SPRU
Science and Technology Policy Research

SPRU Electronic Working Paper Number 184

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March 2010

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Draft SEWP 23 March 2010

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Keywords: low carbon innovation; socio-technical transitions; grid-group cultural theory.
JEL codes: B; O; Q.

Abstract

Low carbon innovation policy is in flux. The neo-classical economic paradigm that has dominated energy policy in recent decades is loosening its grip under the challenges decarbonisation present to energy systems. Other frameworks for interpreting and responding to those challenges are available. We can see this plurality evident in the UK Low Carbon Transition Plan, where neo-classical approaches sit alongside more interventionist industrial strategy and initiatives for engaging civil society in energy restructuring. Amongst the issues that implementation of the plan will involve, we highlight four as especially critical. These are: negotiating technological priorities and portfolios; long-term signals and adaptable policy; social innovation and technology fixes; and the roles of incumbents and outsiders in energy system transformation. We focus on two heuristics for interpreting these issues – the multi-level perspective in socio-technical transitions theory, and grid-group cultural theory. Both indicate how the framing of any issue has important consequences for subsequent policy actions.

Our analysis does not advocate one heuristic over the other. We should be wary of any framework that claims to definitively and comprehensively incorporate all dimensions to the LTCP. Rather, we suggest a more reflexive and thereby constructive dialogue over LCIP is possible when the underlying heuristics informing different perspectives are made more transparent. Reflecting upon these heuristics might improve the inevitable politics of low carbon transition by enhancing mutual understanding, identifying common ground, respecting differences, and hopefully improving the legitimacy of what are likely to be wide-scale and deep-seated changes to our energy systems and our lives.

1. Introduction

Low carbon innovation policy (LCIP) in the energy sector is in the making and its framing is contested. A neo-classical economic paradigm in energy policy is increasingly unsettled by the challenges of decarbonisation. Reliance upon market mechanisms remains strong, but a suite of new policy measures see the state intervening in the provision of innovation content much more directly, such as prioritising technologies, rather than policy setting contextual frameworks and allowing the market to fill in the content. At the same time, but on a smaller and more tentative scale, civil society is being engaged in LCIP through a number of initiatives to promote energy projects in local communities. This is about energy sustainable energy citizenship rather than atomised consumers. Each of these initiatives is embedded in other overlapping discourses, principally those of 'climate', 'energy', 'industrial', 'community' and 'innovation' policy. Each makes assumptions, bounds, and understands LCIP issues in ways different to the free market 'certainties' under the neo-classical paradigm. The UK presents a particularly interesting context in which to understand, deliberate and formulate LCIP, in part because these discourses sit uneasily with one another and with the UK's economic liberalisation legacy.

Taking recent developments in UK LCIP as our point of departure, we discuss the new Low Carbon Transition Plan (LCTP) (HM Government, 2009). Whilst the economy (and society) as a whole is the object of LCTP ambitions, it is the energy sector that is a major focus. Not simply because it is currently a major source of emissions, but also because it powers so many other areas of the economy and our lives. Whilst still rooted in a neo-classical economic paradigm, the LTCP is nevertheless informed by additional perspectives that see the challenge differently to internalising market failures through price corrections. There is a strong element of industrial policy in the LTCP, whose strategy justifies the state as nurturing infant low carbon industries; and there is an element supporting local community solutions, in which sustainable energy innovations derive from civil society networks. Meanwhile, the overall ambition for a low carbon transition to a new kind of economy (and society) suggests a problem framing way beyond the market scale. So there are a variety of 'framings' within the LTCP (Schön and Rein, 1994). Each of them bounding the systemic problem of decarbonisation differently, understanding causes and consequences in different ways, each seeking different solutions, and justifying them on different grounds.

In this paper we argue that understanding the implementation of the LTCP (and especially its political dimensions) can be informed by appreciating the different heuristic frameworks that are in play. We illustrate this by contrasting two heuristics as alternatives to the neo-classical paradigm in energy policy. These are the multi-level perspective in socio-technical transitions theory (MLP), and grid-group cultural theory deriving from anthropology (GGCT). We use each to

explore how their different understandings of LCI lend themselves to different policy prescriptions. This is done by addressing four critical issues that earlier work with stakeholders led by SPRU recognised as significant challenges for LCIP, and which the LCTP is now addressing (Kern *et al*, 2008). These critical issues are: negotiating technological priorities and portfolios; long-term signals and adaptable policy; social innovation and technology fixes; and the roles of incumbents and outsiders in energy system transformation.

Neither of the heuristics is necessarily better than the other. Others could have been included, such as practice theory (Shove and Walker, 2010). Nor do we advocate one heuristic over the other. Rather, our purpose is to anticipate how constituencies drawing upon those heuristics will engage with the LCTP in different ways, and that thinking about how they frame the LCTP will help us understand some of the politics of its implementation. As such, this paper is aimed at researchers, policy-makers and practitioners interested in LCIP in the energy sector.

Exploring alternative heuristics to the free market model also has potential value in emphasising ongoing issue framings in low carbon transition policy that would otherwise remain implicit and hidden. Emerging policy practices demand consideration of the potential for new heuristics that better address socio-technical and cultural dynamics in low carbon transitions. Like the free market model, any such heuristic needs to have wide appeal for understanding and justifying policy issues, deliberations, positions and initiatives. Ideally, in addition to illuminating important dynamics, they should have clear readability for normative implications, and ideally have some fit with stakeholders' prior mental furniture.

2. The UK Low Carbon Transition Plan: a loosening of the neo-classical economic paradigm?

In 2009 the UK government announced ambitions and initiatives for a 'low carbon transition' (HM Government, 2009). Prior to this climate policy was pursued largely on the international stage through diplomacy, which has informed domestic level target setting. While it has developed some market mechanisms, international climate policy making formed under Kyoto arrangements has (rightly or wrongly) been criticised as ineffective so far as actually cutting emissions, and as excessively bureaucratic or 'top-down' in focus (Verweij et al, 2006; Prins and Rayner, 2007a). Meanwhile, on the domestic UK political stage, neo-classical economic emphasis on the short-run efficiencies of free market provision of goods and services justified a principle of disinterest in energy and innovation policy, particularly in its social and cultural dimensions. On these grounds from 1992 to 2009 the UK had no energy ministry and public R&D budgets declined severely.

2.1. LCIP under the neo-classical economic paradigm

Until the LCTP, a neo-classical economic understanding of innovation was rationalised using simple policy heuristics like 'not picking winners' and the 'linear model of innovation'. However limited such a model may appear in ordering thinking around innovation policy, its use is noteworthy because it does represent an attempt to unpack innovation dynamics to some extent (Scrase and MacKerron, 2009), most notably in international forums and in countries like the UK. Taken simply to its conclusion, this economic theory sees little role for the state in relation to innovation other than to enable competition (e.g. 'cut red tape') and to correct for certain market failures. Here a conceptual schemata based on perfect competition (well defined property rights; many small, perfectly informed actors engaged in free market competition and so on) has predominated.

Free markets are recognised to fail in under-rewarding investors in R&D, and in not internalising external social costs such as those caused by carbon emissions. Some support for basic R&D in low carbon technologies and the use of market mechanisms to price carbon are therefore justified (Watson, 2009). However a principle of disinterest prevails – government should take a 'hands off' approach, for example avoiding 'picking winners' wherever possible. Assumptions are made that innovation will simply happen if markets are operating efficiently, and whatever innovation emerges will be for the good of progress. This justifies a situation in which society as a whole has little say in the composition or overall direction this innovation or progress might take.

This free market model displays some elements of what makes it alluring for policy purposes. The free market model describes empirical phenomena and dynamics (market entry and competition, innovation to gain competitive advantage) in an idealised form with clear normative implications: respecting the model's dynamics is held to be good for society. Idealised markets in the model are welfare maximising, and therefore any policy action beyond correcting for market failures is likely to reduce efficiency and be detrimental to overall welfare over time. Clear boundaries are drawn between activities of the market and legitimate policy intervention in it. Innovation is conceived as a private sector concern, with its own dynamics and equilibriums, and thus minimalist interests in innovation or its significance for the *direction* of 'progress' are justified.

In simplistic free market models, people are understood as atomised, rational, utility seeking individuals, and therefore the 'social' realm is largely an irrelevance. However with respect to certain policy goals people may be seen to act with imperfect information. This will inhibit enlightened rationality and proper competition, so there is a role for government in providing better information. In this extreme form we can now caricature the free market model's normative prescriptions regarding low carbon innovation, including its cultural dimensions as follows. Government should: 'cut red tape' and remove the 'dead hand of the state'; provide information to influence the 'behaviour' of atomised individuals;

'get the prices right', preferably through market mechanisms; support some basic R&D but not try to 'pick winners' through investments or regulations.

This approach dominated UK energy policy until 2008. Despite criticisms that the linear model is an unrealistic representation of the complex dynamics of innovation (Dosi *et al*, 1988), the linear model remains central to justifications for targeting policies (Balconi *et al*, 2009) and institutional remits (e.g. UK Low Carbon Innovation Forum, Carbon Trust, ETI, TSB). These remain key elements in the new LCTP. However, growing awareness of the scale of re-investment needed to transform our energy systems into more sustainable and secure forms, and only limited signs that the markets were rising to the challenges, were prompting a re-assessment of the roles of the state. The situation changed significantly in 2009, in which the LCTP was announced.

