Creating a national citizen engagement process for energy policy

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This paper examines some of the science communication challenges involved when designing and conducting public deliberation processes on issues of national importance. We take as our illustrative case study a recent research project investigating public values and attitudes toward future energy system change for the United Kingdom. National-level issues such as this are often particularly difficult to engage the public with because of their inherent complexity, derived from multiple interconnected elements and policy frames, extended scales of analysis, and different manifestations of uncertainty. With reference to the energy system project, we discuss ways of meeting a series of science communication challenges arising when engaging the public with national topics, including the need to articulate systems thinking and problem scale, to provide balanced information and policy framings in ways that open up spaces for reflection and deliberation, and the need for varied methods of facilitation and data synthesis that permit access to participants' broader values. Although resource intensive, national-level deliberation is possible and can produce useful insights both for participants and for science policy.

public engagement | national dialogue | energy system transitions

Delivering public engagement about science and technology topics is a goal in many areas of current science policy in both Europe and North America. Much of the literature on this topic stresses the importance of early and extensive engagement between the science and policy communities on the one hand, and stakeholder groups and the wider public on the other, particularly when decisions involve contested societal values, complex tradeoffs between risks and benefits, and uncertain science and technology (1, 2). For science communication practitioners, these developments have signaled a methodological as well as a conceptual shift, with more traditional forms of one-way communication making way for dialogic or discursive fora that aim to empower people regarding the issues which might affect them or their communities (3). Increasingly, an additional aim of such dialogue is to reflect useful social intelligence back to scientists, engineers, and policy makers regarding public values and interpretive frames, such that decisions might be achieved that genuinely reflect diverse societal concerns (4, 5).

A clear conclusion to be drawn from experience with deliberative science communication to date is that members of a varied cross-section of publics are perfectly capable of debating quite complex issues of environmental science, technology, and policy with which they have little day-to-day familiarity given the right tools and sufficient opportunity to do so (6–8). Although people will typically come into a research exercise (e.g., an interview, focus group, deliberative event, or informed preference survey) with very limited technical knowledge of the topic, many will engage enthusiastically with the subject by drawing on a range of shared cultural narratives and resources regarding the way in which science and technology is located in (and shapes) society, often expounding insightful views on the institutions involved and on the promise and perils of scientific progress. In this respect people often focus less on the technology or science per se, than on the social context within which it is to be deployed, including complex arguments about the regulatory or governance conditions surrounding the application of science. However, designing successful deliberative fora is not a simple matter, and in this paper we outline a series of interlinked science communication challenges associated with conducting public deliberation on national-level topics. We use as our illustration a recent citizen dialogue about energy system change for the United Kingdom.

Moving Citizen Engagement to the National Level: The Case of Energy System Change

At the first Sackler Science of Science Communication Colloquium, Thomas Dietz observed (9) that, although the existing base of empirical evidence on public deliberation in many countries is rich and diverse, much of that experience derives from cases involving local or regional issues (10). Particularly in the United States, national-level public deliberation is relatively rare, and where it does occur is often restricted to policy-focused questions with professional stakeholder representatives and groups as participants. Outside of North America there is more experience with national-level issues, with examples evident in a number of European countries; e.g., Danish consensus conferences, Swiss referenda, and the UK Sciencewise-Expert Resource Centre (ERC) program.

Dietz (9) makes the related methodological point that scale also matters for national-level issues. At the local level, deliberation often emerges around a specified problem for which relatively bounded sets of options, attributes, risks, and benefits can be defined—the local siting of a waste incineration facility for example, or proposals to alter water abstraction and flow in managed wetlands. National-level issues by contrast typically bring with them significant additional layers of complexity and uncertainty, alongside a need to frame issues in terms of wider policy goals and system linkages. A local public engagement process for siting a single wind farm might consider such things as impacts on wildlife, visual intrusion into the local landscape, and community compensation or coownership. Debating the question of an appropriate future share of renewable energy for a nation or region as a whole, by contrast, would need to

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consider all of these local factors, set alongside national policy drivers for change, the alternatives for delivering low-carbon energy, as well as wider system implications such as provision of network infrastructure or financing and national spending.

Although there has been considerable prior research on what citizens think about particular elements of possible future energy systems—such as nuclear power, renewable energy, or energy efficient technologies and behaviors in the home and transportation (11)—we know far less about responses to the idea of energy system change as a whole, or to elements of the system when placed in the context of other available options for change. Some recent research has begun to explore aspects of this question, either by eliciting people's judgments of portfolios of energy supply options (12–14) or of future energy scenarios for particular cities and communities (15, 16). What was unique about our own project was the desire to develop engagement methodologies that would permit us to elicit a range of public attitudes and values toward energy system change for the United Kingdom as whole (i.e., encompassing simultaneous supply- and demand-side changes), and in relation to current national policy imperatives. In doing so we therefore had to meet the design challenges set by a genuine national-level deliberation. This led to the design of a major 33-month program of research conducted between 2010 and 2013 (hereafter the "Energy System Project"), involving interdisciplinary collaboration between social and engineering scientists and supported by the UK Energy Research Centre. Although the detailed findings of this research can be found elsewhere (17–19), we focus in the current paper on some of the design challenges associated with developing national-level deliberation processes about such a complex sociotechnical issue.

