

Regulating Land Use Technologies: How Does Government Juggle the Risks?

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[a]Introduction

It is a fact of life that action to reduce one risk can lead to the unintended or unforeseen creation of another. When governments try to make things better the consequences of their actions can conspire to make things worse; this is the law of unintended consequences. The complex technologies associated with new uses of land offer potentially huge benefits for the amelioration of the risks posed by climate change and energy insecurity. They also carry with them however their own significant social, environmental, economic, legal and human challenges. As a result, the interventions made by governments to harness these technical ‘solutions’ often create new sets of countervailing risks. By incentivising the production of bioenergy crops for example, governments may reduce CO₂ emissions from transportation and diversify energy supplies. But such measures may shift risks elsewhere, for example increasing global food insecurity and deforestation. The extensive reach of government across many sectors and the fact that risks are experienced globally makes the central challenge faced by decision-makers double: they must choose the most appropriate policy instruments to manage the primary risks in question and also anticipate the secondary risks that may arise as the result of these choices.

Changes in land use are the result of decisions made by governments juggling multiple and often interdependent ‘risk trade-offs’ (Graham and Wiener, 1995)¹ that grow in number and change in form before their eyes. This chapter explores the interconnectedness of policy responses to risk (Graham and Wiener, 1995) and the risk trade-offs associated with land

diversification by focusing upon two themes of government activity: how they *effect* policy action and how they can *detect* and resolve problems that arise from it (Hood, 1983). By outlining the pre-eminent policy measures and economic instruments deployed to harness new technologies associated with land use diversification some of the most significant risk trade-offs associated with these policy ‘solutions’ to reduce CO₂ emissions and increase energy security are illuminated. Empirically a wide net is cast with examples drawn from a variety of bioenergy technologies and countries – notably the UK, EU, United States (US), Canada, Brazil and Japan – and contextualised within the bewildering array of local, regional, supranational and international agreements and political pressures that are prevailing. The discussion is by no means exhaustive. Indeed, each of the examples could warrant a case study to themselves, and those readers looking for in-depth technical analysis should explore the individual chapters in this volume. Rather, the main aim is to provide some early reconnaissance of the risk trade-offs that are dominating emerging technologies and initial policy responses to climate change and energy security that implicate the land. What are the countervailing risks of policies that treat the land as the potential receptacle for a wide range of technological fixes? Who are the winners and losers in the trade-offs being made? Which risks are seen as more manageable and acceptable than others? How aware are decision-makers of the need to anticipate perverse effects of regulation and weigh up the risks associated with them? How can governments minimise overall risk?

The risk trade-offs decision-makers encounter in attempting to exploit the potential of the land are pervasive and complex. The survey illustrates that while technologies that draw upon the land carry their own risks for the environment and public these are exacerbated by the variety of regulatory strategies deployed and have resulted in new risks to ways of life, some of which exert a disproportionate effect on vulnerable populations. Not all unintended risks

are of equal gravity and discussion here is limited to risks that are considered to be significant relative to the main aims of reducing CO₂ emissions and increasing energy security. We should be clear; the risks occasioned by particular policy measures involving the diversification of land use and new technologies designed to counter CO₂ emissions and increase energy self-sufficiency are not necessarily unhelpful in themselves but rather need to be analysed and balanced on a case-by-case basis. The impact of a countervailing risk is mediated by temporal and spatial context; what is a hazard in one particular time or place may not be seen in the same way in another. By learning from experts, citizens and experience, decision-makers are better placed to anticipate trade-offs coming down the line and identify so-called ‘risk-superior’ (Graham and Wiener, 1995) options that reduce overall risk. This is important because while the propagation of complex countervailing risks appears to be a pervasive feature of regulations devised to exploit the potential of the land, we need not be entirely pessimistic about governments’ ability to anticipate unintended consequences and knock-on effects of policy action. With this in mind, the second part of the chapter addresses the other side of the coin – how governments detect risk trade-offs and learn to resolve them. Again, these are illustrated using examples of practice from around the world.

The discussion is timely. The best way to exploit land resources and to mitigate the risks associated with climate change and insecure energy supplies are matters of global concern and contention. In particular, there is a growing awareness in both government and society that policy responses can be counterproductive and are prone to being overtaken by rapidly changing technology. Such policy limitations risk the original goals becoming displaced and opportunities from new technologies may also be lost as a result of uncertainty and incomplete risk governance. Moreover, where society is not getting the level of protection that it expects, the credibility and legitimacy of decision-makers who are developing and

implementing policy and scientists and stakeholders advising government on future uses of land may be under threat giving way to cynicism or apathy (Graham and Wiener, 1995).

[a]Characterising Risk Trade-offs

The intersection of two global risks – climate change and energy insecurity – sees environment and energy policy and interests intertwined at the top of political agendas around the world simultaneously, possibly for the first time ever. High stakes in ecological, economic and security terms have given rise to an ever increasing array of technological innovations and policy instruments with the potential to fundamentally change land use patterns across the world. Embedded within these ‘solutions’ is a complex range of countervailing risks that pose technically and politically challenging risk trade-offs. A single policy intervention may simultaneously give rise to multiple and often unrelated countervailing risks which leave decision-makers with risk trade-offs that are discrete and easy to discern if not easy to weigh. Countervailing risks may also form part of a domino effect where one unintended consequence sets off chain reactions propagating new, and drawing in additional, countervailing risks. The complex web of risk trade-offs that results is far harder to negotiate. It is worth pointing out that while the idea of countervailing risks is associated often with negative side-effects, unanticipated but welcome consequences can also emerge from seemingly unrelated policy action. Analysis of such ‘ancillary benefits’ (Rascoff and Revesz, 2002) will also be included in the discussion that follows.

Coherent analysis of the challenges decision-makers face requires a clear characterisation of the distinguishing features of these trade-offs. Risk analysts explore what is at stake through two questions (Graham and Wiener, 1995: 22-24)². The first concerns whether or not the adverse outcomes are of a different type to those that the policy aims to eliminate. When

compared to the risk being regulated or ‘target risk’, has the nature of the adverse outcome changed or remained the same? The second considers the population affected by the countervailing risk. When compared to the target risk, does the countervailing risk affect the same or a different population? The resulting four categories – offset, substitution, transfer and transformation – are not mutually exclusive. A single policy intervention can give rise to multiple trade-off types.

Table 1. Graham and Weiner’s Typology of Risk Trade-Offs (1995: table 1.2, 22)

Compared to the Target Risk, the Countervailing Risk affects:	Compared to the Target Risk, the Countervailing Risk is:		
		SAME TYPE	DIFFERENT TYPE
	SAME POPULATION	Risk Offset	Risk Substitution
DIFFERENT POPULATION	Risk Transfer	Risk Transformation	

[a]What’s the Problem? How do Governments’ Define the Target Risks?