2.2. The Low Carbon Transition Plan: up for the challenge?

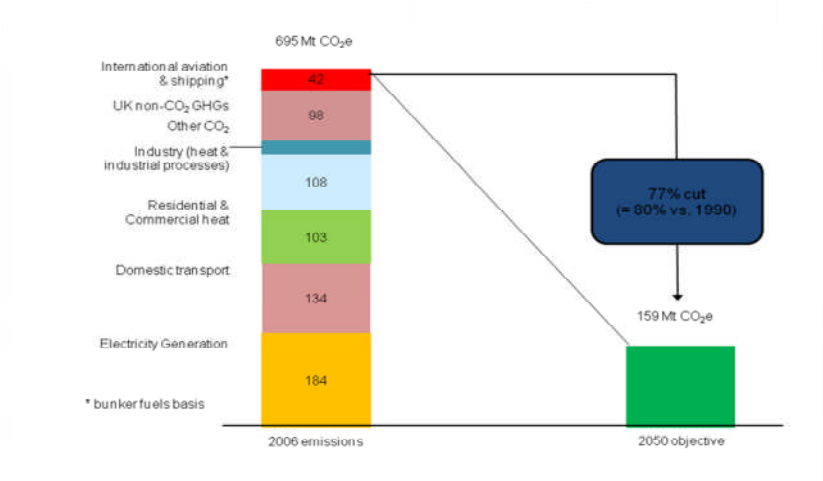
To interpret the LCTP as the substitution of the neo-classical paradigm for a self-contained alternative would be wrong. The LCTP was no revolution. Neo-classical economic thinking still informs much at the core of the plan. The principle driver behind the planned activities is an effective carbon price achieved through the European emissions trading scheme. However, it is debatable whether price signals alone will smoothly generate the extensive reconfigurations of infrastructures, technologies, and practices implied by ambitious carbon reduction targets that the LCTP addresses. Nor is it clear price signals can do this without rising to levels that risk serious political and social disruption (given historical UK experience with fuel price protests and fuel poverty issues). The LCTP recognises this, and so complements its commitment to emissions trading with a series of demonstration and deployment subsidies, information and advice programmes, planning procedures and grants across a range of activities that will (hopefully) improve the elasticity of innovative responses to carbon prices.

The LCTP sets out measures for how government envisages the UK achieving emissions reductions of 18 per cent on 2008 levels by 2020, and with a longer-term objective of 50 per cent reductions by 2050. When one considers the scale of carbon emission reduction ambitions (see Figure 1), then it soon becomes apparent that we not only talking about some incremental greening around the edges of our daily energy practices. Difficult as it is to re-orientate innovation systems towards providing a flow of lower carbon energy goods and services, it still might not be sufficient. Indeed, the diffusion of these goods and services is facilitated by wider infrastructural and institutional change (Elzen *et* al, 2004). Ultimately, we are talking about the sustainable, low carbon transformation of entire sectors. This implies not just low carbon products, but low carbon infrastructures and institutions too. In the energy domain, this means that new institutions for governing sustainable transitions have to be developed in a context of existing (neo-classically informed) institutions, whose development

was concerned with the liberalisation of existing energy systems rather than their transformation into low carbon forms (Smith, 2009).

Historical studies note that these kinds of transition have been drawn-out over periods of 50 or more years, and suggest we might expect the same timescales for future transitions (Geels and Shot, 2007). This is dispiriting compared to the urgency to mitigate that scientific consensus suggests is needed in order to avoid dangerous climate change. Historic transitions include a long period of experimentation, demonstration and constituency building, before achieving the institutional and infrastructure reforms that enable a take-off of the novel practice. Arguably, we have had 30 years of experimentation with some transformative energy technologies that are also low carbon – so perhaps there are reasons to be hopeful, *if* institutional reforms remove uncertainties and commit to these alternatives rapidly (Scrase and Mackerron, 2009).

Figure 1 The decarbonisation challenge in UK policy (source: Committee on Climate Change, 2008).



The kinds of institutional reforms proposed in the LCTP include: the prioritisation of RD&D in specific areas, including low carbon vehicles and marine renewables; financial support for offshore wind, microgeneration, and carbon capture and storage; favourable planning procedures for nuclear energy and large energy infrastructure projects; consultations for developing smart energy grids; and schemes to help local communities and households become more actively low carbon in their energy practices. These institutional reforms are beginning to manifest in a series of initiatives, such as loan guarantees and investment subsidies for car manufacturers in the UK, the creation of an agency to co-ordinate carbon capture and storage investment, the development of national land use plans for the energy sector.

However, the plan and these activities remains a package of measures, rather than a coherently co-ordinated programme. The prospects for each specific

measure are tied to the framing assumptions informing that measure. One can aggregate the carbon reductions from each measure, but this form of comprehensive, plan-level analysis does not consider in depth how each measure will interact with the other measures. Moreover, the assumptions in each measure may not be mutually compatible. Were community energy measures to succeed and diffuse widely, for example, then would this require ownership models and energy infrastructures quite different to those presumed to persist under the revival of nuclear energy? How to ensure a productive co-existence?

There is no explicit theory of transition underpinning the measures in the LCTP, other than an implicit assumption that adjusted or supported price mechanisms, working through friendlier planning frameworks, addressing better informed consumers, who inhabit willing communities, will be sufficient. Here we see the continuing influence of the neo-classical paradigm. As pro-active and aspiring as the UK plan is, it remains rooted in a particular vision of change, and which historic research into transitions suggests captures only part of the picture. Other heuristics can highlight other aspects of the decarbonisation challenge confronting LCIP, and suggest alternative ways of taking the LCTP forwards. The remainder of this paper argues why a more plural approach to the LCTP could be fruitful for its future implementation.

We do not advocate searches for a comprehensive new paradigm to inform low carbon transitions. We should be wary of any framework that claims to definitively and comprehensively incorporate all dimensions to the LTCP. Rather, we are suggesting a more reflexive and thereby constructive dialogue over LCIP is possible when the underlying heuristics informing different perspectives are made more transparent. Reflecting upon these heuristics might improve the inevitable politics of low carbon transition by enhancing mutual understanding, identifying common ground, respecting differences, and hopefully improving the legitimacy of what are likely to be wide-scale and deep-seated changes to our energy systems and our lives. If anything, this approach is more ambitious and challenging for theory, since it requires debate about which theories are appropriate and work best for specific transitions issues and instances, and, more significantly, how theory-informed policies relate to one another, and what implications they have for other transition processes elsewhere.

3. Policy heuristics: the MLP and GGCT

Simon (1976) argued that decision-makers and others operate under bounded rationality, which requires the construction of simplified mental models. On a routine level this may involve simple rules of thumb, and reasoning by analogy or metaphor. When faced with complex strategic questions such as those around low carbon innovation, problems are often thought through, deliberated and justified with reference to heuristic schemata for certain underlying dynamics.

The hold that free market welfare economics has had over energy policy in recent decades illustrates how significant and powerful such heuristics can be in this field. Shortcomings in this framing point to the potential value in considering alternative heuristics, two of which – the MLP and GGCT - are outlined below. Reflecting this paper's interest in policy deliberations rather than theory development, each heuristic is no more than a sketch for the purposes of LCIP interpretation (the same is true of our broad-brushed characterisation of the neo-classical paradigm). None gives a proper sense of the nuanced debates found in the wider literatures from which they are derived.

3.1 The multi-level perspective on socio-technical transitions

The 'multi-level perspective' on socio-technical transitions (Geels, 2002, 2004) draws together insights from diverse academic traditions, including evolutionary economics (e.g. Freeman and Perez, 1998), social constructionism (e.g. Bijker, 1995), historical studies of innovation processes (e.g. Hughes, 1983) and sociology (e.g. Giddens, 1984). The heuristic we are interested in here is represented in Figure 2.

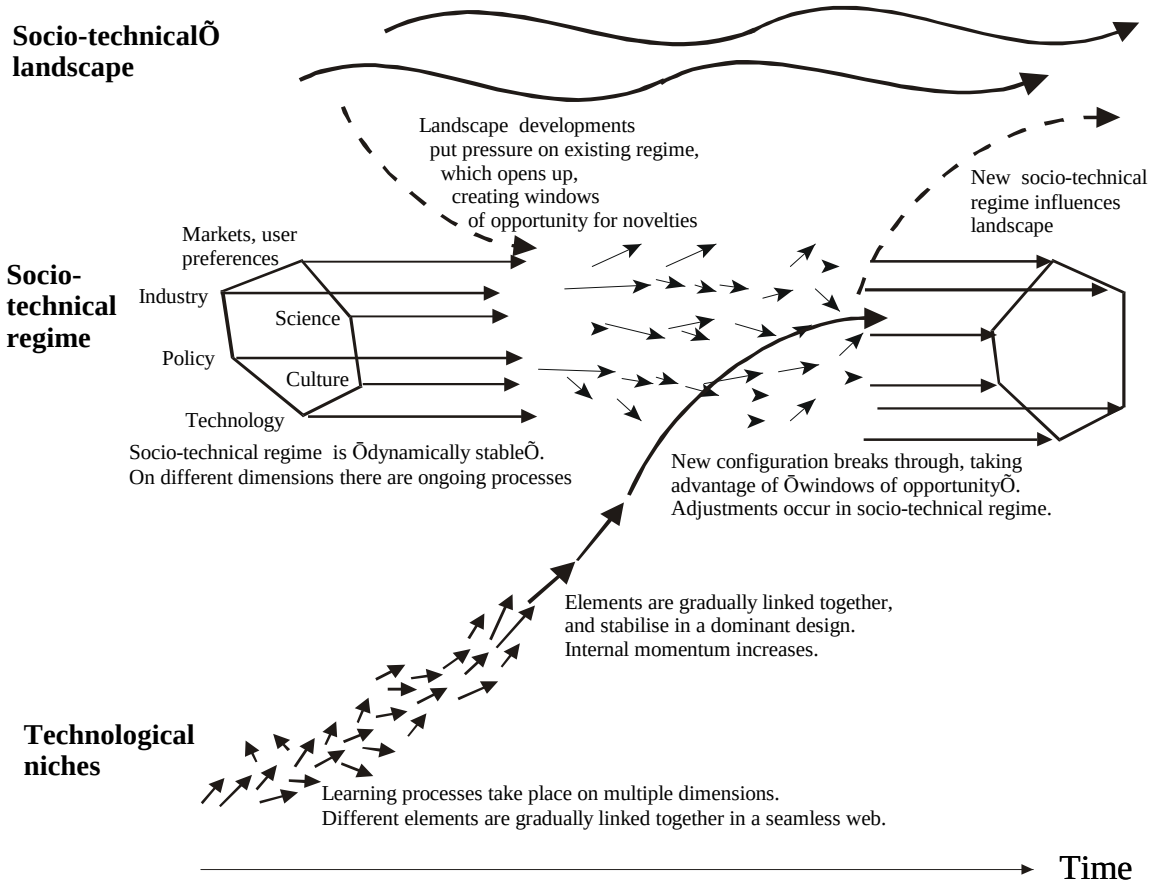
Freeman and Perez (1988) distinguish four levels of innovation, moving from a firm-level focus to dynamics at the level of entire economies. These levels are 'incremental innovation', 'radical innovation and product discontinuities', 'change of technology system' and changes in the 'techno-economic paradigm'. The MLP is intended as an "analytical and heuristic framework to understand technological transitions" (Geels, 2002, p. 1273) at the third of these levels - defined here as the level of 'socio-technical regimes' (Geels, 2002) rather than 'technology systems'.