The Complexity of National-Level Issues

In addition to their substantive policy dimension, science questions with national significance—issues such as climate change, energy systems, or the disposal of radioactive wastes—tend to be complex in several ways. First, they almost always involve multiple interconnected elements combining technical, behavioral, and institutional issues. Second, they tend to have extended scales of analysis and prediction, not only the more familiar geographic scales of nation and territory, but also across social (family, community, societal) and temporal scales. Energy systems are designed to operate over a 50–60-year timescale, the climate change impacts of current fossil fuel use will stretch beyond the end of this century affecting different global communities in very different ways, and some radioactive wastes must be contained for many thousands of years affecting generations currently unborn. Finally, many national-level science policy problems are difficult to model, or relevant data may be sparse, leading to uncertainty, ambiguity, or even ignorance (20). Policy issues with all three characteristics are sometimes labeled wicked (21) or postnormal (22), and almost by definition have relatively few direct referents in the everyday lives of ordinary citizens. Accordingly, engaging lay citizens with such topics is a particularly challenging task for science communication.

In conducting any significant national-level deliberation involving complex and interconnected topics, we identify at least 4 key methodological challenges to overcome. The first (*Challenge 1*) can be characterized as one of articulating systems thinking, problem scale(s), scenarios and future visions: With any national-level topic, participants need some appreciation of the nature and scale of the systems at hand, and the degrees of freedom available for change. A second challenge (*Challenge 2*) is to provide additional supporting balanced information and policy framings in ways that allow people to grasp the technical and social complexities involved but without overly constraining their possible options or deliberations in advance. Provision of information alone is rarely sufficient to prompt deeper reflection about a complex science and technology issue, especially where a national-level topic is concerned. The third challenge (*Challenge 3*), then, is one of opening and maintaining deliberative spaces with diverse publics, such that different forms of engagement and reflection can occur. The fourth methodological challenge (*Challenge 4*) is finding varied methods of facilitation and data synthesis suitable for accessing broader values, alongside any possible contingencies and complex negotiations of competing values that might then emerge regarding the issue terrain.

Challenges and (Some) Solutions

Adopting a mixed-methodology approach to the study, structured in three phases, was the first key design decision for the Energy System Project. Such designs are becoming more common in the applied social sciences (23), including some examples from risk communication research (24–26). They can take on a number of forms depending on the overall study aims and the particular strengths and intended contribution of the different methodologies being used. A principal orientation for adopting the particular mixed-methods design for this research was to combine several relevant data sources. First, expert interviews and analysis of published scenarios in phase 1 identified key policy concerns and existing scenarios. Second, a qualitative deliberative approach was adopted in phase 2 to provide explanatory depth and insight into the meanings, understandings, and values that citizens themselves brought to bear when debating the scenarios and issues involved (17). Six 1-day workshops were held in different locations across the United Kingdom with 11–12 participants in each. Although there is no hard and fast rule regarding the number of groups and participants required for national-level public engagement, in our case the final numbers and composition reflected a desire to gain a diversity of average-citizen views from a nationally diverse sample (see discussion of sampling in *Challenge 3*), set against the resources available to the project both to convene the groups and analyze the material generated in a timely but sufficiently detailed manner. Finally, a nationally representative online survey (total $n = 2{,}441$) in phase 3 yielded statistical representativeness while also allowing for provision of key information to participants. In this way the synthesized findings from phases 2 and 3 could be sufficiently deliberative but also stand to reflect wider, nationally held public views. Fig. 1 presents an outline of the key methodologies used for the project.

Challenge 1: Systems Thinking, Problem Scale(s), Scenarios, and Future Visions. Energy systems comprise a set of interacting components including supply technologies, patterns of demand and behavior, and governance and regulatory structures (27). Nations and regions have developed very different approaches and portfolios of sociotechnical change, depending on historical and contemporary policy priorities and the availability of primary energy sources locally. For example, the National Academies' program of work on America's Energy Future (28) is assessing the relative maturity of technologies to reduce US dependence on oil imports and combat CO_2 emissions, while ensuring that affordable energy is available to sustain economic growth. European analyses tend to offer more integrated visions, through a range of scenarios for whole-system change (29–31). Societal acceptability will be of critical importance for many of these developments, and understanding what the public thinks about such changes could ultimately provide a basis for improved dialogue, more robust decision making, and the anticipation by policy makers and the science community of possible points of conflict (32).

