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*for the humanities and social sciences*

# Initial scoping review of the social science and humanities aspects of deep disposal of radioactive waste

A briefing on behalf of the British Academy  
for the Council for Science and Technology

July 2014

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Registered Charity: Number 233176

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Published July 2014

Designed by Soapbox, [www.soapbox.co.uk](http://www.soapbox.co.uk)

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# Executive summary

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In October 2013, the Council for Science and Technology asked the British Academy to provide a briefing regarding the role of the social sciences and humanities in illuminating the siting processes for the eventual disposal of radioactive wastes in a deep geological facility somewhere in the United Kingdom.

This report is designed as a scoping study to lay out the thought provoking features of this contested and protracted process.

It covers the history of radioactive waste management over the past half century. It summarises the sequence of reports and studies reviewing procedures for approaching the siting of a Geological Disposal Facility (GDF) over the past 30 years. It assesses the many aspects of both political judgement and social psychology which underpin the stark differences in risk perception and public trust which have led to conflict and non-decision making. It reviews comparative international experience for siting GDFs. It provides commentary on the key aspects for new procedures for trust building and shared agreement following the responses to the latest consultation. And it offers commentary on possible ways forward.

This briefing is not intended to advise any official body or political entity over the best ways to proceed in order to reach a mutually informed consensus over the final deep disposal of radioactive waste. Its aim is to throw light on the reasons why this is proving to be such a contentious, divided, and prolonged process, and to offer perspectives, based on research and insight, as to what changes in future procedures may prove of value.

The principal reasons for conflict and delay lie in the manner in which the feelings of many different “publics” are shaped by the history of the scientific and engineering, as well as planning, approaches to the issue; in the very diverse reactions to trust and confidence building in the context of the unease held by many regarding the very long term consequences of seemingly permanent (from a human perspective) dangerous materials being stored at the surface or underground; in the instabilities of seeking to unite “expert” and “lay” judgements; and in the very sensitive manner in which final decisions are

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both entirely voluntary and subject to the ultimate approval by those concerned. This in turn places fresh perspectives on the relationship between local deliberative conversations and national/local formal planning procedures and democratic decision making.

The troubled history of this issue influences the relative perceptual imbalances between regarding any GDF as a national economic asset because of its associated power generation and surrounding economic investment, on the one hand, and local acceptance of the national appreciation of offering a site and of being selected on the other. This history also stimulates political and value biases between organised groups who strive to get their way, and who tend to dominate and amplify contention over the more silent voices who may be more accommodative to these benefits but who may well be silenced or drowned out. Public perceptions are shaped by the apparent incongruity between recognition of the manifold benefits of generated electricity (keeping the lights on) and aversions to radiation-related risks. In the latter case, social psychologists (such as Fischhoff et al. 1981) have long shown that the various publics are overall ambivalent about nuclear power. It is unlikely there will ever be wholehearted support, and even lukewarm backing has to be won over. The main reasons for this unease lie in the potentially catastrophic aspects of uncontrolled radiation release; the long term possible health effects (especially to women); the apparent unavoidability of escape from any exposure; the recency of accidents; the anxious sense of dependency on technology and management systems which are seen as inherently fallible; and a powerful feeling of the need for fairness of treatment and of a moral responsibility for the wellbeing of future generations.

The publics are inconsistent over these matters. There is a perfectly understandable rationale to both the wish for the “goodies” of electricity and the fear of the “baddies” of generation risks. In his comparison of energy generated risks, David MacKay (2009, 250) concludes with this exhortation: *“we need to stop saying no and start saying yes. We need to stop the Punch and Judy show and get building.”*

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The briefing suggests that in order to move forward, it will be necessary sensitively to reiterate the obvious need to do something over a waste stream which cannot go away. It looks to redefine the timing and finality of any removal of the Right of Withdrawal; the appropriate locales for sequential political decision making; how assurances over the scope of the future inventory to any GDF can be guaranteed; how revised planning procedures can be dovetailed into prolonged and very sensitive local trust building processes; and through what channels the nature and purpose of community benefits (over and above any local gains from investment and jobs linked to a GDF) can be successfully fashioned.

Circulating around these issues are more profound questions which are addressed in this larger brief. How far is it “right” that an elected group from today’s democracies create an outcome where any eventual risks apply to future citizens with no say in the original decision? Clearly this suggests a more sensitive and scenario based way of presenting options and solutions for the very long term risk safeguards. What is the “right” political space for a site selecting decision when neither the District Councils nor the County Councils cover the territory where there is a decision-making interest? What procedures should be put in place for assessing the possible longer term outcomes for future citizens when current decisional and regulatory procedures are geared, for most part, to much more short term considerations? How can much more local and community centred approaches to consultation and shared understanding be put in place to permit more “authentic” local voices to be heard, both for siting and for determining the characteristics of an “appreciation” fund?

The introduction of possible “new nuclear” to the UK energy mix adds considerable complications to the GDF siting process. There may be an open endedness to the final waste stream, a prolonged period of disposal and a lengthening of local disruption, though also continued investment and job security. Also vital in this context is a fuller comparison of the relative costs and benefits, along with associated risks and assessments of who pays across generations, of any decision to prolong above ground (interim) storage. This comparative process should be

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included in the decentralised deliberative community orientated procedures suggested in the briefing which follows.

Two particular themes are given prominence. One relates to the provenance of decision-making for the connected sequence of choices lying from the public enquiry over any new nuclear build, to the generic GDF siting procedures, to site specific GDF analyses including planning considerations. The briefing suggests that the CST consider holding a workshop, through the British Academy, to explore these and related issues more thoroughly.



Background  
to the project

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The Council for Science and Technology has asked the British Academy to prepare a briefing regarding the social science and humanities aspects of any process for determining the eventual siting of a geological disposal facility (GDF) within the UK. Deep final disposal of the nation's radioactive waste (following a period of safe interim storage of all existing radioactive wastes) is the preferred option as set out by policy announcements over the past decade. This matter is currently the subject of a consultation promoted by the Department of Energy and Climate Change initiated in September of this year and due to be completed by early December 2013 (DECC 2013).

