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Note: This paper presents work in progress. Whilst we encourage comments and suggestions, we would appreciate it if you seek our permission before citing.

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Introduction

A curious tension exists in the literature on the governance of sustainable technologies; one that this paper will highlight and discuss. On the one hand, analysts recognise technology development as a highly social activity (thus opening possibilities for deliberate steering). On the other hand, governance interventions struggle with these same social underpinnings of technology development (thus understating the potentials for negotiation, deliberation and participation). In this paper we consider how this tension relates to the conceptual positioning of governance in relation to technology – whether 'inside' or 'outside' – and draw practical implications for steering.

The socio-technical turn in environment and technology studies provides a good example of this tension. The advance on earlier environment-technology studies is the recognition that technological infrastructures and practices emerge through complex interactions between artefacts, institutions, and agents. It is the operation of this 'socio-technical system' that services (and constitutes) human needs, and which must be rendered more sustainable. Existing technology governance arrangements tend to be considered as endogenous features of the socio-technical systems themselves. Yet when it comes to recommending how socio-technical change might best be steered in more sustainable directions, analysis tends to step outside the system to objectify its workings, with governance characterised in terms of exogenous 'mechanistic' interventions.

To an extent, such abstractions are an inevitable feature of any process for appraisal or accountability in the process of steering. But it is an expediency that stores up problems further down the line, because wider understandings of governance recognise the central roles of value-laden social processes of open deliberation, argumentation and negotiation. In practice, collective agency and social commitments in the governance of technology arise not so much through discrete, rational, 'mechanistic' closed 'decisions' in an ***external*** governance arena, as through more complex and diffuse systemic interactions within extensive but ***internal*** networks of variously compliant or recalcitrant social actors and artefacts. Under the former, relatively closed, 'decisionistic' understandings – where 'appraisals' are conducted and 'decisions' taken by an external governance subject on a subordinate socio-technical object – many key uncertainties, ambiguities, indeterminacies as well as power distributions amongst relevant actors, are expediently neglected.

Our argument is not that conceptual distancing between socio-technical subjects and objects is always necessarily unhelpful or wrong. The point is rather that the interlinkage between socio-technical appraisal and socio-technical commitments must become more reflexive. In particular, there needs to be greater appreciation of the ***internal*** loci of governance processes within the socio-technical systems themselves, and of the necessarily more 'open' role of appraisal under these conditions. In contrast to governance that is placed outside the system, positioning governance inside the process of socio-technical change requires tools that can open up debate and reveal technology's inherently political nature. In short, we need to move from a view of 'steering as management' to an understanding of 'steering as politics'.

In practice, few practical initiatives in governance are characterised purely by one or other of the two ideal types – 'outside' or 'inside' - that we set up here. The same is true of academic

perspectives. Indeed, studies into the governing of socio-technical transformations towards sustainability are only now beginning to grasp the political implications of a fully reflexive, internal account of governance (Voss and Kemp, 2006). This said (and though some treatments do come close for heuristic reasons), the existing socio-technical governance literature is rarely so politically naïve as to espouse a purely managerial, external conceptualisation of governance, and most accounts of governance, and most practical instances, wrestle with the tensions between the two positions that we set out here. On the one hand, governance processes have to be recognised as 'political' if they are to account for the different actor problem framings and socio-technical commitments of different actors and so enable the building of legitimacy. On the other hand, the objectification of the socio-technical facilitates coordinated interventions and management, *so long as actors agree over the object around which they are supposed to be coordinating*. By teasing apart the source of this tension into two ideal-typical conceptualisations of socio-technical governance we hope to provide a scheme for a deeper appreciation of this unavoidable dynamic.

The paper is structured as follows. First, we will review the unprecedented background provided by sustainability concerns for growing imperatives and ambitions to large scale deliberate transformations in socio-technical systems. This presents a variety of formidable challenges, which have been well explored in earlier work. Next we turn to a more innovative theme, based on a distinction between 'social appraisal' (concerned with understandings of contending problems and possibilities) and 'social commitments' (involving the forming of tangible material and discursive interventions). We use this to draw out some of the practical implications of currently sometimes ambiguous discussions of 'reflexive governance'. Building on this conceptual structure, we then describe two ideal-typical ways to think about the governance of socio-technical systems – with governance alternatively conceived (or represented) as being on the 'inside' or 'outside' of the systems themselves. In our concluding discussion, we argue that this framework helps to address some presently neglected ambiguities and challenges in the existing literature on the sustainable governance of technology. In particular, it helps to underscore the importance of upholding the essentially ***political*** – rather than increasingly ***managerial*** – role of governance in this area.

The governance challenge: transforming socio-technical systems

In recent years, a socio-technical systems perspective has come to the fore in studies of technology and sustainable development (Elzen *et al*, 2005; Weber and Hemmelskamp, 2005). The governance challenge is no longer simply to promote cleaner technological artefacts. Instead, it lies in transforming wider socio-technical systems (Berkhout, 2002). The new governance focus thus recognises that technologies are embedded within broader socio-political and economic networks. Some of the reasons sustainable technologies are not diffusing more rapidly relate to overarching structures of design criteria and routines, markets, patterns of final consumer demand, institutional and regulatory systems, and inadequate infrastructures for change. Technology developers have limited room for unilateral manoeuvre in relation to these system-level factors. Reinforcing this focus at the broader socio-technical level, is a realisation that radical changes at a whole system scale are needed to deliver the revolutionary material efficiencies and emission reductions that sustainable development demands (Rotmans and Kemp, 2001).

Since successful socio-technical development emerges through a complex network of actors, artefacts and institutions, so attempts at its coordination and steering will need to engage across many of the points and processes within that network (Smith *et al*, 2005). Imposing normative goals of sustainability upon existing socio-technical systems, implies connecting and synchronising changes among a formidable array of actors, institutions and artefacts at many different points in the system. Governance must consequently fulfil diagnostic, prognostic, prescriptive and coordination functions. First, it must identify problems of unsustainability in the socio-technical system. Secondly, it must look forward through the highly complex and uncertain dynamics of nested and tighty-coupled technological, social and environmental systems. Third, it must develop a set of shared normative criteria with which to appraise the best governance solutions to those problems. Fourth, it must implement these solutions by forming commitments to change and making interventions. In exercising and monitoring all these functions, governance must be especially adaptable, since 'the dynamics

of many socio-technical processes are such that the matching governance practices seem to be continuously 'out of breath': they have been overtaken by the developments, because the developments are more dynamic and the governing is not dynamic (enough)' (Kooiman, 1993: 36). Amongst these new developments will be the unintended consequences of earlier governance interventions (Voss and Kemp, 2006).

Constructing the necessary governance network to fulfil the above functions is far from straightforward. A wide variety of distributed knowledges, discourses, skills, and other resources (e.g. technical, finance, legitimacy, authority) must be marshalled if socio-technical development is coherently to be comprehended and steered. The challenge is to bring appropriately resourced actors into the governance arrangements needed to steer socio-technical change. This observation brings us to the question of organising the governance network – referred to in the literature as the 'meta-governance' question (Jessop, 2003; Kooiman, 2003). To what extent does governance need some kind of discrete facilitating and/or guiding agency? The literature on policy networks, which is closely aligned to the governance literature (Marin and Mayntz, 1991; Hoff, 2003), maintains that state actors continue to hold an important facilitating position. Networks build up around the government ministries formally responsible for a policy sector. It is through these networks that policy gets formulated and implemented (Marsh and Rhodes, 1992; Smith, 1999; Rhodes, 1997). So for many analysts the state retains an important role in governance. Yet one of the features of the socio-technical systems perspective is that it typically cuts across both policy sectors and public-private institutional boundaries. This implies multiple government agencies will be involved alongside an array of wider commercial and civil society actors, each with their own commitments. The steering of socio-technical transitions is negotiated across a diversity of locations that effectively recalibrate the role of government in governance. Limitations of space mean this paper must hold open the relationships between government and governance in transitions (see Grin, 2006 for a discussion). However, our two conceptualisations of governance – 'outside' and 'inside' – will clearly have different implications for these relations, e.g. a much more directing and excluding role for government in governance on the outside.