The presentations and the other materials used during the workshops and survey phase with the public were informed by work undertaken in the first phase of the project (Fig. 1). This involved interviewing individuals prominent within UK government policy, the third sector (e.g., national nongovernmental

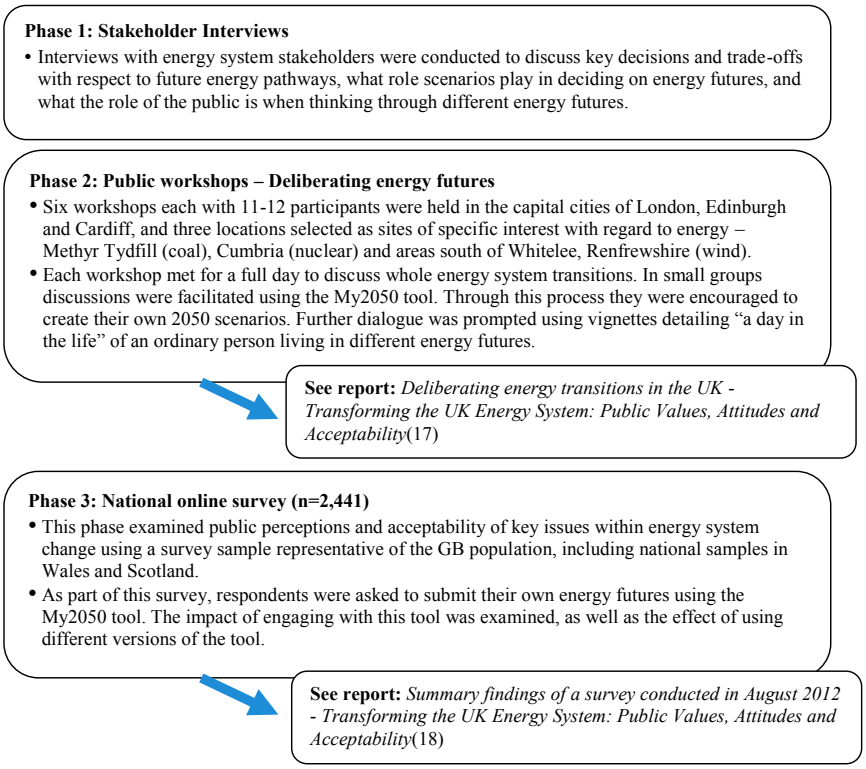

Fig. 1. Summary of research phases; see also refs. 17–19.

environmental organizations), and scientific experts. These were supplemented with reviews of existing published system change scenarios for the country, and collaboration with project partners that brought expertise in engineering and energy system transitions, to build a picture of current expert understanding of energy system change. The information gathered through this process was used to ensure an accurate representation of different but plausible energy system transitions for the United Kingdom up to 2050.

We needed, then, to find ways to engage citizens with both the scale and national specificity (both technical and societal) of the current energy system, in this case for the United Kingdom as a whole. We then wished to articulate the different possibilities for changing this system, as a viable set of plausible future visions for UK energy supply and demand, alongside their relevance to people's (future) everyday lives. Underlying all of this was the concern to avoid reductionism (which would risk merely reproducing known results about attitudes toward individual elements of the system) by keeping the whole system in view for participants throughout the process of eliciting their attitudes and values for system change. In this way people could be supported to develop views about the totality of changes proposed alongside specific elements of change, while also exploring acceptability in the light of alternative options and technological pathways, and taking account of aspects of context (that is contingencies) that have the capacity to change the acceptability of particular pathways or technologies for people. The challenges inherent in conveying the complex interconnected nature of energy system change were addressed in a number of different ways, most notably the use of a scenario building tool, supplemented by scenario narratives in the deliberative phase, and questions designed carefully to explore attitude conditionality in the survey phase.

Using interactive scenario tools for conducting public engagement is a relatively novel methodological development, with documented examples from campus-wide (33) and city-level energy projects (16). The scenario-building tool used in the Energy System Project was a national-level model developed before this project by the UK government's Department of Energy and Climate Change (DECC) and the United Kingdom's public engagement with science program of Sciencewise-ERC (Fig. 2).

The my2050 tool represents a simplified version of a detailed 2050 energy system calculator (34) for the United Kingdom, also developed by DECC. Piloting had shown that many members of the general public did not find the overly technical graphs, language, and operation of the full calculator engaging. The my2050 tool that we eventually adopted (available online at http://my2050.decc.gov.uk) (35) by contrast has a more user-friendly interface and simplified structure, but nevertheless encompasses many of the supply- and demand-side changes of plausible transitions.

