

Inside or out? Open or closed? Positioning the governance of sustainable technology

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Note:

This paper presents work in progress. An unfortunate but necessary implication of this continuing development is that the paper is overly long. We nevertheless hope other workshop participants have the time and patience to consider our contribution thoroughly. In the spirit of the workshop format, we look forward to receiving feedback and criticism, as well learning from other participant contributions, helping us to produce a more succinctly argued version of the paper after the workshop.

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Introduction

For good or ill, technology mediates our relationships with one another and with nature. Whether an ox-drawn plough in the hands of a peasant, or remote sensing equipment feeding back data from a satellite, technology informs and shapes our place in our environments. It is therefore unsurprising that technological development occupies a central position in debates about governance for sustainability. Yet 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, policy debates treat steering itself as relatively asocial, (thus understating the roles and 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’, ‘open’ or ‘closed’ – and draw practical implications for steering.

The socio-technical turn in environment and innovation studies provides a good example of this tension. Here it is recognised 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 they are also unhelpful, 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, can be expediently neglected.

The artificial separation of governance from the functioning of the socio-technical system may appear to simplify the process of identifying relevant selection pressures, adaptive capacities and modes of intervention. Yet, in so doing, it becomes more likely that neglected complexities will re-emerge in even more polarised and exacerbated forms in order to resist, dissipate or undermine efforts at steering. In the end, the resulting process of politicisation will force the re-internalisation of the governance process into the socio-technical system in newly intensified and sometimes disruptive ways (see also Hajer, 2003). In order to avoid this inefficient and potentially disabling cycle, it is desirable that technology governance becomes more reflexive over its own intrinsic role in the functioning of power relations, structured interests, value systems, policy networks and patterns of agency and discourse within the socio-technical system. Only in this way can efforts at steering engage more effectively right from the outset with the associated uncertainties, ambiguities and indeterminacies.

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 social appraisal and steering must become more reflexive. In particular, there needs to be greater appreciation of the **internal** locii of governance processes within the socio-technical systems themselves, and of the necessarily more 'open' role of appraisal under these conditions. In striving towards technology governance conceptualised from

within socio-technical systems, we suggest how novel tools in technology appraisal may lend themselves to this internal positioning. 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'.

The paper is structured as follows. The next section introduces key arguments about relationships between technology, sustainability and social choice. The two subsequent sections contrast external and internal perspectives on the sustainability governance of socio-technical systems. Two images are compared, one of governance of governance as 'outside' and intervening in socio-technical change, the other conceiving governance as 'inside' and co-constituting the socio-technical. The contrasting conceptual positioning of governance in relation to sustainable technology lends itself to different approaches to the opening-up and closing-down of options in the social appraisal of technology and the socio-technical. This is discussed in the penultimate section of the paper before we conclude with some final remarks arising from our analysis.

Technology development and sustainability

As pointed out in the introduction, technology plays a powerful role in sustainable development. It is an ambivalent role in the sense that technologies can have negative or positive environmental or social ramifications. This is a widely recognised point. Writing to Romano Prodi, President of the European Commission, in 2003, Goran Persson and Tony Blair (the Swedish and UK Prime Ministers respectively) noted: 'New technologies and processes can contribute to the goal of decoupling economic growth from environmental degradation. However, to a large extent the technologies and systems of the past still dominate in important areas such as transport, energy, industry and agriculture. In each of these sectors new and better technologies are available or emerging. To speed up the

replacement of old technologies there is a need to set clear targets, develop stronger market based incentives and make more use of the instrument of public procurement'.¹ Implicit in this view is that sustainable technology development can be relied upon simply to 'happen'. Cleaner technologies are ready and waiting in relatively 'autonomous' forms, requiring only an appropriate 'nudge' here and there to establish them in markets. The task for government (and broader governance) is to set the right conditions for selecting the most 'sustainable' technology options. Contrasting with this view is an understanding of technology development as an intrinsically social and (as has been argued) political activity. Technologies have to be *made* to happen – requiring active processes of 'social construction' at every stage in the innovation process. Both views are discussed in this section because they inform perspectives on technology governance in important ways and have relevance for its conceptual positioning.

The 'autonomous technology' perspective

The essence of this perspective is that technology development operates according to an internal logic of inventiveness largely independent from the wider social world. Innovation is an autonomous process that can be relied upon to respond to signals and generate technology fixes for social problems like unsustainability.² Such a view of technology is implicit in both market and hierarchical approaches to co-ordinating technology development. Both focus efforts on creating the right signals to which innovation efforts will respond. Either the right market incentives or regulatory mandates are needed to encourage sustainable technology development. As argued by the Prime Ministers above, governing technology is simply about stipulating standards, externalising uncertainties or influencing pricing through appropriate market or regulatory frameworks. This autonomous, asocial perspective is blind to the possibility that innovation processes might themselves be products of similar

¹ Open letter sent 25 February 2003. At: www.defra.gov.uk/environment/business/envtech/pdf/blair-persson.pdf. Accessed 9/12/2005.

² This optimistic characterisation of autonomous technology contrasts with more pessimistic and familiar notions of 'technology out of control', beyond the agency of humans (Winner, 1977).

social processes to those causing the problems of concern (with concomitant constraints on technological problem-solving capacity).

Within the autonomous perspective, a neo-classical economic understanding sees innovation and technical change as responding largely to market signals. Shifts in relative factor prices alert and refocus innovative effort. Accordingly, a market-oriented co-ordination mechanism ought to be sufficient to steer technology development in more environmentally sustainable directions. The task for government is then to correct market failures such that the monetary values associated with adverse effects on the 'environment' are included in associated market prices. Environmental taxes (e.g. waste charges) and the creation of markets for environmental services (e.g. carbon emissions trading) aim to shift the market context in which innovation takes place and technologies emerge.

Such market-oriented co-ordination mechanisms rose to prominence in the late 1980s and throughout the 1990s. This approach emerged within and consequently chimed with neo-liberal ideological agendas prominent at that time. Market-oriented co-ordination of sustainable technology was a welcome antidote to the hierarchical, top-down mode of co-ordination epitomised by an earlier generation of command-and-control environmental regulation.³

For its part, command-and-control regulation seeks to direct technological development through the imposition of environmental controls (e.g. emissions limits) or technology standards (e.g. best available techniques). Hierarchical co-ordination mechanisms such as these were subsequently characterised by critics as economically inefficient, environmentally ineffective and administratively cumbersome. However, this often involves rather circumscribed and expedient understandings of efficacy and efficiency, under which existing market structures and priorities remain privileged and unquestioned. In practice, command-and-control regulation of technology

³ Instituted at a time when prevailing ideology was happier with a more proactive, interventionist role for the State.

allows broader aspects of efficiency and efficacy to be addressed. Indeed, for this reason, command and control instruments remain more significant in contemporary technology governance than is often conceded – and continue to offer indispensable tools for the promotion of more sustainable technologies (Smith, 2000).

