

“Opening Up” and “Closing Down”

Power, Participation, and Pluralism in the Social Appraisal of Technology

Andy Stirling

University of Sussex

Discursive deference in the governance of science and technology is rebalancing from expert analysis toward participatory deliberation. Linear, scientific conceptions of innovation are giving ground to more plural, socially situated understandings. Yet, growing recognition of social agency in technology choice is countered by persistently deterministic notions of technological progress. This article addresses this increasingly stark disjuncture. Distinguishing between “appraisal” and “commitment” in technology choice, it highlights contrasting implications of normative, instrumental, and substantive imperatives in appraisal. Focusing on the role of power, it identifies key commonalities transcending the analysis/participation dichotomy. Each is equally susceptible to instrumental framing for variously weak and strong forms of justification. To address the disjuncture, it is concluded that greater appreciation is required—in both analytic and participatory appraisal—to facilitating the opening up (rather than the closing down) of governance commitments on science and technology.

Keywords: *technology choice; social appraisal; participatory deliberation; power; pluralism; diversity*

Author’s Note: I would like to acknowledge a debt to all those who commented on earlier incarnations of this analysis (Stirling 2005), especially Adrian Smith, Melissa Leach, Luigi Pellizzoni, Les Levidow, Carolyn Hendriks, Susan Owens, Nick von Tunzelmann, and Brian Wynne. Three anonymous referees made useful further comments and, as editors, Martin Lengwiler and Ulrike Felt provided invaluable guidance. The research reported here was supported by the UK Economic and Social Research Council. That I have been unable to reconcile all the good advice received is entirely my fault! Please address correspondence to Andy Stirling, Freeman Centre, University of Sussex, Brighton, East Sussex, Brighton BN1 9RF; e-mail: a.c.stirling@sussex.ac.uk.

Participation, Technology, and Progress

Worldwide policy attention is refocusing on new frameworks and methods for fostering engagement with stakeholders and the public in the governance of science and technology. Diverse manifestations are variously presented as moves to more “inclusive” (W. Brown 2002), “discursive” (Dryzek 1990), “deliberative” (Leib 2005), “pluralistic” (Bohmann 1996), “reflexive” (Voß, Bauknecht, and Kemp 2006), and “participatory” (Pellizzoni 2001) approaches. Arising first in individual projects and programs (Chambers 1983) and extending to wider processes in environmental planning, regulation (Owens 2000), and the governance of “technological risk” (Renn, Webler, and Wiedemann 1995), the result is a proliferating variety of new institutions, processes, and tools. From here, new political arenas look set to open up as “upstream” processes of knowledge production and innovation acquire their own distinctive “participatory” discourses (Wilsdon and Willis 2004). In each successive field, attention begins with radical entrepreneurship and moves on to successively more structured professionalization and institutionalization.

These apparent moves toward enhanced social agency and accountability reflect epistemic as much as cultural and political developments (Jasanoff 2005). Despite cross-disciplinary differences, understandings of society–technology relationships arising in philosophy, economics, history, and sociology paint a remarkably congruent picture (Williams and Edge 1996). Early linear, deterministic notions of technological “progress” are giving way to more complex, dynamic pictures of contingency (Mokyr 1992), social shaping (Bijker 1995), coconstruction (Misa and Brey 2003), path dependency (David 1985), momentum (Hughes 1983), lock-in (Arthur 1989), autonomy (Winner 1977), and entrapment (Walker 2000). In short, innovation is a vector, rather than just a scalar quantity. It includes the crucial but neglected normative property of direction. Accordingly, the form and orientation taken by science and technology are no longer seen as inevitable, unitary, and awaiting discovery in Nature. Instead, they are increasingly recognized to be open to individual creativity, collective ingenuity, economic priorities, cultural values, institutional interests, stakeholder negotiation, and the exercise of power (Stirling 2007b).

This raises something of an irony. Just when processes of corporate concentration, institutional harmonization, and economic globalization render the governance of science and technology ever more obscure and inaccessible (Barry 2001; Feenberg 2002; Jasanoff, 2003), so we begin to appreciate the inherent openness to the exercise of human agency and, potentially,

to deliberate social choice. Of course, in areas such as energy, agriculture, chemicals, pharmaceuticals, and transport, contemporary social choices are typically deliberate only from the point of view of a narrow set of incumbent interests. It is against this background that emergence of new discourses on participation and the underdetermined nature of technological commitments may be seen as moves toward empowering wider social agency in technology choice.

Meanwhile, however, more exclusive, linear, deterministic notions of technological progress still dominate policy debates (Broers 2005). Governments repeatedly justify technological choices on the basis of “sound science” (Blair 2003). Skepticism (even questioning) about *specific* technologies are routinely labeled by defendants of the incumbent order as *generally* antitechnology in sentiment (Taverne 2005; United Nations Development Programme 2000; Council for Science and Technology 2000). The direction of particular innovation pathways is typically justified simply by reference to a general “pro innovation” position (G. Brown 2004). Technological innovation is portrayed without qualification as self-evidently good (HM Treasury 2004). The ways in which context, purpose, and power shape the outcomes of technology choice are thereby downplayed and tacitly denied. Transparency, accessibility, accountability, and agency are correspondingly diminished.

The irony is thus intensified. As *languages* of participation proliferate, so unitary deterministic notions of technological progress seem to entrench. Indeed, the progressive concept of “upstream engagement” (Wilsdon and Willis 2004) is itself curiously resonant with linear notions of innovation. For all its value as a “boundary object” (Gieryn 1995) enabling effective critique, the term “upstream” also displays the deterministic connotation of a necessary direction of flow. If engagement processes are to escape instrumental use as “technologies of legitimation” (Harrison and Mort 1998), then this unidirectional stream metaphor is revealingly unhelpful.

This article seeks to examine some of the conceptual and policy issues raised by this irony. Distinguishing between “appraisal” and “commitment” in social choice of technology, it explores a variety of different rationales and imperatives in appraisal and examines neglected conditioning effects of power. Affecting participation as much as analysis, incumbent interests typically act instrumentally to frame appraisal such as to “close down” the range of possible technological commitments. This article argues that efforts both to understand and to affect progressive change should shift attention away from stylised analysis/participation contrasts and toward “opening up” analytic and participatory appraisal alike.

Appraisal and Commitment in the Governance of Technology

The starting point for this analysis is a distinction between parallel, interlinked, and mutually coconstituting processes of commitment and appraisal in technology governance. Here, “governance” is taken to encompass the diverse totality of actors, discourses, structures, and processes implicated in guiding and shaping technological configurations (Kooiman 1993). In these terms, appraisal is about *informing*, and commitment is about *forming* tangible social choices in the governance of science and technology (Smith and Stirling, 2007).

Taking technological commitments first, these represent “ontological” (Feenberg 2002, 3), discursive, institutional, economic, and infrastructural attachments to particular technological pathways (implying consequent deliberate or incidental neglect of others). Although often diffuse and distributed—and sometimes more emergent than deliberate—such commitments are nonetheless highly concrete. They encompass a range of structures and processes for allocating resources (such as policy attention, research funding, venture capital, training investments, regulatory standards, fiscal support, contractual risks, and legal liabilities). Divergent patterns in such allocations may yield radically different outcomes for contending technologies. As such, commitments need not necessarily take the form of explicit, discrete, or even deliberate decisions (Wynne 2001).

For instance, in recent U.K. policy on nuclear power, activities broadly constituting social commitment include statements of “necessity” by senior officials (King 2005), announcements of government objectives (Blair 2005), drawing up of international agreements (Blair 2006), enactment of laws (Nuclear Industry Association 2006), establishing organizations (Beckett 2002), issuing licenses and setting standards (Health and Safety Executive 2006), developing new research programs (Engineering and Physical Science Research Council 2006), introducing educational curricula (Office of Nuclear Energy 2006), and establishing training and procurement exercises. Technological commitments are also constituted in a host of initiatives, contracts, relationships, and agreements that are equally tangible, yet less visibly acknowledged in the public domain.

The social appraisal of technology, on the other hand, concerns the ways in which knowledges, understandings, and evaluations are constructed and rendered salient to inform these commitments. Here we find epistemic processes of learning and communication (Webler, Kastenholz, and Renn 1995; Wynne 1995), rather than substantive ontologies of intervention and

deliberate choice (Leach, Scoones, and Wynne 2005). Appraisal does not just imply formalized assessment routines, but also includes wider sociopolitical discourse in what is elsewhere termed the “agora” (Nowotny, Scott, and Gibbons 2001). For instance, activities that might be seen broadly to constitute social appraisal in U.K. energy policy include parliamentary inquiries (Environmental Audit Committee 2005), government reviews (Strategy Unit of the Prime Minister [SU] 2002), advisory body reports (Sustainable Development Commission 2006), and academic and commercial (de W. Waller et al. 2006) assessments. The wider discursive aspects of appraisal include media interventions (BBC 2006), nongovernmental organization initiatives (Nuclear Spin 2006), and wider cultural activities (BBC 1985).

The practices, networks, institutions, and discourses that sustain and mediate appraisal shape the ways in which the social actors understand, represent, and interpret the available alternatives for commitment. Whether spontaneous or structured, it is through processes of social appraisal that actors engaged in technology choice learn of the salient differences between their own values and interests and those of others. Indeed, where potentialities are ambiguous and uncertain, social appraisal is a means by which actors come to appreciate even their own private values and interests (Wynne 1992).

Of course, social appraisal is also reflexively coconstituted—and its outcomes conditioned—by preexisting and encompassing commitments (Wynne 2002; Stirling 2006b). This is also exemplified in U.K. energy policy. Here, formal government appraisal exercises (normally occurring with decadal frequency) have followed three in a row for a four-year period. An initial two-year study by the Prime Minister’s Strategy Unit (SU 2002) clashed with pronuclear positions of senior figures, including the prime minister (Adams 2002), by favoring renewables and energy efficiency. Revisited by an immediately subsequent Energy White Paper, nuclear energy was again confirmed as “unattractive” (Department of Trade and Industry [DTI] 2003). A third and more cursory *Energy Review* (DTI 2006) finally reversed this negative picture, but in a fashion determined as “flawed” by subsequent judicial review (Woodward 2007). Yet, the prime minister responded that the legal requirement to reconult “won’t affect the policy at all” (BBC 2007). It is in such ways that social appraisal is conditioned by the commitments it supposedly informs.