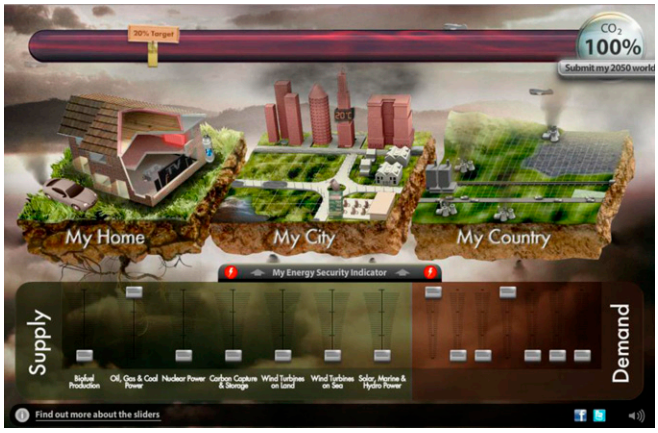

Fig. 2. The my2050 scenario-building tool illustrating the seven supply-side sliders (contains public sector information licensed under the United Kingdom's Open Government License v2.0).

This tool enables respondents to explore different energy futures, where the goal is to meet the United Kingdom's 2050 carbon target of an 80% cut in emissions (30) while still achieving energy security (primarily defined as supplying enough electricity and fuel as prescribed by demand). A participant does this by modifying the energy system (e.g., adding or subtracting different levels of renewable or nuclear power, reducing home temperature by set amounts, changing transportation modes, etc.) through changes to seven supply-side and seven demand-side levers, each with four possible levels of effort ranging from "no change" to "heroic measures." The tool incorporates its own information about the change levers; e.g., the four levels for onshore wind turbines are described as 0, 8,000, 13,000, and 20,000 onshore turbines by 2050 compared with the 3,000 existing in the United Kingdom in 2010 (see also *Challenge 2*). Participants were given additional information by the facilitators to facilitate their engagement with the tool (*Challenge 3*), including aspects of energy system change that were not explicitly part of the tool itself: for example, scenarios for additional carbon savings made through reductions in flying or meat consumption. Accordingly, and in contrast to offering scenarios constructed by experts, this gave participants the opportunity to develop their own scenarios reflecting their values and views on how energy systems should change. Although the tool sets a number of constraints on the choices people can make, the data provided valuable insights into people's views and choices about a desirable future when considering multiple options and tradeoffs in the context of each other.

Our use of the my2050 tool in the survey phase (Fig. 1) differed from that in the workshops. In the survey, participants created their own energy futures individually, after having first answered a 20-minute question set about their attitudes toward different aspects of energy system change (policy drivers, supply technologies, demand-side options, etc.) (18). As in the deliberative workshops, the intention in using my2050 was to present some of the complexities of system change as a whole, but with the additional advantage that we could collect the submitted 2050 futures from a statistically reliable and fully representative sample of the British public. Following this, a range of further questions were asked, including probing changes in views after using my2050 and responses to using the tool itself.

The usefulness of a tool such as my2050 for engagement purposes, which carefully balances simplicity and complexity, was evident in the responses of people in both phases. After submitting their my2050 futures in the survey phase, participants indicated that they were enthusiastic, interested, and showed evidence of having carefully evaluated what they wanted to achieve: e.g., "I tried to select changes which were ambitious but not unrealistic." Responses to the tool were invaluable for additional insight into the kinds of considerations people were bringing to bear when evaluating choices against the whole system context. Similarly, insights from use of my2050 in the workshops helped reveal how participants interpreted individual levers and their positions in the scenario tool, and whether these understandings deviated from the intended meaning.

In addition to the my2050 scenario-building tool, a further set of innovative approaches to engagement with whole system transitions were adopted within both phases of the research. The deliberative workshops used three scenario narratives portraying different energy futures. These were based on existing modeling work and change scenarios identified in the first phase (Fig. 1), but translated into the first-person perspective to make accessible the implications of energy system change for everyday life. The first reflected a do-nothing-more scenario, with continuing reliance on fossil fuels along with associated impacts from climate change and energy insecurity. The second was a high-technology response with increased use of nuclear energy, fossil fuels with carbon capture and storage, and a small reduction in energy demand. The third narrative centered on extensive renewable energy deployment and extensive changes to energy use and its management in the everyday sphere.

Within the survey it was more difficult to engage respondents with implications for everyday life, and it therefore focused on exploring the conditionality of respondents' preferences and attitudes in more detail. The main questionnaire was structured to prompt consideration of key issues in turn, including clusters of items on (*i*) policy framings; (*ii*) key energy supply options; (*iii*) electrification of cooking, driving, and heating; (*iv*) demand reduction and demand-side management issues; and (*v*) overall system change. Although it is difficult to conduct a survey that keeps the whole system in mind throughout, questions within each cluster were constructed to examine basic preferences and acceptability as well as conditionality, attached concerns, and the contexts in which preferences might differ. This allowed inferences to be drawn about public perceptions and acceptability beyond simple support for and opposition toward proposed changes. Questions were specifically designed to examine perceptions at both a more specific level, for example attitudes toward the inclusion of specific technologies, such as nuclear power, and at a more superordinate level such as preferences for overall demand- versus supply-side changes.