Debates over ‘command and control instruments’ and ‘market based measures’ are well rehearsed. This is not the place to debate their relative merits as means to promote sustainable technologies. The purpose of this discussion is rather to highlight the somewhat neglected point that both hold in common a somewhat ‘autonomous’ view of the innovation process. Each represents a different form of external ‘selection pressure’, acting on an innovation system that is seen as essentially separate from the process of governance. As such, both contrast with a governance mode that relies on negotiations and deliberation over technology development taking place within networks of state and non-state actors operating as part of the innovation systems themselves. It is just such a view that emerges from the recent ‘socio-technical turn’ in technology studies. Here it is recognised that technology development is a networked, uncertain, highly path-dependent enterprise. Under this perspective, market-based understandings fail to comprehend the impossibility of deriving definitive monetary representations of inherently incommensurable environmental goods and services (Arrow, 1963). And market-oriented measures alone would in any case remain insufficient, because innovation processes simply cannot respond with the requisite speed, facility, sensitivity or fidelity to stimuli that are as coarse-grained, volatile and ambiguous as ‘price signals’. At the same time, ‘command and control’ approaches can struggle fully to address the internal complexities and potentialities of innovation systems. Centralised linear processes of decision making in state agencies simply cannot assimilate the necessary information, deploy sufficient resources or address the full heterogeneity of conditions required to ensure effective technological changes. As a result, both ‘market based’ and ‘command and control’ approaches sit within a wider governance context in which it is interdependent actors in distributed networks that make crucial social choices about

technology development. This requires a different view of technology governance, in which it is recognised that sustainable technology development arises best through negotiations and interactions of multiple actors, state and non-state (Kooiman, 1993; Glasbergen, 1998).

The 'socio-technical' perspective

The sociology of technology, particularly the constructivist perspective, highlights the importance of socio-political processes in the promotion, selection, development and use of technologies. This seriously qualifies and conditions any notion of there existing a single 'inherent logic' driving the development of any given technological artefact – thus dissolving any apparent 'autonomy' on the part of the encompassing innovation system. Technologies, promising prototypes, or prospective design solutions, possess (or are held to promise) certain qualities and performance (e.g. speed, efficiency, power, entertainment, warmth, cleanliness). But these qualities, whilst important and necessary, are insufficient for guiding technology development. They *underdetermine* technology choice. It is socio-political processes that present criteria against which these qualities are understood and judged, and whether the technology represents a worthwhile means for satisfying a human need⁴ (Yearley, 1988). The is the *performative qualities* of a prospective technological solution – and the ways these are taken up, interpreted, invested in meaning, and exploited – that clinch the manner of any eventual development.⁵ Such an understanding of the innovation process means that technology development simply cannot be seen as a technical exercise. Instead, it becomes inherently political (see later).

Of course, the implications of sociological analysis are more nuanced than this. The above characterisation might still be taken to imply a process in which a suite of different technologies 'appear' with certain qualities inherent,

⁴ Though human need is a far from obvious objective, largely socially determined (see Leiss, 1978).

⁵ Judgements are often based upon a mix of impressions, informed by such things as values, prior experience, comparison with the qualities of incumbent technologies, expectations, knowledge, and institutions.

and are subsequently sifted out against socially negotiated criteria. Such a view would still be compatible with the hierarchical and market approaches to the normative co-ordination of technology development. In practice, the crucial point is that the 'social' and the 'technical' are in a continual and recursive process of reflexive co-constitution. In other words, socially derived performance priorities are themselves informed and conditioned in plural and ambiguous ways by visions of the existing and emerging technical possibilities to which they are ostensibly applicable as independent evaluative criteria. At the same time, the search for technological improvements (and the understanding of technical possibilities) is equally informed and conditioned by shifting socio-political priorities and criteria. So, for example, the use of sheeps' wool as a basis for a modern thermal insulation technology in construction only becomes apparent when sustainability criteria are salient (i.e. the material was 'sifted' positively relative to conventional materials, like mineral-derived rock wool). Yet identification of this potential only occurred once developers – driven by shifting socio-political agendas - began to think about the material differently and to seek out new performance properties that could advance its use as a building insulation material (cf. the conventional perception of wool as a textile).

On this latter point, it becomes important to remember that not only technology selection but also technology creation happens in highly social settings. These dynamic environments are themselves shaped by wider processes, such as peoples' habits and routines, markets, institutions, the infrastructures upon which individual technology artefacts depend, and so on. Continuing our example, even if sheep's wool has been identified as a promising material, it still has to enrol wider support by engaging favourably with existing design practices and skills sets, manufacturing and distribution channels, and the routines and infrastructures associated with modern house-building and renovation.

As a result, technological change tends towards incremental, path dependent developments within existing systems of technological practice (Rip and Kemp, 1998). Relatively non-disruptive technologies, like sheep's wool,

generally have a better chance than radically alternative design concepts, like straw-bale housing. The former can slot into the existing complex of practices without too much change. More revolutionary alternatives require more pervasive, hard-negotiated changes within wider and more complex networks of diverse actors.

The term 'socio-technical' has been coined to capture this nexus of complex, mutually influencing and co-reinforcing processes. Those socio-technical 'configurations that work cannot be demarcated from the rest of society in a simple and obvious way' (Rip and Kemp, 1998: 331). The web of interactions can be extensive. If the development of the socio-technical is a highly social process, then ultimately it is different social actors who negotiate technology development. Yet imposing a normative goal like sustainability upon the existing socio-technical system implies connecting and synchronising changes among a formidable array of actors, institutions and artefacts at many different points in these systems.

In recent years, the 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. Governance can only really do this by transforming wider socio-technical systems (Berkhout, 2002). In part, this reconsideration of the governance challenge arises from a recognition similar to that made above. The new governance focus recognises that technologies are embedded within wider socio-political and economic systems. 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 on the socio-technical is a view holding that radical changes at the system-level are needed to deliver the revolutionary material efficiencies and emission reductions that sustainable development demands. An expression of this is the 'transition management' approach to

governing the transformation of socio-technical systems (Rotmans and Kemp, 2001). This essay will make allusions to this approach at appropriate points, but its basic intent is clear. It provides a suite of normative guidance for governance that hopes to steer the radical transformation of incumbent socio-technical systems towards more sustainable outcomes.

A consequence of this view is that ideas of technology governance must take on a social, political and networked pattern that is consistent with the emerging understanding of the socio-technical systems themselves. Since successful technological development emerges through a complex network of actors, artefacts and institutions, so attempts at its control will need to engage across many of the actors within that network. 'All relevant social groups contribute to the social construction of technology; all relevant artefacts contribute to the construction of social relations' (Bijker, 1995: 288). Consequently, governance should involve all 'relevant' actors or groups. The key term here is 'relevant'. Bijker offers an implicitly pluralist view: relevance is an open competition between different groups possessing various, but always incomplete, levels of technological agency. A marxist view would consider relevance as structured by the imperative of capital accumulation and proximity to the means of production. An elitist theory of relevance would limit relevant technological agency to elites acknowledged as having scientific and technological expertise. A narrow 'interactionist' understanding might highlight the most proximate actors, whilst neglecting the structuring role of overarching interests and power. The 'relevant' targets and participants in any governance initiative in sustainable technology are thus open to interpretation.