This briefing bears in mind that all matters of science and technology, particularly where either innovative outcomes or untested proposals are concerned, should ideally require some assessment of public understanding and acceptance of the associated science and technologies, of the perceived relative risks involved, as well as the appropriate decision procedures. These perspectives have been the focus of studies of the social knowledge of science over the past 40 years. The government is seeking to reflect this context by assuring all concerned that any GDF siting procedure should be based on voluntarism (expressed as a willingness by local communities to participate in reaching an agreed outcome) and by working in partnership with all communities willing to host such a facility. The consultation (DECC 2013, 19) summarises the lessons learnt from the previous experience of operating the Managing Radioactive Waste Safety Programme since the earlier consultation and white paper, in 2007 and 2008 respectively (DECC 2013, 11–12). A key issue here is that the current consultation specifically addresses the siting of a GDF and not disposal in a variety of ways as has been the case before 2007/8.

This briefing has sought commentary from the Public Policy Committee of the British Academy as well as the Social Science Expert Group of DEFRA and DECC. These remarks are incorporated in this final report.

The purpose of this briefing is to map out the themes that are relevant to the issues raised in the process of assessing the deep

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disposal of radioactive waste. It is neither intended to offer advice to government nor to guide policy. Its aim is to throw light on the social science and humanities aspects of pursuing ways of deciding the siting of a possible GDF anywhere in the nation in the context of long term disposal of radioactive waste.

Because of the short timescale and the wide ranging aspects of the research and evidence base of this issue, the briefing will consist of an initial scoping report which will be delivered before the end of the year. If all parties agree this will be followed by a second, final, briefing which will respond to requests and themes raised in discussions over the initial report.

# 01

Setting the scene

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Matters nuclear tend to generate controversy. Man-made radiation is, for the most part, ill understood, slightly feared, regarded as everlasting, deemed possibly uncontrollable, potentially valuable in a properly engineered and continually monitored power station, and linked to military use. Geological deep disposal in the UK of nuclear waste has a very long history of dispute and dissatisfaction over decision procedures. Memories die hard. Any fresh approach to decision making over possible site selection has to climb the hill of thwarted past failures. This particular history is punctuated with many trials and much learning. The DECC consultation process (DECC 2013) reveals that learning is still taking place.

At the heart of all of this history of GDF siting examination are six fundamental aspects:

- Nuclear waste is a given: it has to be disposed of somehow and somewhere by the present generation so this legacy is not passed to our offspring to resolve.
- The amount of any additional nuclear waste any successful GDF may be expected to accept (over and above the existing inventory) creates an important and potentially divisive extra consideration.
- Nuclear power is broadly accepted for its overall benefits of base-load electricity generation by a reasonable (but not large) majority of those who do not have to be concerned about any waste deposition close by to where they live. Residual unease over matters nuclear can only be overcome by agreed assurances over future safety and reliability of waste disposal, and by honest assessments of the likely reasonable costs of the whole nuclear cycle. These cost aspects will also have to address who pays and over what time period. Lack of clarity here will weaken trust and undermine genuine dialogue. Concern over GDF siting is not therefore confined to the management of the waste stream: it is also very much to do with the ethical, economic, political and distributional handling of benefits and costs of the whole nuclear cycle.
- There is always an asymmetry in perceptions of safety, of cost, of long term guarantees, and of fairness of treatment (manifest by a wide range of ambivalence) between those

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whose neighbourhood is being considered for a GDF and the rest of the nation who enjoy the fruits of nuclear generated power. A national planning policy framework does not easily sit beside a locally determining siting process.

- Trust in the procedures of GDF site selection has to be earned by providing satisfactory safeguards over technological fallibility and future political non-responsiveness, as well as a capacity to meet all demands of decency of treatment. Such trust has to be both proven and constantly accommodated, in essence forever. As yet this is not yet the case for GDF siting procedures.
- The more openness and receptiveness of innovative site selection procedures the more demands may be made as to the fairness of the process and appreciation of the benefits by any targeted community. This can have the perverse outcome that the more the siting process is subject to adjustment via honest learning, the more those who are unalterably opposed to deep disposal increase their demands on, and expectations of, the siting process.

Public opinion over nuclear power generation is influenced by a history of accidents (Windscale, Three Mile Island, Chernobyl, and Fukushima); by ambivalence over the fallibility of the technology and the underlying science; by the very long term period of active radioactivity in the waste streams; by associated concerns for the wellbeing of future generations who will have to live with any legacy; by an unease over guarantees over total safety over extremely long periods of time for any engineered waste disposal facility; and by the changing fortunes, costs and politics of alternative sources of power generation.

It may be possible successfully to address siting of a GDF if:

- the unavoidability of dealing with existing waste is highlighted;
- the relative risks and costs associated with above ground continuous storage and below ground deposition are fully compared;
- the future amounts and compositions of waste streams are agreed;

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- the willingness to experiment with site selection procedures is prolonged and patient (DECC 2013, 23 suggests up to 15 years); and
  - there is agreement over methods of conversing with a wide range of interested publics over a range of themes arising from the existing consultation outcomes, as suggested in this briefing.

# 02

On public acceptance



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Ray Kemp (Kemp 1992, 164–166) summarised what has become a familiar litany of ways to seek public understanding and tolerance of proposals for locally contested land uses where there is a broad national benefit, but potential local disadvantages:

- **A shared understanding** of the relevant scientific and technological issues based on the principles of familiarity and comparison. This requires relevant knowledge to be appreciated through independent assessments which are understood and accepted by those whose livelihoods and moral sensibilities are invoked. It is also essential that there is a common belief that no safer or more reliable management option exists and that this assessment has been thoroughly tested and compared.
- **Trust**, based on an independent and authoritative assessment of safety and performance. This requires involvement by broad public representation which seeks outcomes by staged discussions and shared learning with the aim of providing common assurances of the tolerance and acceptability of any risks associated with any site-specific disposal option (including continuing with above surface repository for a long period).
- **Phased consultation**, based on formal but flexible, widespread and open processes of debate and examination, as detailed levels of community identity and common perspective.
- **Negotiation**, founded on informal and/or formal arrangements for safety reassurance and community based benefit. Any coverage of such benefits requires careful handling of wording as well as an extensive discussion of fairness and reasonableness.

Pidgeon and Demski (2012, 47) add to this list:

- Seek consensus.
- Initiate a broad-based participatory process.
- Seek to establish trust.
- Achieve agreement that the status quo is not achievable.
- Choose a facility design that best addresses the problem.
- Fully address all negative aspects of the facility.

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- Seek acceptable sites through a voluntary process.
  - Consider a competitive siting process.
  - Work for geographic fairness.
  - Keep multiple options open and on the table at all times.
  - Guarantee that stringent safety standards will be met.
  - Make sure that the host community is better off.
  - Use contingency agreements.
  - Set realistic timetables.

# 03

Preparing the case

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The need for a comprehensive, long-term solution for Radioactive Waste Disposal (RWD) is well documented, while the establishment of processes and criteria for the siting of a GDF have proven to be protracted and contentious.