We conclude that the objective of keeping the whole system in view had been achieved, evidenced by the connections participants offered themselves. To take just one example, when discussing the deployment of electric vehicles, participants qualified their support for these, arguing that this would in part be dependent on the way the electricity was supplied (17). In addition, the use of the my2050 tool in conjunction with the scenario narratives in the workshops also enabled the contextualization of these future scenarios in terms of making them relevant to people's lives. In the survey phase we were able to compare people's attitudes in the questionnaire with choices made when creating their my2050 energy futures, further exploring conditionality in people's responses and beliefs.

Challenge 2: Balanced Information and Policy Framings. The challenge of engaging citizens with complex, interconnected, and at times unfamiliar science and technology issues includes the more specific question of providing the right information and framings (36). The project therefore needed to develop information and frames that could support initial engagement with the issue and its complexity to enable participants to provide informed views. A core principle of information provision in both the workshops and survey was to include balanced information, but wherever possible to allow participants to bring their own understandings and framing to the engagement process, in addition to the policy frames provided (*Challenge 3*). Scholars working with the ideas of upstream public engagement (4, 37) and anticipatory governance (10) have also begun to explore this issue in relation to national-level dialogues for emerging science issues such as nanotechnologies (38, 39) and climate engineering (40).

The extensive scenario scoping and interviews with UK energy stakeholders in phase 1 informed the subsequent development of information and framings for both phases (2 and 3) of the research with citizens. Although many aspects of energy and climate policy are politically contested, one means for achieving at least some degree of balance in representing both the science and technology involved, and in wider issue framing, was through extensive consultation with a project advisory panel, comprising representatives of academia, the energy industries, regulators, environmental and energy nongovernmental organizations, and UK government departments. The advisory panel provided extensive support and guidance throughout the project from conception, design, and data analysis to dissemination.

In both workshops and survey a core objective was to provide opportunity for reflection on the issues presented (see also *Challenge 3*). Achieving this goal was more straightforward within

the deliberative phase, as such processes lend themselves well to open discussion. Here extensive piloting helped to anticipate the kinds of information that members of the public would find most engaging or where they would require more support to meaningfully engage. For example, information requested by participants during the deliberative piloting ranged from simple figures, such as the number of existing houses in the United Kingdom and how many there are expected to be in 2050, to more complicated questions about the current state of energy demand and supply in the United Kingdom (e.g., how much of demand is currently met by which sources, and how much of demand can be met with different sources like wind). Throughout the workshops we also had on hand an energy engineering colleague to answer participants' technical questions. To illustrate some of the communication challenges, we know that a proportion of people in the United Kingdom take a skeptical stance on climate change (41). To respond to this we chose to represent this as a risk issue (42), stating that, irrespective of whether one agreed with the consensus position that science had arrived at or not, it might nonetheless be prudent to take measures now as an insurance policy against future losses. Interestingly, one of the unexpected findings arising from the deliberative workshops was that some participants who expressed skeptical views about climate change were nevertheless enthusiastic about energy system change (including a move away from fossil fuels) at the end of the workshops (17).

The survey, in contrast, built on recent methodological thinking in 'informed preference' survey design, which in the energy field have been developed in a number of recent studies of attitudes toward carbon capture and storage and energy portfolios (12, 43). The idea here is to support people's construction of preferences by providing additional information embedded in the survey instrument. The survey design again drew on pilot work, the advisory panel, and scenario inputs, but also the initial analysis of data from the deliberative workshops to construct this information. Following the logic used in the deliberative workshops, the introduction to and questions in the first part of the survey (e.g., on climate change, energy security, supply- and demand-side issues) served as an introduction to the policy issues while supporting definitions and other information was provided (e.g., of carbon capture and storage, or descriptions of the operation of future smart meters) where necessary during the survey.

Within both the deliberative work and the survey, basic information about the policy drivers for system change was a necessary precursor to engagement. Here we took the view that being explicit in presenting participants with the challenge as viewed by UK policy makers (30) offered a means of dealing with some of the issues associated with framing. This gave the participants a basic understanding of how the issues were being viewed within policy circles, whereas at the same time giving them freedom to react against this framing and express their own conceptions of the key challenges and issues involved. The success of this approach is evidenced by the fact that the concerns that people brought to understanding energy system change exhibited considerable convergence, but also at times some major divergences from the three policy drivers of tackling climate change, future energy security for the United Kingdom, and delivering affordable energy. For example, participants identified a range of other questions relevant to energy system change, including distrust in and unhappiness with current system operators and system organization (17). This highlights the need to provide the right deliberative spaces for participants to reflect on their views and enable them to bring their own knowledge and experiences to bear on the engagement process.

Challenge 3: Opening and Maintaining Deliberative Spaces with Diverse Publics. Provision of information tailored to questions of complexity, scale, and participant unfamiliarity is rarely sufficient on its own to prompt deeper engagement with a science and technology topic, especially where national-level policy is concerned. Providing the right (and varied) vehicles and exercises crafted to facilitate the desired level of deliberation is therefore a key design issue for science communication and public engagement more generally. The delivery and framing of information, and how participants' own reflections and existing knowledge are treated, hold significant implications for the particular methodology adopted.

