developed to consider the unfolding of technical reality in greater detail, positioning over the dialectic model to demonstrate how a single unit of meaning is at once the interpretation and construction of technical reality. This also provided a useful and novel framework for the empirical analysis of material, without which many empirical findings could not have been achieved- for example the differentiation of locution-referent and referent-sense dissonance in the controversy.

Empirical

These theoretical contributions were mobilised for empirical exploration, resulting in insights specific to biofuel technology and controversy that also contribute to a small body of theoretical considerations of biofuel technology (Thompson, 2008) and controversy (Landeweerd *et al.*, 2009). No such study has considered material from the controversy in the UK and their consideration in terms of this unfolding of technical reality with reference to a semiotic triangle is a novelty in itself.

More specific contributions to the field, however, are also offered. These largely emerge from the discussion in Chapter 7, considering in turn how the technology and the controversy shape each other's development. For example, how the technology supports the maintenance of multiple conflicting discourses and provides the appropriate conditions for the emergence of a controversy, and how the ongoing negotiation about the organisation of internal variety of the technology can affect biofuel development through the establishment of certification schemes and other regulations.

Further discussion of the case of biofuels contributed to understandings of power, responsibility and potential resolution. All actors have some power in their margins of manoeuvre to transform the technology, but the distribution of this power is never equal.

This distribution is not *exclusively* political and may be also affected by extra-discursive reality. Technical artefacts can come to remotely serve the interests of those who transform them, yet it is difficult to distribute responsibility for outcomes across the dialectic model, regardless of who's interests the technology comes to serve. Some of the discursive conflict in the controversy could be mitigated by broadening the vocabulary associated with the technology. This process is subject to negotiation and could have other unpredictable effects as all developments constitute the transformation of future conditions of development.

Unlike many discourse analyses, the present thesis is permeated by an explicit appreciation for ontological realism and the limits to the reaches of socially constructive processes. The empirical and theoretical contributions are strongly linked to each other, and neither could have been achieved without the support of the other.

8.5 Closing Remarks

In this final chapter, after providing a summary of the thesis, its conclusions were compiled in theoretical and empirical categories. These informed a discussion of the further potential and ultimate limits of the theoretical framework and the empirical study. The implications of the study for further development of both the technology and the controversy were then considered, with particular reference to participation in technical development and the potential resolution of the controversy. Finally, the intellectual contributions of the thesis, both to the study of technology in general and biofuels in particular, were presented.

The legacy of the project and its unfolding semiotic account of the relationship between technology and controversy remain open. Further developments and refinements of the theoretical framework, its methodological application and empirical basis are keenly anticipated with the support of critical engagement with and from other scholars engaged with contemporary technology literatures.

References

AGARWAL, A. K. 2007. Biofuels (Alcohols and Biodiesel) Applications as Fuels for Internal Combustion Engines. *Progress in Energy and Combustion Science,* 33 (3)**,** 233-271.

AJANOVIC, A. 2010. Biofuels Versus Food Production: Does Biofuels Production Increase Food Prices? *Energy,* In Press, Corrected Proof.

ARCHER, M., BHASKAR, R., COLLIER, A., LAWSON, T. & NORRIE, A. (eds.) 1998. *Critical Realism: Essential Readings,* London: Routledge.

BELL, A. 1994. Climate of Opinion: Public and Media Discourse on the Global Environment. *Discourse and Society,* 5 (1)**,** 33-64.

BHASKAR, R. 1975. *A Realist Theory of Science,* Leeds, Leeds Books.

BHASKAR, R. 1979. *The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences,* Brighton, Harvester.

BHASKAR, R. 1993. *Dialectic: The Pulse of Freedom,* London, Verso.

BHASKAR, R. 1994. *Plato Etc.: The Problems of Philosophy and their Resolution,* London, Verso.

BHASKAR, R. 2000. *From East to West: Odyssey of a Soul,* London, Routledge.

BIJKER, W. 1995. *Of Bicycles, Bakelite and Bulbs: Toward a Theory of Sociotechnical Change,* Massachusetts, Massachusetts Institute of Technology.

BIJKER, W. 2010. How Is Technology Made? - That Is the Question. *Cambridge Journal of Economics,* 34 (1)**,** 63-76.

BIOFUELWATCH 2007a. *New Report Calls for "Reality Check" on Biofuels.* Paris.

BIOFUELWATCH 2007b. Protest Outside Biofuel Finance and Investment World Conference.

BIOFUELWATCH 2008a. Biofuels - a New Threat to Climate and Climate Justice.

BIOFUELWATCH 2008b. Greenergy and Tesco, Stop Trashing the Planet for Biofuels!!