The MLP's main applications have been in empirical historical research on transitions in areas such as transport and sanitation (see Geels 2005a; 2005b; 2006; 2007). Other empirical studies have used the framework to explain the (limited) influence of green alternatives (niches) over time, such as organic food and eco-housing (Smith, 2007). It has also been used in normative policy analysis, for example in advising the UK Department for the Environment on ways in which it might better stimulate 'transformative innovation' in sectors such as food and farming (Scrase et al, 2009). More significantly, the MLP is central to a wider literature on 'transition management' that has shaped the Dutch government's embryonic transitions policy for sustainability (Rotmans *et al.*, 2001; Kemp et al, 2007; Smith and Kern, 2009).

The heuristic in Figure 2 is explained below in a minimal way sufficient for the uses to which it is put in this paper, and its main implications are then noted. There are three levels of analysis, and these are seen to co-evolve over time, from left to right in Figure 2. Note below that 'regimes' and 'landscapes' both have cultural dimensions. The MLP proposes a 'structuration' (Giddens, 1984)

argument, in which agency and structure are two sides of the same coin (Geels, 2002). Thus culture has a structuring effect on socio-technical regimes, which is manifested in local practices and cultures, which in turn change the structural (including cultural-structural) context for subsequent agency.

Figure 2 Schematic of the multi-level perspective on socio-technical transitions.



Source: Geels (2002)

The 'socio-technical landscape', then, is a slowly changing overarching level 'consisting of a set of deep structural trends' (Geels, 2002a, p. 1260) which are 'technology-external' and are assumed to be beyond the unilateral influence of actors at the lower 'regime' and 'niche' levels (Rip and Kemp, 1998). This landscape 'contains a set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, *cultural and normative values*, environmental problems' (Geels, 2002a, p.1260, emphasis added). To illustrate, nineteenth century political and economic liberalisation in Britain is described by Geels as a 'landscape process' (Geels, 2002, p. 1265). For the purposes of the heuristic this is understood as an evolving context or structure within which regime and niche level agency is exerted. Note that 'cultural and normative

values' are mentioned at this landscape level, so certain cultural dynamics are identified as slowly evolving elements of structural context.

The 'socio-technical regime' is the central focus in this approach. It is understood as a dynamically stable system operating within the 'landscape', such as our energy systems. In stable socio-technical regimes various groups' roles and rules of interaction are well defined. Regimes are understood to have economic, technological, scientific, policy *and cultural* dimensions. The literature offers theoretical reasons and historical evidence to suggest that most innovation generated within a stable regime itself will be of an incremental nature. Regime actors are competing for small competitive advantages over one another, while also responding and contributing to gradual evolutionary change at the landscape level. Regimes are said to be 'locked-in' to certain technological pathways (which may be identified as unsustainable) when technical, social, economic and cultural mechanisms promote stability and resistance to change. Regime actors may actively resist potentially transformative innovations, bringing an overtly political dimension to regime 'lock-in'.

However, path-breaking and transformative innovations also emerge outside this 'regime' in protected 'niches' – the third level in the MLP heuristic. These are shown in Figure 2 as the small arrows gaining momentum around a dominant design, and when conditions are right (weaknesses within prevailing regime and/or external pressures from the 'landscape' unsettling the regime) penetrating and transforming that regime. The MLP also draws attention to the processes through which niche technologies develop into socio-technical configurations with sufficient momentum to precipitate such a transition.

A selection of the main observations the heuristic offers for LCIP include the following:

- Socio-technical regimes resist transformation (this is often referred to as socio-technical 'lock-in');

- However socio-technical transitions do happen, and their dynamics can be explained in a general way;

- Niche technological uses are always important in such transitions, but their role in regime transformation is also dependent on higher-level dynamics and structures.

In interpreting the LCTP through the MLP heuristic, one therefore seeks evidence for how the various policy measures will contribute to multi-level transition processes. The LCTP should be assessed for the way it nurtures and develops low carbon niches, including empowering the constituencies advocating these niches. The extent to which the LCTP is unsettling incumbent energy regimes is another feature valued under the MLP heuristic, thereby opening opportunities

for promising low carbon niches. Finally, the MLP is interested in how the LCTP articulates together this creation of low carbon alternatives and destruction of carbon intensive practices, such as measures that support the translation of niche ideas and practices into more mainstream markets, and made promising by regime unsettling. This is quite different to a neo-classical economic reading of the LCTP. It is also quite different to GGCT.

3.2. Grid group cultural theory

While the MLP is part of an intellectual tradition rooted in Schumpeterian economics, GGCT has its intellectual roots in Weberian and Durkheimian sociology. British anthropologist Mary Douglas initially proposed *grid-group analysis* as a 'crude typology' in the 1970s (Douglas, undated, p. 2) to explain the distribution of social values in societies and the kinds of social organisation each upholds. It has been applied to questions of innovation policy (e.g. Schwarz and Thomson, 1990; Ney, 1999), climate policy (e.g. Verweij et al, 2006) and the idea of sustainable transitions (Tukker and Butter, 2007). It has also been used to gain insights into the development and use of scenarios in the UK's Foresight Programme (Eames and Skea, 2002).

The two-by-two grid and axis labels (see Figure 3) remain in contemporary GGCT, which has been developed since 1990. In Douglas' words, the "group dimension measures how much of people's lives is controlled by the group they live in… Apart from the external boundary and the requirement to be present, the other important difference between groups is the amount of control their members accept. This is measured on the other dimension: grid gives a measure of structure…Combining high or low grid and group scores gives four 'opposed and incompatible types of social control, and plenty of scope for mixing, modifying or shifting in between the extremes' (Douglas, undated, p. 3).

Figure 3 An early heuristic model for grid group analysis

high grid	atomized subordination	ascribed hierarchy
low grid	Individualism	factionalism
	low group	high group

Details as in Douglas, 1982, p.4

Combining the two dimensions gives four cultures within any community. First, high group and high grid indicates a 'positional' or 'hierarchical' culture associated with bureaucratic rationality. A relevant example here would be the culture of government bureaucracies engaged in regulating energy markets or investment. Second, low grid and low group indicates an individualist culture, associated with market rationality. An example might be the culture around oil

exploration and development, or in energy trading. Third, high group but low grid indicates an egalitarian, 'enclavist' or factionalist culture, associated with group-specific rationality akin to Weber's 'religious charisma' (Douglas, p. 3). An example here might be the culture within Greenpeace or the Centre for Alternative Technology in Wales. Fourth, high grid but low group indicates a culture of 'atomized subordination' characterized by a fatalist outlook. Examples here might be energy consumers who feel they do not effectively have a choice or any say about their energy consumption or fuel bills, less still about climate change policy.

According to Mamadouh (1999b), as a heuristic map Figure 3 GGCT makes three claims:

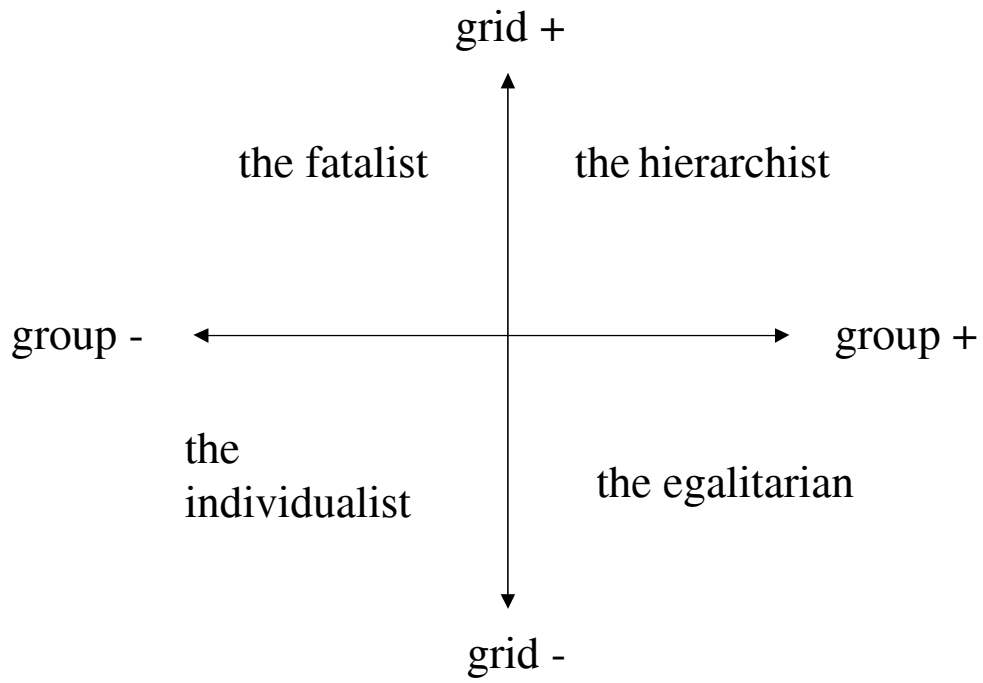
1. Culture matters – "Preferences and justifications shape the world of social relations. Everything human beings do or want is culturally biased."