Governments have a variety of policy instruments or arrows from which to select to reach their policy targets (Black, 1995; Hood, 1983; Eliadis et al, 2005). To understand what governments are trying to achieve and why one arrow has been chosen to address a risk as opposed to another we must first understand how the cause of hazard is conceptualised. Problem framing determines who the key participants will be on an issue and sets the boundaries to conflict (Schön and Rein, 1994). The dual challenges of climate change and energy insecurity are recognised by governments across the world as externalities rooted in a single and global market failure – high carbon dependence (Stern, 2006). A low carbon economy with a mix of energy types and sources has emerged as the pre-eminent paradigm

informing the selection of policy arrows. Government interventions to address environmental, economic and geopolitical distortions and inefficiencies created by carbon dependence revolve around regulatory controls on CO₂ emissions and investment incentivizing low carbon technologies that may implicate the land. We cannot assume however that actions work in the way decision-makers intend; just as markets fail so do governments (Graham and Wiener, 1995: 229; Wolf, 1988). Harnessing the potential of the land to help correct the market is a complex task involving decision-makers from multiple sectors – most obviously energy, environment, agriculture, trade, development, R&D, economy and transport. The crowded nature of these policy arenas presents the considerable challenges of designing policies that are mutually supportive across sectors, anticipating the potential risk trade-offs that may occur and resolving them in ways which accommodate different geographical contexts and balance competing interests.

[a]Effecting Risk Reduction and the Countervailing Risks of Policy Instruments Driving New Uses of Land

Regardless of the specific policy instrument selected by decision-makers, there are countervailing risks associated with changing old technologies and encouraging new ones.. Such iatrogenic potential – where a remedy threatens to be worse than the malady – is rooted in the inherent uncertainty of moving innovations from small-scale controlled environments to large-scale where they must function technically, economically and environmentally. That said, decision-makers still exercise a good deal of influence over how risks play out. It is policy instruments that determine the ways in which and extent to which iatrogenesis occurs. Where markets are encouraged, or even created by regulatory measures, the action of governments help to determine levels of certainty and confidence in industry. The same is

true of institutional structures. Innovations often raise legal as well as technical dilemmas. The manner in which decision-makers negotiate these will bear heavily upon the character of risk associated with innovation.

When it comes to complex policy problems silver bullets and single global approaches are rarely found. Policy instruments are rarely used in isolation. Rather, the overall picture of governance reflects a mix of measures (Howlett, 2005). Indeed, since the Kyoto Protocol's agreement in 1997, more than 1,000 carbon abatement policies have been implemented world wide (Simeonova, 2007). Changes in behaviour are sought through a cocktail of incentives and capacities. This chapter discusses the risk shifts and trade-offs implicating the land that have been facilitated by four policy interventions that dominate governments responses: target setting, price and rights-based trading schemes, subsidies to encourage market penetration and direct intervention through grants for research and development (R&D).

[b] Setting Targets

Setting quantitative targets on emission reductions and energy self-sufficiency, and achieving regional and international agreement on how to reach them, have emerged as a central policy agenda driving global changes in land use. Such targets provide the overarching framework within which more detailed strategies and diverse policy tools are developed. The use of fiscal tools to create a carbon price, deploy subsidies and give R&D grants are all driven by the initial targets set at local, national and international levels. Before exploring the countervailing risks that arise from these three policy choices that flow from targets, we explore the risk trade-offs that can arise as the result of how targets themselves are designed. Specifically, the issue of goal displacement is scrutinised where the targets that

are set under conditions of uncertainty fail to anticipate future developments perverting the overall policy intention.

To explain how goals become displaced and the original risks of climate change and energy security are offset, transferred and transformed, the framing power of targets must be understood. Targets set the tone for policy action; they embody the specific behaviour governments want to address and the level of commitment that a government attaches to a problem. The more ambitious the targets are, the more effective institutional arrangements are required to ensure both the successful achievement of the targets themselves and the link-up with the delivery of overall policy goals. Where the problems are both pressing and characterised by uncertainty and technical novelty, as is the case here, the targets set may be overly ambitious and lacking in appraisal as to how they are to be achieved. In such situations, the technological 'solutions' favoured by those who must comply may meet the target but ultimately deracinate the overall goal.

The targets set around the world for biofuel use encapsulate the problems decision-makers face in trying to establish regulatory regimes in areas marked by technical uncertainty, and the rapid change in land used for energy crops represents an archetypal example of goal displacement. Nearly twenty countries have mandates for blending biofuels into vehicle fuels (Monfort, 2008). The EU took the lead in 2003 by adopting its first biofuels directive setting targets on biofuel use in petrol and diesel at 5.75% by 2010 (Council of Ministers, 2003). Recent proposals extend this to 10% by 2020 (European Commission, 2008). In its 2007 Energy Bill, the US announced plans to cut gasoline use by 20% over the coming decade. Three-quarters of this is to be achieved by using of 136 billion litres of renewable and alternative fuels by 2022. Similarly, Japan and China have set targets of 6 billion litres per year by 2030 and 13 billion litres of ethanol by 2020 respectively.

Why have such ambitious targets formed around biofuels in particular? When faced with challenges as complex as climate change and energy insecurity, the search for ‘like-for-like’ replacements is a common default position adopted by governments to address risk reduction. The aim here is to select a substitute compatible with current technology that, on the face of it, will cause least disruption to the status quo (Gray and Graham, 1995). As one of the first technologies to emerge as a viable alternative to fossil fuels that could be produced on a large-scale, first generation biofuels have been embraced as a sustainable improvement on oil. The absence of any fundamental re-thinking of policy problem – in this case to focus on the demand side as opposed to supply side of the contribution of transportation to the target risks – means that such substitute technologies are liable to produce risk offsets. Encapsulated in the idea of a ‘rebound effect’ (Schipper, 2000; UKERC, 2007)³, the environmental savings made by biofuels may be undermined by the systemic responses and inefficiencies that accompany their production. For example, millions of hectares of peatland in Southeast Asia have been drained for oil palm crops. As carbon sinks, it is estimated that 40-50 billion tonnes of carbon is stored in this watery land and its clearance is calculated to be equivalent to 10% of global emissions from fossil fuels (Wetlands International, 2007). Similarly, the need for fertilizers, increased water quantities, the importance of fossil fuels in harvesting energy crops, and release of carbon in clearing the land for crops reduce the benefits of biofuels in reducing CO₂ emissions. Biofuel crops also represent a major risk offset where changes in land use have been facilitated by deforestation that increases CO₂ emissions. For example, the United Nations (UN) estimates that if current rates of production of palm oil – the world’s main biofuel – continue, virtually all Indonesian and Malaysian rainforests will be destroyed by 2022 (Uryu et al, 2008). This offsetting of risk – the same risk of increased CO₂ emissions from a different source – has been enough for some experts, such as Dr Richard Pike (2008), Chief Executive of the Royal Society of Chemistry, to reject

first generation biofuels as a technological dead end. There are those who take the more benign view, arguing that while offsetting risk in these ways is clearly not desirable in the long-term, in the early phases of policy when the goal is to engender behavioural change such targets alter mindsets about dependencies on fossil fuels in transport. In this way, first generation biofuels may represent a necessary but interim ‘transitional technology’ whose rebound effects will be mitigated later as argued by bioenergy researchers at Imperial College (Templer and Woods, 2008).