Analysing governance: appraisal and commitment

However governance is characterised, then, it necessarily involves complementary, intertwined and mutually co-constituting (but nonetheless analytically distinct) processes: 'social appraisal' and 'social commitment'. In these terms, appraisal comprises essentially 'epistemic' processes – 'ways of understanding' the socio-technical system. Here, knowledge is constructed, imbued with meaning and subjected to social learning. Social commitments, by contrast, involve more 'ontological' 'ways of being' in relation to the socio-technical system (Stirling, 2005; 2006; forthcoming). Here real relationships are formed, tangible resources produced and deployed and concrete governance interventions undertaken. Seen in this way, the recursive interlinkage of appraisal and commitment cross-cut other, more elaborate sequential taxonomies through which to understand governance functions in the steering of sociotechnical systems. For instance, successive stages of 'problem identification', 'goal formulation, and 'strategy implementation' (Vos and Kemp, 2006), may each be seen to comprise elements both of appraisal and commitment in theses senses.

In terms of sustainability, the aims of governance across these functions are essentially to make robust diagnoses and prognoses of the problems in question, develop shared prescriptions and marshal sufficient resources to make the appropriate corrective interventions. By highlighting the more straightforward dual distinction between appraisal and commitment, we hope better to explicate what we hold to be the important but neglected contrast between managerial and political perspectives on these various functions of socio-technical governance. This said, it may be useful to review in a little more detail some of the contrasting attributes of commitment and appraisal.

Commitments

Social actors can be 'committed' to a socio-technical system in a number of overlapping and related senses. One form of commitment is rooted in material interests, in the sense that actors rely on the functioning of the system in order to satisfy some need, e.g. for housing, food, clothing, mobility, entertainment, lighting, warmth. A more direct and constitutive form of

material commitment resides in the way that the functioning of the system itself requires the coordinated mobilisation of actors and resources. Obvious examples include capital finance, operational subsidies, infrastructure rights, contractual security, regulatory protection, political patronage, support in knowledge production, intellectual property guarantees, user demand, promotion of learning, facilitation of recruitment or measures for the externalisation of liability. The way in which actors engage in the production and reproduction of these relationships and resources represents a distinct form of commitment to particular configurations of the sociotechnical system in question.

Obviously, this form of constitutive commitment relates closely to the reciprocal benefits deriving from participation in the reproduction of the system.[1] Benefits underpinning the commitments of, for example, a business producing a component within the system include the generation of a financial profit or some other institutional vested interest. Consumers in the socio-technical system derive benefits from the particular efficiency, convenience or style in which the system helps them meet their need, at the same time as furnishing a demand (and resources) for the reproduction of the system. Governments commit to the system because it facilitates further economic development, or fosters social cohesion, or contributes to policy goals, (e.g. well-functioning transport, energy or housing systems) or displays more specific and expedient political benefits, whilst state regulation and enforcement of property rights contribute to system reproduction. Citizens commit to socio-technical systems because they facilitate civic and community activity over and above individual consumption benefits. However, commitments need not be hard and fast; if an alternative sociotechnical configuration can furnish equivalent benefits in some other way, then actor commitments may shift to the alternative.

Overlaying, facilitating and informing these kinds of material commitments are discursive commitments.[2] These may arise simply as privately-entertained normative values concerning an existing system configuration founded on the material commitments reviewed above. Alternatively, such values may be more openly expressed, representing to wider discourses support for particular constituent socio-technical structures and practices. Again, these discursive commitments may be developed for varying substantive, normative or instrumental reasons (Stirling, 2005). Whatever form they take, they play an important role in coordinating action amongst different governance actors. In this regard, it is desirable that discursive commitments display a degree of interpretive flexibility, such as to maximise the engagement, recruitment or assimilation of as wide a range of actors as possible.

Discursive commitments have obvious epistemic qualities that shade into the social appraisal processes of governance (and which we hold as analytically distinct). The crucial difference between discursive commitments and related aspects of appraisal, however, hinges on the distinctively 'ontological' character of commitments. For example, when a government minister articulates a range of ***specific merits and/or shortcomings*** displayed by a particular sociotechnical configuration such as nuclear power, then the epistemic quality of this intervention renders it a discursive contribution to wider discourses of social appraisal. When the minister's intervention has the effect of ***asserting a position*****,** by contrast (for instance concerning the necessity or unique favourability of nuclear power), then the intervention has a more ontological form – as a tangible indication of positive intentions towards this configuration. The effect of this kind of discursive commitment, maybe then to prompt a cascade of co-ordinating alignments on the part of the commitments of other actors. It is in this way that appraisal and commitment are mutually co-constitutive – and may be present as aspects of the same intervention – but are nonetheless for our purposes analytically distinct.

Complicating this picture of material and discursive commitments are institutional and structural factors. These can be approached by distinguishing between the role of established

[1] These benefits can be material, economic, social or psychological.

[2] Some argue we can only really come to know and practice these material commitments through discourse (e.g. Hajer, 1995).

commitments in system reproduction and new commitments to system change. Governance processes seeking to transform a socio-technical system are structurally constrained by historically established commitments embodied in infrastructures, networks, institutions, practices and discourses. The formation of commitments for socio-technical transitions must therefore work against these structures, and require strategic governance intervention. For instance, new imperatives may be introduced through constitutive commitments to new innovation activities or liability regimes or new actors may be enrolled through discursive commitments to sustainability.

A number of actors whose resources are relevant to the governance challenge will necessarily be committed to precisely the features of the socio-technical system for which governance is seeking sustainable reconfiguration. That is, they contribute to the reproduction of the socio-technical system and enjoy advantages from that position. Examples in the case of energy include utility companies, economic and environmental regulators, consumer associations, and capital goods developers and suppliers (e.g. gas-fired power station contractors and wind turbine manufacturers). Some of the functions and resources that these actors bring to bear in the reproduction of system functions, precisely for this reason, will be essential in realising commitments for change.

Some actors are more intensively involved in the reproduction of the socio-technical system than others. As such they enjoy quite powerful positions, benefit strongly from the status quo, and occupy important gate-keeping positions (Smith *et al*., 2005). Established commitments are often reinforced (and entrenched) by past investments in supportive infrastructures (e.g. fuel supply networks) and institutions (e.g. energy market regulations). Whilst these investments stabilise commitments to the existing socio-technical system, they also represent a form of structured power, which must be overcome in the formation of commitments to more sustainable configurations.

Once a system undergoes change toward an alternative, more sustainable configuration, then the relative socio-technical position of different actors and their commitments will undergo a concomitant shift. Thus a renewable energy utility, whose position and voice was relatively marginal in the incumbent, centralised, fossil fuel energy system, would become much more central in a decentralised energy system powered by renewable energy technologies. Conversely, actors unable to adapt to change and diversify into the new socio-technical practices will find they suffer, for instance through declining profitability. Such threats mean there will inevitably be resistance to governance interventions aimed at promoting sustainability. Actors in structurally powerful socio-technical positions under the status quo can be well placed to exercise strong influence over governance attempts. Stoker notes how ‘in a governance relationship no one organisation can easily command, although one organisation can dominate a particular process of exchange’ (1998: 22), and clearly there will be structural biases against radical socio-technical change. The importance of counteracting such bias by building up a governance arrangement that possesses sufficient legitimacy, authority or technological agency thus becomes clear.