The above discussion underscores the role of human agency in technology development. But it is an agency that is complex, diffuse and subject to negotiation between actors, institutions and artefacts. And it is here that there seems a curious disjuncture in discussion about the governance of technology that this sociological view opens up. On the one hand, recognising the social in technology development illuminates new possibilities for a normative, goal-directed governance of technology. On the other hand, there is a risk that this very conceptualisation of the socio-technical as a 'system' inclines towards a

detached view of governance – as a separate overarching arena from which the system can be subject to discrete, deliberate interventions.

In practice, the fundamentally socio-political nature of innovation means sustainability governance cannot sit apart, but has to be addressed as part of the negotiation within the socio-technical system itself. We illustrate this point in the following two sections where the implications of an unsatisfactory conceptualisation of governance taking place ‘outside’ the socio-technical system is contrasted with a conceptualisation of governance as constituting the system in vitally important ways. It will be argued that these contrasting views hold important implications for the way we go about ‘opening-up’ and ‘closing-down’ collective decision-making about sustainable technology development.

Governance on the outside: intervening in socio-technical change

First we will consider the image of governance as sitting apart from the socio-technical object that is to be governed. In this view, governance considers the changes deemed necessary, and then intervenes to reconfigure socio-technical arrangements into more sustainable forms (Glasbergen, 1998). Governance is largely a functional, managerial exercise. The governance challenge rests in co-ordinating the resources and efforts of actors towards the common goal of sustainability. Essentially, the tasks are: 1. an accurate diagnosis of the socio-technical problem, and 2. marshalling the resources needed to make corrective interventions. Governance functions are self-evident and the challenge rests in identifying and co-ordinating between the actors that, collectively, can provide those functions. This is quite a technocratic image of governance.

‘Technocracy presupposes a rational administrative sphere capable of monitoring and regulating social systems efficiently and effectively through complex patterns of input, output and feedback’
(Torgerson, 2003: 114-115)

Obviously, the co-ordination challenge remains considerable. It is interesting that socio-technical change is often taken as illustrative of how governance can struggle to get to grips with its object, '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). Whatever the outcome of this race, the tasks and purposes of governance remain relatively clear. Voß *et al.* (2006) characterise these governance functions as problem identification, goal formulation and strategy implementation. In transition management, the governance challenge is to develop a sustainability vision and agenda that can guide change, then create transition experiments and programmes for innovating the system, whilst also developing outcome and process indicators for monitoring and revising progress (Kemp and Rotmans, 2005).

So governance must fulfil diagnostic and prognostic functions. First, it must identify problems of unsustainability in the current socio-technical configuration. Secondly, it appraises the best solutions to those problems. Thirdly, it implements those solutions by making interventions. Finally, it monitors the consequences of its actions and makes necessary adaptations. Not only is there a conceptual distance between the socio-technical 'object' and the intervening governance arrangement, but governance follows a distinctly sequenced process.

The tasks governance must fulfil in delivering each of these staged functions are elaborated briefly here (see also Smith *et al.*, 2005). The first is for governance to facilitate the social appraisal of both problem identification and goal formulation. By 'social appraisal', we mean the reflective and reflexive processes of social learning through which multiple social actors come to understand the implications and conditionalities associated with different possible technological commitments (Stirling, 2006). Depending on the context, this appraisal may take more expert-analytic or more participatory

and deliberative forms (Stirling, 2005). These are a necessary corollary of intentional technology governance itself, since a perceived need for governance would not arise if there were not some explicit, (and to some extent shared) understandings of problems and possibilities. In other words, whether by socio-political pressure or some other force, some dissatisfaction with an existing socio-technical arrangement must prompt governance formation. Once initiated, however, an early governance imperative is to further explore the parameters and underlying causes of the problem and scope the contending potentialities. It is this which forms the first element in social appraisal.

As more clearly formed understandings of the motivating problem begin to emerge, then different options for meeting sustainability goals must also be appraised and commitments made concerning the most appropriate to pursue. Though in practice much of this process is necessarily distributed and implicit in nature, some array of explicit decision criteria do typically emerge here. These may variously arise (or be seen) as substantive structuring heuristics, instrumental legitimacy resources or more normative democratic procedures for accountability (Stirling, 2005). . Ideally, these will be deliberated and arrived at in a transparent way – though this is not always guaranteed and both ‘expert’ and ‘participatory’ governance processes for regulating technologies can be quite opaque in different ways (Irwin, 1998; Wynne, 2003). Either way, the goal is to identify some shared understanding of preferred directions and trajectories for socio-technical change and of the associated implications for different social actors.

In seeking to act on this initial process of appraisal, governance can actively seek to steer socio-technical change by intervening in two related processes. Firstly, governance can aim to *articulate selection pressures* bearing upon a socio-technical system such that they generate a force for change in the desired direction. Secondly, governance can attempt to *foster adaptive capacity* such that actors within the socio-technical system in question are better able to respond to pressures for change (Smith et al, 2005).

Articulating selection pressure requires governance to develop and implement policy instruments and other activities that create clear and coherent signals, incentives, inducements and requirements for changes desired to the socio-technical system. There are a variety of means available for such articulation. Examples include the kinds of instruments already reviewed in relation to 'autonomous' understandings of innovation – environmental taxes, standards and regulations, voluntary agreements, supply chain pressures – as well as deeper institutionalisations of environmental concerns, such as those embodied in discussions of 'environmental policy integration' (Hertin and Berkhout, 2003).

Governance can contribute to adaptive capacity either by building upon those existing capabilities in the socio-technical system likely to help responses to (socially articulated) sustainability pressures, or by nurturing new capabilities. Examples include greener R&D, environmental management systems, training policy, and favourable infrastructure provision. Some or all of these initiatives may already be in place. Governance for socio-technical change is about seeing them in a new light and co-ordinating them with the broader goal of system innovation in mind. Governance must consider how these existing processes can be better harnessed, revised and complemented in order to bear more directly and effectively on the socio-technical object in question, and steer its development towards the sustainability vision and targets of the appraisal process.

Illustrating this last point is the transition management idea for governance processes to support strategic green niches or transition experiments (Hoogma et al, 2002; Weber et al, 1999; Smith, 2004). Niches are initiatives that explore and develop alternative, sustainable socio-technical practices (thereby building up adaptive capacity and, if successful, applying competitive pressure on the incumbent system). The creation of these niches is considered a joint task of 'state policy-makers, a regulatory agency, local authorities (e.g. a development agency), non-governmental organizations, a citizen group, a private company, an industry organization, a special interest group or an independent individual' (Kemp *et al.*, 1998: 188). This alternative

socio-technical constituency has to create a climate in which niche practice appears as a reasonable expectation for the future. It has to persuade resourced actors that their interests and values can be reframed and best met through the alternative arrangements in the niche, compared to the older practices extant in the incumbent socio-technical system. It is this networked, multi-stakeholder approach that suggests 'strategic niche management' is more a governance approach than a specific policy instrument or task of government (Kemp *et al.*, 1998). Indeed, embedding niche lessons will require co-ordination across a variety of policy instruments (e.g. fiscal incentives, regulatory measures, education and training, public procurement). Yet the image of governance remains that of a process on the outside. Lessons are built up exogenously, in niches, and then taken up and transmitted to the incumbent socio-technical system. Governance nurtures the niches and transmits the lessons.