2. There are a limited number of cultural types. A typology of cultures can be constructed that "includes viable combinations of patterns of social relations and patterns of cultural biases (or cosmologies). These combinations are often called (sub-)cultures, ways of life or rationalities, sometimes ways of organising, social orders, solidarities, political cultures, or simply types."

3. The typology of viable combinations is universal. "It can be applied anywhere anytime because the two dimensions of sociality grasp the fundamental nature of the social being… Grid-group analysts can therefore deduce preferences, attitudes and behaviours regarding all kinds of topics for each ideal type." (quotations from Mamadouh, 1999b)

GGCT was developed from these early ideas, by Douglas and her colleagues Steve Rayner, Aaron Wildavsky and Michael Thompson among others. Thompson et al (1990) developed GGCT as a dynamic theory. They "showed that any community has several cultures and that each culture defines itself by contrast with the others" (Douglas, p.8), and each competes with the others for members, prestige and resources. This can include competition over the framing and organisation of policy and ensuing measures. The form of the heuristic in Figure 4 presents the 'cultural theory' version of grid-group (see Schwarz and Thompson, 1990 for applications to 'technology, politics and social choice').

Figure 4 Cultural theory representation of grid group



Details from Schwarz and Thompson, 1990, p.7.

As a 'full explanatory theory' GGCT makes some additional propositions (Thompson et al, 1990). It also creates a 5th cultural 'way of life' – the hermit, who withdraws from the strictures of the other 4 possibilities.[i] According to Mamadouh (1999b) the four additional propositions in GGCT are:

1. The 'compatibility condition'. This "asserts that social relations (patterns of impersonal relations) and cultural bias (shared values and beliefs) cannot be combined contrary to each other: they must be mutually supportive. It implies both consistence and coherence: the first refers to the fact that both are patterned (a cultural bias is a consistent bunch of preferences) and the second that the two patterns reinforce each other."

2. The 'impossibility theorem'. This "states that there are five and only five ways of life (the ones deduced from the grid and group dimension) that are viable combinations of bias and relations."

3. The 'requisite variety condition'. This "alleges that ways of life need each other to be viable: because of its specific blind spots, each cultural bias leads to catastrophe if it is not 'corrected' by the others…In addition, each way of life needs its rivals to define itself against. There is interdependence: 'conflict among cultures is a precondition of cultural identity'. As a result, the authors assume the five ways of life to be present

in any society at any time, be it in various strengths and in various patterns of interaction. The competition between the ways of life is a state of constant disequilibrium: adherents are constantly moving from one way of life to the other."

4. The 'theory of surprise': "Ways of life are resistant to change, and events that do not fit the expectations raised by a way of life, are explained away. But the cumulative impact of successive anomalies or surprises (major, painful accidents) provoke a change of paradigm" (quotations in 1-4 from Mamadouh, 1999).

Hierarchs and egalitarians might form coalitions to maximise 'group' social relations, or individualists and egalitarians might form alliances to minimise 'grid'. However GGCT places more emphasis on relations between sub-cultures on the diagonals of Figure 3 or 4. Hierarchs and individualists are referred to as forming the 'the positive diagonal' or 'the establishment', while egalitarians and fatalists form the 'diagonal of withdrawal' or 'negative diagonal' (Mamadouh, 1999b).

If one was to choose key insights this heuristic take on GGCT offers to the current analysis of LCIP, they might include the following:

1. Behaviours, cultural biases and social relations are patterned in relation to one another, creating identifiable, interacting sub-cultures around any issue such as low carbon innovation.

2. Innovation and technology use should be understood as behaviours that are functional in upholding the social relations and cultural biases within a group's sub-culture.

3. When radical change occurs, the complexity of cultural dynamics is such that the form that change will take cannot be readily anticipated.

4. Asserting the values of just one cultural type (e.g. hierarchy) will have unintended consequences, and can threaten the legitimacy and viability of a policy approach.

In interpreting the LCTP through the GGCT heuristic, one therefore seeks evidence for how the various policy measures embody cultural biases and the ways they balance other cultural biases in order to permit action. Certain measures are more clearly associated with hierarchical perspectives, such as the centralising reform of land-use planning, and GGCT would look to the way this measure will accommodate the concerns of other cultural types, and on that basis anticipate the kinds of outcomes and degree of success that are likely. Similarly, GGCT associates community energy measures most strongly with more egalitarian cultural milieu, and would anticipate the implementation of this

measure through evidence for the extent, influence and position of this kind of energy citizenship in the UK compared to, say, individualist energy consumers.

3.3 Comparing the heuristics

Table 1 summarises some of the key differences between the mainstream neo-classical paradigm take on LCIP and the MLP and GGCT heuristics.

Table 1 Free market economic, MLP and GGCT insights for LCIP

	Mainstream economics approach	**Evolutionary economics / MLPapproach**	**Anthropological / GGCT approach**
Heuristic model, policy target	Free market/ 'Market failures'	MLP, system failures	GGCT 2-by-2 diagram, cultural failures
Model of innovation,	Linear, mechanical	Systemic, evolutionary	Cultural, functionalist
Driving dynamics in innovation	Competition between economic agents, market equilibrium	System level 'lock-in', ST momentum, long-run market disequilibrium	Shifting alliances between cultural types, cultural disequilibrium
Actors	Atomised, rational individuals and firms	Actor network constellations around specific regimes and niches	Cultural types with more or less regulated and more or less atomised members
Measures of success	Private R&D expenditure, investment, national economic gain	Momentum in niche socio-technical configurations, learning and regime transformation	Cultural non-dominance ('requisite variety'), cultural viability
Key recommendations on LCIP	Encourage R&D, get the prices right, to get sufficient low carbon innovation and investment	Support niche technologies, pressurise regimes to enable transformative low carbon innovation.	'Clumsy solutions' for 'requisite variety' in culture of low carbon innovation.

The MLP is an 'appreciative theory' (Geels, 2002) of the 'socio-technical' processes through which 'regimes' for societal provision (in areas such as transport, sanitation or energy) are stabilised, and sometimes transformed, over time. Its guiding concepts for normative policy prescriptions derive from its heuristic in which 'socio-technical regimes' are subject to external 'landscape' pressures and stresses, and are challenged by new socio-technical configurations emerging from 'niche' uses. The approach is 'multi-level' in that it focuses attention on long-run dynamics played out at three conceptual levels – those of the 'landscape', 'regime' and 'niche'. Using a parallel from evolutionary theory, these three levels can be understood to interact through processes of variation, selection and retention.

Like the MLP, GGCT seeks to explain both stability and transformative change.

GGCT or 'Cultural Theory' (e.g. Douglas, 1982; Thompson et al, 1990; Mamadouh, 1999; Verweij et al, 2006) is a dynamic theory of the patterned interplay of cultural biases and social relations said to be identifiable in many, or arguably all, areas of social life. It is concerned with understanding people's cultural biases (preferences, norms, values, views) in terms of two dimensions of sociality – 'hierarchy', 'individualism', 'egalitarianism' and 'fatalism'. GGCT identifies and understands stability and change in terms of the dynamic interplay of these four 'ways of life' as they compete with one another for members and influence. Its application to LCIP suggests a policy focus on the possibilities of forming alliances between different groups in order to mobilise resources behind low carbon innovation. Clearly, it emphasises some of the cultural dimensions to transitions.

The remainder of this paper takes a similar approach to Eames and Skea (2002) in that GGCT is applied (by authors who are not otherwise associated with GGCT literature) to policy deliberations that were not explicitly informed by GGCT. The current authors are associated with the MLP. However, these ideas were neither explicit nor central to the deliberations on the critical issues for LCIP under scrutiny below. Nevertheless, given our backgrounds, the framing of the issues and deliberations no doubt owes more to the evolutionary school of thought to which the MLP belongs than to GGCT.

4. Critical issues for the Low Carbon Transition Plan

In implementing the LCTP, the government and its business and civil society partners will have to confront many challenges. A number of these are enduring aspects of low carbon innovation for widespread change. In February 2008 the Sussex Energy Group at SPRU and the UK Energy Research Centre (UKERC) held a two-day workshop on four 'critical issues in UK low carbon innovation policy' (Kern et al, 2008). These issues were arrived at through consultation with energy researchers, policy-makers and business leaders. They are neither exhaustive nor comprehensive. However, they are as salient now as they were two years ago. Implementing the LTCP will mean getting to grips with these issues, as some of the ensuing announcements and initiatives under the LTCP indicate. We introduce each issue in this section as a prelude for seeing how our two heuristics would view these issues.[1]

The four critical issues were:

(i) 'Technology priorities and portfolio appraisal' – is there a case for technology-specific policies ('picking winners'), and, if so, how should government appraise technologies and technology portfolios?

[1] Note that each heuristic would probably suggest its own set of critical issues. We choose a common set of issues for the purposes of comparison and to illustrate how each heuristic provides an interpretative frame for that issue.

(ii) ‘Long-term signals and adaptable policy’ – how can energy innovation policy provide stable incentives for low carbon innovation while remaining sufficiently adaptable to learn from experience?

(iii) ‘Social innovation and technology fixes’ – how can policy attend to the social dimensions of the innovation process, and encourage ‘social innovations’?

(iv) ‘Incumbents and outsiders’ – how can policy support a broader range of low carbon innovators, and include a wider set of stakeholders in developing innovation policy?

An invited group of 24 individuals from academic, government, non-government and commercial organisations participated. The objective was to open some troublesome issues and tensions confronting LCIP, and which to explore ways of understanding and addressing them.

Two of the key messages (Kern et al, 2008, p. 4) from the final synthesis session were that the critical issues might usefully be brought together and understood under a single framework, and that policy discourse needs a better grasp on the social dimensions of innovation. We do not go into the diverse sets of workshop suggestions here (see Kern et al, 2008). Both the MLP and GGCT literatures do offer conceptual frameworks in which the issues can be drawn together, while keeping the social dimensions central. However, as this paper demonstrates, the two approaches arrive at different recommendations for LCTP engagements in these issues. Our review suggests plurality in policy deliberations is wiser than totalising frameworks. This raises questions over the normative grounds on which certain heuristics ought to prevail for particular issues and circumstances, and the political processes by which this comes about.