The unintended and indirect consequences of mandatory targets for biofuels in environmental terms are also now becoming clear. Making the adoption of a technology obligatory, distorts markets by creating certainty for biofuel producers but transferring risk to other groups. Biofuel targets have stunted other forms of land diversification, with biofuel technology and the well-organized industry behind it becoming ‘locked in’ at the expense of other, and potentially superior, innovations. Most notably, an argument often championed by the carbon capture and storage (CCS) and anaerobic digestion industries is that ‘what gets measures gets done’ and setting targets that support like-for-like technologies does little to encourage investment in technologies that are less well known and arguably riskier, but address emissions more directly.

In addition to these risk offsets, the external impact of biofuels targets also leads to risk being transformed and transferred. Forests being felled and replaced by palm oil crops increase CO₂ emissions but also displace forest animals (most notably the already endangered orang-utan (UNEP, 2007), and take energy away from ecosystems through soil erosion and nutrient depletion (Haberl et al, 2007). Here both the adverse outcome and population affected are changed and the nature of risk transformed from the reduction of CO₂ emissions produced by citizens in the industrialised ‘North’ to threatening future land use of those in the rural

‘South’. This human dimension has been brought into sharp focus by the United Nations (UN). Victoria Tauli-Corpuz (2007), chair of The UN Permanent Forum on Indigenous Issues, warns that land displacement as the result of deforestation could create up to 60 million ‘biofuel refugees’ – 5 million in Kalimantan, Indonesia alone – who will either migrate to the mega-cities of the global South or grind out a subsistence living in the rural communities that remain.

[b] Driving Innovation through Carbon Pricing and Trading in Pollution Rights

Lasting innovations are rarely realised by a simple investment by government in research and development (R&D) into new technologies developed in universities or industry (Freeman and Soete, 1997; OECD, 2007)⁴. Rather, governments aiming to achieve socially defined objectives, encourage market opportunities for new technologies by combining *rights-based measures* that give actors the right to emit CO₂ up to a certain limit, *price mechanisms* that allow these rights to be traded, and *taxes* to persuade heavy polluters to reduce their emissions (Beder, 2001; Hahn and Hester, 1989). Setting a price for carbon has become established as one of the main ways to energise these innovation networks by incentivising the efficient energy use and stimulate investment in technologies that aim to manage CO₂ or lower it. Specifically, in the past two decades, industrialised countries have introduced emissions pricing systems – notably CO₂ taxes and tradable allowances – as the main policy mechanisms through which to meet their emissions targets. Commercial energy users and suppliers are levied for the amount of fossil fuels they use and produce through a cocktail of schemes administered at local, regional, national, transnational and international levels. For example, since 1991 eight European countries have introduced CO₂-based taxes – Denmark, Finland, Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom, and

since 2005 all energy intensive firms in the EU have been able to buy and sell CO₂ permits in the most ambitious attempt to establish an international carbon market – the EU Emissions Trading Scheme (ETS) (Anderson et al, 2005). Similar initiatives are underway in North America: one joining eight US states with three Canadian provinces and another of ten Northeastern and Mid-Atlantic States⁵. Indeed, according to a recent survey for the Point Carbon consultancy, the expectation among the majority of traders (73% of a survey of 3,700) is that a global price for carbon will have emerged by 2020 (Point Carbon, 2008)⁶.

The design of these markets underlines the view of climate change and energy insecurity as negative externalities, unwelcome costs that have been imposed on societies by industry users and energy suppliers. Through emissions rights and carbon pricing these costs are reflected in the decisions taken by these firms; with the rate of CO₂-based taxes usually dependent upon the CO₂ content of fossil fuels being used and / or produced. The primary intention of these levies is to change behaviour rather than raise revenues and as such the success of these schemes is measured in the extent to which revenue falls. In the most basic schemes, firms and suppliers that increase their energy efficiency reduce their tax burden. Additional incentives are common where companies receive rebates for reaching their efficiency targets or can trade unused allowances in carbon markets. For example, the Climate Change Agreements (CCA) introduced to complement the UK Climate Change Levy (CCL) reward success with up to 80% rebates.

The logic of these price mechanisms is to link abatement with innovation. Behavioural change in energy consumption among firms alters the signal communicated to energy providers and potential investors, stimulating investment in new technologies that among other things implicate the land. Market approaches such as this are associated with the idea of an ‘option value’ (Gross and Foxon, 2003) – they create choices between different

technologies from which investors can select. For this value to be realised, however, a threshold effect must be achieved whereby innovations enjoy enough investment to become commercially viable.

While increased investment in alternative energy sources mean that the dual targets of reducing CO₂ emissions and mixing the balance of nation states' energy supplies are addressed by combinations of rights and price-based measures, there is significant variation in the type of land-based technologies that are beginning to benefit. While energy crops for biofuels are the recipient of significant levels of private investment, this is not the case for technologies whose commercial viability is yet to be established (UNEP, 2008). The key issue here is the strength of the price signal sent out to firms. By setting carbon prices through fixed period schemes such as the CCL and ETS, the stable incentives required to encourage large-scale investment in risky technologies are not generated. A type of risk offset may result where lack of investment in emerging technologies turns them into missed opportunities and limits future energy-generation options. Such restriction on future solutions could jeopardise countries' abilities to ameliorate CO₂ emissions and create an optimal energy supply mix. Nowhere is this scenario more marked than in relation to carbon capture and storage (CCS). Though this is an 'end of pipe' technology that promises a smart way of dealing with CO₂, CCS is a costly technology, is yet to be proven and will push up the cost of electricity⁷. It also requires significant re-thinking of key parts of the production and regulatory processes. Questions concerning what types of land are suited to CCS and what are acceptable leakage rates can only be answered through trial-and-error research.