BIOFUELWATCH 2008c. Monocultures for Biofuels: Stop a Climate, Ecological and Social Catastrophe!

BIOFUELWATCH 2008d. Newark Exposé.

BIOFUELWATCH 2009a. Biofuels East Launch Exposé.

BIOFUELWATCH 2009b. Biofuels: Help to Stop Another Quick Way of Heating the Planet.

BIOFUELWATCH 2009c. Blue NG's Agrofuel Power Plant Makes Them an Entrepreneur without Conscience.

BIOFUELWATCH 2009d. Help Us Stop Deforestation and Hunger Due to Biofuels.

BIOFUELWATCH. 2009e. *Press Releases* [Online]. Biofuelwatch. Available: http://www.biofuelwatch.org.uk/pressreleases.php [Accessed July 24th 2009].

BIOFUELWATCH. 2009f. *Resources* [Online]. Biofuelwatch. Available: http://www.biofuelwatch.org.uk/resources.php [Accessed July 24th 2009].

BIOFUELWATCH, CARBON TRADE WATCH/TNI, CORPORATE EUROPE OBSERVATORY, ECONEXUS, ECOROPA, GRUPO DE REFLEXIÓN RURAL, MUNLOCHY VIGIL, NOAH (FRIENDS OF THE EARTH DENMARK), RETTET DEN REGENWALD & WATCH INDONESIA 2007. Agrofuels: Towards a Reality Check in Nine Key Areas.

BIOFUELWATCH & NFU 2007. Biofuels: Earth Saving or Climate Changing? 21st November 2007, Council Chambers, University of Manchester, Manchester.

BLOOR, D. 1999. Anti-Latour. *Studies in History and Philosophy of Science,* 30 (1)**,** 81-112.

BOSWELL, A. 2012. *The Biofuels Delusion,* London, Stacey International.

BOUCHER, P. 2010. What Next after Determinism in the Ontology of Technology? Distributing Responsibility in the Biofuel Debate. *Science and Engineering Ethics,* In Press.

BRYANT, L. 1976. The Development of the Diesel Engine. *Technology and Culture,* 17 (3)**,** 432-446.

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.* London: Routledge.

CARTER, B. & NEW, C. (eds.) 2004. *Making Realism Work: Realist Social Theory and Empirical Research,* Abingdon: Routledge.

CASHELL, K. 2009. Reality, Representation and the Aesthetic Fallacy: Critical Realism and the Philosophy of C. S. Peirce. *Journal of Critical Realism,* 8 (2)**,** 135-171.

CHERUBINI, F., BIRD, N., 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.

CHIU, C.-W., SCHUMACHER, L. G. & SUPPES, G. J. 2004. Impact of Cold Flow Improvers on Soybean Biodiesel Blend. *Biomass and Bioenergy,* 27 (5)**,** 485-491.

CLARENS, A. F., RESURRECCION, E. P., WHITE, M. A. & COLOSI, L. M. 2010. Environmental Life Cycle Comparison of Algae to Other Bioenergy Feedstocks. *Environmental Science and Technology,* 44 (5)**,** 1813-1819.

COLLIER, A. 1989. *Scientific Realism and Socialist Thought,* Hertfordshire, Harvester Wheatsheaf.

COLLINS, H. 1981. Son of Seven Sexes: The Social Destruction of a Physical Phenomenon. *Social Studies of Science,* 11**,** 33-62.

DANERMARK, B., EKSTROM, M., JAKOBSEN, L. & KARLSSON, J. C. 2002. *Explaining Society: Critical Realism in the Social Sciences,* Oxon, Routledge.

DANISH CENTER FOR BIOFUELS 2009. No Title. Danish Center for Biofuels.

DE SAUSSURE, F. 1986. *Course in General Linguistics (Edited by Bally, C. And Sechehaye, A. Translation by Harris, R.),* Chicago and La Salle, Open Court.

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 (5)**,** 588-601.

DELSHAD, A. B., RAYMOND, L., SAWICKI, V. & WEGENER, D. T. 2010. Public Attitudes toward Political and Technological Options for Biofuels. *Energy Policy,* 38 (7)**,** 3414-3425.

DEMIRBAS, A. 2009. Biofuels Securing the Planet's Future Energy Needs. *Energy Conversion and Management,* 50 (9)**,** 2239-2249.

DEPARTMENT FOR TRANSPORT 2008a. Summary of Responses to Consultation on Rtfo's Carbon and Sustainability Reporting Requirements. London: Department for Transport.

DEPARTMENT FOR TRANSPORT 2008b. Summary of Responses to Part Two of the Consultation on the Draft RTFO (Amendment) Order 2009 *In:* DEPARTMENT FOR TRANSPORT (ed.). London.