This coconstitutive, iterative, and reflexive interweaving of social appraisal and commitment raises important challenges to transparency and accountability (Munro and Mouritsen 1996). These are discussed in a burgeoning literature (Power 1999; Strathern 2000). For the present purposes, however,

the value of a simplistic heuristic distinction remains in that it usefully highlights the necessary role of intentionality in governance (Lash 2001). The appraisal/commitment distinction provides a basis for engaging with issues of “authenticity” and accountability, without negating important questions about appropriate modalities for “transparency” (N. Brown and Michael 2002) and audit (Neyland and Woolgar 2002). The central point is simply that governance discourses about transparency and accountability are necessarily predicated on assumptions of intentionality. It is in these terms that appraisal and commitment are (logically and heuristically) asymmetric and sequential (Stirling 2006b). If technological commitments embody even elements of deliberate choice, this necessarily involves (implicit or explicit) appraisal. Conversely, the fact of such appraisal need not necessarily result in the requisite resource alignments implied by “deliberate choice” (Smith, Stirling, and Berkhout 2005). Appraisal is thus a *necessary* precondition for intentional commitments, yet only *circumstantially* so informed in return. This asymmetry between appraisal and commitment raises questions for current participatory discourses. In short, what is the purpose of structured exercises in participation? Are they about informing, or actually forming, the commitments themselves?

Analysis and Participation in Social Appraisal

On the face of it, the more modest of these two aspirations lies in appraisal. Here, according to participation proponents, we are faced with an apparently stark dichotomy. On one hand, there are established, narrow, rigid, quantitative, opaque, exclusive, expert-based, analytic procedures tending to privilege economic considerations and incumbent interests (Collingridge 1980; Schwartz and Thompson 1990; Flyvbjerg 1998). Broadly, these include approaches like risk/cost–benefit analysis, technology/life cycle assessment, Delphi methods, and expert advice. On the other hand are seen new, relatively unconstrained, qualitative, sensitive, inclusive, transparent, deliberative, democratically legitimate, “participatory” processes promising greater emphasis on otherwise marginal issues and interests such as environment, health, and fairness (Fischer 1990; Irwin 1995; Sclove 1995). In this way, in fields such as agriculture, energy, transport, and communications (Renn, Webler, and Wiedemann 1995; Joss and Durant 1995), citizen engagement is defended by contrast with (if not a substitute for) conventional expert analysis.

In many instances, this remains a substantive dichotomy. Whether as cause or effect, participatory practices do often embody increased acknowledgement

of, aspirations to, and sometimes even achievements for wider and more deliberate social agency in technology appraisal. Many see this as welcome, overdue, and insufficient. Yet, there also exist countervailing (expedient and rhetorical) factors in emerging discourses on participation (Harrison and Mort 1998; Levidow 1999; Owens and Cowell 2002; Pellizzoni 2003). Irwin (2001), for instance, discusses ways in which structured “public engagement” in biotechnology can actually be conceived and implemented more as public education than empowerment. Likewise, Wakeford (2001) argues that engagement initiatives on radioactive waste management presented as “bottom up participatory process” are better understood as constrained “top-down” exercises in legitimation.

The apparently stark dichotomy thus becomes more complex and nuanced, with the substance residing more in detailed context and implementation than in stylized notions of expert analysis versus participatory deliberation. If the devil thus lies in the detail, the question arises whether the analysis/participation polarity itself is overdrawn. Are there commonalities, synergies, or tensions transcending the apparently simple dichotomy? Are there conditions under which specific expert-analytic processes might potentially be *more* conducive to enhanced social agency or (conversely) particular participatory procedures less so? To address this, we must first consider more general queries about the rationales and motivations for interest in participation by different social actors. Yet, answers to such questions in policy debates are usually given in similarly dichotomous terms. Antagonists take up polarized positions, with others constructing intermediate or synthetic perspectives, equally framed according to analysis/participation dichotomies (Rauschmeyer and Wittmer 2006). There seems curiously little critical attention to the validity and utility of the dichotomy itself. This is the subject of the next section.

Empowerment, Trust, and Quality

One crucial, common feature of participation and analysis lies in the importance of intentionality. Here, attention focuses on the rationales and motivations underlying appraisal and involves three quite starkly distinguishable types of imperative: “normative,” “instrumental,” and “substantive” (Fiorino 1989). In short, normative imperatives yield appropriately designed appraisal simply as the right thing to do, without reference to the ends in question. Under substantive imperatives, appropriately designed appraisal aims at achieving generally better ends. Under instrumental imperatives,

appraisal design aims to secure particular ends, favored for (often tacit) proximate reasons independently of more widely deliberated social values. Applying equally to participation and analysis, each of these imperatives will be taken in turn.

Normative imperatives take a variety of forms, all focusing on the *process* of appraisal (Pellizzoni 2003). In expert analysis, a range of idealized Mertonian or Popperian norms are invoked to characterize ostensibly “value free” (Morris 2000) and “sound science” (Blair 2003). In participatory deliberation, normative imperatives variously highlight Habermas’s notions of “ideal speech” (1968), “legitimacy” (1975), and “communicative rationality” (1984); Rawls’s “public reason” (1993, 1997); or qualities of “social learning” (Wynne 1992), “authenticity” (Dryzek 2002, 1), and “reflexivity” (Wynne 2002; Stirling 2006b). These in turn yield evaluative criteria variously invoking the scope, resourcing, openness, representativeness, accessibility, facilitation, transparency, or accountability of engagement (Renn, Webler, and Wiedemann 1995; Petts 2001; Horlick-Jones et al. 2004). Involving all “interested and affected parties” (National Research Council 1996), normative democratic imperatives thus hinge on capacities for social empowerment (especially for otherwise excluded groups). In short, under normative democratic perspectives, a well-conducted (i.e., criteria-compliant) participatory process is a self-evidently good thing.

However, such widening of social agency beyond immediately proximate political actors can be problematic for incumbent interests. As a consequence, examples abound of participatory exercises being ignored by their sponsors (Pimbert and Wakeford 2002). Tony Blair illustrates the underlying attitude in the above-cited assertion that repetition of a consultation process will not affect policy. Accordingly, practitioners and researchers alike frequently find themselves reflecting on the persistent failure of participatory appraisals to “impact” tangibly on policy making (Renn, Webler, and Wiedemann 1995).

This syndrome reflects the second group of imperatives in appraisal: the *instrumental*. Rather than process-based norms, these focus on outcomes (Pellizzoni 2001). Again, they apply equally to participation and expert analysis. Either way, appraisal is regarded in terms of efficacy in realizing particular favored ends. The grounds for favoring such ends are simply assumed, without social deliberation or any reference to qualities such as Habermasian legitimacy or Rawlsian public reason. Efforts thus concentrate on the interests of specific constituencies, institutions, or technological systems, irrespective of wider normative values. Although instrumental imperatives may as readily be pursued by marginalized groups as incumbent

interests, it is by definition the latter that exercise the predominant influence on technology choice.

Manifestations of instrumental imperatives are as contrasting as the normative frames to which they (usually implicitly) relate. Particularly prominent in participatory discourse (especially in funding proposals!) are concepts of trust. Although conventionally treated as a self-evidently positive quality (Margolis 1996; Misztal 1996; Seligman 1997; O'Neill 2002), the normative implications of trust actually depend on the specific orientations. Where the focus lies on a trusting participant (e.g., the public), rather than a trustworthy object (i.e., the specific technology or institution in question), then the instrumentalities become clear. Inherently instrumental concerns about "reputation management" in public and private organizations (Griffin 2002), for instance, frequently highlight the importance in securing trust through declared commitments to participation (Holt, Mulroy, & Germann Public Affairs 2003). Yet, such claims may be made, even where participatory recommendations are effectively ignored. This is often so, even in the paradigmatic case of Denmark (Zurita 2006), arguably the most successful site for institutionalized participation (Vig and Paschen 2000). Preoccupations with public trust can thus be a useful indicator of otherwise tacit instrumental perspectives.

Further indications of instrumentality can lie behind ostensibly objective evaluations of participatory process. Under a normative democratic perspective, nonadoption of recommendations from criteria-compliant participation represents failure on the part of sponsoring institutions. Where evaluation criteria frame "unusable" outcomes as a failure of participation itself (Rowe and Frewer 2000), then corresponding instrumental imperatives are revealed. For example, the U.K. government's elaborate "GM Nation" initiative (Department for Environment, Food and Rural Affairs [DEFRA] 2003) actually exercised little impact on policy (Baldwin, Webster, and Elliott 2004). In justifying their caution (DEFRA 2004), the government itself cited a critical officially contracted evaluation in which negative conclusions were partly based on application of this kind of policy impact criterion. Ironically, much of the grounds for concern in the evaluation were actually attributed to insufficient provision of finance, time, and expertise—responsibilities of the government as sponsors (Horlick-Jones et al. 2004).

A further instance of a different kind of instrumental imperative in participatory appraisal lies in certain interpretations of the concept of "social intelligence." Properly intended to evoke general processes of social learning (Grove-White et al. 1997; Grove-White, Macnaghten, and Wynne 2000), this imperative can also carry more conventional connotations of intelligence—as

a means to facilitate more effective political management of dissent. Many approaches to participation may in principle serve this function, but the tendency is most pronounced in methods (such as focus groups) where the agency in design, conduct, analysis, and representation of deliberation lies most exclusively with commissioned experts and (potentially) their sponsors.