Appraisal

It is against this background that appraisal is described as the ‘epistemic’ corollary to the more ‘ontological’ form of commitments (Stirling, 2005; forthcoming). In other words, it relates to ‘ways of knowing’ rather than ‘ways of being’ in the socio-technical system. Accordingly, appraisal is about production of substantive understandings, social learning and cultural meanings concerning the socio-technical system. It is in on this basis that more concrete commitments are formed in wider governance. In these broad terms, then, appraisal involves a very wide variety of discursive processes, institutional practices, disciplinary approaches and methodological tools. In contrast to conventional distinctions between different styles of appraisal – such as expert-analytic versus participatory-deliberative – our analysis highlights two important but rather different cross-cutting distinctions. The first concerns the breadth of the ***inputs*** to appraisal: which may variously be ‘broad’ or ‘narrow’ in a number of different ways. The second concerns the way that the ***outputs*** of social appraisal serve to ‘open up’ or ‘close down’ the formation of discursive and material commitments in wider governance.

The breadth of the 'inputs' to appraisal can be understood according to many different dimensions (Stirling, 2003). These may concern the kinds of issue that are taken into account in forming the salient bodies of knowledge – extending, for instance, from technical and financial to environmental, social and ethical considerations. They may reflect the depth in which causal relationships are explored and represented (concerning successively less 'direct' or more 'complex' effects and implications). Likewise, appraisal may be relatively broad or narrow in terms of the treatment or acknowledgement of associated uncertainties and ambiguities. It may also vary in the breadth of the intervention options that are addressed (across alternative technologies, measures, policies, practices and institutional frameworks). Finally, the inputs to appraisal may be relatively 'broad' or 'narrow' depending on the range of contending social, institutional or disciplinary perspectives that are involved in producing and deliberating the knowledge, learning and meanings in question. All else being equal, the broader the appraisal process, the more 'precautionary' the resulting picture of governance options, in the sense that greater attention is paid to the full range of associated uncertainties, contingencies, conditions, contexts and persistent gaps in knowledge (EEA, 2001).

Irrespective of whether the inputs are 'broad' or narrow' in these terms, the outputs of appraisal may equally be variously 'open' or 'closed' in form (Stirling, 2005; forthcoming). This concerns not the scope of the methods, practices, institutions or discourses involved in social appraisal, but the manner in which the consequences are represented to – and reflected in – the formation of governance commitments. Does this take the form of 'closure' around the merits of particular technologies or interventions? Or does it rather comprise a more reflexive 'opening up' of understandings of the particular contingencies, contexts, conditions or perspectives under which different possible technologies or governance interventions might alternatively be favoured. This is not a necessary corollary of breadth in the inputs to appraisal. A broad-based 'precautionary' appraisal process may yield normative grounds for the 'closing down' of commitments around a particular course of action. A relatively narrow technical expert appraisal, on the other hand, may (through relatively technical procedures like sensitivity analysis or minority opinions) serve to 'open up' wider discourse, by highlighting the validity of a variety of contending judgements or interpretations.

In these terms, then, closing down in appraisal is about 'defining the right questions, finding the priority issues, identifying the salient knowledges, recruiting the appropriate protagonists, adopting the most effective methods, highlighting the most likely outcomes and so determining the 'best' options' (Stirling, 2005b: 21-22). Opening-up, by contrast, reveals to wider governance discourses the open-endedness, contingency and capacities for social agency in technology choice. 'Instead of focusing on unitary prescriptive recommendations, appraisal poses alternative questions, focuses on neglected issues, includes marginalised perspectives, triangulates contending knowledges, tests sensitivities to different methods, considers ignored uncertainties, examines different possibilities and highlights new options' (Stirling, 2005b: 22). In particular, by highlighting the way in which the picture yielded in appraisal is contingent on, and conditioned by, prior perspectives – and thus commitments – of different actors, an 'opening up' mode represents a greater degree of reflexivity (Stirling, 2006).

The distinction between 'breadth' and 'opening up' in appraisal helps to reveal the implications of a crucial – but often obscured – difference between 'reflective' and 'reflexive' governance. In these terms, the 'breadth' of appraisal is about the quality of reflectiveness – the extent to which different issues, possibilities and perspectives have been taken into account. The degree to which appraisal serves to 'open up' or 'close down' commitments, on the other hand, relates to reflexivity proper. Where appraisal serves to 'close down' the picture of potentially viable or legitimate interventions, then – all else being equal – there is a relatively low degree of reflexivity over the conditionalities bearing on the particular way in which the closure has been framed. By relating the rather conceptual discussion of 'reflectiveness' and 'reflexivity' to the form taken by the 'inputs' and 'outputs' of appraisal – and their associated implications for commitments, the present distinction between 'breadth' and 'opening up' helps ground the discussion in concrete practices and procedures and form a firmer basis for practical conclusions. Reflexivity entails more specific 'recognition of the recursive co-constituting of governance processes and perspectives and socio-technical systems and possibilities' (Stirling, 2006). As such, appraisal is a "necessary but insufficient"

element in the governance of technology, being "nested and inter-related" in institutional terms with wider processes of socio-technical commitment (Stirling, 2006). The importance of the role of intentionality in socio-technical governance compounds the importance of recognising this kind of distinction (Stirling, forthcoming).

In these terms, then, the broad distinction between interlinked epistemic processes of appraisal and the more ontological formation of commitments helps to address some key issues in the 'reflexive governance' literature. Here, key authorities use the term 'reflexivity' in a number of quite fundamentally different ways (Giddens, 1990; Beck, 1992; Adam et al, 2000; Lash, 2001). In our view, reflexive governance is not simply a strategic orientation based around the idea that governance interventions generate unintended consequences that feedback and require governance to rethink and respond differently. This kind of literal reflex has dogged earlier forms of governance too. It is not new. Recent literature does argue that unintended consequences are becoming more severe and disabling (Beck, 1992), and a corollary for some is that 'mastery' over socio-technical systems is nigh impossible (Latour, 2003 cited in Rip 2006). Others recognise a pragmatic governance need for coping strategies that recognise their own implication in unintended consequences and anticipate adaptive responses. This innovation involves what Voss et al (2006) term 'second order reflexivity' in the sense that governance becomes aware of how certain forms of appraisal process – e.g. narrow inputs – can exacerbate unintended consequences, and so avoids those kinds of process and seeks a more integrative and interdisciplinary knowledge, operating across a broader consideration of factors, and taking longer-term and adaptive perspectives. Whilst not disputing these aspirations in governance, we feel they do not reveal an important additional quality in *fully reflexive governance*, which is awareness of how appraisal and commitments condition, represent and recondition one another recursively, such that social appraisal rarely closes down definitively upon a given socio-technical object. Reflexive governance must develop strategies for accommodating this realisation (which is not a new phenomenon – see Law and Urry, 2004). Our characterisation of 'governance on the inside' draws out this important distinction (see below), but first we introduce a less reflexive form of governance, which is 'governance on the outside'.