Each issue is introduced below. The following sections consider each from the perspective of the MLP and GGCT.

4.1 Technology priorities and portfolio appraisal

Under the neo-classical paradigm, the UK government was committed to non-discriminatory support mechanisms for low carbon energy technology deployment (see above). The IEA [*International Energy Agency*] praised the UK for its emphasis on market-based instruments, but with qualifications; “market-based policies have not ensured innovation and deployment of new energy technologies to address the long-term challenges facing the UK... It is likely that both direct incentives for carbon reduction and incentives for innovation in lower carbon technology will be necessary” (IEA, 2007). The IEA, in line with other commentators (Anderson and Gross, 2000; Foxon et al, 2005; Watson, 2009), argues policy must guide research, development, demonstration and deployment of specific low carbon technologies more explicitly.

The LTCP reinforces changes already in the air. The 2007 Energy White Paper had already suggested banding the renewables obligation[2] into support levels differentiated by technology will increase "development and deployment of a broader set of renewables technologies" DTI (2007). This has been done for marine renewable and offshore wind amongst others. Feed-in tariffs are targeting smaller scale generation technologies. UKERC was set up to provide a better overview of low carbon innovation; the Energy Technologies Institute forges research links with business, and it has given initial priority to offshore renewables; public RD&D spending has risen substantially and devotes considerable attention to certain areas, such as smart metering. Other low carbon technologies are supported through grant programmes (different levels of grant are available for different technologies under the low carbon buildings programme), or by co-funding demonstration plants (e.g. full scale post-combustion coal-fired carbon capture and storage) or, arguably, reforms to the planning process (as with nuclear). Taken in the round the government now explicitly states it has a low carbon industrial strategy, and a number of agencies are being added to the list to oversee elements of that strategy (e.g. an agency for CCS, Infrastructure UK, cf. Carbon Trust and Technology Strategy Board).

Critics argue this creeping technological prioritisation risks repeating costly mistakes associated with 'picking winners' in the past, and that carbon taxes or permit systems provide the best incentives for innovation (Helm, 2006).Whatever the arguments, Watson [(*2009*)] suggests 'picking winners' happens informally anyway, and ought to become more explicit and strategic. Government wants policies to support future winners rather than losers. The historical track record on technology support is mixed, though not as negative as popularly supposed. Limited government resources require prioritisation and co-ordination so that they are not spread so thinly that their impact is slight. In this view, innovation policy should openly and transparently acknowledge the different stages of development for alternative technologies and be technology specific rather than generic. The question is whether the current layering of new initiatives onto old provides the right kind of dialogue for co-ordinating, monitoring, and revising priorities in the light of experience.

Furthermore, innovation policy should seek a variety of complementary technologies, which together contribute to an embryonic low carbon energy system. Some candidate technologies have huge institutional and infrastructural requirements, such as hydrogen, marine renewable or electric vehicles (the former now falling out of fashion, which raises questions about the seriousness of current industrial policies), which present opportunity costs and hold resource implications for other technologies. Innovation policy has to support portfolios of options which 'fit together', and account for different technological requirements in terms of supportive infrastructures, skills sets, degree of commercialisation,

[2] A UK requirement on licensed electricity suppliers to source a specific and annually increasing percentage of the electricity they supply from renewable sources

future market opportunities, user contexts and application domains, and so forth. When bringing technologies together into a portfolio, it is important that policy-makers consider these differences, and similarities, and how they might align and link. A portfolio approach has to be carefully and strategically managed by government in order to stimulate diversity for reasons of security of supply (Grubb et al, 2006) or minimising fuel price risks (Awerbuch, 2006) or promoting further innovation through creative learning across diverse technologies (Stirling, 2007).

So what are key rationales and selection criteria in the LTCP for a more active and discriminating energy technology policy? Existing appraisal methods, such as cost-benefit analysis, may not be adequate for this kind of portfolio-based approach. The Carbon Trust's Low Carbon Technology Assessment prioritises technologies "that offer the greatest carbon saving potential and where support from the Carbon Trust can be material in bringing them forward" (a heuristic) (Carbon Trust, 2007). Watson suggests broader selection criteria that include current costs, potential future costs, risks, diversity of different portfolios, the potential for UK competitive advantage, and the stage of technological development.

4.2 Long-term signals and adaptable policy

Business often seeks relatively stable policy frameworks that set clear, long-term goals and within which they can develop their business. The significance of this is recognised in the LCTP. Indeed, policy acknowledged this earlier. The negotiated targets in Climate Change Levy Agreements are a long-standing low carbon policy example. Carbon reduction targets and five yearly budgets in the Climate Change Act introduce longer term certainty across the economy.

Research indicates that minimising risks for investors is a major contributing factor to the success of renewable energy policy in Germany (Mitchell et al, 2006). In their Renewables Innovation Review the DTI [*former Department of Trade and Industry, now part of the Department for Business, Innovation and Skills*] and the Carbon Trust acknowledged this point and stated "that countries that have successfully and cost-effectively deployed renewables on a wide-scale, such as Spain and Germany, have a clear, coherent set of long-term policy measures" (DTI and Carbon Trust, 2004). Long-term signals facilitate the calculations that make risks manageable (Dinica, 2006; Gross et al. 2007; Mitchel et al, 2006). However, such signals need to be strong as well as clear if they are to prompt shorter-term responses. Parker argues it is unclear how targets under the Climate Change Act tie in specifically with short-term energy measures (Parker, 2007).

Policy decisions over infrastructure development, in particular, and how to pursue centralised or decentralised pathways, or some combination, pose a challenge (Unruh, 2000, p. 817; Parker and Rees, 2006). Large low carbon infrastructure

investments require long-term assurances that give investors confidence to commit to change now. The 2010 Budget statement in March announced reviews into the form and strength of signals, where the remit is to see how sufficient existing arrangements are for a low carbon transition will be studied.

However, research into sustainable innovation also recommends policies that are adaptable to emerging circumstances and the unanticipated consequences of earlier policy interventions (Foxon et al, 2005). Policies need to build in flexibility and be open to the positive and negative lessons generated by changing circumstances - but without disrupting investor confidence or trust in the overall innovation process. Too much flexibility may create stranded assets and fuel uncertainty. Frequent changes in policy support can be counter-productive (van Rooijen and van Wees, 2006). The challenge for the LCTP is to strike the balance between sending clear long-term signals whilst retaining room to adapt to emerging circumstances and lessons.

How can energy innovation strategy reconcile this tension between certainty for investors and flexibility of policy to adapt? Adaptable support policies require mechanisms capable of assessing innovation trajectories against long-term goals; that learn from experiences; and reconsider the options. Given the difficulties of measuring success objectively, a combination of qualitative and quantitative criteria may be desirable in policy appraisal and review (Gallagher et al, 2006). The literature on 'transition management' makes some interesting suggestions (Kemp et al, 2007). Here scholars suggest evaluators look beyond immediate effects (like performance criteria) and include the contribution a policy makes to the overall transition process in the energy system. Process-based criteria, concerned with things like stakeholder inclusion, or the kinds of learning being generated and implications for future policy, may be quite different to performance-based criteria. Important lessons arise from failures as much as successes. However, the pressure for policy-makers and developers to demonstrate success can obscure valuable lessons arising from failures.

4.3 Social Innovations and technology fixes

Transforming the UK economy to a low carbon economy is not just a technological challenge. It requires changes in infrastructure, regulations, institutions, business models, consumer behaviours and life styles. It is impossible to think of technologies without linking to the social contexts of development and use that give those technologies meaning and effectively make them work (Russell and Williams, 2002). Policy makers have long realised that purely 'technology push' approaches will not suffice in tackling climate change (Rip and Kemp, 1998). The question is how this social dimension translates into energy innovation policy.

The 'social' is important in two distinct yet related ways. First, innovation is an inherently social process conducted amongst networks of people working within

social institutions. Technology innovation policy has to attend to these social dimensions. Second, innovations can be social in nature as well as technological, such as new lifestyles, business models, and consumer practices. Innovation policy needs to become inclusive and supportive towards these social solutions. The idea of energy service companies selling 'warm homes' or 'lighting' rather than x cubic meters of gas or y kWh of electricity is an example of a social innovation that has caught the imagination of some in energy policy.

Attending to the social dimensions of innovation involves policy in the provision and support of skills, social networks, ideas, financial expectations, user relations, knowledge translation and so forth; all of which helps make low carbon technologies and practices evolve and spread (Smith, 2007). Social processes underpin the development and use of low carbon technologies, and insufficient attention to them can impede the development of new 'socio-technical practices' on the demand side that reduce carbon footprints. For example, technology development and R&D depends on highly skilled scientists, sometimes in emerging disciplines like bioenergy; expanding the deployment of solar heating technologies implies sufficiently trained plumbers. The success of low carbon technology initiatives, ranging from the Technology Strategy to the Carbon Trust, the National Energy Technology Institute to the Energy Programme, to new ones for CCS and offshore wind under the LCTP, rests upon their engagement with these social processes.

The second challenge is to take social innovations seriously. Sometimes they fall below the radar of official innovation policy, such as car clubs, energy service models, green concierges, financing packages, community renewable schemes (Seyfang and Smith, 2007). This is not always the case. Social innovations like personal carbon allowances received considerable policy attention for a period. Under the LCTP there is an explicit goal to engage with civil society as well as business as a player in low carbon social innovation. The Low Carbon Communities Challenge provides competitive funds for local communities to realise their own low carbon initiatives. But this is usually outside the innovation policy domain and a matter for policy-makers working on behavioural change, green consumption or public participation. And yet these initiatives are essential for the diffusion [*of*] low carbon technologies on the demand-side. Indeed, these initiatives benefit from technological support, such as online IT systems and smart cards for car club bookings. Should energy innovation policy stick to technology policies (like supporting basic research, R&D, or demonstration projects)? Or can it provide a fresh perspective and open up 'behavioural change' policy, say, and help nurture social innovations? Should innovation policy attend, for example, to community development models appropriate for renewable energy at that scale? Can the LCTP scale-up these local initiatives and move them into other contexts (Walker et al, 2007)?