DEPARTMENT FOR TRANSPORT 2008c. Summary of Responses to the Consultation on the Draft Renewable Transport Fuel Obligations Order. London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2006. *RTFO Biofuels Benefits* [Online]. Available: http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/roads/environment/rtfo/biofuelsbenefits [Accessed February 17th 2010].

DIRECTGOV. 2009a. *About Directgov* [Online]. Available: http://www.direct.gov.uk/en/SiteInformation/DG_4004497 [Accessed 22nd July 2009].

DIRECTGOV. 2009b. *Biofuels* [Online]. Available: http://www.direct.gov.uk/en/Environmentandgreenerliving/Greenertravel/DG_171015 [Accessed 22nd July 2009].

DOULTON, H. & BROWN, K. 2009. Ten Years to Prevent Catastrophe? Discourses of Climate Change and International Development in the UK Press. *Global Environmental Change,* 19**,** 191-202.

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.

ELDER-VASS, D. 2005. Emergence and the Realist Account of Cause. *Journal of Critical Realism,* 4 (2)**,** 315-338.

ELENA, G. & ESTHER, V. 2010. From Water to Energy: The Virtual Water Content and Water Footprint of Biofuel Consumption in Spain. *Energy Policy,* 38 (3)**,** 1345-1352.

ELLE, M., DAMMANN, S., LENTSCH, J. & HANSEN, K. 2010. Learning from the Social Construction of Environmental Indicators: From the Retrospective to the Pro-Active Use of SCOT in Technology Development. *Building and Environment,* 45**,** 135-142.

ENVIRONMENTAL AUDIT COMMITTEE 2006. Reducing Carbon Emissions from Transport: Ninth Report of Session 2005–06. House of Commons.

ESCOBAR, J. C., LORA, E. S., VENTURINI, O. J., YÁÑEZ, E. E., CASTILLO, E. F. & ALMAZAN, O. 2009. Biofuels: Environment, Technology and Food Security. *Renewable and Sustainable Energy Reviews,* 13 (6-7)**,** 1275-1287.

EUROPEAN COMMISSION 2006. 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. Brussels.

EUROPEAN PARLIAMENT 2003. Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport. *Official Journal of the European Union,* L123**,** 42-46.

EUROPEAN PARLIAMENT 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC. *Official Journal of the European Union,* 140**,** 16-62

FAIRCLOUGH, N., JESSOP, B. & SAYER, A. 2002. Critical Realism and Semiosis. *Alethia (Now the Journal of Critical Realism),* 5 (1)**,** 2-10.

FAIRCLOUGH, N., JESSOP, B. & SAYER, A. 2004. Critical Realism and Semiosis. *In:* JOSEPH, J. & ROBERTS, J. M. (eds.) *Realism Discourse and Deconstruction.* Oxon: Routledge.

FEENBERG, A. 2002. *Transforming Technology: A Critical Theory Revisited,* New York, Oxford University Press.

FLEETWOOD, S. 2005. Ontology in Organization and Management Studies: A Critical Realist Perspective. *Organization,* 12 (2)**,** 197-222.

GALLAGHER, E. 2008. The Gallagher Review of Indirect Effects of Biofuels Production. Renewable Fuels Agency: St Leonards-on-Sea, United Kingdom

GEELS, F. 2010. Ontologies, Socio-Technical Transitions (to Sustainability), and the Multi-Level Perspective. *Research Policy,* 39**,** 495-510.

GEELS, F. & SCHOT, J. 2007. Typology of Sociotechnical Transition Pathways. *Research Policy,* 36**,** 399-417.

GREENERGY 2008. Greenergy Warns against over-Simplification of Relationship between Biofuels and Food Prices.

GREENERGY. 2009a. *Biodiesel Production* [Online]. Greenergy. Available: http://www.greenergy.com/biodiesel/index.html [Accessed 22nd November 2009].

GREENERGY. 2009b. *Bioethanol - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009c. *Biofuel Sourcing* [Online]. Greenergy. Available: http://www.greenergy.com/feedstock_sourcing/index.html [Accessed 22nd November 2009].

GREENERGY. 2009d. *Carbon Benefits of Biofuels - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009e. *Company Overview* [Online]. Greenergy. Available: http://www.greenergy.com/company/index.html [Accessed 22nd July 2009].

GREENERGY. 2009f. *Deforestation - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009g. *Food Vs Fuel? - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009h. *Jatropha - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009i. *Making Biodiesel from by-Products - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009j. *Meeting Future Demand for Oil – Considering Alternatives to Biofuels - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009k. *Palm Oil in Biodiesel - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009l. *Perspectives* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].

GREENERGY. 2009m. *Press - Current Releases* [Online]. Greenergy. Available: http://www.greenergy.com/company/press.html [Accessed 22nd November 2009].