Governance on the outside: intervening in socio-technical change

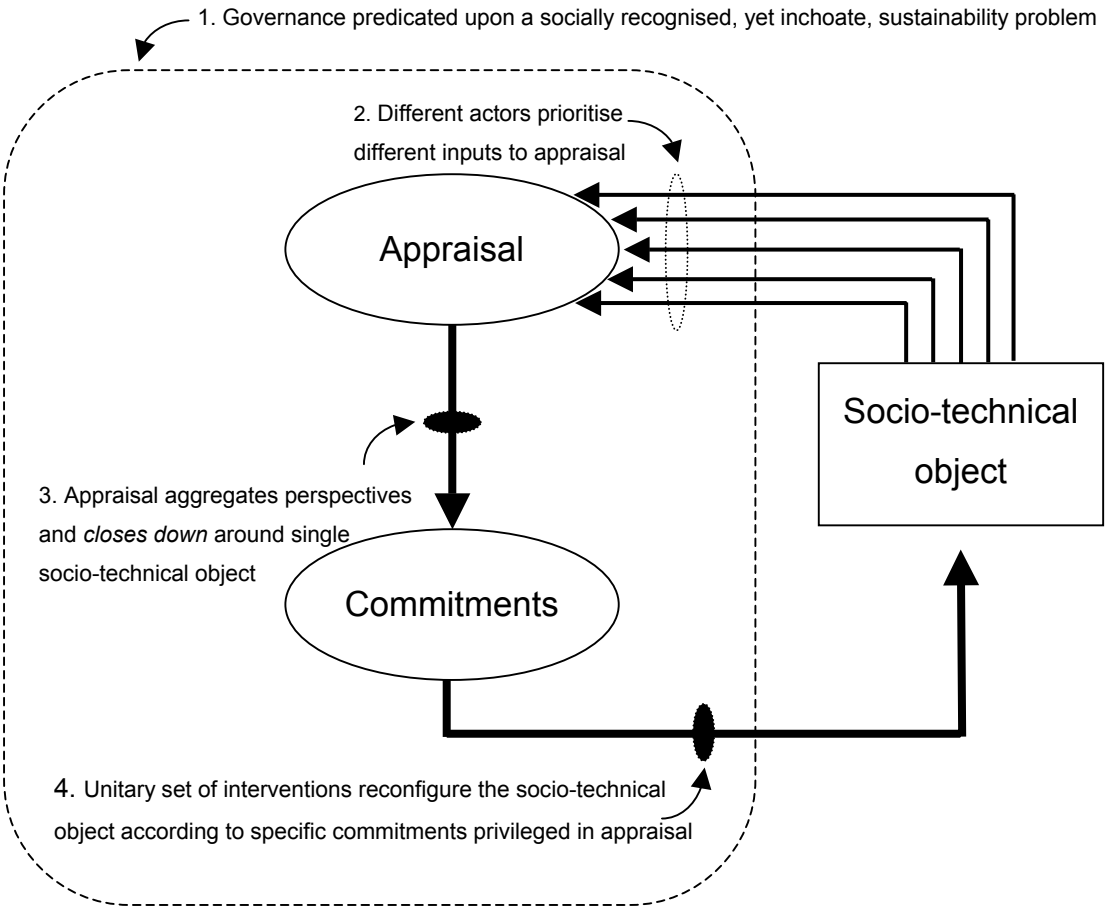
In the previous section we contrasted the roles of appraisal and commitment in governance. Here we develop a framework for analysing governance using two ideal-type conceptualisations based on contrasting appraisal-commitment relationships. The first ideal-type – 'governance on the outside' – considers governance arenas as conceptually apart from the socio-technical objects. The second ideal-type – 'governance on the inside' – conceptualises governance as co-constituting the socio-technical. In practice, and in much of the literature, both ideal-types have a presence. There is a dynamic tension between managerial processes seeking to objectify the socio-technical and political processes constructing the socio-technical. We hope the ideal-typical analytical framework that we develop (see table 1) will contribute to evolving understandings of the dynamic tensions in socio-technical governance, and help encourage more reflexive governance practices.

Implicit to a 'governance on the outside' view is a socio-technical object whose unique operation, boundaries and consequences can become known to governance through appraisal, and that can be predictably altered through a reordering and redeployment of commitments. Nearly all accounts of governance recognise that this requires negotiation across different actor perspectives. However, 'governance on the outside' still perceives this as something that can be negotiated with reference to a commonly held, unique and discrete 'unsustainable' socio-technical object. In other words, the domains of environmental sustainability, the socio-technical system and governance itself are each conceptualised as essentially separate and knowable in their own right. Only in this way can governance processes be seen as sufficiently rational and synoptic – providing self-evident frameworks for identifying an objectively 'best' plan for intervening in the socio-technical system (conceived as an 'object') and managing its relations with wider society and nature.

Associated with this perspective, we can identify a distinct conceptualisation of the relationship between appraisal and commitment. These are represented schematically in

Figure 1. The first thing to notice is how governance necessarily seeks to close down the outputs of appraisal around the socio-technical object. The inputs to appraisal can be broad, but because a definitively knowable socio-technical object is presumed to be 'out there', then appraisal can be expected to identify this and so characterise the 'best' options. 'Governance on the outside' presumes a single episteme and is therefore reflective rather than reflexive. The multiple perspectives and knowledges held by relevant actors are considered to furnish individual pieces of an overall jigsaw. Broadening the inputs to appraisal creates a more rounded picture of the problem, with each perspective contributing slightly more data about the overall socio-technical object of study and optimum courses of action. As such, the meta-governance task is to ensure that relevant stakeholders are consulted, with appropriate techniques, so that governance can close-down around the best option as identified by appraisal.

Figure 1. Governance on the outside: intervening in the socio-technical object



Simplistic use of terms like 'sound science' and 'evidence-based policy' by some governance actors imply this perspective. Sustainability indicators are treated literally – as 'metrics' of the socio-technical object, its impact on the environmental system, and for recording progress in transforming the socio-technical object. Appraisal is episodic and learning is oriented towards checking the efficacy of the committed interventions in relation to the particular closed commitments, monitoring subsequent changes to the socio-technical object, and recalibrating outputs accordingly.

Since closure is reached in appraisal, the reconfiguring of commitments in 'governance on the outside' is relatively straightforward (at least in principle). Appraisal not only reveals the socio-technical object and courses of action, but there is a clear distinction between established and new commitments. By integrating sufficiently broad perspectives, the evidence attains an objective legitimacy free of existing commitments, such that it automatically entrains and

reshapes the sustainability commitments required of different actors. Commitment formation follows on deterministically from appraisal, and interventions have to realign established commitments into forms identified by the appraisal.

'Governance on the outside' requires actors not only to contribute to the objective appraisal of the system, but also to adhere to the intervention recommendations arising from that appraisal, by shifting commitments accordingly and reconfiguring the way they contribute to the reproduction of the socio-technical system. This perspective is functionalist in the sense that all actors respond to the imperative of the system overall, and if that imperative becomes more inclusive of sustainability criteria, then actors will redefine and remake their commitments accordingly. Clearly, this managerial task has a political dimension, but ultimately it remains 'managerial' because the politics is about strategies for persuading, cajoling, and forcing actors to bring their commitments into line with the closure reached around appraisal. Governance 'fails' either because the appraisal is subsequently recognised to have been inaccurate, or because insufficient actors have come into line.

Dilemmas confronting governance on the outside

Clearly, ideal-typical 'governance on the outside' derives from a positivist position that is difficult to maintain. In a complex and dynamic world, any closure around appraisal will always be provisional. Pervasive uncertainties and surprises of one sort or another will always arise, leaving space for competing (re)interpretations by the variously committed actors. We nevertheless contend that this perspective has analytic advantages because it does reveal in stark form the governance processes necessary to objectify and manage socio-technical systems - even though political realities mean those externalising processes are inherently problematic. Even under conditions of broad consensus, the managerial challenge can appear daunting, requiring the coordination between processes over different scales and which have different temporal horizons. These lead to mismatches between emergent structures at different levels and disruptions by ever-present contingent 'events', and reinforce Kooiman's point about governance forever trying to catch up. Some degree of governance 'failure' appears inevitable (Jessop, 2003).