An orienting distinction that we used in the project was that between "open" and "closed" approaches to deliberation and communication (44). More open processes emphasize the contingency, open-endedness, and uncertainty of information and systems (as well as capacity for social interests and individual agency to cut across strictly technical issues), whereas closed processes involve framings that attempt to bound the messy and intractable uncertainties found in the real world within more constrained concepts such as monetary value or risk. The aim within both workshops and the survey was to ensure as open a process as possible, avoiding premature closure of particular options or framings, while striking a balance with providing enough information to make meaningful engagement possible. We found it useful here to consider the methodological challenge in terms of upstream public engagement (see also *Challenge 2*), where the aim is to generate an effective conversation between participants over the values, visions, and wider societal implications of the science and engineering issue under consideration as well as exploring how citizens might themselves choose to frame the key issues involved (4).

In the workshops, the extended discussion between participants stretching over some 6 hours was the primary means of prompting depth of deliberation, organized in stages to maintain both interest and variety across the day, including basic information provision, the scenario narratives, plenary group discussions, use of the my2050 tool, as well as small groups World Café style (45) for more informal discussions. Within this context, the my2050 tool facilitated a critical, and central structured discussion itself lasting several hours in which participants collectively deliberated the creation of their own energy futures in small groups. The main group of 12 was divided at this point, and also for the scenario narrative tasks, because piloting had shown us that small group discussion gave participants more freedom to express their own views. The role of the research team as both group facilitators and expert informants was key here, as they had the task of introducing many of the issues addressed by the tool, responding to technical questions (backed up by extensive data and information sheets chiefly for their own use), as well as contextualizing them in relation to the policy debate. In this way we collected participants' views on the policy drivers, elements of system change, and interactions among system elements. Critically this process also elicited conditions on acceptance of particular options, as the facilitators probed for whether changes in context or the availability of additional options would alter preferences (as they sometimes did). Facilitators were always careful to explore with people why they were asking particular questions and what a question signified about what mattered to them before attempting to answer or give concise explanations. This was a particularly important characteristic of the dynamic engagement process developed among the workshop participants, which also provided the research team insight into the kinds of concerns, values, and worldviews participants brought with them (*Challenge 4*) and which was used to understand and formulate their views about this complex topic.

The informed preference structure of the national survey phase was also designed to provide capacity for prompting deeper participant reflection on the issues involved. As discussed in *Challenge 1*, groups of questions, supplemented by additional information, took participants although a series of issues in

a logical sequence (policy, energy supply, increased electrification of everyday activities, demand-side management, and overall system change). Participants also had to engage fully with the interactive my2050 tool, eventually submitting their individual 2050 worlds. In theoretical terms it is important to note that we assume here that people do not come to public engagement exercises with stable attitudes or preferences fully formed, but are likely to go through a process of preference construction (46, 47). Equally, we know that people translate new information and observations about the world in relation to their particular values and frames, connecting the things they see happening with the kind of happenings they would like to see (48). One consequence of this insight is the understanding that new information is often interpreted within and in relation to existing frames. Significantly, this means that although preferences and views toward novel issues can often appear superficial and amenable to change with every new frame or piece of information, they can also often reflect quite deep-seated preexisting cultural values and knowledge (*Challenge 4*).

Generating varied opportunities for reflection is also related to the issue of citizen representation. For a national-level topic, the process design needs to consider how in-depth participant involvement and findings could be complemented with methods yielding statistically representative data, while in turn recognizing the constraints on deliberation introduced by statistical methods. The mixed-methods approach adopted here was our response to this issue, although such designs are both expensive to conduct and can prove difficult to report and analyze (*Challenge 4*). The survey in phase 3 (n = 2,441) used a fairly standard nationally representative quota sample of the British population (i.e., England, Scotland, Wales) aged 18 years and older, weighted toward the known population on the basis of age, sex, geographic location, and occupation to ensure the generalizability of findings. In a similar manner the participants in all six deliberative workshops in phase 2 were recruited to reflect a typical spread of sex, age, and socioeconomic status, as well as characteristics significant for this particular research topic, such as household tenure (owned, renting, etc.). The workshops were held in different locations in England, Scotland, and Wales, and in both urban and rural settings to ensure further diversity of views. The aim in the workshop sampling could not be strict representativeness in the statistical sense, but its qualitative equivalent: i.e., to recruit to the deliberations as diverse a set of prior perspectives as possible, representing people drawn from a broad cross-section of society. Accordingly, where clear themes do arise in the combined data analysis (see also *Challenge 4*) one can be confident in the wider relevance of this view. The first three workshops were convened to reflect a cross-section of citizens living in urban locations: London, Cardiff, and Edinburgh. However, given that many future energy developments are likely to directly affect rural communities, and that rural use of energy is rather different from that in cities, the final three workshops were held in rural areas selected for their geographical relationship with energy infrastructure (with participants also recruited here to be demographically diverse). These were close to the United Kingdom's main nuclear reprocessing facility (Sellafield, Cumbria), an area with a long history of coal mining (Merthyr Tydfil, South Wales), and close to the United Kingdom's largest onshore wind farm (Whitelee, East Renfrewshire, Scotland). The choice of six workshops also reflected a pragmatic decision, ensuring that the qualitative dataset (running to over 60 hours of recorded conversational material as it was) was large enough to elicit a multiplicity of views, but could still be subject to a detailed qualitative analysis within a reasonable period by the research team (17).