Although the governance objective is relatively clear-cut, constructing the necessary governance network to fulfil the functions above is far from straightforward. A wide variety of knowledges, skills, and other resources (e.g. technical, finance, legitimacy, authority) must be marshalled if socio-technical development is to be comprehended and steered. These resources are distributed across different state and non-state actors. The managerial challenge is to bring these actors and their resources together into the governance arrangements needed to steer socio-technical change.

A number of actors whose resources are relevant to the governance challenge will necessarily be participants in the socio-technical system whose sustainable reconfiguration is being sought. That is they contribute to the reproduction of the socio-technical system. 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 also be needed in governance interventions 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 that mean they benefit strongly from the status quo and which positions them as important gate-keepers for change (Smith *et al.*, 2005). Any governance arrangement will have to consider the position and involvement of such actors. But the governance goals may also elevate the position of hitherto marginal actors, such that their position in the governance arrangements is more central than their position in the socio-technical system.

Of course, once the system undergoes change toward an alternative, more sustainable configuration, then the relative socio-technical position of actors 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. There is a structural bias against radical socio-technical change. Actors in structurally powerful socio-technical positions under the status quo can be well placed to exercise strong influence over governance attempts. 'In a governance relationship no one organisation can easily command, although one organisation can dominate a particular process of exchange' (Stoker, 1998: 22). The importance of building up a governance arrangement that possesses sufficient legitimacy, authority or technological agency becomes clear. Governance for sustainability must overcome structural impediments and intervene in the face of inertia and active opposition.

This observation brings us back 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 – defined as self-organisation between mutually interdependent actors - need some

kind of 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). One of the features of the socio-technical perspective is that it often cuts across policy sectors, which implies multiple government agencies will be involved. In the transition management literature, a state actor of some sort remains the facilitating agent, e.g. a ministry or public agency (Kemp and Rotmans, 2005). In the case of Dutch energy transition initiatives, for example, it is the economic ministry that has facilitated development and interactions in the governance 'transition arena' in which socio-technical change is negotiated.

As a governance mechanism, the Dutch notion of the his 'transition arena' is conceived 'in addition to (partly independent from) the normal policymaking networks dominated by incumbent companies having an interest in the status quo' (Kemp and Rotmans, 2005: 146). The selection of participants in this arena is considered to be 'of vital importance' (Kemp and Rotmans, 2005: 146). Qualities expected of participants include being visionary forerunners, empathetic to sustainability goals, open-minded, able to convey the 'transition vision' back to their constituency and influence its behaviour, and willing to invest the time, energy and other resources needed in the governance challenge. The role of government in this is to create the transition arena and recruit and facilitate interaction amongst stakeholders identified with these qualities. The arena itself 'coordinates action between mutually dependent actors' (Kemp and Rotmans, 2005: 149), but the state appears to hold the ring.

Clearly, in this practical initiative deliberately to manage socio-technical transformation we see a conceptualisation of governance as something apart and separate from incumbent socio-technical institutions and practices, but which seeks to intervene and engage them for change. The transition arena is

where the problems of unsustainability are analysed; sustainability visions and transition agendas are formulated (i.e. 'a joint action programme for initiating and furthering transitions' (Kemp and Rotmans, 2005: 149)); and transition experiments (i.e. niche alternatives) and programmes for system innovation (i.e. socio-technical transformation) are instituted.

However, it is precisely at this point where a conceptualisation of governance as 'outside' - as exogenous to the object it seeks to govern – begins to encounter difficulties. Identifying the functions that are needed in order to promote a given change is relatively straightforward and can garner quite broad consensus. Acknowledging that these functions require resources that are distributed unevenly across a diverse array of actors is similarly largely uncontroversial. But controversy is likely to become more pronounced once we consider how those actors negotiate the details of governance functions. It is no easy undertaking to construct a sustainability vision which is at the same time clear enough to drive through powerful, radical change, whilst commanding consensus across a wide variety of resourceful actors. It also remains unclear whether all the mutually interdependent actors will see one another's positions in the same way. They are likely to possess alternative, disputed framings of one another's roles in the wider system and their respective contributions to sustainability problems and solutions.

Even the most politically naïve account of governance as a managerial exercise recognises that mutual frameworks and visions have to be negotiated. However, the managerial perspective still perceives this as something that can be negotiated with reference to a commonly identified '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. Only in this way can governance processes be seen as sufficiently rational and synoptic – providing self-evident frameworks for identifying the an objectively 'best' plan for intervening in the socio-technical system (conceived as an 'object') and managing its relations with wider society and nature.

A contrary perspective holds that governance negotiations are highly argumentative, laden with power relations, and open to a diversity of criteria and options. The outcomes of these governance negotiations can perpetuate or alter the socio-technical system in many different ways – but all are the product of those negotiations. The very constituting of the ‘natural’ and the ‘socio-technical’ are, in important ways, a product of governance negotiations. Yet actors within the sociotechnical system will typically hold great influence (and some play key roles) in conditioning this governance discourse. Conversely, state actors charged with ‘holding the ring’ will also hold – and be seen to hold – their own institutional interests in the system itself. A conceptualisation of governance as ‘inside’ – and partly as constitutive of – the problem itself, thus begins to have greater resonance. It is to this perspective that we now turn.

Governance on the inside: co-constituting the socio-technical

The image here is of governance actors and processes as inseparable, pervasive and partly constitutive internal features of the sociotechnical system itself. In this view, it is through governance debates and negotiations that we 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 perspective, the ‘external intervention’ description of the task of governance (discussed in the preceding section) 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: 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).

This is not to say that the governance functions as envisaged under the 'external intervention' perspective are erroneous, irrelevant or unrealistic under the 'internal co-constitutive' view. The point is rather that the fulfilment of these functions will necessarily be socially constructed – and as such requires due attention to deliberative process. This does not mean we should 'give up' on governance. 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).

Perhaps the best way to illustrate this point is to consider two concepts which exogenous accounts of governance treat as relatively unproblematic objects, but which an internal account identifies as fundamentally political. The first is the 'sustainability' goal itself. The second is the 'socio-technical' object of governance. By discussing each in turn, we can appreciate some of the more detailed implications of the 'internal co-constitutive' view of the governance of sociotechnical systems.

1. The contestability of sustainability

A key, initiating governance function identified in the preceding section was problem identification and goal formulation, typically involving some kind of sustainability goal or 'vision' that can inform appraisals, indicator sets and interventions, e.g. a low carbon energy system (Kemp and Rotmans, 2001: 4). The point to note is that the starting point for the governance process is the articulation of a goal or vision in response to the salience of an issue on the public agenda.