An open question for energy innovation policy is thus how to support, incorporate and learn from those new social initiatives that are quite different from

mainstream business or social practice, and how to help to translate those ideas into wider consumption and production practices. This might simply involve energy innovation policy-makers working more closely with other policy domains, and provide helpful lessons about the way new ideas and socio-technical practices spread and exert influence. Or it could involve an extension of innovation policy into these social domains.

4.4 Incumbents and outsiders in UK energy innovation policy

This critical issue also has two facets to it. First, focusing on innovation, the ways policy can help a broader variety of innovators and innovations. Second, focusing on policy making, considering how a greater variety of stakeholders can be included in policy development.

Innovation studies suggest processes for learning across diverse initiatives is important. People able to think 'outside the box' can make important contributions to radical innovation (Bower and Christensen, 1995). The interests that these 'outsiders' have in existing production and consumption systems tend to differ from the interests of incumbent firms, who carry more 'sunk costs', and whose routines and experience ties them more to existing trajectories of development. This is why "[d]isruptive technologies rarely 'make sense' to incumbents, so that their development tends be left to small, outsider organisations" (Winskel et al, 2006). Conversely, newcomers can struggle to develop their radical innovations in niche markets, but which, if successful, can disrupt and deflect the mainstream trajectory of development (Carbon Trust, 2003).

Established power plant manufacturers have, for example, found it difficult to absorb the relevant manufacturing capabilities for distributed generation markets, since their traditional strength rests more in centralised systems integration capabilities. If exploiting new technologies favours new organising principles and structures, then incumbent companies can struggle to promote commercialisation of such technologies (or even resist it) (Magnusson et al, 2005). At the same time, incumbent energy companies have resources like knowledge, expertise, commercial credibility, finance, and markets that are central to successful low carbon innovation processes.

Conversely, disruptive innovators, who are developing "cheaper, easier-to-use alternatives to existing products or services often produced by non-traditional players that target previously ignored customers", can be overlooked by conventional innovation policy institutions (Willis et al, 2007). Fine tuning innovation policy to the needs of newcomers offering low carbon ideas can be difficult (e.g. low visibility, lack of track record, insecure basis for the business). However, this is not necessarily an issue of small versus big players, but of incumbents in a particular field versus newcomers, which can also be large companies themselves. Smart metering innovations might see firms that already

provide information to households, like BT, Virgin or Microsoft, entering the energy domain.

Partnerships are one means for facilitating exchanges between different groups. Many are being promoted under the LCTP in order to open-up and bring-together a wider diversity of players. Partnerships need to be facilitated with care. Some organisations find it easier to participate than others (see below). It is important that all partners are assured a voice. Successful partnerships will draw upon the respective advantages across the membership, whilst overcoming potential antagonisms. Policies can support single, comprehensive partnerships; or they can promote plural partnerships, organised by affinity and working in parallel. In the latter case, processes for learning across partnerships and initiatives become essential.

An interesting example of the challenges in partnerships for innovative diversity is the 'low carbon vehicles partnership'. This was intended to lead a shift to low carbon vehicles and fuels. It was announced by the Department for Transport in their 2002 Powering Future Vehicles Strategy, and intended to play a key role in delivering the strategy (DfT, 2003). The partnership includes car companies, oil companies, several government departments and agencies, Universities and NGOs. The main goal was to promote sales of low carbon vehicles and fuels, and to provide advice to the government. Whilst these present considerable innovation challenges for incumbent players, looked at more broadly it still represents an incremental improvement of the existing automobile transport system, rather than a structural shift to new forms of mobility and logistics. Recent grants and soft loans for vehicle manufacturers in the UK to develop electric and low emission engines will perpetuate this framing.

Government may identify and invite innovative 'outsider' stakeholders to participate in these initiatives, but they may be reluctant to take up the offer. A Sustainable Mobility Partnership might provide a more meaningful network and agenda for them. It could serve to link ideas for high speed rail to automobility partnerships. Either way, people who have dissenting ideas can find it difficult to engage with partnerships whose remit is framed inappropriately for them.

Government looks to these partnerships for input to policy development as well as delivery. Broadening the variety of stakeholders involved in the development of the LTCP, whether through partnerships or other means, could lead to a suite of approaches tailored to a wider set of innovator and innovation goals and circumstances. Similar challenges prevail to those above. Typically, larger players will have much more time and resources available to commit to developing LCTP implementation. Their visibility is more immediate to time-pressed and Whitehall-based policy-makers seeking to engage with stakeholders. Opening-up policy development around innovation to a variety of players, small and large, established and new, resourced and fragile, is a critical issue for policy. This has been happening for some time with the developed

administrations (Smith, 2007b). Low Carbon Communities initiatives, and the Low Carbon Economic Areas initiative, could also serve to open-up participation. We note that any solutions coming from these initiatives will need to engage with inherited energy systems whose institutional legacy is highly centralised. Local authorities will need to learn how to help govern low carbon community district heating for instance (in terms of managing investment, business models, technology, skills, user cultures, etc).

4.5 The treatment of these critical issues prior to the LCTP

Before considering how our heuristics interpret these issues, it is worth recapping how they might be seen under the neo-classical paradigm. For 'technology priorities and portfolio appraisal' the central conclusion here is that government should avoid 'picking winners' as far as possible. Government's role is to leave the details of innovation to the private sector, while correcting for certain 'market failures'. The market is understood to under-reward *innovation in general* because the embodied knowledge has public good characteristics, and low carbon innovation *in general* because the social costs of greenhouse gas emissions are not fully reflected in energy prices. The conclusion is that government should avoid 'selecting' any specific low carbon technologies for support, and should not think in terms of a national 'portfolio' of low carbon technologies.

On 'long-term signals and adaptable policy' the free market framework suggests policy will arrive at a 'correct' set of price signals to innovators and investors (ones that accurately correct for market failures). This should then be sustained, and whatever the market delivers is to be deemed optimal for society's welfare. Whereas the MLP and GGCT both emphasise the importance of 'policy learning' (adjusting policy in the light of what 'works'), the free market model would point to a principle of only adjusting policy to make it more 'correct' – how market actors then behave need have no bearing on subsequent policy.

On 'social innovation and technology fixes' the free market model also points to a disinterested stance. Whether innovations are 'technical' or 'social' should be irrelevant. However the model's assumption that actors interact as atomised individuals reduces the idea of 'social innovation' to one of 'behavioural change' at the level of the individual. There is a role here for policy in providing information, which markets might be expected to under-provide. In essence, in this view there is no 'social' dimension to innovation policy, and the emphasis is on energy supply-side technical fixes.

On 'incumbents and outsiders' in low carbon innovation and low carbon innovation policy, a similar disinterest prevails. A strict divide between the public and private spheres should be observed, and questions of *who* is involved in innovation or related policy do not arise, less still their identities in relation to an 'incumbent' energy 'system'.

This disinterested stance is extreme, and actually caricatures the neo-classical position. As the discussion indicates above, UK policy-makers were already intervening and seeking to guide proactively LCI processes before the LCTP. But the free market model is at a loss to interpret practices other than as market correctives. Alternative perspectives can like GGCT and the MLP can provide more sophisticated interpretations linked to analyses of the dynamics of cultural change and innovation respectively. Both reject neo-classical economic theory's assumptions about atomised rational actors engaged in perfect competition. Both offer potentially useful heuristics that might better inform policy analyses and deliberations around low carbon innovation – one stressing evolutionary processes around innovation, and the other focussing on enduring cultural traits and dynamics.

5. Using the heuristics

This Section interprets the 'critical issues' in the light of the MLP and then the GGCT.

5.1 Interpreting the critical issues in the light of the MLP heuristic

The MLP suggests that energy systems consist of dominant 'locked in' socio-technical regimes, and that there are roles for policy in putting pressure on the diverse actors that reproduce these regimes, attempting to overcome various mechanisms of lock-in, and supporting promising niche technologies that might contribute to a transformation to low carbon regimes. There are clear rationales for technology specific policies, and the criteria for their selection might be measures of radical, path-breaking, 'transformative potential'. What can policy do to help niche innovations with such potential to gather momentum and challenge established ways of meeting society's needs and wants? As for guidance on designing a national 'portfolio' of technologies to support, the MLP suggests this should be guided by consideration of long-term system-level dynamics and implications for a transition to a more desirable future energy system.

This might point to an approach similar to Dutch 'transition management', which emphasises learning processes such that long-term sustainability visions and signals from ongoing stakeholder deliberations guide niche experimentation and scaling-up. Emphasis on experimentation and learning entails recognition that many supported innovations will never enjoy market success, and others will take many years or decades to gather momentum and market share. Overcoming 'lock-in' will then involve a lot of trial and error. In this reading of the MLP the emphasis is on niche-driven change and ongoing policy learning. However the MLP can equally point to the importance of 'long-term signals' generated by policy-makers and other pressures, such as civil society, in unlocking incumbent regimes. Such signals would be interpreted as 'landscape level' structural factors

shaping evolutionary pressures at the lower levels. Therefore legal commitments to cutting carbon emissions, if credible, would be a welcome landscape level influence. The heuristic on its own, however, does not clearly suggest how such long-term commitments should be arrived at or framed, nor how they can be legitimately defended as more detailed policy evolves.

Where the linear model of innovation focuses on technological advance as an essentially asocial phenomenon involving specific hardware, the MLP also draws attention to the social dimensions of innovation. Explanations or justifications for policy guided by an MLP perspective demand attention to cultural, political, economic and scientific variables. The idea of socio-technical 'niches' as a driving force might suggest a central focus on the specific hardware that defines a given niche. Dutch Transition management has been criticised for an over-emphasis on niche developments, and for centring associated policy on niches defined by certain artefacts such as zero carbon vehicles (Kern and Smith, 2008). However, returning to the ecological parallel from which the concept derives, a 'niche' is defined as much by its context as by its content. A niche can be filled in many ways, including through 'social innovations' such as new behavioural patterns or business models. However the MLP heuristic does not suggest any specific way to understand the social relations within a niche nor at the other levels. This non-determinism with regard to social relations is a positive benefit when interpreting historical socio-technical transitions – the temptation to shoe-horn historical details to fit theoretical assumptions is reduced. However, for normative purposes, some additional way to conceptualise social relations, such as GGCT, may be needed if 'social innovation' is to become a policy object.