The third and final general imperative in social appraisal is the substantive. Again, this applies equally to analytic and participatory approaches. Like instrumental imperatives, it concerns outcomes rather than explicitly normative preoccupations with process. The distinguishing feature of a substantive perspective, however, is that the outcomes in question are not defined instrumentally, in terms of particular values or interests (whose normative justifications remain implicit or concealed). Instead, the focus is on explicit, socially deliberated, publicly reasoned evaluative criteria for the outcomes themselves. In other words, rather than aiming instrumentally to yield specific forms of acceptance, trust, or intelligence, the focus lies on general qualities such as “environmental quality” (Coenen, Huitema, and O’Toole 1998), public health (European Environment Agency 2001), or broader human well-being (O’Brien 2000).

One particular instance of this substantive perspective on appraisal is found in high-profile debates about the “precautionary principle” (O’Riordan and Jordan 2000). Lying at the heart of globalizing discourses on risk, trade, and technology, precaution is conventionally interpreted by bodies such as the European Commission as a decision rule, of relevance only in risk management (forming social commitments) rather than risk assessment (a form of social appraisal; Commission of the European Communities 2000). However, a recently emerging literature unpicks many substantive implications of precaution for appraisal itself—concerning the array of options that are considered, the breadth and depth of issues that are examined, the range of uncertainties that are explored, and the diversity of methods and disciplines applied (Stirling 1998b). By broadening out appraisal in these ways, it is argued that greater confidence can be gained that resulting outcomes will fulfill substantive criteria concerning general human well-being or the environment (European Science and Technology Observatory 1999).

These substantive understandings of precaution-as-process in appraisal also highlight the value of participation (Stirling 2003). Such substantive arguments for pluralistic appraisal go back a long way. Schwartz and Thompson (1990) give an example of a new consumer chemical product, where (unsought and unwelcome) critical engagement by environmentalist stakeholders in Germany led to what even manufacturers eventually acknowledged not only as environmental and health but also technical and economic

improvements. Similar substantive arguments are advanced by the European Environment Agency, for whom

The point is not that lay people are necessarily more knowledgeable or environmentally committed [than specialists]. Rather the benefit of attending to lay knowledge rests in its complementary character, its sometimes firmer grounding in real world operational conditions . . . and the associated independence from the narrow professional perspectives that can be a downside of specialist expertise. Often too, lay knowledge of a technology or risk may be based on different assumptions about what is salient, or what degree of control is reasonable to expect or require, whereas technical specialists may simply respond to granted authority without further reflection. (European Environment Agency 2001, 177)

Even more strongly, for Nowotny “more involvement on the part of society means not a better social solution, or a better adapted solution, or one that brings social tranquility to a community, but a better technical solution” (2006, para. 24).

This kind of substantive focus on appraisal outcomes may raise eyebrows in some social constructivist circles. It can appear decisionistic, essentializing quality criteria and obscuring underlying social contingencies (Wynne 1997; Pellizzoni 2003). It is therefore notable that constructivist perspectives also give rise to their own quite distinct but equally substantive imperatives. These hinge on concepts of “social robustness,” as a substantive property of contending technology commitments (Grove-White, Macnaghten, and Wynne 2000). Although variously characterizable in epistemic (Goldman 2001), ontological (Leach, Scoones, and Wynne 2005), or hermeneutic (Wynne 1996) terms, social robustness is a substantive matter of the degree to which technological commitments are congruent with, or authentically embody, societally deliberated, publicly reasoned values, knowledges, and meanings. In this sense, processes of social learning in appraisal may be distinguished from instrumental notions of social intelligence in that they are oriented toward informing the substance of the social commitments themselves, rather than conditioning the modalities for their implementation or presentation. In other words, under a substantive approach to participation, citizens are engaged as subjects rather than as objects of discourse.

To conclude this part of the discussion, it is important to recognize that this threefold partitioning of rationales and imperatives bearing on different approaches to appraisal are intended neither to represent idealized schema of world views—as in the fourfold categories of cultural theory (Schwartz and Thompson 1990)—nor an empirical taxonomy of “policy cultures”

(Elzinga and Jamison 1995). In any given context, normative, instrumental, and substantive rationales may be invoked for contrasting reasons under diverse perspectives. Any given cultural perspective is likely, over time, to entertain all three as imperatives. The U.K. Treasury (HM Treasury 2004) and Department of Environment (DEFRA 2004), for instance, variously acknowledge both normative democratic and substantive rationales for more inclusive upstream engagement, while privately prioritizing more instrumental imperatives. Alternatively, an instrumental perspective can equally be adopted toward the ends favored under radical egalitarian or environmentalist agendas as under incumbent business or government interests.

Any given instance of participatory appraisal, then, may simultaneously be justified in any or all three of these fashions. Indeed, it is arguably precisely this interpretive flexibility (Bijker 1995) that underlies the current proliferation of participatory discourse in high-level policy circles (Stirling, forthcoming). Grove-White (2006) examines these complex dynamics in the case of the recent high-profile U.K. government “GM Dialogue.” The steering board convened to oversee that the “GM Nation” public engagement program articulated all three perspectives (DEFRA 2003). Likewise, the parallel “GM Science Review” also embodied an unprecedented integration of substantively justified scientific deliberation on uncertainties and normatively justified engagements with diverse societal perspectives and instrumental imperatives to yield operational policy outcomes (GM Science Review Panel [SRP] 2003). The point, then, is not to draw one-to-one empirical or conceptual correspondences but to recognize the significantly different power dynamics associated with each imperative. These crosscut more simplistic distinctions between analytic and participatory appraisal and hold important methodological implications.

Framing, Justification, and Power

Having identified crosscutting attributes of appraisal (applying equally to analytic and participatory approaches), it becomes relevant to consider the role of political, institutional, and economic power. While theoretical literatures do critically engage at a general level with questions of power (Pellizzoni 2001), these tend to be neglected in more specific literatures on appraisal. It is relatively well understood that expert-analytic approaches are susceptible to influence by powerful incumbent sociopolitical actors (Collingridge 1980; Schwartz and Thompson 1990; Renn, Webler, and Wiedemann 1995). Yet, the mere adoption of approaches commonly referred

to as participatory often seems sufficient in itself to encourage impressions that issues of power are automatically addressed. Is this really so?

An explicit focus on power can sometimes be seen to imply a simplistic, partisan, or conspiracy-hunting position. It is therefore wise first to clarify what is—and is not—meant here by power. Colloquially, power is about the exercise by one group of social actors of influence, control, authority, command, or dominion over others. When subject to scholarly scrutiny, however, power becomes a more diffuse, slippery, and multifaceted social phenomenon (Lukes 1974). It has an ambiguous relationship with intentionality (Foucault 1980), discourse (Hajer 1997), and political and economic interests (Giddens 1979). As a capacity to influence action, power may be exerted from contending directions through disparate media to divergent normative ends (Giddens 1986). Operating in different ways in various distinct fields (Bourdieu 1996), gradients of power may display contrasting orientations at varying scales at different times and in diverse contexts. It is therefore not necessarily the case that exercise of power in any particular appraisal exercise will be explicit or deliberate, nor that the particular power structures immediately concerned will automatically be those that are extant in wider governance.

Likewise, given the complex dynamics of social appraisal, it cannot be guaranteed that any given instance in the exercise of power will necessarily serve to achieve the intended ends (Foucault 1980). Accordingly, in the absence of detailed analysis or intimate experience of the case in question (usually reinforced with hindsight), the substantive consequences may often be indeterminate (Wynne 1992). This indeterminacy is compounded by intrinsic normative ambiguities in the analysis of power (Foucault 1980). In other words, whether the exercise of power is judged to be good or bad depends on the context and the point of view. Indeed, sometimes localized power relations bearing on a particular appraisal exercise may have the effect of countering larger scale power gradients. The present attention to the role of power in appraisal should not therefore necessarily be seen to be critical or indeed to hold any particular political connotations. It is simply an acknowledgement of an important but sometimes neglected feature of social context.

With the background and implications thus qualified, it follows from the preceding analysis of normative, instrumental, and substantive approaches to participation that each will tend to display different power dynamics. Normative democratic imperatives aim to ameliorate the effects of wider power inequalities. Instrumental imperatives tend to support ends conditioned by proximate power structures. Substantive imperatives are ostensibly blind

to power, focusing instead on apparently transcendent qualities such as precaution or robustness. The evaluative implications of these tendencies will vary, depending on context and perspective. Of more general interest are the questions raised about the specific modalities for the influence of power on social appraisal.

The most well-established context for discussion of power in appraisal concerns the way in which outputs of ostensibly definitive expert analysis are highly susceptible to various kinds of “framing” (Goffman 1974; Wynne 1987; Jasanoff 1990). Choosing policy questions, bounding institutional remits, prioritizing research, including disciplines, accrediting expertise, recruiting committees, setting agendas, structuring inquiry, forming hypotheses, choosing between methodologies, defining metrics, characterizing decision options, prioritizing criteria, interpreting uncertainties, setting baselines, exploring sensitivities, conducting peer review, and constituting proof all provide ample latitude for contingency or agency. These factors are generally considered external to analysis and are excluded from explicit reflection. Many are essentially subjective in nature and are thus eminently contestable. Yet, they often exert a determining influence on appraisal results, the full scope of which typically remains concealed or underacknowledged.

What is less well recognized is that the design, implementation, and interpretation of participatory appraisal also display similar latitude for contingency and agency (Scoones and Thompson 2001; Wakeford 2001). Forming relationships with sponsors, constituting oversight, structuring process design, choosing focus, partitioning perspectives, engaging stakeholders, recruiting participants, phrasing questions, bounding remits, characterizing alternatives, providing information, selecting the medium of discourse, conducting facilitation, reading the demeanor of practitioners, considering the personalities of protagonists, understanding the dynamics of deliberation, managing dissensus, documenting findings, and articulating with policy all provide ample scope for contingent variability, inadvertent bias, or the exercise of deliberate conditioning influence. There seems little reason, *a priori*, to distinguish technical analysis and participatory deliberation in terms of their general sensitivity to framing.