Slow progress in securing investment has also encouraged the same inertia in terms of setting the framework for regulation. Filling the considerable legal vacuum that exists around CCS is pressing however. In particular, who should be liable for leakage is arguably the thorniest

issue yet to be addressed by governments. As carbon will be sequestered over decades by multiple actors it will not always be possible to identify a single actor responsible for injecting CO₂ into a site. And pinpointing the cause of a leak – for example injection method or site stewardship – is unlikely to be straightforward. These concerns have led to suggestions from industry, for example Dr Mike Farley (2008) Director of Technology Policy Liaison for Doosan Babcock that long-term financial liability should be assumed by national governments but a consensus on this solution is yet to emerge (International Risk Governance Council, 2008). Thus while it is expected to take more than a decade to assess the efficiency of a CCS plant it may take just as long for the required investment to be secured and for the institutional rules of the game to be established.

For commercial viability, a self-reinforcing innovation system needs to exist around high risk technologies such as CCS. This requires significant long-term financial support. For example, it has been estimated that commercial CCS projects require a sustained price of around €30 per tonne of CO₂ emissions avoided. However, the EU phase one of trading has seen market prices peaking at €30 for only one month and falling as low as €0.10 per tonne (Kema, 2007 in IRGC, 2008). Even if the costs of emitting carbon stabilizes at the level analysts estimate is required to incentivise investment in emerging technologies such as CCS, this will do little for those who want to invest early (Forward, 2008) and the fact that such a price is set for a fixed and relatively short period of time makes forecasting long-term revenues impossible. Thus, while the emissions trading scheme has been welcomed across Europe's energy and industry sectors, the absence of stronger long-term pricing signals or commitments by governments to underwrite a price jeopardises large-scale investment.

Experts from the worlds of both science and industry agree that CCS could become a missed opportunity with the uncertainty generated by short-term price mechanisms creating an

impermeable blockage in the innovation system (Stromberg, 2008)⁸. The absence of legislation requiring new coal-fired power stations to be CCS compatible in the world's largest energy producers⁹ and recent withdrawals of governments from CCS projects will do little to embolden the private sector to move beyond R&D ventures¹⁰. In one of the most recent high profile cases, Saskatchewan's planned development of CCS has been characterised by protracted uncertainty with the public electricity company – SaskPower – undermined by the new federal government's commitment to nuclear power which is viewed as a better investment than CCS (Salaff, 2008: 12). The surge of interest in nuclear power underlines the competitive market within which emerging technologies must attract investment. It also suggests that societies are not taking into account the risks of missing the CCS opportunity and are reducing technology options for the tackling climate change and energy security in the future.

The lack of full commercial exploitation of land-based technologies such as CCS may however also transfer risks to developing countries whose ability to harness land resources to address climate change and energy insecurity is heavily reliant upon the transfer of knowledge from the industrialised world. As climate change economist Sir Nicholas Stern observes: '[U]nless the rich world demonstrates, and quickly, that CCS works, developing countries cannot be expected to commit to this technology' (Stern, 2007).

[b]3. Subsidies for Land Diversification

For innovation systems to operate successfully, actors must be incentivised to alter their behaviour in a way that facilitates adoption. Subsidies are a key way in which governments attempt to remove informational, financial and cultural barriers to behavioural change and

defray the costs of mandatory standards. Those who manage and tend the land are encouraged to respond to the changing energy market and meet emissions targets through direct economic support. In particular, subsidies to encourage the growth of energy crops for biofuels and combined heat and power generation and incentives for anaerobic digestion schemes and on-shore wind farms are commonplace across both industrialised and developing worlds. Early experiences confirm what policy analysts have long known: the success of subsidies is a function of the context within which they are applied and the technology to which they are applied.

The operation of the UK's Renewables Obligation (RO) scheme illustrates the importance of the legal and administrative context for the success of subsidies. The RO scheme obliges electricity providers to source an increasing proportion of their electricity from land-based renewables. Policy tools are not deployed in a vacuum however and must compliment the existing rules and regulations on the statute books. There is concern that problems in obtaining planning permission (Upreti 2004) and access to the grid for projects involving technologies with which regulators and citizens are unfamiliar – notably anaerobic digestion – have led to a risk offset (DEFRA, 2007). Consumers are effectively paying for projects regardless of whether or not they help mitigate CO₂ emissions (Ofgem, 2007).

The suitability of a particular technology for subsidies also has implications for the intensity of the countervailing risks that arise. This is perhaps exemplified by the contrasting impacts of first generation biofuel crops in Brazil and the United States of America (USA) (Mol, 2007). From the 1970s to 1990s, the production of sugar cane for the production of ethanol was subsidized. This transformed Brazil's agricultural economy, boosting employment and reducing both CO₂ emissions (with more than 40% light vehicles' fuel consumption from ethanol) and oil imports. In spite of these benefits, there is famously another side to the

biofuels story where the subsidised displacement of traditional agricultural products by biofuel crops has produced only modest reductions in CO₂ emissions. Keen to emulate Brazil's success, the US subsidises maize production for ethanol at the cost of US\$5.5 billion to US\$7.3 billion a year through over 200 support measures (World, Bank, 2008)¹¹. Significant direct and indirect side-effects have resulted from this subsidy regime.

In terms of direct trade-offs, the cost-effectiveness of such subsidies in both cases is low and use of land inefficient – when the costs of motorists and taxpayers are taken together biofuels costs are almost double those of fossil fuels (Doornbosch and Steenblik, 2007; Global Subsidies Institute, 2007; IEA, 2006). Moreover, the conversion of maize to ethanol is also significantly less energy efficient than using sugar cane. Biofuels from sugar in Brazil are estimated to have 86% CO₂ emissions reduction as compared with 10-30% of maize-based biofuels produced in the US (Macedo et al, 2004; Searchinger et al, 2008). Significant research published in *Science* estimates that once land use changes are factored in, instead of producing a 20% saving, maize-based ethanol nearly doubles CO₂ over 30 years (Searchinger et al, 2008).

The USA's drive for ethanol production combined with income growth in industrialising economies, widespread drought (attributed by many to climate change), an increased population and changing patterns of food consumption has resulted in emissions and energy insecurity effectively traded for increased food prices globally and food insecurity in world's poorest regions (Evans, 2008; FAO, 2008; World Bank, 2008). In 2006, the United States Department of Agriculture (USDA) estimated that around 20% of the total corn harvest in the US was used by the biofuel industry – an increase of 63% since 2004. This figure is expected to increase to 30% by 2009. The result was an increase in wheat prices by 130% between March 2007 and 2008 (IAASTD, 2008) and 60% in maize prices from 2005 to 2007. The

prices of feedstock and fertilizers have increased accordingly. The magnitude of the competition faced by dairy and cattle farmers in the feed markets and food producers and consumers across the world is only just becoming clear. While these risk substitutes affect the world population, voice was given to these concerns most forcibly by those most adversely affected – the poor of the developing world – when in 2008 demonstrations in Egypt, Mexico and Yemen and almost a dozen other countries became increasingly violent.