Right at the outset, there are serious difficulties in determining whether any given guiding vision is socially viable, or is actually desirable from the perspective of society as a whole. Governance conceptualised as 'outside' the socio-technical object develops a picture of an iterative and reflective process, providing for reviews of both guiding visions and the socio-technical configurations that emerge following earlier interventions (Stirling, 2006). This will inevitably involve co-ordination between the contending perspectives of a variety of social actors. However, it remains unclear precisely how it can be ensured that the particular set of actors engaged in the development of any given vision or intervention do indeed reflect an appropriate range of social interests and perspectives. Governance conceptualised as exogenous has a tendency to treat as unproblematic the feasibility and desirability of aspirations to societal consensus aimed at identifying some determinate 'public interest'.

This is not an abstract or trivial problem. It strikes right at the heart of the normative character and public policy aspirations of the governance of sustainable technologies. In short, decades of work in the field of social choice has shown that there can – neither in principle nor in practice – be no definitive means to integrate divergent perspectives, interests and preferences, such as to yield a single coherent ordering of technological (or other policy) options (Arrow, 1963, Bezembinder, 1989). Such managerial aspirations are confounded by the incommensurable dimensions of technological performance, strongly divergent socio-political interests and perspectives (Brown *et al.*, 2000), recursive inter-relationships between the social and evaluative context, 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 'guiding visions'. In the main cases of interest involving dominant socio-technical systems with high political and economic stakes in complex plural societies, not only the process of consensus building, but the very notion of public interest itself is thus often highly problematic.

Unqualified and unproblematised notions of 'societal consensus' or 'public interest' can therefore often represent little more than rhetorical resources. Where the underlying assumptions, processes and limitations are not made explicit and examined, such concepts lend themselves to deliberate manipulation by socio-political interests on all sides of any debate on technological change. This blurs the distinction between emergent and historically-contingent processes of system change, and the normatively-driven concept of sustainability governance. It raises the prospect that the implementation, design – and even the very notion of sustainability governance itself – might simply constitute further political resources and arenas for the interplay of the contending interests embodied in competing socio-technical systems.

That different socio-political constituencies often disagree profoundly as to the best way forward is especially true in the context of technology policy for sustainable development. Here researchers have noted a vast array of competing definitions and interpretations (Pearce, 1989). To some, this all-things-to-all-people quality is a fundamental weakness in the sustainable development vision: one that makes any realistic hope of sustainable development sheer folly (Beckerman, 1994). To others, including the present authors, the contested nature of the sustainable development 'vision' can be seen as a strength since it creates debate, necessitates continuing reflection, requires us to sift evidence from rhetoric, emphasising the importance of being explicit about what is being sustained, for whom it is being sustained, how it will be sustained, and why it should be sustained for them (Jacobs, 1999; Dobson, 1998).

Either way, the real value of the notion of the 'guiding vision' in governance does not lie, as is often implied, in its apparently unproblematic normative policy credentials. Quite the contrary: by focusing on the role of guiding visions, attention is concentrated on the importance of legitimate and effective deliberation and learning, and on the crucial role of providing for plurality, reversibility and sustained dissent. This raises issues concerning the diversity and resilience of wider social commitments to different technological

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 and visionary goals for sustainable socio-technical systems, these are only ever provisional. Priorities shift. 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.

2. Negotiating the socio-technical

Voß *et al.* (2006) 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' (p.427). In addition to the preceding comments about the sustainability problem space being open to interpretation and negotiation, 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). Similarly different participants in a system of socio-technical practice will have contrasting mental mappings 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). As such, system boundaries, operation and change dynamics are open to subjective interpretation. This is particularly acute for actors participating in the reproduction of the socio-technical system (and even academic analysts seeking to map the system).

Take as an example the 'household' socio-technical actor in the energy system. Households, even those including sociologists of technology, are unlikely to constantly reflect upon how their activities involve them in the reproduction of an energy socio-technical system. Rather, in wealthier households in richer countries at least, the householder is accustomed to enjoying the services of a variety of goods (e.g. chilled foodstuffs, television entertainment, lighting, laundry, cooking) in a comfortable, warm home. Indeed, for many services the enjoyment is not even conscious but a hidden routine within the structures of everyday life (Southerton *et al.*, 2004).

Periodically, households will be charged for these services – which is when their demand becomes visible and they provide the financial resource underpinning the system. Very rarely the system might fail. Ironically, it is then, at this point of absence, that the functioning socio-technical configuration becomes visible to the household.

If public surveys are to be believed, many households are vaguely aware that their use of energy is connected to environmental problems, but the precise connections are unclear for many, and it simply is not a priority. An official UK government survey of 3,736 households in 2001, for example, found that 20 per cent of respondents identified their use of gas and electricity as contributing to climate change (although 71 per cent knew carbon emissions contributed to climate change) (National Statistics/Defra, 2002). A smaller sub-set of households are aware that their house is systematically implicated in problems of unsustainability, but may feel powerless to do a great deal about it. Even the few greener households are relatively limited in the choices they can make over reconfiguring their relationship with the energy socio-technical system and so lessening their environmental burden (e.g. use low energy products, insulate their home, install small-scale renewables). It seems that relatively few households are self-consciously involved in a socio-technical system; and only a few are aware of the limited choice sets available (Levett *et al.*, 2003). Households carry different conceptualisations of their position in socio-technical practices.

The point being laboured here is that 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, 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 in order to impact upon those 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 set of social and economic commitments. As a result, governance necessarily involves an interplay between different mental maps of the 'system', concerns over how it operates and priorities for change – each associated with different forms and degrees of power and agency to effect change.

The above two observations overlap when we consider how the sustainability challenge will be constructed differently across the various socio-technical practices that could be considered to be part of the overall 'system'. For instance, suspicions about the possible health effects of electromagnetic radiation due to high-voltage electricity transmission are a priority issue for some relatively marginal pressure groups. Yet they are unlikely to become a focusing sustainability problem for many other actors on any scale comparable with, say, carbon emissions from power stations, or consumption patterns creating demand for that power. The salient distinguishing feature of the latter two examples with respect to governance, is that each has enrolled wider concern amongst diverse social actors.

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. Some conceptualisations will draw in broader coalitions of actors than others. Amongst these competing conceptualisations will be those that have enrolled the support of powerful actors in structurally privileged positions within incumbent socio-technical practices. The way governance processes cut into and set their focusing boundaries around the complex web of real world socio-technical interdependences will be intimately related to political coalition building and the persuasiveness and legitimacy of different conceptualisations of the system, its sustainability problems and remedies.

In sum, the socio-technical system, as well as its associated sustainability challenges, is an ambiguous, negotiated and contingent analytical construct. Its construction is a primary task for governance. But it is unlikely to be a self-evident object for governance. 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 wide participation not only becomes a desirable feature of governance, but 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 in the sense that it involves competition between conceptualisations seeking to be that which drives and directs governance efforts (each underpinned by different knowledge claims, social values and material interests).

Inclusion and exclusion in the construction of socio-technical sustainability

One has to be cautious with the 'internal co-constitutive conceptual positioning of governance being elaborated here. Sustainability governance need not –indeed often does not – have a monopoly position on understanding and directing socio-technical change. It 'merely' attempts to advance *sustainable* socio-technical change arguments and initiatives. A sustainability governance arrangement – like a transition arena – will play a constitutive role to the extent that it becomes *the* focusing site for thinking about and negotiating strategic socio-technical change in contrast to other arenas and processes (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, one must not lose sight of the processes that 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 which offer limited interpretive flexibility and resist assimilation to the priorities of sustainability governance. Yet, though socio-technical practices and their consequences display interpretive flexibility, they are not completely malleable. In this respect, the argument here must be qualified by acknowledging that power relations, 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.