Framing thus raises important queries both for analytic and participatory appraisal—under normative, substantive, and instrumental perspectives alike. It reveals the enormous latitude for inadvertent, tacit (or deliberate, covert) influence of power. This challenges normative aspirations (and claims) to ideal speech, public reason, and empowering process just as much as to Mertonian norms of value-free analysis or sound science. Indeed, to the extent that normative aims in participation are assumed of themselves to militate

against power, then the challenge to associated aims (and claims) is even more acute. In an unusually explicit discussion of the role of power in conditioning analytic approaches to social appraisal, David Collingridge (1980, 1982, 1983) built on Habermas's insight by highlighting processes of "decision justification." His account bears expansion to include the role of framing in participatory approaches to appraisal.

Collingridge's undifferentiated notion of justification subsumes two important instrumental imperatives that are quite distinct from those already discussed. First, in what might be called "weak justification," incumbent interests are relaxed about the particularities, but insistent that some decision be made. Prominent here are the dynamics of "blame management" (Horlick-Jones 1996; Hood 2002), where the pressure is to avoid or deflect administrative or political exposure to any blame that may arise in the future if any particular decision were to go awry. To this end, appeals to reified authorities of legitimacy, inclusivity, or representativeness in appraisal may serve essentially the same function as more technocratic invocations of independent expertise or value-free analysis. Indeed, to the extent that the credibility of analytic approaches to social appraisal is in decline, there are increasing instrumental incentives to substitute participatory for analytic means to this weak justification (Levidow 1999).

A second aspect may be referred to as "strong justification." Here, there is an instrumental imperative not just in relation to decisions in general, but to justify a particular decision outcome (such as a specific technological commitment). Such an outcome may be favored by incumbent interests for narrow institutional, parochial, cultural, or partisan political reasons that are not expedient openly to declare. Under these circumstances, deliberate conditioning of the framing of appraisal provides a promising means to secure the desired outcomes. Such is the manifest latitude for conditioning appraisal that there need often be no compromise on (let alone violation of) disciplinary rigor, methodological conventions, or individual integrity. The point is not that power will always exert this kind of influence, but that this typically cannot be excluded.

It follows from this that imperatives to strong justification need not necessarily be explicit and deliberate, even on the part of incumbent interests. Both analytic and participatory appraisal subsists in a broader policy context in which incumbent interests, by definition, enjoy privileged economic, cultural, and institutional positions. Such interests are often directly engaged in individual projects through the formal structures of financing, sponsorship, clientship, patronage, or stakeholder oversight as well as in associated general processes of research governance, disciplinary funding, peer review,

and professional advancement. Even without postulating direct and deliberate efforts at manipulation or “capture” (Sabatier 1975), it is typically difficult to exclude the possibility that design, conduct, or interpretation of participatory appraisal are subject to implicit, but potentially powerful, conditioning pressures.

This kind of pressure may often simply operate through unconscious anticipation of possible actions by powerful actors. This is so even if such actions are never actually perpetrated or even contemplated. On those occasions where the dynamics of tacit appraisal processes are later subject to detailed scrutiny, a host of mechanisms emerge under which protagonists effectively second guess imperatives for strong justification. This was the case, for instance, in the late 1980s with management of bovine spongiform encephalopathy in the U.K. food chain. The scientific appraisal process repeatedly anticipated the appropriate way to constitute and present emerging scientific questions and findings such as to minimize the expense, inconvenience, embarrassment, and blame falling on government and industry (Van Zwaneberg and Millstone 2004).

In the case of participatory procedures, there exist many examples of unconscious pressures for weak and strong justification acting on the framing of participatory appraisal by ostensibly independent designers or facilitators. The first U.K. national consensus conference on genetically modified (GM) foods (Biotechnology and Biological Sciences Research Council 1994), for example, was criticized for failing to engage critical stakeholders in design and implementation and effectively excluding consideration of alternatives to GM foods (Weldon and Wynne 2001). In a later national U.K. consensus conference on radioactive waste management (U.K. Centre for Economy, Environment and Development 1999), Wallace (2001) identifies justificatory pressures in the definition and bounding of focal questions, the conduct of facilitation, and the provision of information materials. In the most recent GM Nation exercise already discussed, Mayer (2004) endorses concerns expressed in the official evaluation (Horlick-Jones et al. 2004) about limiting available time, resources, and funding as well as critiquing the use of a government agency as contractor. Reviewing the 2001 Prajateerpu exercise in Andhra Pradesh, Scoones and Thompson (2001) highlight a range of framing issues such as representativeness, facilitation, and the provision of information. It seems clear that the apparent normative democratic credentials of participatory appraisal do not themselves confer immunity to instrumental pressures for the justification of powerful interests.

“Opening Up” and “Closing Down”

The preceding discussion has explored the role of power in applying pressures for strong and weak justification in social appraisal. It has shown how this relates to normative, substantive, and instrumental imperatives in appraisal. It is on this basis that we may now return to the discussion with which this essay began. Aided by undifferentiated linear discourses of progress, processes for forming commitments to particular scientific and technological trajectories remain obscure and inaccessible. How then may we come to understand and realize the associated (often hidden) indeterminacy, open-endedness, and potential for human agency in social choice? What conclusions might we draw for the practice or evaluation of participatory and analytic appraisal? What are the implications for the formation of material technological commitments?

By approaching the issue in this way, it quickly becomes clear that despite their differences, participation and analysis actually hold a lot in common. Both are specific instances of social appraisal. Both are subject to normative, substantive, and instrumental imperatives. Both are equally sensitive to framing conditions. Yet, as conventionally practiced, both have the effect of reducing evaluative diversity. Both are therefore similarly susceptible to processes of justification. Both are applied in institutional environments, which are structured and pervaded by power relationships. Both are vulnerable to strategic behavior. Yet, either approach may be undertaken and presented in such ways as alternatively conceal and reify, or acknowledge and interrogate, these pressures, sensitivities, and susceptibilities. One way to think about these crosscutting issues—pervading both sides of the analysis/participation dichotomy—is as a distinction between the role of social appraisal in opening up or closing down wider policy discourses on science and technology choice.

If social appraisal is about closing down the formation of technological commitments, then the aim is instrumentally to assist incumbent policy-making actors (or perhaps other more proximate sectional interests) by providing a means to (weak or strong) justification. Whether analytic or participatory, social appraisal here cuts through messy, intractable, and conflict-prone diversities of interests and perspectives to develop clear, authoritative, prescriptive recommendations informing decisions. There is a vulnerability to strategic behavior on the part of practitioners or sponsors in the design and implementation of appraisal. Yet, only in this way—so one argument goes—can we achieve the effective management of policy-making attention, enable

efficient and proportionate allocation of resources, and (through mitigating unnecessary conflict) foster satisfactory levels of social and political cohesion. In pursuing this aim, the focus is on defining the “right” questions, finding “priority” issues, identifying “salient” knowledges, recruiting “appropriate” protagonists, adopting “effective” methods, highlighting “likely” outcomes, and so determining the “best” options.

Whether in analysis or participation, the output of this kind of closing down in appraisal takes the form of what might be called “unitary and prescriptive” policy advice. This involves highlighting a single course or a very small subset of possible courses of action (or technology commitments), which appear as preferable under the particular framing conditions privileged in appraisal. These conditioning assumptions and sensitivities will typically not be explored in any detail. The outputs will therefore have the instrumental merit of conveying clear, practical justification for decision making.

Despite many jurisdictional (Jasanoff 1990) and institutional-cultural (Jasanoff 2005) differences, examples of this closing-down approach in appraisal are routine features of scientific advisory processes in many countries. Selected experts are chosen such as to represent an appropriate mix of disciplinary (and sometimes even a limited number of stakeholder) perspectives. Under the assertive guidance of a carefully chosen chair, these work to arrive at a common position in interpreting the available scientific evidence. This is routine practice, for instance, in the U.K. Advisory Committee on Toxic Substances (on which the author served). Despite this breadth of inputs to the deliberations and the frequently significant uncertainties, the outputs to policymaking consistently took the form of unanimous or consensus (i.e., unitary and prescriptive) recommendations, involving single, discrete numerical values for various regulatory occupational safety standards. Typically, these were then simply adopted in policy making. Yet, the specific recommendations often seriously downplay the scope for legitimately divergent interpretation embodied in the preceding deliberations and negotiations. This closing down typically owes much to the quality of the chairing, group dynamics among the membership, and careful management on the part of the secretariat (including processes for evaluation of individual members).

On the other hand, if appraisal is aimed at opening up a process of technology choice, then the focus is rather different. Here, the emphasis lies in revealing to wider policy discourses any inherent indeterminacies, contingencies, or capacities for agency. The aim is then to examine the degree to which results obtained in appraisal are sensitive to different framing conditions

and assumptions. Instead of focusing on unitary prescriptive recommendations, appraisal poses alternative questions, focuses on neglected issues, includes marginalized perspectives, triangulates contending knowledges, tests sensitivities to different methods, considers ignored uncertainties, examines different possibilities, and highlights new options. Here, the relative lack of structured constraints on modes of expression may present a vulnerability to strategic behavior on the part of participants. Yet, only in this way—so another argument goes—can we ensure the robust informing of governance processes and the achievement of appropriate levels of transparency and accountability in technology choice and do so unobscured by smoke screens of justification.

Under an opening-up approach in appraisal, whether analytic or participatory, the outputs to wider processes of social commitment are delivered as what might be termed “plural and conditional” policy advice (Stirling 2003). This involves systematically revealing how alternative reasonable courses of action appear preferable under different framing conditions and showing how these dependencies relate to the real world of divergent contexts, public values, disciplinary perspectives, and stakeholder interests. Accordingly, the lack of imperatives for aggregation will relieve pressures to reify notions such as objectivity, representativeness, or legitimacy. Although the results may be correspondingly ambiguous or equivocal about what constitutes the single best way forward, the openness of the process renders those courses of action that are positively evaluated and all the more collectively robust.