As some very recent discussions in the field of science and technology studies have highlighted, the issue of who takes part has some rather subtle implications regarding how science communication researchers construct who "the public" are. A simple lay jury model, as adopted here for the deliberative workshops, allied with the fully representative sample used in the survey, gives primacy of voice to a very general constituency of average citizens and voters who would not typically expect to express their views on science and technology in the public arena. Such a strategy could be criticized for excluding, or at best muting, the voices of more interested proponents/opponents with a more direct stake in the issues at hand (49, 50). Of course, in terms of participatory (rather than representative) democracy, engaged people with clear views on an issue do have a legitimate contribution to make in any significant public policy debate, although there is no simple resolution to some of the difficult sampling questions that this raises for conducting citizen deliberation processes such as ours (see also ref. 51). The phase 1 interviews, which helped to orient the research team toward key issues engaged commentators wanted raised in the workshops and survey, together with the three workshops held in energy-related locales, were a partial response to this dilemma. It is worth noting here that, albeit with some straightforward exceptions (e.g., different views on transportation in the countryside, or on the impacts of wind energy on local landscapes, or the contribution of a particular energy industry to local employment) the more generic findings from all six workshops were largely consistent.

Challenge 4: Accessing Broader Values. Most issues of science and technology policy raise a range of value questions over and above those of simple risk and benefit assessment. As such, a final challenge arises when attempting to access the broader values that people hold with relation to any complex, partially unfamiliar, national-level science and technology issue. The importance of values for our deliberations about, and preferences for, technologies and policies has long been recognized by researchers in the field of decision science. In a study in the late 1980s in West Germany, Keeney et al. experimented with two public value fora to elicit the values relevant for setting long-term national energy policy (52). Such approaches often use structured decision methods (such as multiattribute utility elicitation), and have been applied to various national-level problems such as setting priorities for the clean up of contaminated sites across the United States (53), and space policy making at the National Aeronautics and Space Administration (54). Understanding what underpins specific preferences and acceptability was considered particularly important in our study because of the complex and unfamiliar nature of the energy system problem in all of its social and technical aspects. Preferences and views might therefore not yet be fully formed, be conditional on other things being realized, and be subject to change (46, 55), and it is the values and worldviews people bring with them to the engagement process that they draw on to understand new information and concepts. Values in this sense can be thought of as guiding principles in life which, as relatively durable entities or moral frameworks, then support the construction of more specific preferences (56, 57). As such, values cannot always be simply be traded-off with each other, but may require a careful negotiation of moral principles.

Within the deliberative workshop phase of the project, three key modes of engagement were used for enabling an understanding of the deeper concerns that underlay people's preferences. First, we counterbalanced people's views by providing information on benefits where people expressed very negative positions, or by providing information on costs and related issues where people expressed very positive responses. Beyond offering a means of information delivery, this acted to provoke greater levels of discussion and reflection on how the participant(s) had come to form their view (see also *Challenge 3*). Second, two phases of discussion were initiated whereby one phase involved participants in detailed discussion of individual system elements and another phase encouraged further reflection

by considering these views in the context of completing the scenario-building tool (my2050). Third, with the narrative scenarios, participants were encouraged to reflect on their choices and ideas for energy system changes in relation to how these might impact on their everyday lives during the transition and implementation periods. These three modes of engagement allowed participants to consider their more personal views on system change within the context of the whole energy system and alternative options available, thereby prompting a deeper level of reflection and questioning. In this way the dynamic discourses elicited, and in particular following the counter posing by facilitators and other participants in discussion of competing value perspectives and priorities, reflected a constant negotiation of value positions rather than a simple set of tradeoffs between different economic preferences or objectives. One example would be the debate that participants engaged in regarding their desires for both affordable energy and clean renewable sources, which was typically moderated in discussion by a profound distrust of energy companies or government to deliver either of these (17).