The 'political realities' referred to here are not confined to the incomplete integration of inputs in closing-down appraisal, nor to the insufficiency of power required to bring actor commitments into line with that appraisal. Both of these could be overcome by doing 'governance on the outside' better (e.g. more computational power in appraisal, greater legitimate authority over commitment formation). Indeed, theories and practices that lean towards 'governance on the outside' advocate both these measures. But in analysing this perspective in terms of the way it relates appraisal to commitments we can begin to understand why it will always be problematic. More of the same will not work, as we show below.

One fundamental political difficulty confronting 'governance on the outside' is the essentially contested nature of sustainability. We have written about this at length elsewhere (see Berkhout *et al*, 2004). Decades of work in the field of social choice has shown that there cannot – either in principle or practice – be any definitive means to integrate divergent perspectives, interests and preferences, such as to yield a single coherent ordering of socio-technical (or other policy) options (Arrow, 1963, Bezembinder, 1989). Such managerial aspirations are confounded by the incommensurable dimensions of socio-technical performance, strongly divergent socio-political interests and perspectives (Brown *et al*., 2000), recursive inter-relationships between the commitments and appraisal, and the profound and ever-present exposure to surprise (Wynne, 1992, Stirling, 2003). Further intractable issues are raised concerning the role of power (Lukes, 2005; Smith *et al*., 2005) and the nature of effective social deliberation (Habermas, 1996; Munton, 2003) in the formation of 'sustainability'.

We have been interpreted elsewhere as concluding from this that there can be no notion of 'public interest' in sustainability (Meadowcroft, 2005). We do not hold this view. That there is no guarantee of definitive specifications of public interest in any area, does not mean that it is not possible to resolve broad conclusions in particular areas (Stirling, 2006). Rather, the

above challenges mean that governance has to concentrate attention on the importance of legitimate and effective deliberation and learning, and on the crucial role of providing for plurality, reversibility and sustained dissent when constructing the 'public interest'. This raises issues concerning the diversity and resilience of wider social commitments to different socio-technical trajectories and the extent to which particular commitments might be withdrawn (Brooks 1986; Wynne, 1992; Stirling, 2003). Even where we do have consensus over appropriate indicators of sustainability, for example, these are only ever provisional. Social priorities shift; knowledge develops; power relations are challenged. In arguing over whose shared view of the world should count, governance processes remain susceptible to the ever-present possibility of spontaneous, dissenting political discourses opening up new terrain. This leaves the appraisal bedrock of 'governance on the outside' susceptible to significant upheavals and confounds its managerial orientation.

Voß *et al*. (2006: 427) encourage governance 'to establish a setting that is appropriate for the relevant problem. In short, the interaction space needs to be congruent with the problem space'. In addition to the preceding comments about the sustainability problem space being open to different framings, it is important to remember that another key component of the problem space (i.e. the socio-technical) is also ambiguous and uncertain. Amongst analysts there is often ambiguity over the most effective level of empirical application of the socio-technical concept (Berkhout *et al*., 2005). Different participants in a system of socio-technical practice will also have contrasting mental mappings or framings of the 'system' and their role in it (e.g. the appropriate boundaries of the system, key causes of sustainability problems, reconfigurations that will resolve the problem, interrelations between system components). As such, system boundaries, operation and change dynamics (i.e. framings) are open to subjective interpretation and inter-subjective construction. As Voß *et al*. (2006) put it, this 'means that the agent of governance gets displaced from its Archimedean point, outside of the developmental context. Instrumental rationalisation and steering are not applicable under these conditions' (p.423). A common framework – if any – will be the emergent product of negotiations between the different actor framings (and the commitments underpinning each).

Taking the electricity socio-technical system as an example, the 'mental map' of householders with respect to the services constituted by a socio-technical system need not correspond with that of the analyst, governance agencies or other members of the 'system', including other households. Even an actor more actively and intensively involved in the reproduction of a socio-technical system, such as an energy utility company, need not have a comprehensive map of their position in the wider system. The energy utility is primarily concerned with customer markets, competitive generating technology, immediate infrastructures, shareholder value and, possibly, social reputation. It maps its energy system accordingly. Governance for sustainability concerns the utility to the extent that it might reframe the context for business operations. If the utility chooses to participate in sustainability governance processes then it, like the householder (or consumer association), will bring to negotiations a particular framing of the socio-technical, associated problems, and plausible solutions.

It is important to stress the co-evolutionary development of these frames. Each actor does not hold a fragment of a whole, such that all mental maps can be stitched together and the global socio-technical topography revealed. Actors can hold fundamentally different framings of the socio-technical that makes straightforward aggregation problematic. This is because, 'the attributes of the subject help condition the representations of the object and … these representations themselves can help recondition the subject … As a result, any associated interventions are also simultaneously contingent on and help condition a series of divergent but equally valid potential subjective representations' (Stirling, 2006: 227).

Each actor's framing co-evolves with the framings of others. As a result, governance necessarily involves interplays between different framings of the 'system', concerns over how it operates and priorities for change. In effect these interactions over what the socio-technical system is, and what it should become, mean other actors constitute one another's room for manoeuvre (Rip, 2006). Each framing is associated with different forms of commitment, and various degrees of power and agency to effect change. Some selection processes are more 'co-' than others in 'co-evolution'; and the logics within one system framing can have an over-riding dominance compared to the logics of other system framings (Jessop, 2002). And of

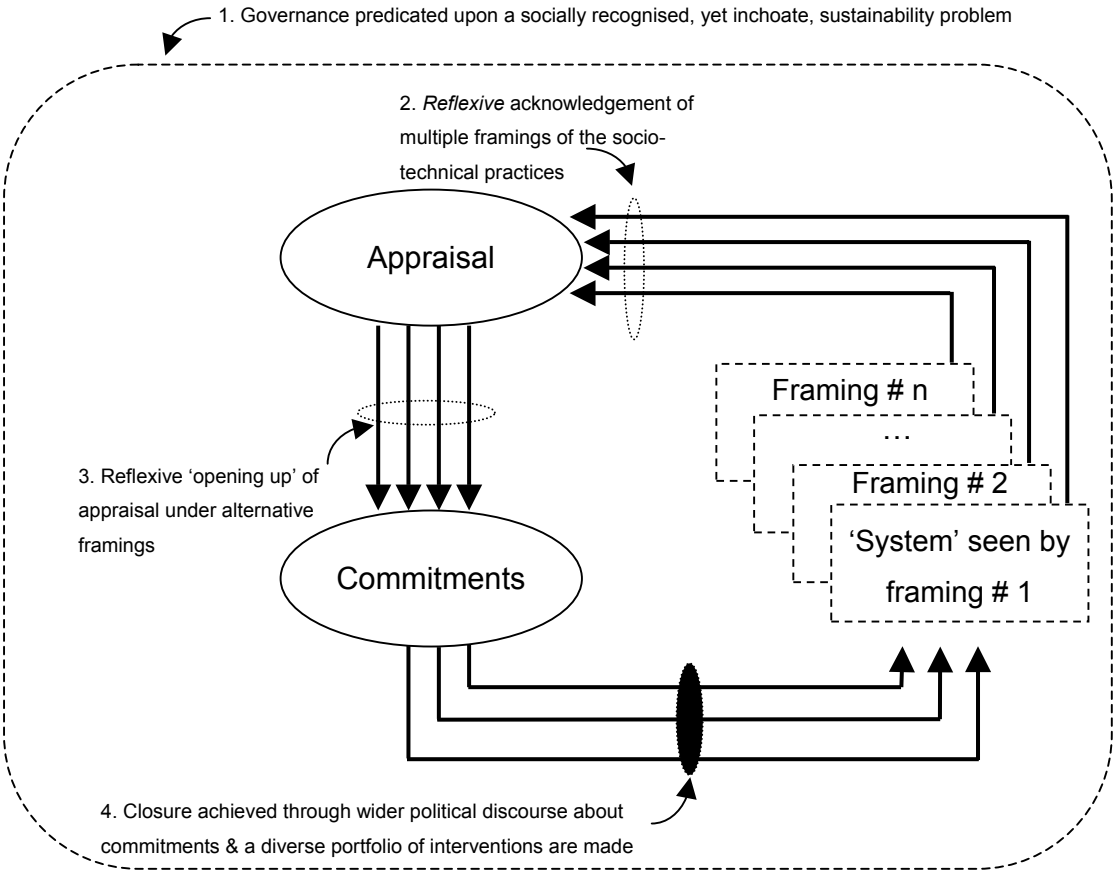
course, if some form of socio-technical construct is agreed (or imposed) collectively, say around energy, and commitments reformed accordingly, then each actor's original framing fits the changed understanding of the situation even more imperfectly than before. Everyone must learn anew, together. 'Governance on the outside' will find its socio-technical object quite elusive.