Counteracting this structuring tendency is 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 political discourse that can, from time to time, disrupt and penetrate 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, 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 Western Europe).

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

Legitimacy in deliberative governance

An advantage arising from the conceptual positioning of governance as constitutive 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.

It is for this reason that the governance of technology should be reflexively open to its co-constitutive role within socio-technical systems (Stirling, 2006). The greater the ambitions of the steering visions, or the momentum of the systems themselves, the more important it becomes for governance to prioritise processes of engagement, dialogue and deliberation. This requires 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. To what extent do governance practices accord with the principles of democratic deliberative processes?

Legitimate governance makes efforts 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. However, legitimacy also demands that an additional element of reflexivity is warranted here. That is, participants in the governance of sustainable technology must have the opportunity to evaluate and negotiate the rules to be followed (negotiation of rules) rather than simply following prior rules (negotiation under rules) (Stoker, 1998).

The second role played by legitimacy relates to the incumbent socio-technical system. How legitimate are existing socio-technical practices in relation to ideas about sustainability emerging in governance deliberations? Radical change to the system is more likely if this aspect of legitimacy has come under question. As such, governance constructions of the socio-technical must question the legitimacy of established practices at the same time as exploring the sources of legitimacy for more sustainable options.

The legitimacy of political authority rests upon social values *shared* by the dominant and subordinate (Beetham, 1991). It is these overlapping values (like the importance of private property and respect for the law in market economies) that underpin the legitimate rules of the game in terms of correct procedures, justified decisions and fair outcomes. Legitimate exercises of power do not transgress the 'rules'. Given that social values develop and change over time, so the common bases of legitimacy between powerful authorities and subordinate subjects are a conditional properties open to renegotiation. Admittedly, a powerful authority may prevail for a time due simply to the privileges of its position, but this will no longer be a *legitimate* position.

Political power can, of course, shape the social values of others such that they converge with those of the powerful – in other words it can influence the basis of legitimacy in its own favour (Lukes, 2005). In practice, it is difficult to realise the ideal Habermasian speech situation in which the legitimacy both of the *status quo* and of proposed change can be deliberated upon in a balanced

and unconstrained fashion. But a governance process concerned with issues of legitimacy should at least proceed with this aim in mind, even if it expects to fall short. 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; Jessop, 2003). Indeed, a key strategy for mitigating such obstructive effects of power relations is to reveal them and discuss them, even if it is difficult to over-turn them. In the field of sustainable governance as elsewhere, the simple recognition of illegitimacy is a major step towards the restoration of legitimacy.

Strategies for reflexivity, flexibility and irony

Jessop understands governance as 'reflexive self-organization of independent actors involved in complex relations of reciprocal interdependence, with such self-organization being based on continuing dialogue and resource-sharing to develop mutually beneficial joint projects and to manage the contradictions and dilemmas inevitably involved in such situations' (2003: 101). This paper has presented a similar view, but with the 'internal' conceptualisation of governance emphasising differences in framings, social commitments and power relations. All these conceptualisations of governance stress the complexities, contingencies and contradictions involved. Thus Jessop argues that governance failure is inevitable, and derives mainly from three characteristics of governance.

First, governance experiences the playing out of the accumulation imperative and legitimacy contradictions inherent in capitalist relations. Thus rhetorics of idealised symmetrical social partnership fail to be borne out in practice. Second, there may be problems of 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'. Thirdly, there is the perennial insufficiency of reflexivity in the way governance processes engage with the complex systems in which they are partly embedded, but which they are trying to shape. 'Indeed, given the growing structural complexity and opacity of the

social world, failure is the most likely outcome of most attempts to govern it in terms of multiple objectives over extended spatial and temporal horizons – whatever coordination mechanism is adopted’ (Jessop, 2002: 105).

However, acknowledgement of the inevitability of some element of governance failure, should not be taken as a counsel of despair. There is much that can nonetheless be done to mitigate the scale and frequency of such failure. In particular, Jessop highlights a number of possible strategic responses (Jessop, 2002), which may be characterised in the following way.

First, there is the imperative to enhance reflexivity in the governance process. This involves substituting hubristic aspirations to optimal solutions, with more modest ‘satisficing’ strategies aimed at ‘acceptable outcomes’. It requires regular self-critical re-assessment of the extent to which these strategies are delivering the outcomes desired under different perspectives.

Second, there is the challenge of deliberately cultivating 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, 2002: 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.

A third, response is to adopt a stance of ‘irony’ in the sense that governance actors acknowledge the likelihood of failure, but proceed as if confident of success. This involves greater humility over limits and fallibility of both analysis and deliberation, whilst retaining a optimism over the efficacy of action. It applies as much to Jessop’s ‘meta-governance’ (discussed above) as to the subordinate governance activities themselves.

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 in the meeting of initial aims are usually qualified by mitigating factors. Policy supporting the development of batteries for electric vehicles, for example, whilst failing in the narrow task of delivering sufficiently effective energy storage, nevertheless prompted more developments in lightweight vehicle construction, aerodynamic design and hybrid-electric power systems (Kemp and Rotmans, 2005). The crucial point is that governance retain faculties for reflexivity, flexibility and irony in respect of failure as much as success.

There are a number of ways in which these general governance injunctions relate to the substantive features of sustainable technology strategies. There exist many resonances with the wider literature on adaptive capacity, resilience and robustness (Folke et al, 2000; Stirling, 2005c) One important but relatively neglected element, for instance, is the deliberate fostering of a diversity of technological and infrastructural options and structures (Stirling, 1994). By developing what he terms 'requisite variety', 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), 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).

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 of 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

Summary

In this section we have challenged the conceptual positioning of governance as an external set of (largely managerial) processes. We have argued that this elides a series of vital and intractable issues around the contestability of sustainable development goals, the ambiguity of socio-technical boundaries, contingency and social construction in the appraisal of options, and the dilemmas of distributed control inherent to governance interventions themselves. As Voß *et al.* (2006) put it, recognising these uncertainties and ambiguities in sustainability ‘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).

Instead, we have explored some of the implications of a more deliberative and reflexive approach to governance. Here the conceptual positioning of governance lies within the ‘socio-technical system’ itself. As a result, ambiguities, uncertainties and distributed control become explicit and so can be handled with greater transparency participation and accountability – thus helping to avert socio-political tensions and associated latent recoil of the accumulated pressures. Recalling governance as an important constituent of socio-technical systems provides for deeper and broader consideration of existing policy institutions and networks; the different social values and economic interests at stake; and prevailing ideas, discourses and coalitions for (and against) different kinds of change. Above all, we appreciated how the governance task is an inherently political project, rather than solely a managerial exercise. This requires greater recognition of, and attention to, the distribution of power and agency; sources of legitimacy; and strategies for reflexivity, flexibility and irony.