Purist economists would argue that such market distortions are temporary – higher prices result in more planting and increased production. Indeed, this thesis is borne out with agricultural production projections for 2008/09 indicating that farmers are cutting cotton and sugar production in favour of wheat, maize and soya. Notably, wheat production is expected to increase by 16% in US, 17% in the EU and 25% in Canada (USDA, 2008). The argument that such risks could be neutralised by increased agricultural productivity may stack-up in industrialised and industrialising countries. In those locations most at risk of food shortages however, it requires greater qualification. For example, with 63% of all plant production in south Asia used or destroyed by humans it is unclear how developing countries can boost productivity and re-calibrate the market (Haberl et al, 2007). And so, while bioenergy crops have the potential to reduce the price of oil which brings obvious benefits to poorer countries, if these crops occupy the lion's share of the best land in these countries the resulting increase in global food prices can be expected to induce a similar increase in the cost of food aid (UN, 2007).

There are also countervailing risks associated with subsidy-induced land-use change that target farmers more specifically. The costs of changing land use and generating abatement are straightforward enough – these involve farmers calculating the opportunity costs of using their land to sequester carbon or reduce emissions in some way rather than producing more

traditional commodities. The transaction costs involved in identifying a market for their goods and enforcing contracts are more problematic however (Lipper and Cavatassi, 2004). The markets for most energy crops and biogas are emerging ones and often highly regional, meaning that opting to diversify in this way involves a higher level of risk than more conventional changes in land use, thereby compounding transactions costs further. This increased burden is rarely reflected in the subsidy levels (Lipper and Cavatassi, 2004). Where it is not, risk transformation is possible where the adverse outcome of increased CO₂ emissions is replaced by significant economic risks that directly affect small-scale landowners and farmers who are already financially vulnerable. Early indications of the new bio-economy that has begun to emerge as a result of the diversification of crop investment confirm that subsidies have not prevented smaller farmers in both the developed 'North' and developing 'South' suffering as large companies determine and control the prices that are paid for energy crops (UN, 2007).

With over 70% of the world's poor living in rural areas, policy action to address the challenges of climate change abatement must also alleviate poverty (IFAD, 2001). International agencies use subsidies to unlock financial and social barriers that inhibit land-use change (Cacho et al, 2002; Olsson and Ardo, 2002; Smith and Scherr, 2002) and enable the creation of synergies between the diversification of land to increase income and carbon sequestration – principally through cropland management, reforestation and revegetation (UNFCCC, 2008; World Bank, 2002). Such double returns make subsidies relatively cost-effective (Smith and Scherr, 2002). Research illustrates that the key to success is to match subsidies to technologies that fit the local context and on the ground support provided by NGOs and aid agencies (Scott, 2006; del Rio and Burguillo, 2008). For example, developing CCS units may be problematic in areas that rely on off-grid energy. In such contexts,

subsidising the growth of biomass for heat and power generation would represent a more efficient low emissions boost to rural communities and economies.

Subsidizing land diversification has a further dimension. Addressing climate change and energy insecurity by encouraging farmers to focus on the carbon output of their land may also imply an additional form of risk transformation where farmers lose a sense of intimacy with the land. For some, the contrast between economic and personal relationships is a stark one; these represent ‘hostile worlds’ governed by incompatible logics (Zelizer, 2005). In this context, encouraging farmers to react to market signals and engage in carbon management is detrimental to sustainable land stewardship, destabilizes biodiversity and erodes a sense of intimacy and kinship with the land¹².

[b]Research and Development (R&D) Grants

Large-scale technological shifts cannot be stimulated by indirect regulation through subsidies or market competition alone. Such innovation requires direct public intervention. The uncertainty that surrounds scientific knowledge of inventions and the high degree of financial commitment and risk involved in piloting and commercialising large-scale technological innovations means private investment in R&D is often far lower than social objectives require (Arrow, 1962; Nelson, 1959; Socorro, 2003). This gap between investor confidence and socio-political targets is particularly marked where innovations seek to combine environmental and economic goals (Klassen and Whybark, 1999). Direct public investment in the form of R&D grants is essential to avoid this potential market failure and the best way to ‘de-risk’ technology. Neoclassical theory tells us that governments aim to secure the optimal allocation of resources required for an innovation to succeed. However, economics

textbooks tell us little about how well equipped government may be to manage highly specialised projects involving a network of actors with their own agendas. Large-scale R&D projects enable government to pool finances with multiple actors with the aim of creating something greater than the sum of their parts. Innovation by consortia implies a whole range of organizational and logistical challenges however. The most pressing is to ensure that all parties possess a shared understanding of what constitutes a successful outcome in the initiative and that government monitors the allocation and use of funds.

How 'success' is defined in a large-scale technological initiative depends upon why a project has been funded in the first place. With R&D monies, governments generally aim to achieve one of two goals: either to try out a risky technology or to showcase a technology to secure further investment and achieve market penetration. Where an unreliable technology is simply to be tried out any failure of that innovation does not equate with the failure of the policy project itself. Indeed knowledge of what does not work can be seen as an ancillary benefit. Where the main goal is to prove to the market that an innovation works technically and is financially viable on a large-scale however, the failure of an initiative can give rise to significant and negative countervailing risks. Most notably, not only may the target risk remain undiminished it may be compounded by reduced confidence within government, industry, stakeholders and the wider public offsetting the risk further still.

The fact that whether a countervailing risk is seen as an acceptable cost or an unacceptable burden often lies in the eye of the beholder has significant implications for grant giving activities. Where there is no shared vision of the ends to be achieved, the acceptability of risk trade-offs and side effects are subjective and may become sites of conflict between partners. An early partnership between the EU Commission, UK government and a biomass investment consortium is illustrative. Despite a 20% reduction in energy-related R&D in the

last two decades (Stern, 2006), significant funding opportunities exist for biomass projects. While they involve higher capital costs than fossil fuel technologies (in some cases by a power of five) they also carry the promise of almost net carbon neutral heat and power generation (Thornley, 2006) and are potentially perhaps less socially controversial than other land-based renewables (for examples see Upreti, 2004; Upreti and van der Horst , 1004; Upsham and Shackley, 2006a; Upsham and Shackley, 2006b). In 1994 it was decided in the EU that all non-fossil fuel funded projects involving energy crops should use the emerging and costly new conversion technologies of gasification and pyrolysis¹³. The main flagship demonstration plant – the £30million Project Arable Biomass Renewable Energy (ARBRE) in Yorkshire – generated electricity for only eight days before succumbing to technical problems associated with gasification and bankruptcy of the contractor managing the project (Piterou et al, 2008). In an effort to ensure that those farmers already contracted to grow willow were not left without a market for their crops and to boost confidence in biomass, the government relaxed its policy allowing the co-firing of coal and wood dust allowed in conventional power stations¹⁴ and left the conventional energy industry importing wood sourced from deforestation in countries such as Latvia and Indonesia, the transport of which produces carbon emissions that are estimated to be three times that of UK biomass sources (Lindegaard, 2005).