- It was acknowledged by the Royal Commission for Environmental Pollution (Flowers Report) as long ago as 1976 that *"Radioactive waste management is a profoundly serious issue... There must be a clear, identifiable, policy centre and a means to ensure that the issues posed by waste management are fully considered at the outset of a nuclear programme, not dealt with many years after the decisions on developments that lead to the waste have been made and when options may have been effectively foreclosed"* (RCEP 1976).

Since the 1976 Flowers Report, successive UK governments have favoured proposals for managing radioactive waste which pave the way for an eventual GDF. UK Nirex Ltd. recommended in 1991 the establishment of a single deep repository for intermediate level waste in the form of an experimental project referred to as a 'Rock Characterisation Facility' (RCF) at Longlands Farm near Sellafield, Cumbria. The Royal Society conditionally endorsed this approach to RWD (Royal Society 1994), as did the UK Government in the 1995 White Paper on Radioactive Waste Management Policy. The RCF was required to test whether or not an eventual GDF could be built. However, an application by UK Nirex Ltd. in 1997 failed to gain planning consent from Cumbria County Council for the RCF proposal, a decision upheld at appeal by the UK Secretary of State for the Environment. After 1997, advisors to Parliament and the government continued promoting a long term resolution to RWD including GDF (POST 106; HoL CST 1999), but advocated the deferral of site selection, placed greater emphasis on gaining public acceptance for such a proposal and argued for decision-making to be the responsibility of Parliament. Subsequently the UK Government re-opened the whole policy question of how waste should be managed for the long-term through the original 2001 Managing Radioactive Waste Safely (MRWS) consultation and the commissioning of the Committee on Radioactive Waste Management (CoRWM)

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to advise on the best long-term option(s) between 2003–2006. During that period policy on long-term management remained open and the GDF option was only selected following CoRWM's recommendations.

CoRWM recommended the GDF option in conjunction with safe interim storage (CoRWM 2006) as a staged process. Following further public consultation in 2007, the 2008 MRWS White Paper set out the UK Government's "*staged framework*" for implementing GDF for the long term management of "*higher radioactivity waste*" (DEFRA 2008). Proposals in the 2008 MRWS White Paper asked the Nuclear Decommissioning Agency for a staged GDF siting process that were put to a national Stakeholder Consultation in March 2011 to establish "*national criteria for site identification and site assessment*" of GDF – i.e. Stage 4 of the MRWS Programme (DECC 2011b). This was only to be applied in a "volunteer area" which had arisen through the wider staged process. The UK Government published its response to the 2011 Consultation together with the re-worked (MRWS Stage 4) Framework itself (DECC 2012a; 2012b).

- Empirical evidence shows the UK public has generally positive perceptions about the benefits of science in society, with reservations about the independence of science, together with a willingness to engage in public debate on radioactive waste (Poortinga and Pidgeon 2003).
- Poortinga and Pidgeon report in a comparative public risk perception study that, "*Radioactive Waste is the most contentious risk case. This risk case was evaluated most negatively on most items. For example, it appeared that about half of the respondents felt that Radioactive Waste was a very bad thing. It was also seen as having the lowest benefits and the highest risks of all five cases. Concern about Radioactive Waste was the highest of the five risk cases, and it was also seen as the least acceptable risk case*" (Poortinga and Pidgeon 2003).

A participatory culture of direct involvement and deliberation on GDF siting can foster shared understanding in potentially affected constituencies, attracting media attention and information

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sharing. Such shared knowledge is shaped through national and local perspectives, and builds on views about the inescapable interdependency between scientific analysis and the policy discourse on the issue.

In any process of siting GDF, the 'public' comprises many 'publics'. These are diverse groups holding different values with no single agenda, whose varying perceptions of risk are based on different knowledges, social networks and biases, who form different judgements about risk, based on different risk contexts (such as national energy need or a previous local association with the nuclear sector) and framings, with varied notions of justice, tolerance and responsibility (Douglas 1982; Douglas and Wildavsky 1992). This situation requires a responsive siting process and invites deliberative decision-making.

The public narrative on risk is informed by expert knowledge, the certitude and predictability of risks and benefits through an analytic risk assessment process (Royal Society 1992, 1997; Stein and Fineberg 1996; Renn 1998; Stirling 1999, 2008; DEFRA 2001). However, where uncertainty, ambiguity and ignorance exist, as in the case of siting GDF, evidence-based risk assessment is a vital introduction in any discussion. But this is only a first step. Such risk assessments also include subjective judgements by experts that are subject to 'framing effects' (mechanisms for determining greater certainties) on incomplete or contested knowledge, such as the lack of empirical evidence and incomplete conceptual models for risks associated with GDF.

- *"(The) indeterminacies of uncertainty, ambiguity, and ignorance are intrinsic to the scientific definition of risk. Their recognition should thus be regarded as much as a necessary feature of scientific understandings as of any other"* (Stirling 2008).
- Post Fukushima Daiichi, Stirling notes *"no matter how stringent the precaution, there is always the possibility of surprise. (...) It is not just Japan that has learned lessons about the prospect of events occurring beyond the levels anticipated in official risk assessments. It has long been clear that risk assessment everywhere, systematically excludes many kinds of possible eventuality"* (Stirling 2011).

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Expert judgements based on best scientific estimates of probabilities and potential harm can influence public perceptions on the tolerability of risks and on cost-effective, proportionate and fair measures required to avoid, protect against or mitigate risks (Renn 2007), although this is not sufficient in itself to assure public support for a GDF siting process. Judgments about risks have deeper roots in culture and social memory.

Scientific analysis is “framed” for and by policy intentions in multiple ways, such as through the setting of agendas, posing questions, deciding context, discounting time, handling uncertainties, constituting proof, defining problems, prioritising issues, setting baselines, choosing methods, recruiting expertise, exploring sensitivities, characterising options, formulating criteria, drawing boundaries, including disciplines, commissioning research and interpreting results (after Stirling 2008). Framing examples evident in the MRWS framework include the following:

- *“National criteria”* for GDF site selection to be applied consistently within any candidate “volunteer areas” were finalised in 2012, in advance of the 2013 Consultation on the GDF siting process. *“Agreed”* national criteria are derived from guidance provided by the International Atomic Energy Agency (IAEA) and CoRWM, and comprise: geological setting; potential impact on people; potential impact on the natural environment and landscape; effect on local socio-economic conditions; transport and infrastructure provision; cost, timing and ease of implementation (DECC 2012b). On top of this, there is scope for site specific criteria relevant for any candidate for voluntary exploration to be created through local consultation.
- DECC caution that: *“However, we would encourage anyone carrying out local engagement to make it clear that these are not intended to suggest a process being imposed centrally, including through the use of clearly explained alternative terminology if helpful in a particular local context”* (DECC 2012a).
- *“Political sensitivity”* was excluded from consideration as a site selection criterion as being *“very difficult to evaluate”* (*ibid*). DECC consider this criterion better dealt with when

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a final decision on siting is made. Framing deliberations in this manner serves the purpose of focussing attention on more ‘technical’ matters such as geology and environmental sensitivity (protected sites for example) but tacitly acknowledges that decisions on siting cannot be made by experts and institutions alone.