GREENERGY. 2009n. *Press - Photo Library* [Online]. Greenergy. Available: http://www.greenergy.com/company/press_photo_library.html [Accessed 22nd November 2009].

GREENERGY. 2009o. *Press Archive* [Online]. Greenergy. Available: http://www.greenergy.com/company/press_archive.html [Accessed 22nd November 2009].

GREENERGY. 2009p. *The Relationship between Biofuels and Consumer Fuel Prices - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].
GREENERGY. 2009q. *RTFO - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].
GREENERGY. 2009r. *Second Generation Biofuels - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].
GREENERGY. 2009s. *Soy Oil in Biodiesel - a Greenergy Perspective* [Online]. Greenergy. Available: http://www.greenergy.com/perspectives/index.html [Accessed 22nd November 2009].
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2007a. Biofuels: A Small Group Makes a Big, Bad Decision.
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2007b. Biofuels: Green Dream or Climate Change Nightmare?
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2007c. Tell the Government to Choose the Right Biofuel or the Orang-Utan Gets It. http://www.greenpeace.org.uk.
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2008. Biofuels: Cool Fuel? Take a Closer Look.
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2009a. Biofuels Policy Doubles CO2 Emissions - New Research.
GREENPEACE, FRIENDS OF THE EARTH, WORLD WIDE FUND FOR NATURE & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS 2009b. New Report Casts Doubt over Biofuels 'Wonder Crop' Jatropha.
GRESSEL, J. 2008. Transgenics Are Imperative for Biofuel Crops. *Plant Science,* 174 (3)**,** 246-263.
GRINT, K. & WOOLGAR, S. 1995. On Some Failures of Nerve in Constructivist and Feminist Analyses of Technology. *Science, Technology and Human Values,* 20 (3)**,** 286-310.
HALL, J., MATOS, S., SEVERINO, L. & BELTRÃO, N. 2009. Brazilian Biofuels and Social Exclusion: Established and Concentrated Ethanol Versus Emerging and Dispersed Biodiesel. *Journal of Cleaner Production,* 17 (Supplement 1)**,** S77-S85.
HARRÉ, R. 1998. Foreward. *In:* PARKER, I. (ed.) *Social Constructionism, Discourse and Realism.* London: Sage Publications Ltd.
HARTWIG, M. 2007a. Agency. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HARTWIG, M. 2007b. Depth or Ontological Depth. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HARTWIG, M. (ed.) 2007c. *Dictionary of Critical Realism,* Oxon: Routledge.
HARTWIG, M. 2007d. Epistemic-Ontic Fallacy. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.

HARTWIG, M. 2007e. Interdisciplinarity, Etc. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HARTWIG, M. 2007f. Intransitive, Transitive and Metacritical Dimensions. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HARTWIG, M. 2007g. Power. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HARTWIG, M. 2007h. Reality. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
HINCHLIFFE, S. 1996. Technology, Power, and Space- the Means and Ends of Geographies of Technology. *Environment and Planning D: Society and Space,* 14**,** 659-682.
HOUKES, W. & MEIJERS, A. 2006. The Ontology of Artefacts: The Hard Problem. *Studies in History and Philosophy of Science,* 37**,** 118-131.
IPCC 2007. Climate Change 2007 - the Physical Science Basis. New York.
IPSOS MORI 2005. You Are What You Read? How Newspaper Readership Is Related to Views.
JOSEPH, J. 2000. A Realist Theory of Hegemony. *Journal for the Theory of Social Behaviour,* 30 (2)**,** 179-202.
JOSEPH, J. & ROBERTS, J. M. (eds.) 2004. *Realism Discourse and Deconstruction,* Oxon: Routledge.
KLINE, R. & PINCH, T. 1999. The Social Construction of Technology. *In:* MACKENZIE, D. & WAJCMAN, J. (eds.) *The Social Shaping of Technology.* Maidenhead: Open University Press.
KROES, P. 2010. Engineering and the Dual Nature of Technical Artefacts. *Cambridge Journal of Economics,* 34**,** 51-62.
KROES, P. & MEIJERS, A. 2006. Introduction: The Dual Nature of Technical Artefacts. *Studies in History and Philosophy of Science,* 37**,** 1-4.
KUHN, T. 1962. *The Structure of Scientific Revolutions,* Chicago, University of Chicago Press.
LANDEWEERD, L., OSSEWEIJER, P. & KINDERLERER, J. 2009. Distributing Responsibility in the Debate on Sustainable Biofuels. *Science and Engineering Ethics,* 15**,** 531-543.
LATOUR, B. 1988. *The Paseurization of France,* London, Harvard University Press.
LATOUR, B. 1992. Where are the Missing Masses? The Sociology of a Few Mundane Artefacts. *In*: BIJKER, W., and LAW, J. (eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change.* Cambridge, MIT Press.
LATOUR, B. 1997. *On Actor-Network Theroy: A Few Clarifications Plus More Than a Few Complications* [Online]. Available: http://www.cours.fse.ulaval.ca/edc-65804/latour-clarifications.pdf [Accessed 7th October 2010].
LATOUR, B. 2002. *The Promises of Constructivism* [Online]. Available: http://www.bruno-latour.fr/articles/article/087.html [Accessed 7th October 2010].
LAW, S. 2004. *After Method: Mess in Social Science Research,* London, Routledge.
LAWSON, C. 2007a. Technology. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
LAWSON, C. 2007b. Technology, Technological Determinism and the Transformational Model of Social Activity. *In:* LAWSON, C., LATSIS, J. & MARTINS, N. (eds.) *Contributions to Social Ontology.* Oxon: Routledge.
LAWSON, C. 2008. An Ontology of Technology. *Techné,* 12 (1)**,** 48-64.
MA, F. & HANNA, M. A. 1999. Biodiesel Production: A Review. *Bioresource Technology,* 70 (1)**,** 1-15.