The national survey was also specifically designed to give some capacity for analytic insights in this regard. Primarily we developed our understanding through examining levels of responses to similar questions, which key features in questions prompted significant changes in responses, and how patterns of responses emerged. Questions tailored for this purpose included, for example, those toward electrification of demand options by presenting questions directly probing contextual factors, such as societal acceptance, that might alter current levels of personal acceptance. In this instance, responses observed highlighted the importance of current comfort and performance levels in acceptance of demand-side changes (18). Insights were additionally derived by examining respondents' reasons for responses to key questions in the survey using open-ended questions. This provided a large dataset of qualitative responses that were then analyzed for emerging patterns, underlying concerns and consistency with the workshop discussions. For example, a pronounced finding pertained to preferences to reduce overall energy use (which many in the survey and workshops endorsed); the answers to the open-ended follow-up question revealed that this was linked to a common perception that energy was currently (unacceptably) wasted in many aspects of life, a point also forcibly expressed by participants in the deliberative workshops.

Although the design and delivery of both the deliberative and survey work was important in enabling our understanding of values, key to developing insight into the concerns underlying expressed preferences was the analytic process. The qualitative and quantitative data contributed to the data synthesis analysis (19) in different ways. For example, the survey was able to provide a certain weight to particular findings due to its large national sample (e.g., the strong preference to reduce fossil fuel use in the United Kingdom), whereas the flexibility of the deliberative workshops allowed for additional or new discussions to emerge (e.g., the importance of distrust in energy companies). Importantly, it was an analysis that considered the data as a whole that provided the most meaningful insights. By combining observations from both phases of research we were able to achieve a deeper level of analysis as the findings and interpretations that arose from one set of data were both complemented and challenged by those arising from the other. Importantly, a whole-system approach was not only used during project design and data elicitation but throughout data analysis as well, especially during the synthesis analysis, informing what has been termed in the qualitative methodological literature the researcher's theoretical sensitivity (58). In this way the data analysis could also draw out views on metaissues such as those of energy affordability, institutional responsibility and trust, and a more general sense of how people are likely to respond to change as a set of interconnected transformations. In our experience, good synthesis analyses across complex qualitative and quantitative datasets derived from public engagement research such as ours are extremely rare, despite the growing popularity of mixed-methods research in the social and communication sciences more generally. In part this is because of the intellectual challenges involved in interrogating very different datasets, and in part from the resource demands of achieving this well.

Conclusion

The Energy System Project was successful in engaging a large number of individuals with a very complex set of technological, social, and economic issues of national policy importance. In part this was because the whole-systems approach was threaded throughout the project from its conception to the final synthesis analysis, and in part because of the way responses were elicited, and participants engaged, as part of the deliberative workshops and survey phases. However, achieving this was intellectually challenging, expensive in terms of financial investment and time, and required different approaches across the various methodologies adopted. Within the survey, the use of my2050 along with survey question sections obtained more detailed responses to important clusters of systems changes. Within the deliberative workshops, use of the my2050 tool, combined with scenario narratives and a protocol designed to explore wider aspects of systems change and their interconnections, helped people engage on a deeper values-based level, including the implications for their everyday lives.

Of course no methodological approach is without its limitations. One here is the restriction brought about by using a predefined scenario-building tool, such as my2050, which comes with its own biases and gaps in information and framing. In our case, the simplified my2050 tool does not allow people to make tradeoffs with the costs of options, which in any event are highly uncertain when projected out to 2050. A second is the definition of "system"; in the current case, fairly easily confined to the United Kingdom as a particular geographical, political, and energy system entity. Although we could tentatively extrapolate parts of our analysis to wider policy changes at the pan-European or North American level, further research and policy exploration using this broad approach would be a desirable next step framed at either a macro (i.e., country or global region) or more fine-grained (state, city, subregional) system levels in other energy and social contexts.

We are only just beginning to understand the methodological and conceptual challenges that such forms of national-level engagement with the public set, for both science communication and science policy formation. An optimistic view would be that this approach, when allied with a clear commitment from research sponsors and policy makers to take account of findings, represents a genuinely innovative way of engaging publics in their varied and multifaceted forms. A further key conclusion to take away is that the type of multistrand process described in this paper can serve as a basis for feeding the detailed understanding of public views, values, and interpretive frames back into policy and expert discourse. In the Energy System Project that policy engagement came in a number of ways, and was built-in from the start: through discussion of design principles and emerging findings with members of the external advisory panel, through ongoing engagement throughout the project with the scientific and policy staff of the UK DECC regarding both their and our use of the my2050 tool, and through a final policy launch at the Royal Society in London allied with the publication of peer-reviewed reports of key findings.

The value of the project in terms of wider science communication goals is that the understandings gleaned from it can form a basis for more informed decision making and wider communication strategies with the public. One example from this research is that members of the public were largely unaware of the government intention to move households away from the

dominant heating source in the United Kingdom, which is currently natural gas. Delivering a sense of key policy trajectories and plans of this nature can thus be highlighted as an important communication objective for policy. Although the discussion here has been specific to our own example of energy system change, it has far wider relevance to other complex technical issues, particularly in terms of the importance of understanding the deeper values and concerns that underlie specific preferences. The challenge now for the academic and practitioner science communication community is to experiment further with innovative methods that might put this considerable promise further into practice at the national level of scale.

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