- The decision to forestall consideration of political sensitivities convey an impression that after 10–15 years of *learning* and *focusing*, site selection through a GDF siting process may become to be a *fait accompli*, through consultation fatigue or the burden of time and cost already incurred in the siting process.
- The UK Nuclear Decommissioning Authority (NDA) will organise an independently facilitated Multi Criteria Decision Analysis (MCDA) “*as an aid to decision making... in consultation with stakeholders*”; although the MCDA will not make decisions in selecting candidate sites. Who the stakeholders are and who determines this remains unclear.
- The opportunity for public and NGO input into the MCDA appears restricted, notwithstanding DECC claiming that it “*will seek to ensure that volunteer communities are confident in the approach and in the experts that are involved in the assessment*” (*ibid*).
- “*Local stakeholders*” will have the opportunity to “*discuss*” weighting criteria (but not scoring scales) in the MCDA site selection analysis. Again, it is not clear who these stakeholders might be and whether they are self selecting or not. Nor is it clear what influence such “*discussions*” will have on any final decision (*ibid*).
- The Consultation on GDF siting refers extensively to a “*local community*”, for example in the context of “*community willingness to participate*”, the “*host community*” and “*community Right of Withdrawal*”. The 2013 Consultation notes “*Yet it (GDF) would be situated in a comparatively small geographical area. The impacts of the implementation and operation of a GDF will, therefore, be experienced by a specific community in a specific area. This community will be providing a vital service to the nation, and its interests must be represented effectively in any revised siting process*” (DECC 2013, 25). Participation, site identification (through



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volunteerism), representation, and the risks and benefits of development are framed at this very local level, supported by reference to the Localism Act 2011, in order to promote competitive volunteerism and community identity-building.

- However, the GDF is also framed as a possible candidate for a National Significant Infrastructure Project (NSIP) and considered an important part of the National Energy Strategy. The relevance and potential impacts and benefits of GDF considerably exceed the physical bounds of the development itself. In terms of the potential health, environmental, transport and financial impacts of GDF (direct, indirect, delayed synergistic and cumulative), it is arguable that a significantly wider constituency may be affected by, for example, unintended and accidental events.
- Framing “the public” that has a part in site identification and selection of a potential candidate site by criteria based on local community can risk excluding other legitimate contributors to the GDF siting process (although these will have a later opportunity for representation of a different nature during the process of development planning consent).
- More broadly, the debate on radioactive wastes/nuclear power has been re-framed in the public arena as a dilemma or an opportunity for choosing between climate change mitigation (by adopting, it is claimed, a low-carbon option of energy from nuclear power), or increasing the national inventory of radioactive wastes (and exacerbating an already protracted issue of RWD). From the government’s perspective there is a wish to separate the need for deep disposal of existing radioactive waste from any additional radioactive waste arising from new nuclear plants. This contentious ‘either-or’ framing of a ‘climate change vs. nuclear’ proposition conflates risks and impedes open debate on alternative strategies to GDF. Bickerstaff notes that *“a risk–risk trade-off between radioactive waste and climate change would not sit comfortably or resonate with the ways in which citizens were framing the two risk issues or problems”* and suggests that various *“critical counter-frames”* (such as safety, environmental, economic and alternative sources of energy) are available to the public in response to an apparent *“nuclear renaissance”* (Bickerstaff et al. 2008).

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- The UK Government has promoted and recently committed the nation to new nuclear power capacity, prior to a lasting resolution to the issue of RWD being achieved. The former Department for Business, Enterprise and Regulatory Reform stated *"The Government has reached the conclusion that new nuclear power stations can help the UK to meet its objectives on climate change and energy security"* (BERR 2008), while a more recent UK Government announcement of a commitment to nuclear power was widely reported: *"The government has given the go-ahead for the UK's first new nuclear station in a generation"* (BBC 2013). DECC require GDF to accommodate both the existing and future inventory of higher-level radioactive wastes, stating *"The Government considers that it would be technically possible and desirable to dispose of both new and legacy waste in the same geological disposal facility and that this should be explored through the Managing Radioactive Waste Safely programme."* (DECC 2012a). In the public arena, GDF is thus framed as 'legacy' and an energy security/cost issue, which injects a further sense of urgency in the GDF siting process, but may have unpredictable consequences for community responsiveness in the GDF siting process, in regards to certainty about the waste inventory and future operational curtailment of GDF.
  - DECC currently does not commit to the waste inventory type and size that GDF might eventually need to accommodate. Instead it proposes to discuss inventory changes with the GDF host community as events arise: *"It is not possible to provide at this time a definitive inventory of radioactive waste that would arise as a result of a new nuclear build programme, as the scale of any new programme is not yet known."* (DECC 2013, 47). At present DECC aim to deal with the wastes arising from 16 GW of new nuclear power. But this is a proposal: it is not definitive. Open-ended intentions, operational longevity and potential impacts of GDF during Stages 1–4 serve to increase levels of uncertainty over the outcome of Stage 5 of the MRWS Framework.

Public awareness and understanding of the science, technology and policy surrounding the siting of a GDF may be extremely variable. However, lay people can be open-minded

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and 'connected' when dealing with complexity in specialist knowledge areas such as multi-layered, engineered, geological containment; hydrogeology; seismic and volcanic events; erosion and uplift rates; climate and sea level change; and the scale, security and costs of maintaining and monitoring (and potentially retrieving) a radioactive inventory, as well as the extent, ubiquity, persistency, delayed effects, reversibility and mobilization of hazards to human and environmental receptors that can potentially result from a GDF or alternative RWD options (Klinke & Renn 2001).

Technical and specialist areas of knowledge are nevertheless legitimate topics of debate for the various publics potentially affected by the siting of a GDF. This is particularly the case when expert judgments and disagreement on risk are contentious or remain unresolved, even beyond Stage 5 (*focusing*) in a GDF siting process when a community Right of Withdrawal ceases.