MCCOMAS, K. & SHANAHAN, J. 1999. Telling Stories About Climate Change: Measuring the Impact of Narratives on Issue Cycles. *Communication Research,* 26 (1)**,** 30-57.
MCGRAIL, R. 2008. Working with Substance: Actor-Network Theory and the Modal Weight of the Material. *Techné,* 12 (1)**,** 65-84.
MITCHAM, C. 2003. Co-Responsibility for Research Integrity. *Science and Engineering Ethics,* 9 (2)**,** 273-290.
MORGAN, J. 2007. Emergence. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
NELLHAUS, T. 1998. Signs, Social Ontology, and Critical Realism. *Journal for the Theory of Social Behaviour,* 28 (1)**,** 1-24.
NELLHAUS, T. 2007. Signs, Semiology, Semiotics. *In:* HARTWIG, M. (ed.) *Dictionary of Critical Realism.* Oxon: Routledge.
NEW SCIENTIST 2007. Editorial : Clearing up the Confusion over Biofuels *New Scientist,* 2634**,** 3.
NFU 2007a. Biofuels: Some Myths and Misconceptions.
NFU 2007b. NFU Welcomes Proposals for the Long Awaited Obligation on Renewable Transport Fuel. National Farmers' Union.
NFU. 2009a. *Biofuels Explained* [Online]. National Farmers' Union. Available: http://www.nfuonline.com/x33919.xml [Accessed 14th November 2009].
NFU. 2009b. *Newhomepage* [Online]. National Farmers' Union. Available: http://www.nfuonline.com/ [Accessed 20th July 2009].
NFU. 2009c. *RTFO - One Year On* [Online]. National Farmers' Union. Available: http://www.nfuonline.com/x38308.xml [Accessed 12th November 2009].
NFU. 2009d. *Vision* [Online]. National Farmers' Union. Available: http://www.nfuonline.com/x191.xml [Accessed 1st July 2009].
NFU. 2009e. *World Biofuels Market 'More Upbeat This Year'* [Online]. National Farmers' Union. Available: http://www.nfuonline.com/x38309.xml [Accessed 12th November 2009].
NIDIRECT. 2009. *Biofuels* [Online]. Available: http://www.nidirect.gov.uk/index/environment-and-greener-living/greener-travel-and-leisure/biofuels.htm [Accessed 22nd July 2009].
NIGAM, P. S. & SINGH, A. 2010. Production of Liquid Biofuels from Renewable Resources. *Progress in Energy and Combustion Science,* In Press, Corrected Proof.
OXFAM 2008a. Another Inconvenient Truth: How Biofuel Policies Are Deepening Poverty and Accelerating Climate Change. Oxford: Oxfam.
OXFAM. 2008b. *EU Reduces 2020 Biofuels Target* [Online]. Available: http://www.oxfam.org.uk/applications/blogs/policy/2008/09/members_of_the_eurpean_parliam.html [Accessed 1st November 2009].
OXFAM. 2008c. *Oxfam Calls on Government to Rethink Reckless Biofuels Policy* [Online]. Available: http://www.oxfam.org.uk/applications/blogs/scotland/2008/04/oxfam_calls_on_government_to_r.html [Accessed 1st November 2009].
OXFAM. 2008d. *Oxfam Welcomes EU Caution on Biofuels Targets as a Step in Right Direction* [Online]. Available: http://www.oxfam.org.uk/applications/blogs/pressoffice/?p=1118& [Accessed 1st November 2009].
OXFAM. 2009a. *Easy Guide to Biofuels* [Online]. Oxfam. Available: http://www.oxfam.org.uk/oxfam_in_action/issues/biofuels.html [Accessed 24th July 2009].