The EU's selection of a risky technology indicates that its goal was for ARBRE to be a test bed for gasification. The UK government however provided the project with a 15-year contract from the Non Fossil Fuels Obligation (NFFO) scheme deployed for innovations that were expected to make it to market (Piterou et al, 2008). This clash of goals was never resolved and resulted in the project being judged by standards, in the UK at least, which it could never have hoped to satisfy. The ARBRE case also underlines the problems

governments may have in keeping a grip on their R&D initiatives. Grants enable government to increase the stock of knowledge in an area and draw on specialist capacity that they do not have. But, the highly specialised nature of R&D projects means that, after providing the funds, governments often takes an arm's-length approach to management and progress monitoring is often cursory. The result can be a pronounced asymmetry of information where decision-makers find themselves out of touch with events on the ground and are often not alerted about problems until it is too late. Certainly in the ARBRE case, the main protagonists involved agree that the lack of structured oversight obscured the most fundamental problems that led to the project's collapse (Piterou et al, 2008).

High profile cases such as ARBRE represent important learning experiences for those involved and the trade-offs can be rationalised as part of the process of creative destruction that fuels successful innovation (Schumpeter, 1942). But where negative perceptions become attached to a technology the ripples often extend well beyond any specific case and time giving rise to non-technical barriers to future innovation which may offset the original risk and 'lock out' emerging technologies (IEA, 2005). High profile failures do little to encourage farmers to change their land use, or to convince citizens and local government, already prone to 'nimbyism', when faced with applications to host large-scale plants, that such projects will be successful in the long-term. In the ARBRE case the efforts of government and industry to demonstrate the benefits of a technology were undermined by this lack of confidence. Specifically, there has been concern that the development of biomass for heat generation may have been slowed as a result of the lack of obvious success with electricity-focussed initiatives (UK Biomass Task Force, 2005).

The propagation of complex countervailing risks is a pervasive feature of decision-making in general and, as this account demonstrates, of the policy tools deployed to exploit the potential of the land in particular. The emergence of high profile risk trade-offs should not be mistaken as an indication of policy failure however. Not all side-effects can be anticipated prior to policy action, particularly where the risks being regulated are complex and pressing and the technological solutions novel. Though the preceding discussion has highlighted the fallibility of policy action, this is no tract against government intervention. The risks occasioned by particular policy measures involving the diversification of land use and new technologies designed to counter CO₂ emissions are suggestive of incomplete risk governance (Graham and Wiener, 1995). However, it is through learning that corrective action can be taken and trade-offs coming down the line anticipated more readily.

How can decision-makers know which trade-offs deserve close attention? How might they decide which ones to ignore? In short, from what and whom can decision-makers learn? Examples of how governments are beginning to meet the countervailing risks that swirl around land diversification technologies and fashion risk-superior options that reduce overall risks brings into relief three learning types that help complete risk governance – epistemic learning, social learning, and institutional learning (Dunlop and James, 2007). These are discussed in turn.

[b]Epistemic Learning

Unintended side-effects often occur because, like all humans, decision-makers have limited cognitive capacity and difficulty in attending to more than one thing at a time (Simon, 1957; Jones, 1994). And so, while the choice of policy instrument is motivated by self-interest,

decision-makers' bounded rationality means that their sense of what is politically rational and efficient is not always accurate. As a result they may resort to received wisdom, ideology and inaccurate 'heuristics' to guide policy design (Wiener, 1995: 233; Kahneman and Tversky, 1979). If they are to anticipate the consequences of policy action more readily and provide information to reduce uncertainty in the marketplace, decision-makers must find ways to develop more accurate policy heuristics. This is where evidence and experts come in. By engaging in analysis and with analysts – epistemic learning – decision-makers are better placed develop the peripheral vision they require.

The information production at the heart of epistemic learning carries significant material costs. There are also temporal barriers. The time constraints that decision-makers must negotiate and those that govern knowledge creation are very different. While decision-makers face political pressure to act now, research into the different scenarios that may flow from policy action can stretch out indefinitely – there is always something more to be learned and taken into account about a policy problem and the proposed solutions. Mining the analytical capacity already established by industrialised governments for which the costs have already been sunk – domestic research services and international specialist agencies for example – is a way to mitigate these barriers. International players such as the International Energy Agency (IEA) already show early signs of becoming an epistemic hub around which national regulators can converge for substantive advice as well as proactive lobbyists for emerging technologies.

Governments are also making significant new investment into learning about the pros and cons of technological responses to climate change and energy insecurity. Much of this takes the form of specialist domestic and transnational agencies and institutions that have been established to commission research. Of course having the knowledge is one thing; using it is

quite another. The example of biofuels and the UK's RTFO illustrates that taking an evidence-based approach to weighing the pros and cons of competing trade-offs is a matter of political will as opposed to lack of information. The defence that such risk trade-offs were inadvertent at the time initial targets were set is undermined by the fact that decision-makers who are now armed with a growing body of evidence of the additional adverse outcomes that are arising have been slow to reform their approaches or build headroom into policy targets to allow for the rebound effects. Most notably, the formulation of sustainability clauses to limit the cultivation of 'bad' biofuels and require producers to prove that their biofuels are not the product of damaging agricultural practices (Council of Ministers, 2008) is not expected to come into force until 2011 at the earliest. Environmentalists and scientists argue that in the meantime irreversible damage may be done (Monbiot, 2005; Barlow, 2007). The implication of transferring and transforming risks in the biofuels case is that in the short term it is acceptable for some groups to bear more risk than others. Such choices are inherently political but to be credible and legitimate they require evidence that the benefits of pressing ahead without sustainability criteria justify the costs implied by the use of unsustainable biofuels. Despite the growing evidence based on the subject, such cost-benefit analyses are yet to be conducted by government.

Thus substantive knowledge creation is not an end in itself. For real epistemic learning to take place and for evidence to have policy-relevance, decision-makers must ensure that it is used to inform the analysis of the policy choices under consideration. Industrialised countries are certainly well placed to make this happen using the analytical tools – notably impact assessment and risk analysis – that have become commonplace in the last two decades. Thus far, however, very little commitment has been shown to risk-based philosophy in relation to

the countervailing risks that flow from policy tool selection which aims to harness the potential of the land.