There is no agreement, for example, on the geological aspects. Entering the GDF siting process, uncertainty pervades the supporting science. One example, cited by Feng Liu notes "*the performance of the repository as a whole (waste, buffer, engineering disturbed zone, host rock), and in particular its gas transport properties, are still poorly understood*," specifically the long-term integrity of argillite- bentonite plug seals against gas pressure build-up in a proposed low permeability engineered zone (Feng Liu et al. 2013, i). How it is proposed to handle uncertainty of such a technical nature following the 2013 consultation on the GDF siting process may itself influence community responsiveness to the Framework process.

While the proposed *learning* phase of the GDF siting process may go some way to addressing gaps in public awareness, understanding and presumed scientific illiteracy, it is unlikely to achieve a shared consensus on the science, technology and policy surrounding GDF. Honest recognition and openness about any lack of certainty and predictability within the scientific-analytic debate would contribute to *learning* by opening up the scope for reassessments earned through dialogue.

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The publics apply subjective judgements on the tolerability of risk in any analytic-deliberative process and have a democratic expectation that the public affected by development would play a part in determining of the criteria, and trade-offs between criteria, for the acceptability of risks associated with the siting of a GDF, as well as helping to determine resilience strategies necessary to deal with enduring uncertainties (Renn 1988). The distinction between acceptance and tolerance of risk depends on the trust building procedures adopted in the shared understanding discussions.

Public judgements will form concerning the reputation, integrity, competence, openness, credibility, intent, fairness, reliability and historic record of both expert and community participants in the GDF siting process. Such judgements influence the outcome of deliberations and trust in process as much as people. Publics hold values on nuclear technology, such as dread and fear, "*rooted in an historical iconography of catastrophe, death, and institutional failure* (in resolving the issue of RWD)" (Bickerstaff et al. 2008), which likewise affects public confidence and trust in the process and people.

Trust and confidence in the integrity and managerial competence of a GDF siting process are necessary for successful social functioning of deliberative processes, where dissent and criticism are treated fairly and openly and not simply dismissed as irrational, anti-technology, mistaken, NIMBY-ism or as media-driven risk amplification.

- 'NIMBY-ism' for example, may instead be attributed to the history of policy shifts and "*a hierarchy of concerns about environmental risks*" (Kemp 1990).
- The media may influence public perceptions of risk through, for example, a "*narrative of reassurance*" or the "*sustained suppression of plausible (and highly relevant) worst case possibilities*". Indeed "*it seems to be assumed that present-day assurances by the nuclear industry on the completeness of risk assessment carry greater weight than the demonstrably self-interested bias and errors of the past*" (Stirling 2011).

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The public narrative includes various ethical judgements concerning, *inter alia*, the equitable distribution of social benefits and risks, the voluntariness of the risks, meeting present energy needs and addressing hazardous wastes arising without compromising inter-generational equity or future choices on energy mix. So the targeting of involvement needs to incorporate those most vulnerable to risks, however unpredictable these are.

Bickerstaff notes, in relation to the wider debate on nuclear power, the "*problematic experience of science and technological decision-making in the UK over the past two decades*" may be attributed to institutional blurring of interests between science, politics and business (Bickerstaff et al. 2008). If so, trust in regulators and scientific expertise guiding the GDF siting process is equally important to its success.

# 04

Lessons from  
international experience

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It is confidently claimed that GDF is internationally recognised as the preferred approach to RWD, with "*a number of UK learned societies such as the Royal Society, the Geological Society, the Royal Society of Chemistry*" (DECC 2013c, 13, 21) and The International Atomic Energy Agency voicing support for the concept (DECC 2012a, 24). It is noted in the MRWS Framework that "*The UK is therefore well-placed to benefit from international experience in this field, while using and maintaining domestic capabilities. Close scrutiny of international best practice and exchanging experience with other countries will be a key part of a geological disposal facility development process over the coming decades* (DEFRA 2008, 27).

- 39 countries were reported in 2006 to have significant nuclear waste inventories, of which: none were considering long term surface storage; all had existing interim surface storage; 25 had taken final decisions on a long-term policy favouring GDF; 6 expressed a preference for GDF; and the remaining 8 were undecided about GDF (DEFRA 2008, 24).
- By 2006, France, Canada, Finland and Sweden were already investigating preferred GDF sites, with Finland and Sweden having existing shallow GDFs for Intermediate Level Waste (ILW) and Low Level Waste (LLW), the USA having an operational LLW/ILW GDF and additionally, Sweden were testing a deep GDF (DEFRA 2008, 24).
- It has been noted that the approach of voluntarism and partnership supported in the 2013 GDF Consultation on siting is "*making good progress in countries like Canada, Finland, France and Sweden*" (DECC 2013b, 3) and that the evidence suggests a process of successful decision making.

Uncertainty and "expert" disagreement over the advantages and disadvantages of technique(s) which the UK will adopt through its GDF will always cause concern within any Potential Host Communities, and indeed the wider public, in the actual siting of any GDF. This means that whether such a decision is made prior to or after a Community Right of Withdrawal is exercised is significant for building trust in the siting process. It has not been possible here to establish what, if any, effect the attribute of certainty over the chosen type of GDF has had on community

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response in countries where decisions have been made or where development has commenced for chosen types of GDF.

- In a comparative study of the technical merits and challenges faced by 12 different international approaches to the GDF, a UK NDA study concludes that *"It is not necessary yet, nor appropriate, to select a preferred Concept. Indeed, it would be beneficial to maintain a flexible approach to design to allow optimisation of elements of several appropriate Concepts to actual site conditions"* (Baldwin et al. 2008, 70–71). Baldwin et al. consider that *"A wide range of generic repository Concepts is available that can provide safe and secure geological disposal options to suit any appropriate UK geological environment. The Concept(s) that eventually form the focus for the NDA programme once potential sites emerge can be based upon those presented here (and that) it is important to appreciate that the developed and optimised design that will finally be built may look considerably different in detail when adapted to site conditions and programme drivers."*

NDA discusses 'retrievability' as a considered technical (but not ethical or social) option (Baldwin et al. 2008, 24), and the 2013 UK GDF siting process does not rule out the option of retrievability being adopted in the UK, nor does it clarify whether this approach precludes other feasible GDF options. However, it has not been possible to establish here what, if any, effect the attribute of 'retrievability' in a GDF has had on community responses in countries where it has been applied or not been applied.