OXFAM. 2009b. *New Biofuels Legislation Falls Well Short of the Mark* [Online]. Available: http://www.oxfam.org.uk/applications/blogs/campaigners/2009/01/new_biofuels_legislation_falls.html [Accessed 1st November 2009].

OXFAM. 2009c. *Page Results for 'Biofuels'* [Online]. Oxfam. Available: http://www.oxfam.org.uk/oxfam_in_action/issues/biofuels.html [Accessed 24th July 2009].

PARKER, J. 2004. How Might the Inclusion of Discursive Approaches Enrich Critical Realist Analysis? The Case of Environmentalisms. *In:* JOSEPH, J. & ROBERTS, J. M. (eds.) *Realism Discourse and Deconstruction.* Oxon: Routledge.

PERSONAL COMMUNICATION. 2009a. *RE: Personal Conversation with Tesco Employee Regarding the Absence of Tesco Communications About Biofuels. 3rd February 2009, Manchester.*

PERSONAL COMMUNICATION. 2009b. *RE: Telephone Conversation with Biofuelwatch Team Member, October 15th 2009.*

PERSONAL COMMUNICATION. 2009. *RE: Telephone Conversation with NFU Press Office, 1st July 2009, Manchester.*

PINCH, T. & BIJKER, W. 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 (3)**,** 399-441.

POPPER, K. 1959. *The Logic of Scientific Discovery,* London, Hutchinson and Company.

POUSA, G. P. A. G., SANTOS, A. L. F. & SUAREZ, P. A. Z. 2007. History and Policy of Biodiesel in Brazil. *Energy Policy,* 35 (11)**,** 5393-5398.

REASON, P., COLEMAN, G., BALLARD, D., WILLIAMS, M., GEARTY, M., BOND, C., SEELEY, C. & MAUGHAN MCLACHLAN, E. 2009. Insider Voices: Human Dimensions of Low Carbon Technology. University of Bath Centre for Action Research in Professional Practice.

RENEWABLE FUEL AGENCY. 2010. *Benchmarks of Sustainability Standards and Certification Schemes* [Online]. RFA. Available: http://www.renewablefuelsagency.gov.uk/reportsandpublications/guidance/carbonandsustainabilityguidance/benchmarks [Accessed 10th August 2010].

RFA. 2009a. *About Biofuels* [Online]. Available: http://www.renewablefuelsagency.org/aboutbiofuels.cfm [Accessed 2nd November 2009].

RFA. 2009b. *Ensuring Biofuels Come from Sustainable Sources* [Online]. Available: http://www.renewablefuelsagency.org/aboutbiofuels/ensuringbiofuelscomefromsustainablesources.cfm [Accessed 2nd November 2009].

RFA. 2009c. *Home* [Online]. Available: http://www.renewablefuelsagency.org/ [Accessed 2nd November 2009].

RFA. 2009d. *How Biofuels Can Reduce Greenhouse Gas Emissions* [Online]. Available: http://www.renewablefuelsagency.org/aboutbiofuels/howbiofuelscanreducegreenhousegasemissions.cfm [Accessed 2nd November 2009].

RILEY, S., SIMS-SCHOUTEN, W. & WILLIG, C. 2007. The Case for Critical Realist Discourse Analysis as a Viable Method in Discursive Work. *Theory and Psychology,* 17 (1)**,** 137-145.

RIP, A. 1986. Controversies as Informal Technology Assessment. *Science Communication,* 8 (2)**,** 349-371.

RIP, A. 2006. Folk Theories of Nanotechnologists. *Science as Culture,* 15 (4)**,** 349-365.

RIP, A. 2008. Nanoscience and Nanotechnologies: Bridging Gaps through Constructive Technology Assessment. *In:* HADORN, G. H., HOFFMANN-RIEM, H., BIBER-KLEMM, S., GROSSENBACHER-MANSUY, W., JOYE, D., POHL, C., WIESMANN, U. & ZEMP, E. (eds.) *Handbook of Transdisciplinary Research.* Springer Netherlands.

RIP, A. 2009. Technology as Prospective Ontology. *Synthese,* 168 (3)**,** 405-422.

RIP, A. & KEMP, R. 1998. Technological Change. *In:* RAYNER, S. & MALONE, L. (eds.) *Human Choice and Climate Change, Vol 2 Resources and Technology.* Washington D.C.: Batelle Press.