Processes of opening-up and closing-down in governance

Recent accounts of the social appraisal of technology and its role in governance for sustainability have distinguished two processes of 'opening-up' and 'closing down' (Stirling, 2005; Voß *et al.*, 2006). In this section, we draw upon our contrast between governance as outside or inside the socio-technical in order to identify how each emphasises different elements and characteristics in processes of opening-up and closing-down. This aims to advance on recent accounts, in which elaborations of the governance implications associated with these processes have been relatively limited.

Stirling's original characterisation of contrasting processes of 'opening up' and 'closing down' in technology choice invokes of a variety of different dimensions of governance. These may variously concern the appraisal of contending technologies, policies or strategies and involve a wide range of interests, perspectives, discourses, institutions, procedures, framings, disciplines, issues and possibilities. Either way, in these terms, closing down 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).

Thus opening up or closing down is concerned with the range of outputs that are simultaneously advanced by an appraisal process and 'conveyed to wider governance (as reasonable candidate social choices)' (Stirling, 2005b: 24).

Characterised in this way, we can see how governance conceptualised outside the socio-technical is inclined more to a closing-down mode of operation, whilst governance conceptualised within the socio-technical emphasises processes associated with opening-up. However, we must not presume this is a one-to-one mapping, exclusive to each conceptualisation of governance. Whilst external or internal conceptualisations may be more *inclined* to closing-down or opening-up in general, each could nevertheless accommodate both kinds of process. Each may, for example, focus upon a different set of characteristics when opening-up or closing-down to the exclusion of others. It is this differentiated and partial consideration of characteristics that is considered in the remainder of this section.

In order to appreciate the detailed implications, it is important to note that Stirling's distinction between 'opening up' and 'closing down' is focused particularly on the social *appraisal* of technology (2005). This is concerned primarily with diverse processes for 'social learning', which may variously involve elements of expert analysis, policy deliberation, stakeholder negotiation and public participation. This 'epistemic' notion of social appraisal contrasts with the wider 'ontologies' associated with governance processes for the forming of more concrete commitments in the 'social choice' of technology (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 'technology choice' (Stirling, 2006).

For their part, Voß *et al.* (2006) pick up this contrast between opening up and closing down in relation specifically to what they term processes of problem analysis, goal formulation and strategy implementation. Unfortunately, though interesting and provocative, this extended application of the terminology does have the effect of eliding what Stirling refers to as the 'reflexively co-constituting' relationship between distinct processes of appraisal and learning on the one hand, and the substantive ontologies of institutional commitment and technology choice on the other. After all, although they iterate recursively, there is a necessary narrative sequence to any intentional process of appraisal and choice. Likewise, if we are to appreciate the ways in which

learning and choice condition one another, there has to be some basic analytic distinction between the two. The importance of accountability in democratic governance compounds the imperative to make this distinction. Unfortunately, the use of opening up and closing down equally as properties of 'goal formulation' and 'strategy implementation' conflates these distinctions.

Likewise, Voß et al's adoption of the terminology of opening up and closing down also elides other distinctions that Stirling holds to be important. These concern the contrast between 'inputs' and 'outputs' of social appraisal (Stirling, 2005; 2006a) and associated properties of 'reflection' and 'reflexivity' in technology governance (Stirling, 2006b). By reference to usage elsewhere in the 'reflexive governance' literature, reflection refers to 'deep serious consideration in governance to all salient aspects of, and perspectives on, the socio-technical system'. Reflexivity, by contrast, in these terms entails more specific 'recognition of the recursive co-constituting of governance processes and perspectives and socio-technical systems and possibilities'. Again, the importance of the role of intentionality in technology governance compounds the importance of recognising this kind of distinction. Otherwise, as Stirling argues, discussion of 'reflexive governance' can amount to little more than the rather modest assertion that everything is linked to everything else (2006).

Building on this, Stirling proposes a further useful distinction between 'inputs' and 'outputs' in the relationship between appraisal and wider processes in technology governance. The 'inputs' to appraisal may alternatively be relatively 'broad' or 'narrow', in terms of the scope for reflection over "issues, possibilities, perspectives and options" (2005:xx). In these terms 'opening up' and 'closing down', by contrast, concern the 'outputs' of appraisal to these wider governance discourses, relating to the extent to which contingencies and conditionalities are acknowledged such as to promote greater reflexivity (rather than reflection) in technology choice (2006). In other words, a broad-based appraisal may be more precautionary, but where it emphasises optimisation or consensus-building, then it may nonetheless serve to 'close down' technology governance (2005; 2006). Likewise a relatively narrow analytic or deliberative appraisal exercise may nonetheless fulfil a reflexive

'opening up' role, if procedures for sensitivity analysis or the communication of minority opinions present a 'plural and conditional' output to wider governance discourses (Stirling, 2005).

For Voß et al, by contrast, 'opening up' the problem analysis dimension 'mean[s] extending the system boundaries and increasing the range and diversity of factors and interactions considered in analysing problem causes, dynamics and effects of interventions ... In the dimension of goal formulation, opening up refers to the revising of given targets by taking into account a broader spectrum of values and facing trade-offs that have to be made ... In the dimension of strategy implementation finally, opening up refers to a widening of the range of measures and options that are considered and implemented for problem handling' (Voß et al., 2006: 432). Likewise Voß et al. hold participatory methods inherently to be a strategy for 'opening up' irrespective of whether these are oriented towards consensus or the reflexive communication of dissent (p.433). This kind of usage has the effect of conflating the relationships between 'appraisal and commitment' in technology choice, 'inputs and outputs' in technology appraisal and 'reflection and reflexivity' in technology governance as a whole.

Whilst undoubtedly an interesting and usefully provocative contribution to the debate, we are concerned that this indiscriminate usage of the terminology of 'opening and closing' conflates the different functional dimensions of governance that Voß et al. are themselves earlier at pains to establish. Contrasts and relationships between problem analysis, goal formulation and strategy implementation are all obscured by confluations of appraisal and commitment, reflection and reflexivity, and breadth and openness.

This concern is accentuated and substantiated by our current interest in distinguishing conceptions of governance as an 'external intervention' or 'internal co-constitutive' element in relation to technological systems. Voß et al argue persuasively how governance can be constitutive of problems, goals and strategies and should be pursued reflexively. They explicitly acknowledge that governance for sustainability struggles to maintain the conceptual

distance that an externally oriented account assumes (p.423). Yet – though they make limited, implicit acknowledgment that governance can be internal to sustainability challenges – it remains the case that governance is largely presented in their account in an external ‘managerial’ function.

This ambivalence over the conceptual positioning of governance has been elaborated here precisely because it has clear implications for discussion about opening up and closing down. In particular, it illustrates some of the practical implications for governance of the neglected distinctions which we discuss above. It is by contrasting an external, instrumental, and objectifying governance with an internal, constitutive, and subjective governance, that we can see a key concrete policy implication of the contrast between opening up and closing down. To this extent, we believe that the concepts of ‘internal co-constitutive’ and ‘external intervening’ governance serve as necessary intermediate step between recognition of the importance of opening-up and closing-down in the governance of sustainable technology, and the development of more operational frameworks for analysis and process design.