- *"The UK government's view is that the decision whether or not to keep any geological disposal facility (or vaults within it) open once facility waste operations cease can be made at a later date, in discussion with the independent regulators and local communities. In the meantime, the planning, design and construction can be carried out in such a way that the option of retrievability is not excluded"* (DECC 2013a). Deferring a decision about retrievability and how and by whom such a decision would be made is very likely to influence perceptions of acceptability of GDF.



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- French (in-tunnel (borehole) – horizontal borehole) and Swiss (in-tunnel (vertical borehole) with long- or short-lived canister) GDF designs incorporate the principle of retrievability (Baldwin et al. 2008, 74–94), the French determining by the 1991 Bataille Act to assess the feasibility of deep geological disposal for high-level and long-lived intermediate-level radioactive waste (HLLL), *“based on a rationale of reversibility”* while a further Act in 2006 stipulated that *“a site for a final repository should be selected no later than 2015 and must involve local communities as much as possible”* (Baldwin et al. 2008, 70–71).

In most of the countries reviewed by NDA, community volunteerism precedes geological screening and detailed evaluation of site suitability (NDA 2013, 4–7). This siting process strategy may yield a different public response between nations having different records of public sensitivity to nuclear issues.

On decision-making powers over the siting of GDF, NDA reports that most countries adopt the principle of subsidiarity, that is, the local representative body closest to a proposed site of the GDF has some involvement in site identification and selection (NDA 2013). Local referenda in Sweden resulted in the volunteer host communities, which had no existing nuclear industry connections, all rejecting the Swedish GDF siting process, although subsequently, two nuclear communities agreed to be involved in further site feasibility studies and development.

In France, the siting process, which is currently concluding in a national public consultation exercise, followed an earlier stakeholder engagement process and geological suitability analysis. In the USA, federal, state or mayoral decree determined site selection, without recourse to local referenda or a need to canvas support (which nevertheless did occur later on). Yet the much delayed proposed deep disposal facility at Yucca Mountain in Nevada was abandoned following years of very costly litigation (NDA 2013, 29–32).

What distinguishes the different international siting processes on record is how each reflects the different *“political and cultural*

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*circumstances in that country*" (NDA 2013, 36). In this respect the NDA programme to confine the framework to "desk-based studies" within a volunteer area, is reflected in the DECC decision to exclude "*political sensitivities*" from criteria used to assess Potential Candidate Sites in the MCDA for the current UK siting process, as discussed earlier (DECC 2012a, 21).

# 05

Issues arising from the  
current DECC consultation

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Regarding the specific DECC consultation over the siting procedures for the GDF a number of critical issues will need to be explored further:

### **Rights of Withdrawal**

This is a very politically sensitive issue as it applies to a loss of effective power over the continuing decision process when the right is removed. This is particularly important in any decision environment where voluntarism and partnership working are regarded as paramount. Thus it needs to be very clear to people at what point a properly constituted, legally based Right of Withdrawal exists and at what point this will be taken away, with appropriate safeguards for the ultimate removal of that right. In the Consultation (DECC 2013, 28) the proposal is that such a Right would be withdrawn after formal agreement over community support had taken place. This would mean that the subsequent procedures for detailed facility planning would take place through existing planning processes. Such processes are not universally admired or trusted. This matter needs much more careful coordination with possibly parallel processes of community dialogue and planning procedures working hand in hand with Rights of Withdrawal remaining in place.

### **Identifying the decision-makers / the relevant deciding authority**

There is no guaranteed existing democratic procedure for determining this locus for final approval for the preliminary (candidate) GDF site or sites for subsequent detailed examination. The Consultation (DECC 2013, 26–7) suggests that the locale for final determination of both the willing community acceptance and the removal of Right of Withdrawal should rest with the relevant district council. Since the planning aspects of any design GDF involves many interested parties well beyond the relevant district council, some sort of coordinated procedure of collective responsibility involving a range of political interests across local and national government may need to be invoked.

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The suggestion in the Consultation (DECC 2013, 27) for a “consultative partnership” opens up wide space for dispute. This is because the spread of effective power over the *learning* to the crucial *focussing* stages will be heavily contested by political entities (and others) not represented by the district council. To avoid this would imply some sort of shared decisional responsibility across a range of democratically elected arenas. This has important implications for the design of any subsequent national and local planning process once a voluntarily agreed location for a GDF has been accepted. The Consultation (DECC 2013, 42–5) suggests making use of the National Policy Statement process to set out the generic assessment guidelines for determining a suitable GDF, which would not be location specific. There is a danger here that the processes of planning, from generic to site-specific, could be seen as running parallel to local confidence building and knowledge testing. It is very important that the two arrangements are locked into a common cause. This may require changes in either the existing planning legislation or in new arrangements for joint deliberation between formal planning procedures and informal community dialogue.

### Co-decision responsibility and accountability

Arising from the discussion above emerges a set of questions which introduce more novelty into decision locales and styles. This is because any siting process involves a hybrid arrangement between a broad national consensus over the future of nuclear power, any planning and assessment procedures for the first and subsequent new nuclear power stations; plus site selection for a generic GDF, and actual siting decision-making both of which may involve a mixture of planning and decentralised consultative procedures. In addition there are important questions regarding the rights of future generations to be taken into account as any GDF (or continued above ground storage) will carry risks which bear on those yet to be born. This suggests a mix of decision locales ranging from national government, to specially constructed nuclear station planning enquiries, to more locally focussed site selection and site acceptance procedures.

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## The waste inventory

The Consultation (DECC 2013, 47–50) admits that there can be no definitive assessment of the final amount or quality of radioactive wastes which may have to be disposed in any agreed GDF: *“exact volumes are difficult to predict with absolute certainty at this stage”* (ibid, 47). There is to be an updated baseline inventory which will include additional wastes from both military sources and any new civil nuclear power plants, the number and location of which are currently being discussed by commercial power companies and the government. *“...inclusion of new waste will be taken forward in discussion with host communities as the programme proceeds. GDF design activities will consider the necessary features to safely accommodate particular waste types if that proves necessary”* (ibid. 47). Since the acceptance of any new nuclear plant must cover the regulated disposal of its wastes, this aspect is of immense importance for community support and any determination of community benefit. One theme here is the diversity of publics’ views on “new nuclear”. This highly pertinent matter has not been debated by the public generally. Pidgeon and Demski (2012, 43) suggest that this aspect is very much encased in feelings about additional and open-ended costs, and the viability of deep disposal of wastes. So any local siting process (and indeed national-to-local planning procedures) should be inaugurated over the efficacy and ethics of new nuclear build. If there is uncertainty over the amount and grade of additional wastes heading for any agreed GDF, then there could well be major implications for local acceptance. These would cover the safety and long term assurance elements of deep disposal; the amount of extra nuisance over community impacts from traffic and associated disruptions; and the more subtle ethical elements of accepting an unknown number of additional nuclear build in the nation. All of these matters would introduce vital site selection assessment and assurance features over the three points already covered in this section. Any planning based assessments would have to take this matter fully into account.