Examples of moves toward this approach are provided by another U.K. science advisory body on which the author served. Although not fully realizing all the dimensions of opening up discussed here, the innovative GM SRP was unprecedented in the United Kingdom for systematically exploring a range of divergent interpretations of uncertainties about potential merits or drawbacks of GM crops (SRP 2003). Presentation of final results to policy making was to some extent conducted as an iterative dialogue with stakeholders—responding in constrained ways to a series of openly published comments on a draft report (SRP 2004). By explicitly addressing ambiguities between different disciplines or perspectives and persistent gaps in knowledge, the SRP exemplified certain key aspects of opening up (Grove-White 2006). In the end, though falling far short of a symmetrical appraisal of contending agricultural strategies, the final neither red nor green light conclusion referred to earlier represents a limited and stylized form of plural (if not fully conditional) advice. Crucially, it declined to provide the justificatory resource strongly solicited by government, so it presented a significant

innovation in relationships between science (appraisal) and policy (commitment) in the United Kingdom (Econexus et al. 2003).

Whether as explicit political decisions or as more implicit and diffuse forms of institutional commitment, *de facto* social choices will (and must), of course, still occur. Here, an opening-up approach may still nonetheless illuminate the potential for pursuing a greater diversity of technological pathways (Stirling 2007a). Attention may usefully be directed at synergies and complementarities between technology or policy options. Alternatively, the learning thus achieved may offer a fruitful basis for further appraisal oriented more explicitly toward closing down. Either way, it becomes clearer how to frame transparency and structure responsibility and accountability in decision making and wider governance processes. Far from being radical or impractical when compared with prevailing practices for closing down, appraisal conducted in opening-up mode might in this sense actually be seen as substantively more coherent (and normatively more consistent) with established democratic institutions and procedures. It is in this way, for instance, that we may directly avoid the frequent criticism of participatory appraisal, to the effect that it threatens to render redundant the complex and hard-won existing apparatus of representative democracy, at a time when this is already under threat (Crouch 2004).

A series of specific implications for analytic and participatory approaches follow from this distinction between opening up and closing down as modes of appraisal. In an expert analytic approach like risk or cost–benefit assessment, many of the same quantitative methods may be used in either mode. But instead of aggregating different metrics, methods, and perspectives, an analytic orientation toward opening up makes use of techniques such as scenario (Werner 2004) and sensitivity (Saltelli 2001) analysis or multicriteria mapping (Stirling 1997) to reveal the implications of different assumptions and conditions. The reporting of expert deliberation highlights residual uncertainties, ambiguous findings, contending interpretations, and dissenting views (SRP 2004).

One specific example of such an approach in analysis is multicriteria mapping (MCM; Stirling and Mayer 2001; McDowell and Eames 2006; Burgess et al. 2007; Stirling, Lobstein, and Millstone 2006). This uses a computer-based interview or small group elicitation method of a kind long developed in the field of multicriteria decision analysis (Dodgson et al. 2001). Unlike normal practice in this field, however, MCM uses an unconstrained heuristic process of option characterization, criteria definition, performance scoring, and criteria weighting—including explicit attention to uncertainties and nonutilitarian principles—to stimulate deliberation,

elicit qualitative information concerning reasons and conditionalities, and generate a graphically represented map of the divergent ways in which the contending options can be framed (Stirling 2006a). With appropriate stakeholder oversight in design, such a process can provide confidence that an envelope of potentially viable social commitments (and their respective implications) have been explored in appraisal (Yearly 2001). Although the effect is undoubtedly to open up subsequent policy discourse, such procedures may also serve to close down particular areas. Where low-performing options are identified in common across all explored perspectives, then closure around such understandings may be treated as correspondingly more socially robust.

In participatory appraisal, an opening-up approach would build pluralistic (rather than consensual) discourse (Rescher 1993; Dryzek and Niemeyer 2003). Deliberation centers on sustaining and comparing a diversity of evaluative frameworks rather than on forging common ownership of a single framework. Appropriately conducted, participatory processes such as scenario workshops (Ogilvie 2002), do-it-yourself juries (Wakeford 2002), and open-space methods (Owen 1997)—as well as elicitation techniques such as the Q-method (McKeown and Thomas 1988) and repertory grid (Fransella, Bell, and Bannister 2004)—all offer possibilities. An elaborated, deliberative analytic form of the methodology discussed above—deliberative mapping—provides one further example (Burgess et al. 2007). Here, the distinctive emphasis on mapping extends from quantitative specialist appraisal into interlinked qualitative, deliberative processes including citizen-driven engagements with specialists. Crucially, the emphasis is not in building a final consensus but in exploring systematic divergences of perspective. One finding that can emerge from this is that the apparently stark idiomatic contrasts revealed between different social perspectives by qualitative methods can overstate the associated evaluative differences concerning the policy options actually available for commitment (Davies et al. 2003).

A distinction between opening up and closing down in social appraisal thus pervades both sides of the analysis/participation dichotomy. It is crucially different from notions of breadth of process already discussed in relation to the substantive precautionary rationales for participation. The breadth or narrowness of appraisal concerns the range of inputs that are included (such as issues, possibilities, perspectives, and options). The opening-up or closing-down orientation of appraisal, on the other hand, concerns the range of outputs that are sustained in parallel and conveyed to wider governance (as reasonable candidate social commitments). Of course, there are certain correspondences between the two. All else being equal, an emphasis on opening up

may tend to broaden an otherwise narrow appraisal. Likewise, we might expect it to be easier to effect closing down where an appraisal process is relatively narrow. However, this conjunction of narrowness and closure may exacerbate tensions with wider policy discourses. When a relatively broad-based appraisal process is oriented toward opening up, then challenges will tend to arise in the sheer number and complexity of open-ended elements. When a relatively broad appraisal process is subject to closing down, on the other hand, then tensions may be expected about the specificity and contestability of the particular axis of closure.

Whatever the result, consideration of these questions of framing, justification, and power shows that the distinction between opening up and closing down is of considerable normative, substantive, and instrumental importance. In many ways, the distinction may therefore be more salient than conventional contrasts couched in terms such as new versus old, citizens versus specialists, quantitative versus qualitative, or analytic versus deliberative. The significance is all the more acute for being subject to such relative neglect in the academic and policy literature.

From Plural Appraisal to Diverse Commitments

At the beginning of this article, it was noted that prevailing understandings seem to hold that participatory methods are more democratically progressive when somehow implicated directly in decision making than when merely used in appraisal. In other words, participation is generally seen as more beneficial in the forming than in the informing of governance commitments. However, recognition of the interwoven relationships between appraisal and commitment—and the dynamics of power around opening up and closing down—seriously challenge such assumptions. Indeed, the picture may in some ways be turned on its head. Even under strongly normative democratic perspectives, the role of appropriately conducted participation may be seen as potentially more progressive in appraisal than in ostensibly more ambitious areas of institutional closure and decision making.

The reason for this lies in skepticism that nominally participatory structures for the forming of governance commitments will actually be able to escape the pervasive hidden influence of incumbent or proximate powerful interests. The extent to which this is so will depend on the degree to which processes of closing down are sensitive to the many different forms of framing identified earlier and so to driving imperatives for justification. If the participatory structures are felt to be more susceptible in this regard than wider

unstructured processes of political contention and discourse, then the conclusion under a normative democratic perspective must be that formally constituted exercises in participation are better aimed at opening up appraisal than closing down the commitments themselves. Either way, the greater the tendency simply for the labeling of a process as participatory of itself to prompt suspension of critical faculties over the framing effects of power, the greater will be the grounds for concern.

Of course, such concerns necessarily apply only under normative democratic and substantive perspectives on the role of participation. Where prospects are perceived of being realized, instrumental motivations (of whatever orientation) may lead to different conclusions. Likewise, if the forming of technological commitments were genuinely initiated and driven by broad societal values rather than incumbent interests, focused on human needs and aspirations rather than technological enthusiasms, attended particularly to the needs of the most vulnerable and marginalized groups, and displayed genuine qualities of effective deliberation and public reason, then even the normative and substantive qualifications would not apply. Judgments will thus always depend on context.

Either way, it is important to emphasize that this analysis is not a critique of the increasing profile for participation in the governance of science and technology, nor even of any particular exercise. Both the general language and individual initiatives can have cumulative and catalytic effects extending beyond the sum of inevitably circumscribed parts. Notwithstanding any shortcomings, they may help raise expectations and contribute some diversity and dynamism in technology governance. The point is simply to try to foster more discriminating attention to the conditions and perspectives bearing on appraisal and commitment. In short, participation aimed at the more ostensibly modest goal of opening up appraisal may often be more progressive in its effects than when aimed directly at closing down technological commitments.

It should also be emphasized that this analysis is also not a blanket critique of the closing down of technological commitments themselves. Given the mismatch between human aspirations and possibilities, on one hand, and technological and political actualities in a finite world, on the other hand, continuing processes of closure are under any view simultaneously necessary, inevitable, and desirable. The issue is rather more specifically one of the role of appraisal in this regard. An elaborated discussion of the implications of this analysis for general patterns in technology governance inside or outside the technological system is presented elsewhere (Smith and Stirling 2007). For the moment, the point is that the simple necessity, inevitability, and desirability of closure in commitments need not

imply that this same imperative to closure automatically bears correspondingly on appraisal.

The above discussion of power suggests that a primary epistemic function of appraisal is, by definition, the opening up of plural understandings surrounding closure in commitments. In practice, of course, there will be times, places, and institutions for opening up and corresponding loci for closing down. Contrasting balances will be judged appropriate in various contexts under different perspectives. The articulation of these two processes will itself be a matter for deliberation and contestation. It suffices to say, for now, that a prerequisite for making such articulations effective and legitimate is that the distinctions be recognized in the first place between appraisal and commitment and opening up and closing down. This has been the primary aim of this article, and the discussion in the last section has pointed to a range of practical implications for both analytic and participatory appraisal.