Sustainability governance can consequently be characterised as the emergent outcome of attempts by different coalitions of actors to set priorities and conceptualise the socio-technical system and its concomitant sustainability problems in different ways (i.e. different socio-technical framings). Some framings will draw in broader coalitions of actors than others. Amongst these competing framings will be those that have enrolled the support of powerful actors in structurally privileged positions within incumbent socio-technical practices.
If governance is to work, then participants must identify and negotiate overlaps between their framings as a mutual basis for interaction. In this regard, Jessop notes how provision for broad deliberation not only becomes a desirable feature of governance, but reflexively how it 'will affect in turn the definition of the objects of governance and, insofar as governance practices help to constitute these objects, it will also transform the social world that is being governed' (Jessop, 2003: 115). These constituting practices are highly political (each framing underpinned by different knowledge claims, social values and material interests) and brings us to the 'governance on the inside' perspective.

Governance on the inside: co-constituting governance and socio-technical subjects

Conceptualising 'governance on the inside' acknowledges the contestability and interpretive challenge identified above, and seeks an accommodation with it. It is a reflexive mode of governance since it explicitly recognises at the outset that there are multiple simultaneous ways of knowing the socio-technical system, each with different implications for the way governance engages with and affects it. The image here is of governance actors and processes as inseparable, pervasive and partly co-constitutive internal features of the socio-technical system itself. Figure 2 attempts to summarise schematically how 'governance on the inside' operates reflexively in terms of relations between the socio-technical, appraisal and commitments. The discussion above anticipates many of the features of this reflexive governance.

Figure 2. Governance on the inside: co-constituting of governance and socio-technical subjects



As with 'governance on the outside', an internal perspective seeks to broaden the inputs to appraisal, but rather than reflecting and aggregating multiple perspectives around a shared framing (the socio-technical object), the conceptualisation here presumes various incommensurable framings are possible. There are multiple epistemes. Acknowledging how this renders socio-technical sustainability ambiguous and indeterminate calls for appraisal to be deliberately and pluralistically reflexive. Commitments to different framing conditions prioritise, constrain and shape different salient socio-technical features for appraisal, as well as suggesting alternative methodologies for attaining knowledge about those features, thereby engendering distinct understandings of the system, its sustainability and 'optimum' intervention strategies for change. The meta-governance task becomes: constituting (rather than inheriting) networks, testing (rather than assuming) legitimacy, negotiating (rather than imposing) expertise, addressing (rather than accommodating) power and exercising a facilitating authority based on pluralism rather than objective neutrality (Stirling, 2005; forthcoming).

An important consequence of this perspective is that closure is not reached in objectifying appraisal processes – though appraisal certainly informs - but through negotiated commitment formation. In this view, commitments precede, mediate and are partly formed through appraisal, but important aspects of commitment formation also arise through the diverse normative goals of broader political discourse. Closure is political. There is, of course, a much stronger and reflexive circularity here, in the sense that established commitments and normative political discourses are already informing the multiple and incommensurable framings being grappled with by the appraisal function of governance. Here, an 'ironic' separation between appraisal and commitment (Jessop, 2003), is maintained in order to establish an analytic purchase on the complexities, which contrasts with attempts at more literal separation under a governance on outside view. This also contrasts with an emphasis in 'governance on the outside' on '1st order' learning about the instrumental efficacy of interventions , in that an internal conceptualisation of governance extends this to include more

normative lessons about the socio-technical consequences of different framings (2nd order learning).

It is apparent from the discussion here that closure under the internal co-constitutive account is a much more complex process than the elicitation of unitary outcomes in appraisal. The forming of social commitments to particular technologies is understood in a more conditional, temporary, diffuse and reversible fashion than is suggested by the discrete notion of 'decisions' (Wynne, 1992). Accordingly, rather than the monolithic optimising strategies associated with external governance, internal governance recognises the importance of strategies for 'closure' that build in qualities of flexibility, diversity, resilience and robustness. In other words, the closure that still takes place is as much ontological (embodied in commitments) as it is epistemic (embedded more exclusively in appraisal). Figure 2 illustrates this strategy with governance committing to a diversity of socio-technical options.

In 'governance on the inside', processes of engagement, dialogue and deliberation require explicit and careful attention to questions of power, authority, consent, dissent and, above all, legitimacy. In particular, governance must undertake an open and inclusive normative evaluation of 'the correctness of its procedures, the justification for its decisions, and the fairness with which it treats its subjects' (Grafstein, 1981: 456 quoted in Beetham, 1991: 10). Legitimacy has a double role here. First, there is the legitimacy of the governance deliberations themselves. Efforts are made to ensure key uncertainties are acknowledged, different assumptions and frameworks are rendered transparent, the plurality of social values are debated, and different material interests are addressed. The second role played by legitimacy relates to the socio-technical system. As such, governance constructions of the socio-technical must question the legitimacy of established practices in relation to ideas about sustainability emerging in governance deliberations at the same time as exploring the sources of legitimacy for more sustainable options.

Sources of governance failure are more complex than with governance conceptualised on the outside. In the latter case, these were described above as failures in managing appraisal and commitment relations between socio-technical object and governance arena. When governance is conceptualised as co-constituting the socio-technical, then failure arises through limitations in the degree of reflexivity that is actually achieved (Jessop, 2003). Idealised symmetrical social partnerships, helpful for deliberations in 'governance on the inside', fail to be borne out in practice. Compounded by the perennial insufficiency of reflexivity in the way governance processes engage with the complex systems in which they are embedded, and which they are trying to shape.

Dilemmas confronting governance on the inside

Just as 'governance on the outside' displays its share of problems, so 'governance on the inside' must confront a number of dilemmas. One has to be cautious with the internal co-constitutive conceptual positioning of governance being elaborated here. A particular challenge here arises in relation to the close relationship between 'sustainability governance' and 'reflexive governance' (Vos et al, 2006). The objectives of sustainability (broad and sometimes ambiguous as they are) do not have a monopoly of salience in the understanding and directing of socio-technical change. Sustainability governance 'merely' attempts to advance *sustainable* socio-technical change arguments and initiatives (e.g. through sustainability commissions, partnerships, deliberative fora). A sustainability governance arrangement will therefore play a constitutive role to the extent that it becomes *the* focusing process for thinking about and negotiating strategic socio-technical changes being considered in other arenas (e.g. markets, board-rooms, regulatory agencies, government ministries). There may, for example, be separate governance arrangements aimed at boosting the international competitiveness of firms or sectors that occupy overlapping socio-technical territories, but operate different sets of criteria and activities. After all, existing institutions and governance arrangements not concerned with sustainability questions are also intrinsic elements of the socio-technical system and will need to be addressed in any governance moves for sustainability.