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## Community benefit

The community benefit will vary according to the geography, culture and political perspectives of the community (ies) involved. In the Consultation (DECC 2013, 52) there is a proposal to outline (read limit?) the scale of these benefits. The Consultation (*ibid.*) agrees that such benefits should be additional to the direct financial benefits/incentives to the willing community arising from the investment and jobs creation aspects of a GDF. But if such benefits are also to address the scope for recognising community pride in carrying responsibility for guaranteeing the long term safety of this facility on behalf of the nation forever, then any whiff of “capping” such benefits, especially in the light of a somewhat open-ended waste inventory, would not inspire the establishment of trust which is so vital to any successful siting process. Negotiations over possible additional community benefits, conceivably lasting for generations to come, may best be approached through a decentralised deliberative process outlined below. Again we note the significance of the concern for the wellbeing of future generations in this dialogue.

## The role of the regulators (including planners)

The Consultation (DECC 2013, 34–5) suggests enlarging the membership of the Geological Disposal Implementation Board to include a range of interests in the regulatory procedures. This is vital as there is continuing dispute amongst the engineering and geological fraternity regarding the relevant criteria for site selection (Smythe and Haszeldine 2013). It also asks for comment on the scope for various forms of independent support for community based groups in the *focussing* phase of site selection. There is a case for a more informal interleaving of “interested publics” and “specialist commentators and advisors”. This was attempted on the GM debate. But in subsequent analysis Horlick-Jones et al. (2007, 183–5) pointed out that placing “independent experts” amongst lay people may worsen any deliberative process. This is because “independence” is very much a contentious issue, and “expertise” implies a citizenry which is somehow “ignorant” (Rayner 2003). Placing expertise alongside

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community publics therefore needs to be handled very carefully indeed. This is increasingly the case for both any regulatory process which addresses risk tolerance as well as any planning process which assesses impacts and benefits. Designing mixed dialogues in the nuclear regulatory and planning arenas, but most particularly in the benefits determining stages, requires much more detailed discussion both in the *learning* and *focussing* phases (especially the latter).

## Changing the basis of consultation

Normal consultative procedures don't always work well for this kind of long term contentious issue as people often don't understand how their input into the consultation process works. There's also the broader issue of consultation fatigue: people don't want to keep on saying things they think they have said many times before, particularly when they don't know how much weight will actually be given to their response. This is especially the case when there is a long and disputed political and planning history to the GDF. Often consultations are framed in a certain way so that people feel that they are only able to comment on certain issues and this can put off their enthusiasm for raising issues which they think are highly pertinent. There is also a question of their silence if the antagonistic groups are allowed to shout too much. So there is an ever present danger of "containing" (kettling) the discussion to manageable themes and topics. In so doing, the subsequent amplification of protest can increase the "din" so that other views from the quieter communities involved are effectively "silenced". This possible denial of the "authenticity" of debate may invalidate the democratic legitimacy of the process.

## Above-ground/below-ground comparison

There needs to be an interconnected discussion about the consequences of "doing nothing". Above ground long-term storage carries its own risks and costs which are not always compared to the GDF. This is particularly the case if the future



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inventory is open-ended. Communities and the public at large understand that the issue has eventually to be dealt with, and that there are significant long-term costs (both risk related and economic) to both above and below ground storage. This comparative analysis of relative risks should be included in the extended deliberative processes especially for the *learning* phase as well as any intertwined national-to-local planning phases. In general there is a need to offer as much attention to this aspect as to the GDF technologies and risks and costs if the final, and critical, community acceptance process is to be deemed legitimate and hence acceptable.

## Intergenerational justice

A brief introduction is offered here. The Environment Agency as the authorising body over safety and risk already has a responsibility for overseeing safety for the length of active waste arisings, whether above or below ground. If this can be guaranteed it will be a bit of a miracle. Two additional points need attention. One applies to the manner in which the interests and fairness of treatment for many generations to come are properly taken into account. The other is the hybrid nature of decision locales and styles between democratically accountable forums and specialist and localist forums. On the first, there are some precedents for formally addressing the interests of future generations. The New Zealand Parliament has created an Ombudsman Office for this purpose, while the Welsh National Assembly has established an Office of a Commissioner for Future Generations. The New Zealand Office deals more in a project assessment format so is somewhat technical in its approach. Nevertheless it specifically addresses the possible long term risks and seeks to apply tests of intergenerational safeguard. The Commissioners Office to the National Assembly for Wales is still to be given full authority. It relates more to the policy processes of the elected Assembly. Here may be an angle of relevance for the GDF siting process. It is of interest that CoRWM commissioned a lengthy discussion process amongst pupils of Cumbrian schools. One of the purposes here was to discover the thinking of the coming generation who may live with the outcome

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of any siting decision in the county. The overwhelming view was that permanent deep disposal was the preferred solution. It may be that part of this whole GDF consultation process could involve a discussion of appropriate ways in linking the interests of present generations to their moral responsibilities for their descendants. This may especially apply to any prolonged delay in siting a GDF leaving the next generation to grapple with above ground storage. A future generation framing also invites a discussion not only of the benefits of “new electricity” for “keeping the lights on,” but whether there need be as many lights to put on. This topic is relevant to the current generation, sure enough. But given the possibility of more “new nuclear,” it has particular relevance for future generations. In essence this theme covers the much wider, but highly relevant topic of the limitation of energy consumption in the future, whatever the power sources.

# 06

Decentralised consultation

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Researchers of deliberative processes (Burgess and Chilvers 2006; Chilvers and Burgess 2008) suggest that consultation of both the *learning* and *focussing* phases as proposed by the Consultation should be opened up to a much more decentralised arrangement specifically designed to build confidence and trust. In their 2006 paper they cover the perspectives of representativeness, democracy and mutual learning which are essential to this process. The critical feature is to include those who offer a distinctive perspective, who are likely to be affected by any eventual decision, and who represent arenas of discovery and locales of interest. Such a range of possible participants may spread across geographical space, well beyond the immediate proximities of any generic or final site. Getting such a range of genuine representativeness will take much time and will involve extensive exploration. What is critical in all of these approaches is clarity as to the overall concept of the GDF as well as defined, but agreed, boundaries to the layers of topics to be covered. In previous consultations these two parameters were never satisfactorily met.