The MLP offers clear insights into the questions around incumbents and outsiders in low carbon innovation and in related policy-making. The idea of a dominant socio-technical 'regime' rests, in part, on various mechanisms by which an incumbent set of actors systematically defends its vested interests by excluding potential challengers. Society is seen as 'locked-in' to a high carbon energy system, so there are therefore roles for policy in correcting for 'system failures' in ways that better enable new players to innovate. There is also a case for creating new forums and institutions in which such outsiders' voices can influence policy – if government only listens to 'the industry' or to whatever lobby groups are thrown up by pluralist politics, it will tend to favour incumbent regime actors. Scrase et al (2009) develop an MLP-informed argument that transformative innovation demands changes to the culture around innovation policy, and that this is achievable in part by ensuring more participation by 'outsiders' as innovators and in policy deliberations.

In summary, the MLP clearly indicates important insights into the four critical issues. To some extent the framing of these issues owed a debt to the MLP in the first place, and associated scholarship and policy experience. For example the idea that there are 'insiders' and 'outsiders' in LCIP is a logical extension of the idea of a dominant socio-technical 'regime'. Similarly, its emphasis on niches

and its systemic focus are well suited to questions around technology priorities and portfolios. The MLP suggests both stability and adaptability are important, and points to ways each can be approached - through long-term policy commitments at a high level and flexible, learning-oriented policy at the niche level. However it does not on its own point to how the underlying tensions can be resolved, or what might confer sufficient legitimacy on long-term aims such that they can be credibly defended over time. Lastly, while the MLP draws attention to the social dimensions of innovation dynamics, and can accommodate the idea of 'social innovations', it offers little specific guidance on the implications for policy (or not in this heuristic form, at least). We stress, however, that this is a broad-brush characterisation for the purposes of illustration; just as the neo-classical economic and the GGCT characterisations over-simplify their positions too. The MLP as a heuristic is open to other analytical frames focusing and embellishing specific aspect of its high-level transition narrative (Smith *et al*, 2010).

5.2 Interpreting the critical issues in the light of the GGCT heuristic

The GGCT heuristic does not immediately suggest technology-specific considerations that might guide policy priorities in distributing support. Instead one would first consider the desirability of the social relations and cultural biases for which a policy or technology is functional. Some authors using the GGCT approach are certainly in favour of setting technology priorities. For example Prins and Rayner (2008a, b) favour massive public spending on R&D for nuclear power and geoegineering solutions, modelled on the Manhattan or Apollo projects. However this is recommended as part a portfolio of measures that seeks to avoid an over-emphasis on the perceived interests of any one sub-culture. For example a compensating bottom up approach to renewables is recommended. Verweij et al's (2006) and Prins and Rayner's (2008a, b) principle objection to the Kyoto framework for climate policy for instance, is that is an almost exclusively hierarchist domain based on top-down reduction targets, and consequently ineffective in mobilising real action by, or securing legitimacy amongst people in sub-cultures who see the world differently.

Prins and Rayner (2008, p. vi) conclude: "the best line of attack is not head-on… the policy response to climate change should assemble instead a portfolio of approaches—silver buckshot, rather than silver bullet—that would move us in the right direction, even though it is impossible to predict which of these approaches might stimulate the necessary fundamental change. This is a process of social learning in which we must be always alert to maintain our trajectory towards the goal by constant course corrections and improvements which, by definition, cannot be prescribed precisely beforehand." The criteria for favouring any specific technology then relate to the social relations that accompany associated measures, and whether these will introduce or worsen any imbalance between the competing ways of life, thereby potentially suppressing certain voices and preventing members of some ways of life from contributing by taking action. GGCT authors caution that this will provoke a backlash, making the overall policy

effort ineffective, illegitimate and politically unachievable.

Despite the above allusions to a 'trajectory towards the goal' and the 'right direction', GGCT puts more emphasis on the importance of flexibility in policies than on rigidly pursuing such a goal. In 2006 nine of GGCT's leading authors came together to recommend 'clumsy solutions' to the problem of climate change. These are 'creative and flexible combinations of [the four] ways of organising, perceiving and justifying social relations" (Verweij et al, 2006, p. 818). As with Transition Management, but for different reasons, the emphasis is on experimentation and learning: "The attempt to develop clumsy solutions does not depend on coordinated action. It focuses on social learning. Individuals and countries alike would pick and choose the policy measures that suit their particular circumstances" (Prins and Rayner, 2008, p.39).

In essence the GGCT heuristic suggests flexibility in policy is of paramount importance, while 'stability' is not something government policy should attempt to impose. Outcomes are inherently unpredictable, so long-term commitments and targets are likely to be a folly in this view. Rather there will be "perennial change at the socio-cultural level' due to 'the continuous waxing and waning, merging and splitting, of the four ways of life" and "the enduring clash between policy actors adhering to alternative ways of life, which forces actors to constantly update, revise and reinvent their preferred policies in the light of criticisms received…" (Verweij et al, 2006, p. 821). GGCT, then, does not appear to point to any rationale for promoting a stable policy environment. This would imply the imposition of a single definition of the issue at hand and how it should be resolved – a hierarchist imposition of its preferred way of life (clearly defined rules, justified in terms of the greater social good) on the whole of society.

The essential difference between the MLP and GGCT heuristics here is that while the MLP points to the possibility and desirability of policies that force change, including in cultural dimensions, the GGCT rejects such ambition as culturally undesirable and non-viable. In an approach guided by GGCT, policies "would be aimed to work in the world as it is, rather than being predicated upon changing the world first so that it fits the policy." (Prins and Rayner, 2008, p. 27). The social dimensions of innovation are very much to the fore here, but 'social innovation' is, again, not clearly identifiable as a valid policy object.

On the question of 'incumbents and outsiders' in low carbon innovation and related policy, GGCT authors are in favour of diversity and inclusion of people from all four ways of life. However there is a presumption that it will be individualists who will do the relevant innovating. Hierarchs, egalitarians and fatalists have roles to play, but not as innovators. For example Verweij et al (2006, p. 839) argue for "…institutional arrangements in which none of the voices – the hierarchical call for 'wise guidance and careful stewardship, the individualist emphasis on 'entrepreneurship and technological progress', the egalitarian insistence that we need 'a whole new relationship with nature', and the fatalist's

asking ‘why bother?’ – is excluded, and in which the contestation is harnessed to constructive, if noisy, argumentation.”

In summary GGCT readily indicates rationales for supporting various technologies in distinct ways as part of a portfolio of policy measures. It emphasizes experimentation and social learning - social dynamics that demand policy flexibility. To the extent that policy certainty entails the imposition of binding targets and commitments, GGCT suggests this can backfire as the future is essentially unpredictable, and the approach will not mobilise or gain consent from many people. It also, unlike the MLP, suggests reasons why such stability might lack perceived legitimacy. The social dimensions of innovation are central to a GGCT-informed approach, to the extent that ‘social innovation’ might not be a distinct policy object. The GGCT makes some specific propositions about the dynamics of social relations around technologies, with clearer normative implications for policy than those suggested by the MLP heuristic in this respect.

Lastly GGCT is well suited to addressing questions of ‘insiders’ and ‘outsiders’ in low carbon innovation and LCIP. However rather than thinking about these in terms of the boundaries of a ‘regime’, GGCT encourages consideration of multiple sub-cultures each with differently-observed group boundaries and different associated behaviours and cultural biases. To illustrate this difference between the two heuristics consider the place of apathetic energy ‘consumers’ in relation to the LCTP. The MLP would see their inaction as helping to constitute and stabilise the prevailing high-carbon socio-technical regime, but it does not immediately suggest why they are not, then, policy-making 'insiders'. The GGCT suggests their disengagement is culturally specific and functional – their 'fatalism' provides an essential cultural counter-balance to pressure groups’ 'egalitarian' agitation for change.

5.3 Reflections upon the LCTP

Here we consider recommendations arising from both heuristics in the round, and how LTCP implementation might draw on these when addressing with our critical issues.

5.3.1 Technology priorities and portfolios

Any suggestion that policies under the LCTP should be in line with social and political consensus contradicts the MLP’s emphasis on tackling ‘lock-in’. From a GGCT perspective this suggestion is also problematic, as a consensus among sub-cultures would be unlikely to be sustainable or desirable. Rather, arrangements for conflict management need to be at the heart of the LCTP. GGCT insights appear more relevant to discussion of principles for developing technology portfolios, particularly calls for better recognition of the ‘diversity of innovators and users’, and the point about the symbolic importance of policy successes in cutting emissions. Both heuristics agree on the importance of

experimentation and learning. The long-term strategic considerations relating to ‘roadmaps’ and ‘visions’ are fully to be expected from an MLP perspective, but might be dismissed as hubristic and authoritarian from a GGCT perspective.

5.3.2 Long-term signals and adaptable policies

On the benefits of policy stability GGCT identifies a central problem with the idea that Governments should make commitments to transformative change - there would be unexpected outcomes, potentially undermining the credibility of the commitments. To expect a clear direction of travel or political consensus would be seen as mistaken. Undoubtedly, however, suggestions in policy debates are frequently shaped by a sense of urgency about cutting UK greenhouse gas emissions, and belief that investment will not be forthcoming in an unstable policy environment.

The MLP’s emphasis on transitions gives some sense of these temporal challenges – transitions take decades, and we have few decades to play with in making transitions to a low carbon economy if climate science is correct. Some top-down leadership may appear entirely necessary in this view. GGCT’s valuable additional insight here is that any such ‘hierarchist’ initiative should be counter-balanced by initiatives that also engage people as egalitarians, individualists or fatalists. The diversity of technologies, innovators and users identified by workshop participants suggests there is room for such a culturally diversified approach.