[b]Social Learning

Innovation requires invention and capital (Schumpeter, 1942). As the parties who fund and bear the consequences of policy action and, by their reaction to a policy intervention, are the source of many countervailing risks, citizens are often best placed to remind governments that innovation cannot be at any cost and that social capital is as essential to making inventions work as financial. While decision-makers acknowledge that ‘[P]ublic acceptance is an issue that is almost as dire as financing and in relation to technologies such as CCS, will become more and more critical as we try to implement the projects’ (Panek 2008, p21¹⁵) it is marked however how rarely public voices have featured in policy tools selected by governments. Lay people and experts process risk in very different ways (Slovic, 2000). In order, to anticipate how citizens will respond to regulation, it is essential that decision-makers understand that the political environment within which they operate has a strong ‘public’ dimension (May, 1991) and accept the need to engage in reflexive dialogue or social learning (Sanderson, 2002).

A key challenge of social learning concerns timing – when should dialogue begin and when should it end? Consultation processes that invite citizens to comment on policy proposals are the pre-eminent way in which decision-makers draw lessons from society. Such an approach can only go so far however. Often occurring ‘downstream’ in the policy process – after policy goals have been settled and technologies’ trajectories been ‘black boxed’ (Collingridge,

1980). – consultation exercises can limit citizens contributions to commenting on the strategies that have been selected rather than the fundamental policy objectives.

The developmental nature of many of the technologies that implicate the land offer decision-makers important opportunities to make citizens a core part of the innovation process by going beyond the orthodox approach and engaging citizens in the ‘upstream’ before policy choices are actually made (Latour, 1997) and in the evaluative processes after pilots have been implemented.

Social learning can also be generated through the selection of policy tools that directly implicate citizens. By adapting market-based policy instruments to also empower citizens, some governments have begun to engage in a reflexive dialogue. The most high profile example of such a policy mechanism with implications for land use that links the market to society are feed-in tariffs (FiTs). Widely used across Europe (18 countries at present), FiTs are the main policy alternative to subsidies and certificated incentive mechanisms. By requiring energy companies to buy renewable electricity which is exported to the grid at rates above market value, this system gives energy suppliers the long-term certainty they need to invest in renewables and gives citizens, farmers and small businesses the confidence to diversify their own land by installing renewable energy systems to sell back any excess power to the grid. Research tells us that citizens often readily accept the need for renewable technologies but are opposed to land use changes that impact upon their local community. Yet where such changes do take place local communities often change their minds (Upreti, 2004). By democratizing the economic potential of the land, policy instruments such as FiT allow citizens to control directly how they engage with renewables, boosting buy-in and helping to engender confidence in technologies. Much of the success of anaerobic digestion and wind turbines in continental Europe and mainstreaming of land diversification strategies

in new house design – in particular in Austria and Germany – has been attributed to the security and civic involvement provided by the guaranteed premium energy prices provided by FiTs (Broer and Worthington, 2008; Needham, 2007)¹⁶.

The ‘omitted voices’ (Wiener, 1995) of electorates are not the only ones to which decision-makers aiming to develop their peripheral vision would find it useful to attend. The potential for risk transfer and transformation illustrates the importance of how policy action is experienced by citizens beyond decision-makers’ immediate political radar. The importance of this is probably best understood in relation to knowledge transfer projects where consortia of countries, industry and Universities work in partnership to site large R&D initiatives in the industrialising and developing world. For example, the UK CCS initiative, Near Zero Emissions Coal (NZEC)¹⁷, is currently exploring the feasibility of building coal fired power plants in sedimentary basins in China. To address public acceptance issues, the initiative plans to dovetail with the EU’s Cooperation Action within CCS China-EU programme (Coach). The greater challenge will be for governments to engage with communities whose cooperation they do not need and whose bargaining power is weaker.

[b]Institutional Learning

As well as learning from experts and citizens, governments can learn from their own experiences and from those of other governments. When faced with a pressing problem, ad hoc policymaking is always a danger. The risk of countervailing risks increases where decision-makers select policy instruments without consideration of the context within which they are to be applied, or of lessons that might be drawn from previous experience or other jurisdictions, and how efforts might be coordinated internationally.

Given that there are very few new policy instruments for governments to try, to exploit the land in ways that achieve the so-called ‘risk superior options’, decision-makers increase their chances of success by combining instruments to create bespoke ways of delivering technologies that address both the target risks and potentially significant trade-offs. For example, to move CCS beyond pilot stages to commercial operation, emissions schemes can be supplemented with other policy tools – for example mandatory compatibility on future plants, tax breaks or targets. In relation to the latter, Japan has become a significant contributor to the global development of CCS by setting the target of 200 million ton a year cut (half in Japan, half overseas) in CO₂ emissions using CCS technologies and underpinning these with government funding of the demonstration phase of the technology until the cost of reducing emissions reaches US \$26 per ton (Innovation Norway, 2008).

Part of the move to more sophisticated cocktails of policy instruments has, of course, been stimulated by the direct experience of countervailing risks thrown up by initial policy choices. For example, decision-makers now acknowledge that the leap of faith required for companies to invest in risky technologies is perhaps too wide (Panek, 2008). In the case of CCS in the EU, it has been proposed that plants with CCS are regarded as not having emitted – thus imposing costs only on those power plants that are not CCS compatible and reducing the likelihood that old equipment will be kept in use (European Commission, 2008)¹⁸. Similar lessons are being drawn from the EU experience elsewhere¹⁹.

Identifying the optimum instrument mix or innovative policy solutions is not necessarily straightforward. For example, the market distortion and countervailing risks, that have been the result of biofuels targets coupled with subsidies, highlight the difficulty in achieving a palatable mix. Bolting on sustainability criteria and setting quotas for second generation biofuels not made from food crops is expected to militate against some of the most obvious

countervailing risks. But these correctives will not address the loss of revenues for other innovations. Thus, the mix here will be far from perfect but is superior to the current situation. Similarly, reverse auctions – where industry bidders requiring the lowest amount of public money are subsidized – have been suggested as a cost-effective way to inject market discipline into subsidizing the development of second generation cellulosic biofuels. Convincing the private sector that it should bear the development risks, accept low incentives and technically develop the auctions are challenges which cannot be met overnight (Koplow, 2006)²⁰.