Chilvers and Burgess (2008) point out the ever present danger of “top-down” expertise and nationally framed policy dominating the process of *learning*. This is especially the case in set piece public meetings where empathetic and sensitive conversation cannot take place. This body of research also points to the subtle diffusion of power relations in quasi-formal public meetings, biases which favour the noisy and the advocates of resistance. This process inhibits *focussing*.

There are lessons to be learnt from the GM Nation debate here. Horlick-Jones et al. (2007, 165–85) point out that sincere efforts to create such decentralised and informed approaches to “conversing” in “town meetings” were, for the most part, ill-conceived, poorly planned, weak on the use of informational materials (often ignored or disregarded as biased), and primarily attracted already committed protagonists and antagonists. Moran et al. (2012, 81–2) looked at the GM Nation debate in the context of a Nuffield study on emerging biotechnologies and observed:

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*... public engagement on these issues as virtually intrinsically contestable is well illustrated by the notorious case of engagement over GM in Britain. There is no consensus over whether this was a complete fiasco or highly successful. .... Yet the underlying reasons for many of these concerns were actually contradictory. Some felt the process was deficient because the outcome failed sufficiently to support a policy that was of unquestionable merit. Others were concerned about lack of uptake of engagement outcomes in actual policy making. Some questioned the representativeness of the process; others the folly of striving for representativeness. The resource and time constraints were also criticised by some as a lack of commitment to the process and an attempt to diminish its influence. Engagement exercises may in fact be unwittingly 'designed to fail' if they are circumscribed in their conception for fear of contradicting a preferred outcome.*

Moran's last point is illuminating. If any consultative process exhibits even a whiff of containment or a smidgeon of bias in favour of a preferred outcome, the legitimacy of novel approaches to decentralised consultation will be compromised. And such distrust is almost impossible to remove; so further attempts are often thwarted. Chilvers (2009) admits that getting a more comforting and trust building decentralised deliberative process for radioactive waste siting "right" is very difficult. It very much depends on the context and the characteristics of the participants and of the decision pathways (past and future). It also requires complete openness, honesty and near-certainty over issues which are still vague, such as the amount of the final inventory and hence the scale and length of disruption.

All this could well mean that different decentralised consultative approaches might be considered both for the *learning* and *focussing* phases. It may even result in applying varying methods according to the targeted communities, particularly in the *focussing* stages. Whatever, this extended deliberative process has constantly to be proven to be independent. Even then, as indicated earlier, dedicated "spoilers" could subvert the most carefully designed processes unless they are identified

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and isolated by the participants whose trust in these innovative procedures has been won over.

One possibility is to design a long running but carefully calibrated and monitored process where small teams of informed but mostly local people would be trained to converse with community groups in an empathetic approach. Empathy here means creating an atmosphere of comfort and relaxation so that deeper held views can get to the surface. Empathy means building on trust and confidence. The process would necessarily be long, as time is required to complete the process of conversation through mutual learning over the key themes raised in this briefing.

These themes are: the relative consequences of above and below ground storage for the nation and for any selected locality; the scale and length of waste generation beyond “legacy waste”; the nature of investment and job creation and for whom; the scope for community benefits and by what means, for how long and for whom; matters throughout of equity and fairness of treatment for both current and future generations; when the sanction of withdrawal is finally exercised (if ever); strands of decisional responsibility between national and local governments which may include some form of GDF trustees; a rigorous basis for both monitoring residual risks and communicating them in faithful and intelligible ways; and full independent evaluation of the whole process where everyone is involved.

Training here is vital. For the overall aim is to allow all participants to debate all issues (which they jointly establish) in terms of their own “comfortable” communication and in meeting places that are familiar to them. Local authorities and “experts” aren’t ideally equipped or locally perceived to deal with this sort of intimate and more genuinely representative democracy. Rayner (2003) suggests that the inclusion of outside and professional “experts” (whether that is facilitation techniques or in specialist knowledge) can create imbalances of knowledge and power which may suffocate authenticity and inhibit learning capabilities. This issue afflicted the GM Nation “town meeting” processes (Horlick-Jones et al. 2007, 184). Training suitable local people would require an extensive period of preparation and commitment. The dilemma is

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that much of this needs to be set in motion as part of the overall siting process, even when the outcome is not at all certain. So it will have to include a very high level of serious commitment right from the outset.

The twin aspects of decision representativeness and deliberative processes require much more attention than is offered in the briefing. It is suggested that interested parties convene a workshop, possibly via the British Academy, to examine the issues raised in this briefing, under the auspices of the CST. This workshop would explore in particular the conundrums raised around the character of decision locales (including how to bring in the interests of future generations) as well as the appropriate ways of addressing decentralised consultation. Hopefully this will help guide the CST more clearly as to how best to proceed, bearing in mind the DECC review of its own Consultation.

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## About the authors

**Tim O’Riordan** is Emeritus Professor of Environmental Sciences at the University of East Anglia. He received an OBE in 2010, is a Deputy Lieutenant of the County of Norfolk, served as Sheriff of Norwich (2009–10), and is a Fellow of the British Academy. He holds an MA in Geography from the University of Edinburgh, an MS in Water Resources Engineering from Cornell University, and a PhD in Geography from the University of Cambridge. In June 2013, he was awarded the honour of Distinguished Friend of Oxford.

He has edited a number of key books on the institutional aspects of global environmental change, policy and practice, led two international research projects on the transition to sustainability in the European Union (1995–2002) and edited two editions of the text book, *Environmental Science for Environmental Management*. He has just completed editing (with Tim Lenton) a book on *Addressing Tipping Points* for Oxford University Press and the British Academy, which was published in 2013.

Professor O’Riordan is actively involved in research addressing the themes associated with better governance for sustainability. He is also active in the evolution of sustainability science partnerships. His direct work relates to designing future coastlines in East Anglia in England and in Portugal, so that they are ready for sea level rise and the creation of sound economies and societies for a sustainable future.

He served as a core member of the Prince of Wales’ seminar on Business and the Environment. Through his Associate Fellow position with the Cambridge Programme on Sustainability Leadership (CPSL), he has many contacts with the business world. He serves as Special Advisor to the House of Commons Environment Audit Committee and also as Special Advisor to the CPSL Collaboratory on sustainable water stewardship. He chairs the UK Sustainability Knowledge Network which is a web-based association of active researchers all over the UK.



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