The MLP and GGCT are more or less in agreement on the need for broad experimentation, policy learning and adaptation. However the reasoning differs, with the MLP pointing to its necessity as a means to stimulate potentially transformative niche momentum, and GGCT pointing to the need for society-wide cultural mobilisation and legitimacy. An underlying tension between concerns about urgency and legitimacy in tackling climate change, identified by MacKerron (2009), is salient here.

5.3.3 Social innovations and technology fixes

Neither heuristic points to clear policy implications of treating ‘social innovation’ as a separate policy object. On the ‘social dimensions of the innovation process’ GGCT provides one way of thinking about social relations (such as innovation by social groups, or ‘open innovation’ by networks of technology users). The MLP is not a theory of social relations, but draws on other theories to explain them: Tukker and Butter (2007) draw upon GGCT to try and understanding social relations in socio-technical transitions.

GGCT emphasis on dealing with the way the world is and harnessing dynamics already found there would suggest nurturing social innovatyions rather than trying to create them (Fourcultures, 2009). The suggestion that retraining of mind

sets may be needed if information on energy use and emissions are to be meaningfully communicated to consumers is interesting here. The idea goes beyond a 'deficit model' to suggest there are cultural reasons why some information is not likely to be seen as meaningful. GGCT can offer insights here, perhaps suggesting that consumers have engaged in energy markets as fatalists, and therefore to take an interest in such information is seen as pointless i.e. not part of a viable behavioural strategy given the prevailing social relations and cultural biases.

Ideas for catalysing low carbon innovation from below sit equally well with the MLP or GGCT. An interesting observation in the context of UK 'community renewables' policy initiatives is that they lacked clear 'delivery' goals at the aggregate level, and that the 'tail' of local ideas and criteria had come to 'wag the dog'. GGCT would celebrate this outcome. Moreover research on community renewables has found that the social relations entailed were held by participants to be centrally important – 'community renewables' initiatives were seen to lack legitimacy if they were not taken *by and for* the community concerned (Walker and Devine-Wright, 2008).

5.3.4 Incumbents and outsiders

As mentioned above the framing of this issue owes a great deal to an MLP-informed perspective on innovation dynamics. The picture of UK policy culture around the LCTP that is very interesting from a GGCT perspective. One view is that this is a closed policy community centred on Westminster, with other groups expected to engage in ways that afford them little influence on agendas. GGCT might point to a conclusion that this hierarchical situation pushes people into a fatalist position in this way. Another view identifies a very wide range of current and potential policy stakeholders getting interested in the LTCP, and some fascinating distinctions between them. Differences in groups' boundaries, attitudes to rules, and relationships with other groups become salient in thinking through reasons for non-participation or means by which participation could be encouraged. Where the MLP suggests transitions involve wholesale changes in cultural values at landscape and regime levels, GGCT and the workshop participants' discussions here point to a much more nuanced, piecemeal consideration of specific sub-cultural dynamics.

Table 2 summarises these interpretations. Differences derive from a GGCT view of the 'world as it is' – full of potential for change but this is unrealized because of an over-bearing, top-down policy framework – and a MLP perspective that finds that 'the world as it is' blocks change despite governments' best intentions.
In this respect, but in different ways, the MLP shares an approach with the free markets perspective, in the sense that the challenge is to change contexts in order to allow radical change. The GGCT in comparison looks to work within contexts and build up change on that basis.

Table 2: Summary of critical issues with free market, GGCT and MLP interpretations and suggestions

Critical Issue	Free markets	GGCT	MLP
Technology priorities and portfolio appraisal	Set the carbon price correctly and the market will choose; some public R&D support is justified in terms of widening the choice of competitive technologies.	Technology portfolio must not over-emphasise the interests of one sub-culture.	Focus on long-term system dynamics. Contributions to: unlocking energy systems; niche momentum (learning, expectations, networks, institutions).
Long-term signals and adaptable policy	Not an issue. Market frameworks set the long-term signals, and then competition through the price mechanism incentivises adaptations.	Work with the world as we find it: four immutable and universal cultures. Constant learning and re-adjustment in light of cross-cultural tensions. Top-down, long-term goals are folly (Kyoto). Flexibility avoids backlashes.	Learning and expectation development is a long-term process (decades). Landscape provides long-term signals. No clear suggestions on resolving the underlying tension.
Social innovation and technology fixes	The market is disinterested. It will invest and buy whichever low carbon innovations are optimal, whether predominantly social or technological.	Need to work with prevailing situation from diversity of perspectives (e.g. fatalists unresponsive to behaviour messages).	Socio-technical perspective brings the social into the foreground. Niches defined by context (cf. content) and can be 'filled in' with social innovations as well as technologies. No theory of social relations to inform this process.
Incumbent and outsiders in UK energy policy	Reduce and remove barriers to entry into carbon-corrected markets.	Centralisation of policy pushes people into fatalist group. Solutions need to work across four cultural groups. Boundary work: meaningful for people from each (cf. insider or outsider).	Bring incumbents and outsiders together. Most obviously in new forums for nurturing niches. Need to change the culture around innovation.
Overall recommendations	There is no need, nor the capability, for government to attend to the minutiae of low carbon innovation. Policies that correctly incentivise market players generally are more appropriate.	'Silver buckshot' and 'clumsy solutions' that work at pace of cultural clashes. Authoritarian measures will fail. Need to be culturally savvy. Specific measures justified on cultural grounds: nuclear plus bottom up energy efficiency and geo-engineering.	Niche experimentation and unlocking regimes. Try and accelerate change (inc. cultural). Need to be innovation savvy, but specific measures are unspecified.

5. Conclusions

Both the MLP and GGCT heuristics suggest reasons for considering the four issues as 'critical' for the UK LCTP, with some interesting differences in emphasis and interpretation. The UK policy landscape is moving away from a reliance on setting targets and adjusting market incentives, and has ambitions to bring about a 'low carbon transition' through a low carbon industrial strategy. The MLP is clearly relevant here, pointing to ways to deal with issues of urgency, long-term signals and mechanisms of socio-technical lock-in. The GGCT appears to offer additional insights, particularly on questions of legitimacy, technology portfolios, the social dynamics of innovation processes and what it means to be an 'outsider' in LCIP.

Appreciation of GGCT insights is valuable in cautioning against hubristic beliefs that a low carbon transition can be implemented in an authoritarian manner using 'whole systems approaches'. Different actors will frame the systems differently, and they will seek to negotiate *their* pathways towards sustainable energy systems accordingly. The UK energy system has been characterised by a 'hands off' approach for almost two decades, and the risk of a turn to authoritarianism as a more 'interventionist' (for want of a better term) approach becomes necessary is a real concern. Under the old nationalised energy industries investment was forthcoming, but organisations such as the CEGB were not highly responsive, and were far from democratically accountable or responsive to public concerns. They were, however, using public money to act on society's behalf, at least in principle. In today's situation, where energy industries are in the hands of large private companies, the public's money will again undoubtedly have to pay for major new investment to create a low carbon economy, but the perceived legitimacy of these uses is potentially more problematic. GGCT is a particularly strong source of insights into this side of the tension between urgency and legitimacy in the LCTP (MacKerron, 2009).

Turning to the question of future use of the two heuristics to inform UK LCTP discourse, the analysis here suggests both could be valuable. Moreover there is in principle a fit between the two, in that the MLP takes culture seriously but does not in itself go into its dynamics, while GGCT offers insights into these dynamics but offers less into long-term socio-technical change or how it might be shaped by policy. However combining the two heuristics on a theoretical or conceptual level does not appear a realistic proposition. This would not be impossible but would be unlikely to satisfy academics associated with either school. The MLP can draw on other social theories to address cultural dynamics, and GGCT authors would likely reject use of their ideas to support a 'transition' in which cultural values must change.

Perhaps, then, the two heuristic nevertheless both have value but for use as opposing starting points for further deliberations of the kind undertaken in the

workshop discussed here. However each heuristic remains problematic in its own right for policy uses. The ‘free market’ heuristic discussed here is only as powerful as it is because so many people have a basic grasp of the underlying theory. A majority of UK graduates who enter the LCIP arena are likely to have been exposed to its principles; the same cannot be said of the MLP or GGCT. But there are additional challenges, evident in the paper here, concerning the use of high-level heuristics in developing fine-grained policy measures. Whilst usefully providing broad orientations, each needs further development before the details can be filled in.

Finally, important questions remain over the normative grounds on which some heuristics should prevail over others in policy processes. We see merits in a pluralistic use of various heuristics in policy deliberations. Others may wish to be more assertive in their preference for a single heuristic; but on what normative grounds should policy-makers share that preference? Moreover, to the extent that certain heuristics already prevail, how can we explain their dominance? Here we have tried to demonstrate the significance of heuristics in deliberating climate policy. This needs to be complemented by political analyses of the processes by which some heuristics come to frame those policy deliberations in ways that risk excluding others without reflection on their merits.

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[i] Thompson et al also linked the 5 ways of life to myths of nature based on how members of each way of life view the relationship between resources and needs. Fatalists see nature as a lottery, and feel they can manage neither their needs nor their resources. Egalitarians see nature as 'strictly accountable' – resources cannot be managed so needs must be managed through voluntary frugality. Hierarchs see nature as 'isomorphic with the social realm… forthcoming when approached in the right way by the right people but retributive when pushed beyond these carefully learned bounds" (Thompson et al., 1990, p. 17). Hierarchies define their members' needs, so they must manage their resources. Individualists see nature as a 'skill controlled cornucopia' (Thompson et al, 1990, p.11). Individualists and 'hermits' feel able to manage both needs and resources, with the former aiming to maximise the differential (get as rich as possible)

and the latter to manage the overlap, comfortably enjoying nature's 'freely available' resources (p.11) while eschewing the individualist's and other cultural types' socially demanding ways of life.