Relating this to earlier discussion of the contrast between ‘external intervention’ and ‘internal co-constituting’, Table 1 introduces and summarises some of these more policy-relevant implications. Here, the managerial desire to co-ordinate and guide the resources of different actors to a common sustainability agenda (associated with the ‘internal’ perspective) was contrasted with the political challenge of securing legitimate agendas for change under conditions of multiple framings and power (associated with the external perspective). Each perspective on governance arose from the way it was conceptualised in relation to the socio-technical. A managerial view sees governance as able to distance itself from the socio-technical object and co-ordinate the way it is governed. A more political view considers such separation as impossible; governance will inevitably be entangled within the socio-technical systems whose sustainability is sought and enmeshed in dialogue with wider political discourses beyond those concerned with sustainability.

[INSERT TABLE 1 HERE]

As a result, each conceptualisation will approach the task of opening-up and closing-down in different ways. The dimensions and modalities for opening up and closing down will differ correspondingly.

Opening-up when conceived under an 'external governance' perspective involves consideration of a full range of salient attributes of the problem in question. As such, it is reflective and assumes a wide ambit. Most obviously, this is evident in the way that the object of intervention and change is a socio-technology system rather than a single (cleaner) technology artefact. This breadth of scope is also a characteristic of 'precautionary' approaches to social appraisal. But this synoptic aspiration would also include identifying all the possible environmental consequences of that system and considering a wide range of sustainability indicators. And, of course, it seeks to co-ordinate all the salient resources needed to bring about change towards a common sustainability agenda. Governance conceptualised in this external fashion is reflective, in the sense that it considers the full range of possibilities (Stirling, 2006). However, it remains only reflective rather than truly reflexive in the terms discussed above, because it fails to encompass the mutually constitutive relationship between appraisal and associated perspectives and commitments, and the inherent contingency subjectivity and conditionality of the 'outputs' obtained in social appraisal. It is for this reason that, in closing-down mode, external governance conceptions are preoccupied with the identification of 'best' options. Accordingly, the relevant articulation pressures and adaptive capacities are held to be self-evident in relation to the diagnosis. The effects of these interventions are monitored and lessons are taken up. Opening-up and closing-down are aspects of an essentially managerial process.

When governance is understood as an internal co-constitutive element in the socio-technical system, by contrast, opening up involves exploration not only of a full range of issues, but also a correspondingly wide array of salient representations of the problem of unsustainability itself. These include contending representations of the sociotechnical system itself, as well as the

prospective technology and non-technology solutions. Different framings will interpret the evidence base in disparate ways and each is acknowledged and explored. Contrasting social commitments will yield divergent recommendations for governance interventions (Stirling, 2006). Opening-up is in this case a much more reflexive process. As a result, processes of closure will need to develop legitimating mechanisms. Given the contingency of any consensus decisions, a number of strategies are required for the kinds of decision taken. These are flexibility, diversity and resilience. Overall, governance for sustainability is seen as a fundamentally political process.

The purpose of the comparative framework summarised in Table 1 is to show how processes of opening-up and closing-down can mean different things and imply different activities and goals depending upon how one conceptualises governance. In particular, the comparison makes apparent how managerial views can be blind to important complexities and contingencies. Ignoring these can polarise short term conflicts and compound long term tensions.

Conclusions

This paper has considered the conceptual positioning of governance in relation to sustainable technology. Recent understandings of technology development reveal the highly social quality of the processes involved. This in turn highlights the full scope for the exercise of social agency in determining the form and direction of technological development. This presents significant opportunities for governance processes to shape technological development to wider social ends – and in particular, to the fostering of more sustainable technology. In other words, deliberate choice of technological futures is more achievable than earlier deterministic understandings have allowed.

The central argument in the paper is that the manner in which governance processes may achieve such social agency over technology agency depends on the general way in which governance is conceptualised in relation to technology development. Two distinct conceptualisations were described. Under the first, governance is viewed as an external intervention – framing,

appraising, forming commitments and monitoring – acting upon an effectively separate sociotechnical system. Here governance is considered as an essentially instrumental managerial task. Under the second view, governance is seen as an internal co-constitutive property of the sociotechnical 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 values and interests.

Having drawn these distinctions, the paper considered their implications for current discussions over the ways in which alternative technological pathways are ‘opened up’ and ‘closed down’ in the processes of social appraisal that inform technology governance. It was found that there emerge clear differences between the policy implications of the two different viewpoints. ‘External interventionist’ understandings of governance seek to reflect ‘self-evident’ attributes of the problem and solution(s) in a fashion that is as complete and definitive as possible. ‘Internal co-constitutive’ understandings recognise the serious limits on the detail and efficacy of definitive objective characterisations and aim instead at a reflexive appreciation of the way in which the picture that emerges is conditioned by – and itself conditions – contingent interests and actions.

Attention then turned to the implications for the way in which governance must inevitably close down on certain particular technological commitments in preference to other possible paths. Here, the ‘external intervention’ account of governance looks simply for the ‘best’ options and presumes to construct (or at least portray) as wide a consensus as possible. This is ‘decisionistic’ in that it centres on the focal role of individual discrete and durable identifiable ‘decisions’. An ‘internal co-constitutive’ view, on the other hand, is much more contingent and cautious in its approach to closure. The forming of social commitments to particular technologies is understood in a more conditional, temporary, diffuse and reversible fashion than is suggested by the notion of

'decisions'. 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.

The ideas presented in this paper develop points we have made elsewhere. This is a first step at trying to bring some of them together and push the debate forward a little. Some of the argument is tentative and heuristic. But where we are most confident and assertive, is with the observation that the governance of sustainable technology is a fundamentally political – rather than managerialia – process . When it comes to contemplating our technological futures – sustainable or otherwise – the discourse should be around possibilities, choices and argument, not imperatives, consent and the language of “no alternative”.

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Table 1: Opening-up and closing-down under different perspectives on governance for sustainable technology

GOVERNANCE PERSPECTIVE ROLE OF APPRAISAL IN GOVERNANCE	‘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
Opening-up	<ul style="list-style-type: none"> • Broad-based reflection • Scoping a particular sustainability problem / goal • Identifying ‘relevant’ participants/stakeholders • Developing sustainability indicators • Putting in place learning mechanisms • Broad-based ‘precautionary’ appraisal 	<ul style="list-style-type: none"> • Pluralistic reflexivity • Exploring different perspectives on sustainability • Revealing different cognitive framings – negotiating the socio-technical • Fully confronting divergent interests, values and empowerment
Closing-down	<ul style="list-style-type: none"> • Informing policy decisions • Analysis or deliberation over ‘the best option(s)’ • Articulating appropriate selection pressures • Developing requisite adaptive capacities • Monitoring and institutional learning 	<ul style="list-style-type: none"> • Conditioning institutional commitments • Creating legitimacy for processes • Identifying a flexible repertoire of responses • Ensuring strategic diversity, resilience and robustness • Irony and social learning
Attitude to governance	Largely instrumental managerial function	Fundamentally engaged political process