A final implication of this analysis, however, moves from appraisal directly to address the technological commitments themselves. Thus far, the opening up of appraisal has been discussed against a backdrop of multiple possible orientations for technological commitments, of which only a small subset will—or can—be pursued. This is true, but not the whole story. While some degree of closure in commitments is inevitable, necessary, and desirable, it need not always be as complete as is sometimes assumed. Just as pluralistic opening up can have significant epistemic value in technology appraisal, so too can diversity have corresponding ontological value in the evolution of technological commitments (Stirling 1998a). Pursuit of a diversity of technological pathways respects and nurtures context sensitivity (Collingridge 1980), helps accommodate (rather than manage) irreconcilable values and interests, hedges against ignorance (Stirling 1994), and mitigates premature lock-in (Arthur 1989). The fostering of diversity in commitments (as well as appraisal) is also a means to promote more robust innovation (Grabher and Stark 1997; Smith, Stirling, and Berkhout 2005) and social learning (Aoki 1996). Although clearly a distinct and complex subject in its own right (Stirling 2007a), the present analysis of opening up in appraisal clearly also has implications for diversity in commitments.

The key point, then, is not that closure (in appraisal or commitment) is somehow necessarily negative, but that it tends unduly to be privileged. Both in academic discussion and policy practice, there is scope for more symmetrical interest in processes for opening up as well as closing down. This transcends particular jurisdictions, institutions, and exercises—and even tightly drawn contrasts between analytic and participatory approaches (or, for that matter, appraisal and commitment). While the expansion of structured

participatory processes are undoubtedly of general importance to the project of democratizing technology, there can be no automatic presumption that they will necessarily be sufficient, or even always positive, in their effects. Attention should extend to a more diverse array of process and conditions, involve the practice of specialist analysis as well as participatory deliberation, and focus on appraisal as well as decision making itself. Only in this more open-ended fashion may we realistically hope to achieve a richer, wider, and more vibrant empowering of human agency in the deliberate social choice of technological futures.

References

- Adams, R. 2002. City diary. *Guardian*, December 13, 2002.
- Aoki, M. 1996. An evolutionary parable of the gains from international organizational diversity. In *The mosaic of economic growth*, edited by R. Landau, T. Taylor, and G. Wright, 247-80. Stanford, CA: Stanford University Press.
- Arthur, W. 1989. Competing technologies, increasing returns, and lock-in by historical events. *Economic Journal* 99:116-31.
- Baldwin, T., P. Webster, and V. Elliott. 2004. Blair grasps the nettle on GM crops. *Times*, March 5, 2004. <http://www.timesonline.co.uk/article/0,,8122-1027089,00.html> (accessed August 22, 2006).
- Barry, A. 2001. *Political machines: Governing a technological society*. London: Athlone.
- BBC. 1985. *Edge of darkness*, April 11–September 12, 1985. <http://www.screenonline.org.uk/tv/id/473217/index.html> (accessed December 20, 2007).
- . 2006. *BBC news: The nuclear debate*, July 2006.
- . 2007. *BBC news: Blair defiant over nuclear plans*, February 15, 2007. http://news.bbc.co.uk/1/hi/uk_politics/6366725.stm (accessed December 20, 2007).
- Beckett, M. 2002. Announcement of the establishing of the Committee on Radioactive Waste Management, 29 July 2002. <http://www.corwm.org.uk/content-261> (accessed April 27, 2007).
- Bijker, W. B. 1995. *Of bicycles, Bakelite and bulbs: Toward a theory of sociotechnical change*. Cambridge, MA: MIT Press.
- Biotechnology and Biological Sciences Research Council. 1994. *UK National Consensus Conference on Plant Biotechnology 1994*. London: National Centre for Biotechnology Education.
- Blair, T. 2003. Written answers to questions. *Hansard*, November 10, 2003, col. 14W. http://www.publications.parliament.uk/pa/cm200203/cmhansrd/vo031110/text/31110w04.htm#31110w04.html_sprin1 (accessed December 20, 2007).
- . 2005. Announcement of the government energy review in speech at the Confederation of British Industry, November 29, 2005. <http://www.number10.gov.uk/output/Page8606.asp> (accessed December 20, 2007).
- . 2006. Speech concerning a new Anglo-French agreement on the sharing of nuclear expertise, Paris, June 9, 2006. <http://www.dodonline.co.uk/engine.asp?showPage=article&ID=3237> (accessed December 20, 2007).
- Bohmann, J. 1996. *Public deliberation: Pluralism, complexity, and democracy*. Cambridge, MA: MIT Press.

- Bourdieu, P. 1996. *The state nobility: Elite schools in the field of power*. Cambridge, UK: Polity Press.
- Broers, A. 2005. *The triumph of technology*. BBC Reith Lectures 2005. <http://www.bbc.co.uk/radio4/reith2005/> (accessed December 20, 2007).
- Brown, G. 2004. Speech delivered by the UK Chancellor to UK government conference on advancing enterprise, London, January 26, 2004. http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/advancingenterprise/ent_advent05_index.cfm (accessed December 20, 2007).
- Brown, N., and M. Michael. 2002. From authority to authenticity: The changing governance of biotechnology. *Health, Risk & Society* 4:259-72.
- Brown W. 2002. Inclusive governance practices in nonprofit organizations and implications for practice. *Nonprofit Management and Leadership* 12:369-85.
- Burgess, J., A. Stirling, J. Clark, G. Davies, M. Eames, K. Staley, and S. Williamson. 2007. Deliberative mapping: Developing an analytic-deliberative methodology to support contested science-policy decisions. *Public Understanding of Science* 16:299-322.
- Chambers, R. 1983. *Rural development: Putting the last first*. London: Longmans.
- Coenen, F., D. Huitema, and L. O'Toole, Jr., eds. 1998. *Participation and the quality of environmental decision making*. Dordrecht, Netherlands: Kluwer.
- Collingridge, D. 1980. *The social control of technology*. Milton Keynes, UK: Open University Press.
- . 1982. *Critical decision making: A new theory of social choice*. London: Pinter.
- . 1983. *Technology in the policy process: Controlling nuclear power*. London: Pinter.
- Commission of the European Communities. 2000. *Communication from the Commission on the Precautionary Principle* (COM(2000)1). Brussels, Belgium: European Commission.
- Council for Science and Technology. 2000. *Technology matters: Report on the exploitation of science and technology by UK business*. London: HMSO.
- Crouch, C. 2004. *Post-democracy*. London: Polity.
- David, P. 1985. Clio and the economics of QWERTY. *American Economic Review* 75:332-37.
- Davies, G., J. Burgess, M. Eames, S. Mayer, K. Staley, A. Stirling, and S. Williamson. 2003. *Deliberative mapping: Appraising options for addressing 'the kidney gap.'* Final report to Wellcome Trust. <http://www.deliberative-mapping.org/> (accessed April 15, 2005).
- Department for Environment, Food and Rural Affairs (DEFRA). 2003. *GM nation: Findings of a public debate*. London: DEFRA. <http://www.gmnation.org.uk/> (accessed August 22, 2006).
- . 2004. *Evidence and innovation: Defra's needs from the sciences over the next 10 years*. London: DEFRA. <http://www.defra.gov.uk/science/documents/forwardlook/ScienceForwardLook3rd.pdf> (accessed August 22, 2006).
- Department of Trade and Industry (DTI). 2003. *Energy white paper: Our energy future—creating a low carbon economy*. London: HMSO.
- . 2006. *The energy challenge: Report of the UK Government Energy Review*. London: DTI. <http://www.dti.gov.uk/files/file31890.pdf> (accessed July 16, 2006).
- de W. Waller, D. R., J. Gibbard, P. Maryan, H. Parkinson, J. Craig, J. Perks, C. Downing, D. Forbes, A. Tipping, J. Howland, R. Woolam, M. Pooley, K. Lawson, E. Argirova, and S. Parkash for the AEA Technology Environment and Databuild. 2006. *Analysis of responses to the energy review consultation* (DTI Pub. 06-1565). <http://www.dti.gov.uk/files/file31631> (accessed August 22, 2006).
- Dodgson, J., M. Spackman, and A. Pearman for the DTLR. 2001. *Multi-criteria analysis: A manual*. London: Department of Transport, Local Government and the Regions, HMSO.