In addition, care must be taken to avoid the relativistic trap. To acknowledge that the sheer complexity of natural and socio-technical systems introduces a degree of indeterminacy, does not imply that anything goes (Cilliers, 2005; Stirling, 2006; Grin, 2006). Material structures and institutional processes, however complex, still constrain the way sustainability governance arrangements can interpret and 'construct' an agenda for a socio-technical system. There will be elements of the day-to-day operation and development of technological practices associated with the socio-technical system that offer limited interpretive flexibility and resist assimilation to the priorities of sustainability governance. Few artefacts displaying interpretive flexibility are completely malleable. Power relations and established structures – as well as the inherent properties of technical artefacts and natural environments – limit the diversity of social constructions of socio-technical systems that are available to sustainability governance. The argument is not over whether 'closure' will necessarily – or desirably – occur. Rather, it concerns the locus, form and degree of this social closure.

A further complicating factor in apparently neat distinctions between governance on 'inside' and 'outside', is the nature of wider political discourse. One has to be careful not to be myopic towards politics beyond sustainability governance (environmental or otherwise). The relatively institutionalised deliberations and decisions taken in formal governance settings are not the only arena in which socio-technical practices and problems are considered and articulated. Governance takes place within a wider and more spontaneous political discourse that can, from time to time, disrupt and penetrate more formalised governance deliberations and activities (Hajer, 1995; Torgerson, 2003). As we have sought to argue above, governance arrangements will have an important constitutive position in the construction of socio-technical sustainability, in the sense that it is the site where problems are articulated, directions deliberated, and intervening actions initiated. But wider political discourse provides an influential context. As an example, the ebb and flow of different narratives within political discourse on energy (e.g. environment, security, poverty, dependency, energy 'gaps', liberalization) have been reflected in shifts in support for different energy socio-technical practices in energy governance. The performance of different energy-related socio-technical practices is reconsidered against the newly salient criteria or concerns in political discourse (e.g. the rise, then fall, and now attempts to revive support for nuclear energy).

In other words, the conceptual positioning of governance as an internal feature of socio-technical systems does not mean that these 'internal' governance processes are the sole constituting forces. Rather, governance activities connect and interpret broader socio-technical realities and wider political discourses and provide an important focal site. So the *co*-constitutive role of governance is as a deliberative site shaped by, and shaping, socio-technical systems and political discourses..

Governing under conditions of ambivalence, uncertainty and distributed power

This paper has developed a distinct pair of schematic conceptualisations of sustainable socio-technical governance. Under the first, governance is considered as ***external*** intervention acting upon an effectively separate socio-technical object: appraising the object, forming commitments accordingly and monitoring progress. Here governance is considered as an essentially instrumental managerial task. Under the second view, governance is seen as ***internally*** co-constituting the socio-technical system itself – conditioning and itself conditioned by the relationships, practices, problems and understandings which it seeks to steer. Here, governance is consequently characterised as more political than managerial – highlighting the importance of properties such as transparency, legitimacy and accountability in deliberative engagement between contending framings.

Implications arising from these two ideal-typical conceptualisations are summarised in Table 1. Each suggests different strategies for realising sustainable socio-technical transitions. Correspondingly, each approaches the challenges of sustainable socio-technical transitions very differently. In particular, their approach to questions of ambivalence, uncertainty and power relations in sustainable transformations contrasts vividly. 'Governance on the outside', owing to its fundamental objectifying drive, considers ambivalence and uncertainty as temporary conditions. Uncertainties are 'closed down' through 'better appraisals' (e.g. by

integrating a sufficiently broader set of perspectives and through social learning). Successive appraisals will, over time, feed lessons back into the continual (re)formation of commitments towards sustainability, progressively clarifying the ultimate object (a sustainable socio-technical system). Just as uncertainty is subject to reduction in this way, so too is any ambivalence on the part of contending actors concerning the characterising and prioritising of different aspects of sustainability (e.g. which indicators to trade off), which is assumed to reduce through successive appraisal and deliberations. Even if not clear at the outset, 'optimum' solutions and pathways are expected to become evident in due course.

The question of power in 'governance on the outside' is relevant only in so far as governance processes need sufficient power to bend and co-ordinate actor commitments, such as to respect the findings of appraisal. As understandings about the socio-technical system improve (uncertainty reduced through learning), and as the superior performance of certain sustainable socio-technical practices becomes more evident (ambivalence overcome through converging experience), so the power of argument is enhanced and the need for coercive power reduced. Managing ambivalence, uncertainty and power is undertaken by governance following strategies in the left hand column of table 1.

Table 1: Governance perspectives and implications for processes of appraisal and commitment formation.

GOVERNANCE FUNCTION	**GOVERNANCE PERSPECTIVE**	
	'Governance on the Outside' **external intervention by governance subject in socio-technical object**	**'Governance on the Inside'** **internal co-constituting of governance and socio-technical subjects**
Appraisal	• Broadening-out the inputs to appraisal / extended reflection • Scoping a particular sustainability problem / goal • Aggregating 'relevant' actor perspectives • Sustainability indicators treated as metrics • Drive to objectify the socio-technical object • Informs formation of commitments • Analysis and deliberation over the 'best option(s)' • 1st order learning: effectiveness of appraisal/intervention	• Opening-up the outputs of appraisal / pluralistic reflexivity • Accepting contested nature of sustainability • Exploring different actor framings • Sustainability indicators treated as heuristics • System ambiguity accepted • Empowering deliberation over commitments • Incommensurable perspectives, conditional and situated options • 2^{nd} order learning: consequences of different framings
	Clear distinction between appraisal and commitment in governance stages.	*Reflexive interaction between appraisal and commitment processes in governance.*
Commitment	• Appraisal determines commitment formation • Managing governance interventions • Legitimacy derives from objectivity or authority of appraisal • Concentration and uniformity of commitment • Aversion to failure • Unilinear, unidimensional and discrete interventions • Episodic and isolated commitment making • Interventions seen as functionalist	• Appraisal conditionally informs commitment formation • Closure through wider political discourse • Legitimacy is negotiated through governance • Ensuring strategic diversity, resilience and robustness • Irony and social learning • Multilinear, multidimensional flexible repertoires • Constantly renegotiated and pervasive • Interventions seen as power laden
Attitude to governance	*Largely instrumental managerial function*	*Fundamentally engaged political process*

‘Governance on the inside’ sees things very differently. It has trouble reducing uncertainty, since reductions under one framing merely pose more questions under alternative framings. Ambivalences prevail over how governance should best cut into and simplify the sheer complexities of socio-technical systems and their relations with complex natural systems. Power relations are considered something pervading the negotiation of governance constructs. Ever more accurate appraisal – if such a thing is possible - is unlikely to see the progressive evaporation of such power relations. Rather, such relations must be rendered transparent in appraisal and commitment formation processes and subject to deliberation and scrutiny. Negotiating ambivalence, uncertainty and power is done by following the strategies in the right hand column of table 1. None of these serve to resolve ambivalence, uncertainty or distributed power. Rather they provide means for accommodating and living with them.

The over-riding strategy in the left hand column is to objectify. The over-riding strategy in the right hand column is to enhance reflexivity in the governance process. In both cases (but for different reasons – the respective dilemmas identified above), governance must involve substituting hubristic aspirations to optimal solutions, with more modest ‘satisficing’ strategies aimed at ‘acceptable outcomes’. In practice satisficing happens to varying degrees in virtually all governance settings (even if outward-facing representations by actors present decisions as based on rational optimisation). A more open and transparent satisficing strategy requires regular self-critical re-assessment of the extent to which these strategies are delivering the outcomes desired under different perspectives.