An awareness of the work being done by colleagues in other jurisdictions and sharing of data is an essential part of institutional learning. This is especially true for technologies which carry the greatest knowledge deficits where wide-scale deployment can only be achieved once a broad base of knowledge of what works and what does not is established (Wilson et al, 2007). Decision-makers are beginning to recognise the importance of pursuing complementary strategies. For example, the decision by the UK's Department for Business, Enterprise and Regulatory Reform's (BERR) to restrict its CCS competition to post-combustion on coal was based on the fact that a gap in this particular form of carbon sequestration existed on the international research landscape. Moreover, a key criterion for success of a bid will be the inclusion of initiatives for information sharing (Northmore, , 2008²¹).

[a]Conclusions

The choice of policy strategies is not dispassionate; it is political and reflects the prevailing value hierarchies of a polity and the roles these ascribe to markets, citizens and rules. The aim

of this chapter has been to analyse the impact of the choices that have been made so far in the regulation of climate change and energy diversification with respect to technologies that implicate land use change. The question of why certain policies have been selected over others has not been addressed (though this is important of course). The wide-ranging reconnaissance of government interventions presented here underlines the embryonic state of policy responses and, given that, it would be unwise to draw any specific conclusions on future land use patterns. This survey does however highlight two fundamental challenges with which decision-makers must get to grips if they are to produce more complete risk governance.

The discussion of the pre-eminent policy interventions, and their often ad hoc and opportunistic nature, suggests that, in their early policy responses, decision-makers did not fully recognise that when they act they affect two levels of risk: target risks at the first level and the countervailing risks that flow from government intervention at the second. Reality has intruded however. The quick wins promised by first generation biofuels have been spectacularly displaced by excessive technological lock-in and undesirable trade-offs with food, the environment, vulnerable populations and climate change itself. The sheer scope and range of the side-effects created by government policies encouraging land use change for fuel crops has the potential to become a sort of cognitive tipping point that forces decision-makers to confront the interconnected reality which they must negotiate.

Recognition of the complexity of the task they face and considering the implications of this in policy design are not the same thing of course. To analyse these trade-offs and reduce uncertainty about policy action, decision-makers must be willing to engage with a variety of sources of policy learning. This palliative to countervailing risks can itself be seen as a risk trade-off. Learning from experts and society and reflecting on experience are not cost free

exercises; they can delay policy action and increase the range of conflict around decision-making.

Learning can go much further of course. Organizational analysts exhort decision-makers to engage in ‘double loop’ learning (Argyris and Schön, 1978) where the fundamental assumptions of how problems are approached and solutions exploited are explicated and, where necessary, revised. Given the complexity of getting mainstream policy programmes off-the-ground (even where there is political will), double loop learning encourages thinking the unthinkable and, in so doing, threatens to undermine accepted ways of addressing policy problems. It is the political equivalent of the circus high wire. Adopting the spirit of double loop learning however, where goals are capable of being adjusted and the selection of policy tools problematised, may serve as an antidote to the wishful thinking that underpins some of the more ad hoc policy selection and improve decision-makers’ peripheral vision.

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¹ The economic impacts of externalities have long been analysed by economists. However risk trade-offs are a wider phenomena – encapsulating all the possible side-effects of regulations designed to mitigate adverse outcomes. The idea of risk versus risk was first outlined by Lave (1981) and an analytical framework was first articulated in Graham and Wiener (1995) and Viscusi (1992).

² For a detailed view of risk transfer and substitution see Whipple (1985).

³ This concept is sometimes referred to as the ‘Jevons paradox’ which was formulated in the mid-19th century Britain in relation to the impact of changes in coal consumption (Jevons (1906) [1865]). In their report 2007 *The Rebound Effect*, the UK Energy Research Centre (UKERC) offers one of the most in-depth reviews of the literature and concludes that while the evidence base is weak, rebound effects should not be discounted by decision-makers but rather more empirical studies and economic modelling of the impact of policy targets is required <http://www.ukerc.ac.uk/Downloads/PDF/07/0710ReboundEffect/0710ReboundEffectReport.pdf>

⁴ See Foxon, (2003) for a review of the innovations systems literature.

⁵ For more on the Western Climate Initiative (WCI) and regional Greenhouse Gas Initiative (RGGI) see http://www.westernclimateinitiative.org/WCI_Documents.cfm and <http://www.rggi.org/> Both these schemes could be overtaken by a federal cap-and-trade scheme proposed by Senators Lieberman and Warner.

⁶ This may also precipitate the establishment of an independent international energy agency making the value of carbon must be more predictable and investment more attractive.

⁷ A comprehensive assessment from the IPCC (2005) working group III estimated this at around 25% and a 2007 UN report estimated the increase in costs as lying anywhere between 40% and 90% (cited by Harris, 2007).

⁸ Lars Stromberg is Director of Vattenfall and Bert Metz of IPCC work group III.

⁹ The construction of a regulatory regime to ensure that new coal-fired power stations are CCS compatible is underway in the EU, however the US plans no such demand. States such as Nevada have introduced a compromise whereby firms must sign Memorandums of Understanding (MOUs) with the Nevada Division of Environmental Protection (NDEP) that once CCS becomes commercially viable they will engage in carbon capture (Las Vegas Sun, 2008 in *Carbon Capture Journal*, 2008 1, 1: 11).

¹⁰ For example, in January 2008, the US announced that it was cancelling its involvement in TransGen and restructured its financing of FutureGen Alliance’s coal-fired plant.

¹¹ Renewable Fuels Association (US) reports that 134 ethanol plants currently in operation in the USA as compared with 50 in 1999.

¹² See MacKenzie (2007) ‘The Political Economy of Carbon Trading’ in *London Review of Books* for a more general discussion of Zelizer’s hostile world’s thesis and carbon trading.

¹³ For more on pyrolysis see Van Loo and Koppejan (2008).

¹⁴ The short rotation coppice (SRC) planted for that project is now being used in co-firing at the Drax Power Station in North Yorkshire, UK. Drax Power is now advertising for producers of SRC, Miscanthus and rape grown within 50 miles of Drax power station to supply them through long-term contracts.

¹⁵ Jan Panek is Head of Unit, Coal and Oil, for the European Commission,

¹⁶ For an in-depth appraisal of FiTs see Menanteau et al (2003).

¹⁷ NZEC is funded by the UK Government through DEFRA and BERR and is coordinated by AEA Energy & Environment (UK) and ACCA21 (China).

¹⁸ There are those within the CCS industry who want these proposals to go further and operate a ‘double credit’ whereby CCS power plants are allocated an additional allowance that can then be sold on.

¹⁹ For example, both Australia and New Zealand plan similar clauses for their nascent trading schemes http://www.med.govt.nz/templates/ContentTopicSummary____38284.aspx

²⁰ The 2005 United States Energy Policy Act made \$250 million available to establish a reverse auctions programme (Sec. 942).

²¹ Bronwen Northmore is Director of the Cleaner Fossil Fuels Unit, BERR.