- Dryzek, J. 1990. *Discursive democracy: Politics, policy, and political science*. Cambridge, UK: Cambridge University Press.
- . 2002. *Deliberative democracy and beyond: Liberals, critics, contestations*. Oxford, UK: Oxford University Press.
- Dryzek, J., and S. Niemeyer. 2003. Pluralism and consensus in political deliberation. Paper presented at the annual meeting of the American Political Science Association, Philadelphia, PA, August.
- Econexus, the Five Year Freeze, Friends of the Earth, GeneWatch UK, Greenpeace, the Soil Association, and Michael Antoniou. 2003. *Comments on GM Science Review*. Derby: Genewatch.
- Elzinga A., and A. Jamison. 1995. Changing policy agendas in science and technology. In *Handbook of science and technology studies*, edited by S. Jasanoff, G. Makle, J. Petersen, and T. Pinch, 572-97. London: Sage.
- Engineering and Physical Science Research Council. 2006. *Keeping the nuclear option open*. Swindon: Engineering and Physical Science Research Council. <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/TSEC/KeepingTheNuclearOptionOpen.htm> (accessed December 20, 2007).
- Environmental Audit Committee. 2005. *Keeping the lights on: Nuclear, renewables, and climate change* (Sixth Report, Session 2005-6, HC 584). London: HMSO. http://www.parliament.uk/parliamentary_committees/environmental_audit_committee/eac_18_04_06.cfm (accessed December 20, 2007).
- European Environment Agency. 2001. *Late lesson from early warnings: The precautionary principle 1898-2000*. Copenhagen, Denmark: European Environment Agency.
- European Science and Technology Observatory. 1999. *On science and precaution in the management of technological risk* (EUR19056 EN). Sevilla, Spain: Institute for Prospective Technology Studies. <ftp://ftp.jrc.es/pub/EURdoc/eur19056en.pdf> (accessed April 15, 2005).
- Feenberg, A. 2002. *Transforming technology: A critical theory revisited*. Oxford, UK: Oxford University Press.
- Fiorino, D. 1989. Environmental risk and democratic process: A critical review. *Columbia Journal of Environmental Law* 14:501-47.
- Fischer, F. 1990. *Technocracy and the politics of expertise*. Newbury Park, CA: Sage.
- Flyvbjerg, B. 1998. *Rationality and power: Democracy in practice*. Chicago: Chicago University Press.
- Foucault, M. 1980. *Power/knowledge: Selected interviews & other writings 1972-1977*, edited by C. Gordon. New York: Pantheon.
- Fransella, F., R. Bell, and D. Bannister. 2004. *A manual for repertory grid technique*. 2nd ed. Chichester, UK: Wiley.
- Giddens, A. 1979. *Central problems in social theory: Action, structure and contradiction in social analysis*. London: Macmillan.
- . 1986. *The constitution of society: Outline of the theory of structuration*. Berkeley, CA: University of California Press.
- Gieryn, T. 1995. Boundaries of science. In *Handbook of science and technology studies*, edited by S. Jasanoff, G. Makle, J. Petersen, and T. Pinch, 393-443. Thousand Oaks, CA: Sage.
- GM Science Review Panel (SRP). 2003. *GM science review: First report*. London: DTI. <http://www.gmsciencedebate.org.uk/report/default.htm#first> (accessed April 15, 2005).
- . 2004. *GM science review: Second report*. London: DTI. <http://www.gmsciencedebate.org.uk/report/default.htm#second> (accessed April 15, 2005).

- Goffman, E. 1974. *Frame analysis: An essay on the organization of experience*. New York: Harper & Row.
- Goldman, A. 2001. Social epistemology. In *The Stanford encyclopedia of philosophy*, edited by E. Zalta. Stanford, CA: Stanford University. <http://plato.stanford.edu/archives/spr2001/entries/epistemology-social/> (accessed April 15, 2005).
- Grabher, G., and D. Stark. 1997. Organizing diversity: Evolutionary theory, network analysis and postsocialism. *Regional Studies* 31:533-44.
- Griffin, G. 2002. *Reputation management*. Oxford, UK: Capstone.
- Grove-White, R. 2006. Britain's genetically modified crop controversies: The agriculture and environment biotechnology commission and the negotiation of 'uncertainty.' *Community Genetics* 9:170-77.
- Grove-White, R., P. Macnaghton, S. Mayer, and B. Wynne. 1997. *Uncertain world. Genetically modified organisms, food and public attitudes in Britain*. Lancaster, UK: Centre for the Study of Environmental Change, Lancaster University.
- Grove-White, R., P. Macnaghton, and B. Wynne. 2000. *Wising up: The public and new technologies*. Lancaster, UK: Centre for the Study of Environmental Change, Lancaster University.
- Habermas, J. 1968. *Toward a rational society: Student protest, science and politics*. London: Heinemann.
- . 1975. *Legitimation crisis*. Boston: Beacon.
- . 1984. *The philosophical discourse of modernity*. Cambridge, UK: Polity.
- Hajer, M. 1997. *The politics of environmental discourse: Ecological modernization and the policy process*. Oxford, UK: Oxford University Press.
- Harrison, S., and M. Mort. 1998. Which champions, which people? Public and user involvement in health care as a technology of legitimation. *Social Policy and Administration* 32:60-70.
- Health and Safety Executive. 2006. *Discussion document on review of strategy for regulating new nuclear power station design*. London: Health and Safety Executive. <http://www.hse.gov.uk/PRESS/2006/e06037.htm> (accessed December 20, 2007).
- HM Treasury. 2004. *Science & innovation investment framework 2004-2014*. London: HM Treasury. http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm (accessed December 20, 2007).
- Holt, Mulroy & Germann Public Affairs. 2003. *Reputation management*. Washington, DC: Holt, Mulroy & Germann Public Affairs. <http://www.hmgsa.com/reputation.htm> (accessed April 15, 2005).
- Hood, C. 2002. Managing risk and managing blame: A political science approach. In *Risk, democratic citizenship and public policy*, edited by A. Weale, 73-84. Oxford, UK: Oxford University/British Academy Press.
- Horlick-Jones, T. 1996. The problem of blame. In *Accident and design: Contemporary debates in risk management*, edited by C. Hood and D. Jones, 34-47. London: UCL Press.
- Horlick-Jones, T., J. Walls, G. Rowe, N. F. Pidgeon, W. Poortinga, and T. O'Riordan. 2004. *A deliberative future? An independent evaluation of the GM nation? Public debate about the possible commercialisation of transgenic crops in Britain*. Norwich: Understanding Risk Programme, University of East Anglia. http://www.uea.ac.uk/env/pur/gm_future_top_copy_12_feb_04.pdf (accessed April 15, 2005).
- Hughes, T. 1983. *Networks of power: Electrification in Western society 1880-1930*. Baltimore: Johns Hopkins University Press.
- Irwin, A. 1995. *Citizen science: A study of people, expertise and sustainable development*. London: Routledge.

- . 2001. Constructing the scientific citizen: Science and democracy in the biosciences. *Public Understanding of Science* 10:10-18.
- Jasanoff, S. 1990. *The fifth branch: Science advisers as policymakers*. Cambridge, MA: Harvard University Press.
- . 2005. *Designs on nature: Science and democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.
- . In the democracies of DNA: ontological uncertainty and political order in three states. *New Genetics and Society* 24(2), 2005, pp 139-155.
- Joss, S., and J. Durant. 1995. *Public participation in science: The role of consensus conferences in Europe*. London: Science Museum.
- King, D. 2005. The nuclear option isn't political expediency but scientific necessity. *Guardian*, December 16, 2005. <http://www.guardian.co.uk/climatechange/story> (accessed August 22, 2006).
- Kooiman, J. 1993. Governance and governability: Using complexity, dynamics and diversity. In *Modern governance*, edited by J. Kooiman, 35-48. London: Sage.
- Lash, S. 2001. Technological forms of life. *Theory, Culture and Society* 18 (1): 105-20.
- Leach, M., I. Scoones, and B. Wynne. 2005. *Introduction*. In *Science, citizenship and globalisation*, edited by M. Leach, I. Scoones, and B. Wynne, 3-14. London: Zed.
- Leib, E. 2005. *Deliberative democracy in America: A proposal for a popular branch of government*. University Park, PA: Pennsylvania State University Press.
- Levidow, L. 1999. Democratising technology or technologising democracy. *Technology in Society* 20 (2): 211-26.
- Lukes, S. 1974. *Power: A radical view*. London: Macmillan.
- Margolis, H. 1996. *Dealing with risk*. Chicago: Chicago University Press.
- Mayer, S. 2004. *GM nation? Engaging people in real debate?* Derby: Genewatch UK.
- McDowell, W., and M. Eames. 2006. *Towards a sustainable hydrogen economy: A multi-criteria mapping of the UKSHEC hydrogen futures—full report*. London: Policy Studies Institute.
- McKeown, B., and D. Thomas. 1988. *Q methodology*. Newbury Park, CA: Sage.
- Misa, T., and A. Brey, eds. 2003. *Modernity and technology*. Cambridge, MA: MIT Press.
- Misztal, B. 1996. *Trust in modern societies*. Cambridge, UK: Polity.
- Mokyr, J. 1992. Cardwell's law and the political economy of technological progress. *Research Policy* 23:561.
- Morris, J., ed. 2000. *Rethinking risk and the precautionary principle*. Oxford, UK: Butterworth-Heinemann.
- Munro, R., and J. Mouritsen, eds. 1996. *Accountability: Power, ethos and the technologies of managing*. London: International Thomson Business Press.
- National Research Council. 1996. *Understanding risk: Informing decisions in a democratic society*. Washington, DC: National Academy Press.
- Neyland, D., and S. Woolgar. 2002. Accountability in action? *British Journal of Sociology* 53:259-74.
- Nowotny, H. 2006. *Rethinking interdisciplinarity: The potential of transdisciplinarity*. Paris: CNRS. <http://www.interdisciplines.org/interdisciplinarity/papers/5> (accessed July 16, 2006).
- Nowotny, H., P. Scott, and M. Gibbons. 2001. *Rethinking science: Knowledge and the public in an age of uncertainty*. London: Polity.
- Nuclear Industry Association. 2006. *Nuclear new build: The legal challenge*. London: Nuclear Industry Association. http://www.niauk.org/industrylink/article_152.shtml (accessed August 22, 2006).