As with ‘success’, so is it important to recognise the limits and conditionalities attached to notions of ‘failure’. Just as governance solutions can seldom be ‘optimal’, so are governance failures rarely complete. Incompleteness, insufficiency or divergence from initial aims is usually qualified by mitigating factors. It is important to emphasise that satisficing must not be interpreted conservatively and follow only incremental approaches. More ambitious and radical paths can be realised. The crucial point is that governance retains faculties for reflexivity, flexibility and irony in respect of failure as much as success. This ironic stance derives from recognition of how one is reflexively implicated in the imperfect social construction of a socio-technical ‘object’ and sustainability ‘goal’. It demands greater humility over limits and fallibility of both analysis and deliberation, whilst retaining optimism over the efficacy of action (Jessop, 2003). In these terms, it is better to acknowledge how power relations help shape and curtail deliberation, than to pretend such distortions do not exist (Meadowcroft, 1998).

A second key strategy worth highlighting, this time exclusively under ‘governance on the inside’, is deliberately to cultivate a ‘flexible repertoire of responses so that strategies and tactics can be combined in order to reduce the likelihood of failure and to modify their balance in the face of failure and turbulence in the policy environment’ (Jessop, 2003: 107). From a narrow (economic) and short-term perspective, this may look like inefficient redundancy. But under broader and longer term perspectives, such flexibility is an essential response to dynamic and uncertain environments.

There are a number of ways in which these general governance injunctions relate to the substantive features of our table. There exist many resonances with the wider literature on adaptive capacity, resilience and robustness (Folke et al, 2000; Stirling, 2005) One important but relatively neglected element, for instance, is the deliberate fostering of a diversity of technological and infrastructural options and structures (Stirling, 1994; Smith, forthcoming) (see also point 4 in figure 2 above). By developing a form of ‘requisite variety’ (Ashby, 1957), this may at the same time help to foster each of elements of Jessop’s ‘flexibility’ (Jessop, 2002), whilst also displaying a series of further benefits (Stirling, 1998). Critical cross-comparison between the unfolding implications of each parallel strategy helps promote greater reflexivity. The ‘resource pool’ embodied in the portfolio of disparate options presents more opportunities for effective responses to uncertainty and surprise. And the way in which the parallel pursuit of disparate technological options helps accommodate otherwise irreconcilable social interests and values (Stirling, 1998; Smith, 2006), also has the effect of enhancing Jessop’s faculty of irony. A further strategic benefit of diversity lies in the propensity to help resist market failures associated with ‘lock-in’ under increasing returns (Arthur, 1989; Stirling, 1998). Finally, technological and institutional diversity offers an

important means to foster productive innovation (Grabher, 1994; Stirling, 1998; Smith, 2006b).

An illustrative example here might be the contrast between the relative degree of flexibility associated with electricity supply systems based predominantly around centralised nuclear or natural gas power, and that displayed by a diverse portfolio that includes renewable and distributed generating technologies. In this latter case, reflexivity, redundancy and irony are each furthered through the interplay of disparate arrays of primary resources, industrial dependencies, infrastructure dispositions, trading opportunities, institutional structures and societal and environmental implications.

Conclusions

The central argument in the paper is that the manner in which governance processes may realise sustainable technologies depends on the general way in which governance is conceptualised in relation to socio-technical systems. The question is, do our two idealised governance types always contradict one another, or can they be complementary? The short answer is that their foundational differences are so great that they are inherently contradictory. Each seeks a very different pathway towards sustainability. A longer answer might be more qualified, considering possible accommodations where governance is looked at over time. In reality, both types are present simultaneously, but as opposite tendencies that give governance its dynamism. It is inevitably incomplete attempts to reconcile their fundamental contradictions that help drive governance developments.

Thus analysis can track (theoretical and practical) developments in socio-technical governance as they move around the cells in table 1 and attempt to reconcile contradictions. Current attempts by analysts in formulating 'reflexive governance' can, for example, be seen as a conceptual move to the right hand column of Table 1. Any difficulties in these attempts might be because they retain some of the managerial aspirations of governance in the left hand column (see, for example, the edited volume by Voss *et al* (2006)).

Depending on the context and perspective, it may or may not be reasonable to argue that politics over framings must cease at some point, and governance must arrive at some manageable, objectifying closure.

> 'Even with the benefit of initial understanding and further learning, an 'eternal tension' will remain between the need to fix an approach in order to do something here and now and perhaps make a difference, and the still insufficient understanding of what might happen which makes it difficult to 'fix' the appropriate approach'.
> (Rip, 2006).

However imperfectly formed, pragmatic 'decisions' must be made (whether consensual, majoritarian, elitist, or to meet sectional interests) and commitments formed. Our analysis simply identifies why this (managerial) 'implementation' will always be provisional and, indeed, why 'decisions' have to be put into a broader historical context. One can plot the history of any attempt at the governance of socio-technical sustainability by following moves around table 1. If, for example, governance innovates appraisal procedures that open up the outputs (top right of table 1), but still anticipates appraisal as determining the necessary commitment formations for sustainability (bottom left of table 1), then this contradiction will soon become apparent in disputes over the basis of the course of action taken.

A critic might argue that because governance theories and practices are distributed across our table, then the table is wrong and our fundamental characterisations incorrect. We do not think so because our distinctive types are – in our view – contrasting well-established positivist and critical realist positions. The distributed movements of governance across the table reflect how these contending epistemologies both make claims concerning how we think about governance and on how we are governed.

As for our own position on the most 'appropriate' form of governance itself, this will likely have become clear in this paper. We contend that it is through governance debates and negotiations (including appraisal but also operating in political discourses over commitments) that we best come to understand the socio-technical system, its implications and potentialities, and the array of possible interventions for enhancing its sustainability. Only in this way do the different interests, perspectives, framings and strategies of governance actors become apparent. Under this 'internal co-constituting' perspective, the 'external intervention' description of the task of governance emerges as heroically optimistic, or misleadingly disingenuous. Problems arise equally right at the outset with notions of objectively neutral facilitating agencies, precisely targeted interventions, self-evidently appropriate and complete selections of 'stakeholders' and single consensual, coherent and precisely articulated joint action programmes. Instead, governance must begin with the prior and more fundamentally reflexive challenge of constructing and recruiting to the governance arena itself. Governance thus becomes an inherently political – rather than purely managerial – process.

This is not to say that the governance functions as envisaged under the 'external intervention' perspective are necessarily erroneous, irrelevant or unrealistic under the 'internal co-constitutive' view. The point is rather that the fulfilment of these functions will inevitably be socially constructed – and as such requires due attention to deliberative process. This does not mean we should 'give up' on governance attempts at co-ordination in the public interest. Awareness of the contingencies involved in this process, and an appreciation of the limits to smooth management, urges rather that we should proceed with a keen (even ironic) sense for its inherently political characteristics (Meadowcroft, 1998; Jessop, 2003).

That said, an advantage arising from the conceptual positioning of governance as constitutive of, and constituted *within,* socio-technical systems is that this highlights the open-ended, political aspects of sustainable development. The artificial separation of a governance 'subject' from an unsustainable socio-technical 'object' may provide some convenient simplifications for governance functions, but it quickly becomes apparent that this is just an expedient fiction. Despite managerial attempts to elide ambiguities, obscure uncertainties and exclude dissent, neglected complexities have a habit of re-emerging in ever more compelling ways. At the same time, however, there can be limitations to reflexivity, and a desire in certain governance settings to objectify and fix the sociotechnical despite the above difficulties. In practice, therefore, governance will move between the two poles established by our ideal-types of governance on the 'outside' and 'inside'. The key thing is to acknowledge this dynamic and learn from these recursive movements between reflexivity and objectification.

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