ROBERT, J. & LENNERT, M. 2010. Two Scenarios for Europe: "Europe Confronted with High Energy Prices" or "Europe after Oil Peaking". *Futures,* 42 (8)**,** 817-824.

ROWE, G. & FREWER, L. J. 2000. Public Participation Methods: A Framework for Evaluation. *Science, Technology, & Human Values,* 25 (1)**,** 3-29.

SAAB. 2009a. *1st and 2nd Generation Biofuels* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13400 [Accessed 20th November 2009].

SAAB. 2009b. *How It Works* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13316 [Accessed 20th November 2009].

SAAB. 2009c. *How It's Produced* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13315 [Accessed 20th November 2009].

SAAB. 2009d. *Saab Bio Power* [Online]. Available: http://www.saabbiopower.co.uk [Accessed 20th July 2009].

SAAB. 2009e. *Saab Biopower Range* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13324&rnd=6554342966770999 [Accessed 20th November 2009].

SAAB. 2009f. *Saab Media Centre* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13323&rnd=655439718564159 [Accessed 20th November 2009].

SAAB. 2009g. *Sustainable Fuel* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13399 [Accessed 20th November 2009].

SAAB. 2009h. *World Usage* [Online]. Available: http://www.saabbiopower.co.uk/default.asp?docId=13322&rnd=655108968822356 [Accessed 20th November 2009].

SALAMEH, M. G. 2000. Global Oil Outlook: Return to the Absence of Surplus and its Implications. *Applied Energy,* 65 (1-4)**,** 239-250.

SAYER, A. 1992. *Method in Social Science: A Realist Approach,* London, Routledge.

SAYER, A. 2000. *Realism and Social Science,* London, Sage.

SCHOT, J. & GEELS, F. 2008. Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy. *Technology Analysis and Strategic Management,* 20 (5)**,** 537-554.

SCHOT, J. & RIP, A. 1997. The Past and Future of Constructive Technology Assessment. *Technological Forecasting and Social Change,* 54 (2-3)**,** 251-268.

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 (5867)**,** 1238-1240.

SECRETARY OF STATE 2007. Statutory Implement Number 3072: The Renewable Transport Fuel Obligations Order. London: Office of Public Sector Information.
SHIN, D. 2008. The Devlopment of Community Telecommunication Infrastructure: An Evaluation of Rural Telecommunications Project. *International Journal of Information Management,* 28**,** 322-335.
SHOVE, E. 2003a. Converging Conventions of Comfort, Cleanliness and Convenience. *Journal of Consumer Policy,* 26 (4)**,** 395-418.
SHOVE, E. 2003b. Users, Technologies and Expectations of Comfort, Cleanliness and Convenience. *Innovation,* 16 (2)**,** 193-206.
SHOVE, E. & SOUTHERTON, D. 2000. Defrosting the Freezer: From Novelty to Convenience: A Narrative of Normalization. *Journal of Material Culture,* 5 (3)**,** 301-319.
SHOVE, E. & WALKER, G. 2007. Caution! Transitions Ahead: Politics, Practice and Sustainable Transition Management. *Environment and Planning A,* 39 (4)**,** 763-770.
SHOVE, E. & WALKER, G. 2010. Governing Transitions in the Sustainability of Everyday Life. *Research policy,* 39**,** 471-476.
SHOVE, E., WATSON, M., HAND, M. & INGRAM, J. 2007. *The Design of Everyday Life,* Oxford, Berg.
SIMS-SCHOUTEN, W., RILEY, S. & WILLIG, C. 2007. Critical Realism in Discourse Analysis: A Presentation of a Systematic Method of Analysis Using Women's Talk of Motherhood, Childcare and Female Employment as an Example. *Theory and Psychology,* 17 (1)**,** 101-124.
SIMS, R. E. H., MABEE, W., SADDLER, J. N. & TAYLOR, M. 2010. An Overview of Second Generation Biofuel Technologies. *Bioresource Technology,* 101 (6)**,** 1570-1580.
SMITH, A., VOB, J. P. & GRIN, J. 2010. Innovation Studies and Sustainability Transitions: The Allure of the Multi-Level Perspective, and Its Challenges. *Research Policy,* 39**,** 435-448.
SPEER, S. 2007. On Recruiting Conversation Analysis for Critical Realist Purposes. *Theory and Psychology,* 17 (1)**,** 125-135.
STEIN, K. 2007. Food Vs Biofuel. *Journal of the American Dietetic Association,* 107 (11)**,** 1870, 1872-1876, 1878.
STICKLEN, M. B. 2008. Plant Genetic Engineering for Biofuel Production: Towards Affordable Cellulosic Ethanol. *Nat Rev Genet,* 9 (6)**,** 433-443.
SUPERGEN BIOENERGY 2004. British Bio-Energy News Issue 1. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2005a. British Bio-Energy News Issue 2. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2005b. British Bio-Energy News Issue 3. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2006a. British Bio-Energy News Issue 4. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2006b. British Bio-Energy News Issue 5. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2007. British Bio-Energy News Issue 6. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2008a. British Bio-Energy News Issue 7. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY 2008b. British Bio-Energy News Issue 8. Birmingham: Bio-Energy Research Group.