- Nuclear Spin. 2006. Web-access database. http://www.nuclearspin.org/index.php/Main_Page (accessed August 22, 2006).
- O'Brien, M. 2000. *Making better environmental decisions: An alternative to risk assessment*. Cambridge, MA: MIT Press.
- Office of Nuclear Energy. 2006. *Improving the nuclear engineering and science curricula*. <http://www.ne.doe.gov/university/university1.html> (accessed August 22, 2006).
- Ogilvie, J. 2002. *Creating better futures: Scenario planning as a tool for a better tomorrow*. Oxford, UK: EH Business.
- O'Neill, O. 2002. *A question of trust: The 2002 BBC Reith lectures*. Cambridge, UK: Cambridge University Press.
- O'Riordan, T., and A. Jordan, eds. 2000. *Reinterpreting the precautionary principle*. London: Cameron May.
- Owen, H. 1997. *Open space technology: A user's guide*. 2nd ed. New York: Berrett-Koehler.
- Owens, S. 2000. Engaging the public: Information and deliberation in environmental policy. *Environment and Planning A* 32:1141-48.
- Owens, S., and R. Cowell. 2002. *Land and limits: Interpreting sustainability in the planning process*. London: Routledge.
- Pellizzoni, L. 2001. The myth of the best argument: Power deliberation and reason. *British Journal of Sociology* 52 (1): 59-86.
- . 2003. Uncertainty and participatory democracy. *Environmental Values* 12 (2): 195-224.
- Petts, J. 2001. Evaluating the effectiveness of deliberate processes: Waste management case-studies. *Journal of Environmental Planning and Management* 44 (2): 207-26.
- Pimbert, M., and T. Wakeford. 2002. *Prajateerpu: A citizens jury/scenario workshop on food and farming futures for Andhra Pradesh, India*. London: IIED. <http://www.iied.org/pubs/pdf/full/9135IIED.pdf> (accessed August 22, 2006).
- Power, M. 1999. *The audit society*. Oxford, UK: Oxford University Press.
- Rauschmayer, F., and H. Wittmer. 2006. How to select instruments for the resolution of environmental conflicts? *Journal of Land Use Policy* 23:1-9.
- Rawls, J. 1993. *Political liberalism*. New York: Columbia University Press.
- . 1997. The idea of public reason revisited. *University of Chicago Law Review* 64:767.
- Renn, O., T. Webler, and P. Wiedemann. 1995. *Fairness and competence in citizen participation: Evaluating models for environmental discourse*. Dordrecht, Netherlands: Kluwer.
- Rescher, N. 1993. *Pluralism: Against the demand for consensus*. Oxford, UK: Clarendon Press.
- Rowe, G., and L. Frewer. 2000. Public participation methods: An evaluative review of the literature. *Science, Technology, & Human Values* 25:3-29.
- Sabatier, P. 1975. Social movements and regulatory agencies: Toward a more adequate—and less pessimistic—theory of "cliente capture." *Policy Sciences* 6:301-42.
- Saltelli, A. 2001. *Sensitivity analysis for importance assessment*. Ispra, Italy: EC Joint Research Centre. <http://www.ce.ncsu.edu/risk/pdf/saltelli.pdf> (accessed April 15, 2005).
- Schwartz, M., and M. Thompson. 1990. *Divided we stand: Redefining politics, technology and social choice*. London: Harvester.
- Sclove, D. 1995. *Democracy and technology*. New York: Guilford.
- Scoones, I., and J. Thompson, eds. 2001. *Prajateerpu e-forum on participatory processes for policy change*. London: International Institute for Environment and Development. http://www.iied.org/NR/agbioiv/pla_notes/documents/plan_04610.pdf (accessed December 20, 2007).
- Seligman, A. 1997. *The problem of trust*. Princeton, NJ: Princeton University Press.
- Smith A., and A. Stirling. 2007. Moving outside or inside? Objectification and reflexivity in the governance of socio-technical systems. *Journal of Environmental Policy and Planning* 8 (3-4): 1-23.

- Smith A., A. Stirling, and F. Berkhout. 2005. The governance of sustainable socio-technical transitions. *Research Policy* 34:1491-510.
- Stirling, A. 1994. Diversity and ignorance in electricity supply investment: Addressing the solution rather than the problem. *Energy Policy* 22:195-216.
- . 1997. Multicriteria mapping: Mitigating the problems of environmental valuation? In *Valuing nature: Economics, ethics and environment*, edited by J. Foster, 186-210. London: Routledge.
- . 1998a. On the economics and analysis of diversity. SPRU Electronic Working Paper No. 28, Sussex University, Brighton, UK.
- . 1998b. Risk at a turning point? *Journal of Risk Research* 1 (2): 97-110. <http://www.sussex.ac.uk/spru/publications/imprint/sewps/sewp28/sewp28.html> (accessed December 20, 2007).
- . 2003. Risk, uncertainty and precaution: Some instrumental implications from the social sciences. In *Negotiating change*, edited by F. Berkhout, M. Leach, and I. Scoones, 33-76. London: Elgar.
- . 2005. Opening up or closing down: Analysis, participation and power in the social appraisal of technology. In *Science and citizens: Globalization and the challenge of engagement*, edited by M. Leach, I. Scoones, and B. Wynne, 218-31. London: Zed.
- . 2006a. Analysis, participation and power: Justification and closure in participatory multi-criteria analysis. *Land Use Policy* 23:85-107.
- . 2006b. Precaution, foresight and sustainability: Reflection and reflexivity in the governance of science and technology. In *Sustainability and reflexive governance*, edited by J.-P. Voß and R. Kemp, 335-72. Cheltenham: Edward Elgar.
- . 2007a. A general framework for analysing diversity in science, technology and society. *Journal of the Royal Society Interface* 4:707-19.
- . 2007b. Deliberate futures: Precaution and progress in social choice of sustainable technology. *Sustainable Development* 15:286-95.
- . Forthcoming. Science, precaution and participation: Towards more 'reflexive governance' for sustainability. In *The governance of sustainability*, edited by A. Jordan and N. Adger. Cheltenham, UK: Edward Elgar.
- Stirling, A., T. Lobstein, and E. Millstone. 2006. Methodology for obtaining stakeholder assessments of obesity policy options in the PorGrow project. *Obesity Review* 8 (2): 17-27.
- Stirling, A., and S. Mayer. 2001. A novel approach to the appraisal of technological risk. *Environment and Planning C* 19:529-55.
- Strategy Unit of the Prime Minister (SU). 2002. *The energy review*. London: UK Cabinet Office. <http://www.strategy.gov.uk/downloads/su/energy/TheEnergyReview.pdf> (accessed July 16, 2006).
- Strathern, M., ed. 2000. *Audit cultures: Anthropological studies in accountability*. London: Routledge.
- Sustainable Development Commission. 2006. *Submission to the DTI nuclear review*. London: Sustainable Development Commission. <http://www.sd-commission.org.uk/publications> (accessed August 22, 2006).
- Taverne, D. 2005. *The march of unreason: Science, democracy and the new fundamentalism*. Oxford, UK: Oxford University Press.
- U.K. Centre for Economy, Environment and Development. 1999. *Final report of consensus conference on radioactive waste management*. Cambridge: United Kingdom Centre for Economy, Environment and Development.

- United Nations Development Programme. 2000. *Statement by M. Malloch Brown, head of the United Nations Development Programme*. New York: United Nations Development Programme. <http://www.undp.org/hdr2001/clips/newsweek1.pdf> (accessed April 15, 2005).
- Van Zwanenberg, P., and E. Millstone. 2004. *BSE: Risk, science and governance*. Oxford, UK: Oxford University Press.
- Fig, N., and H. Paschen, eds. 2000. *Parliaments and technology: The development of technology assessment in Europe*. New York: State University of New York Press.
- Voß J., D. Bauknecht, and R. Kemp, eds. 2006. *Reflexive governance for sustainable development*. Cheltenham, UK: Edward Elgar.
- Wakeford, T. 2001. A comparison of deliberative processes. *PLA Notes* 40:7-19.
- . 2002. Citizen's juries: A radical alternative for social research. *Social Research Update* 37:1-5.
- Walker, W. 2000. Entrapment in large technical systems: Institutional commitment and power relations. *Research Policy* 29:833-46.
- Wallace, H. 2001. The issue of framing and consensus conferences. *PLA Notes* 40:61-63.
- Webler T., H. Kastenholz, and O. Renn. 1995. Public participation in impact assessment: A social learning perspective. *Environmental Impact Assessment Review* 15:443-63.
- Weldon, S., and B. Wynne. 2001. *UK national report: Assessing Debate and Participative Technology Assessment (ADAPTA)* (Project No. BIO-CT98-0318). Lancaster, UK: Lancaster University. <http://www.inra.fr/sed/science-gouvernance/pub/ADAPTA/uk-report.pdf> (accessed August 22, 2006).
- Werner, R. 2004. *Designing strategy: Scenario analysis and the art of making business strategy*. New York: Praeger.
- Williams, R., and D. Edge. 1996. The social shaping of technology. *Research Policy* 25:865-99.
- Wilsdon, J., and R. Willis. 2004. *See-through science: Why public engagement needs to move upstream*. London: Demos. <http://www.demos.co.uk/catalogue/paddlingupstream/> (accessed April 15, 2005).
- Winner, L. 1977. *Autonomous technology: Technics out of control as a theme in political thought*. Cambridge, MA: MIT Press.
- Woodward, W. 2007. Judge deals blow to Blair's nuclear plans: Court rules consultation on power stations was 'misleading and flawed.' *Guardian*, February 16, 2007.
- Wynne, B. 1987. Risk perception, decision analysis and the public acceptance problem. In *Risk management and hazardous waste: Implementation and the dialectics of credibility*, edited by B. Wynne, 269-310. Berlin: Springer.
- . 1992. Uncertainty and environmental learning: Reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2:111-27.
- . 1995. Technology assessment and reflexive social learning: Observations from the risk field. In *Managing technology in society*, edited by A. Rip, T. Misa, and J. Schot, 19-36. London: Pinter.
- . 1996. May the sheep safely graze? In *Risk environment and modernity: Toward a new ecology*, edited by S. Lash, B. Szerszynski, and B. Wynne, 44-83. London: Sage.
- . 1997. Methodology and institutions: Value as seen from the risk field. In *Valuing nature: Economics, ethics and environment*, edited by J. Foster, 135-52. London: Routledge.
- . 2001. Creating public alienation: Expert cultures of risk and ethics on GMOs. *Science as Culture* 10:445-48.
- . 2002. Risk and environment as legitimacy discourses of technology: Reflexivity inside out? *Current Sociology* 50:459-77.

Yearly, S. 2001. Mapping and interpreting societal responses to genetically modified crops and food. *Social Studies of Science* 31 (1): 151-60.

Zurita, L. 2006. Consensus conference method in environmental issues: Relevance and strengths. *Land Use Policy* 23:18-25.

Andy Stirling works at Science and Technology Policy Research (SPRU) and the Social, Technological, and Environmental Pathways to Sustainability (STEPS) Centre at Sussex University on issues of uncertainty, diversity, and participation in science and technology governance. He has served on a number of policy advisory bodies in this regard.