SUPERGEN BIOENERGY. 2009a. *Advancing UK Bioenergy* [Online]. Available: http://www.supergen-bioenergy.net/ [Accessed 20th July 2009].
SUPERGEN BIOENERGY 2009b. British Bio-Energy News Issue 9. Birmingham: Bio-Energy Research Group.
SUPERGEN BIOENERGY. 2009c. *Newsletters* [Online]. Available: http://www.supergen-bioenergy.net/?_id=288 [Accessed 20th July 2009].
SUPERGEN BIOENERGY 2010. British Bio-Energy News, Issue 10. Birmingham: Bio-Energy Research Group.
SWIERSTRA, T. & RIP, A. 2007. Nano-Ethics as Nest-Ethics: Patterns of Moral Argumentation About New and Emerging Science and Technology. *NanoEthics,* 1 (1)**,** 3-20.
TESCO. 2006. *Tesco Increases Use of Biodiesel* [Online]. Tesco. Available: http://www.tescofarming.com/v2/newsitem.asp?newsid=8 [Accessed 20th July 2009].
TESCO. 2009a. *Biofuels* [Online]. Tesco. Available: http://www.tescocorporate.com/plc/corporate_responsibility_09/environment/sustainable_products/biofuels/ [Accessed 20th July 2009].
TESCO. 2009b. *Online Grocery Shopping and Delivery Service* [Online]. Tesco. Available: http://www.tesco.com/ [Accessed 20th July 2009].
THE INDEPENDENT. 2007. *Beet That! Britain's Biofuel Future Takes Off. The Independent.*
THOMPSON, P. 2008. The Agricultural Ethics of Biofuels: A First Look. *Journal of Agricultural and Environmental Ethics,* 21**,** 183-198.
UPHAM, P., THORNLEY, P., TOMEI, J. & BOUCHER, P. 2009a. Substitutable Biodiesel Feedstocks for the UK: A Review of Sustainability Issues with Reference to the UK RTFO. *Journal of Cleaner Production,* 17 (Supplement 1)**,** S37-S45.
UPHAM, P. & TOMEI, J. 2010. Critical Stakeholder Perceptions of Carbon and Sustainability Reporting in the UK Renewable Transport Fuel Obligation. *Tyndall Centre Working Paper 143*.
UPHAM, P., TOMEI, J., BOUCHER, P. & ZAH, R. 2009b. Biofuels, Aviation and Sustainability: Prospects and Limits. *In:* UPHAM, P. & GÖSSLING, S. (eds.) *Aviation and Climate Change*. London: Earthscan.
VAN DIJK., T. 2009. Critical Discourse Studies: A Sociocognitive Approach. *In:* WODAK, R. & MEYER, M. (eds.) *Methods of Critical Discourse Analysis*. London: Sage.
VERBRUGGEN, A. & AL MARCHOHI, M. 2010. Views on Peak Oil and Its Relation to Climate Change Policy. *Energy Policy,* In Press, Corrected Proof.
WAELBERS, K. 2009. Technological Delegation: Responsibility for the Unintended. *Science and Engineering Ethics,* 15**,** 51-68.
WILLIAMS-JONES, B. & GRAHAM, J. E. 2003. Actor-Network Theory: A Tool to Support Ethical Analysis of Commercial Genetic Testing. *New Genetics and Society,* 22 (3)**,** 271-296.
WINNER, L. 1993. Social Constructivism: Opening the Black Box and Finding It Empty. *Science as Culture,* 3 (3)**,** 427-452.
WODAK, R. & KENDALL, G. 2007. What Is Critical Discourse Analysis? *Forum: Qualitative Social Research,* 8 (2)**,** 1-7.
WODAK, R. & MEYER, M. (eds.) 2009. *Methods of Critical Discourse Analysis,* London: Sage.
WOOLGAR, S. 2004. What Happened to Provocation in Science and Technology Studies? *History and Technology,* 20 (4)**,** 339-349.
WYNDHAM, J. 1951. *The Day of the Triffids,* London, Michael Joseph.

ZAH, R., FAIST, M., REINHARD, J. & BIRCHMEIER, D. 2009. Standardized and Simplified Life-Cycle Assessment (LCA) as a Driver for More Sustainable Biofuels. *Journal of Cleaner Production,* 17**,** S102-S105.