# Strategic appraisal of environmental risks: a contrast between the UK's Stern Review on the Economics of Climate Change and its Committee on Radioactive Waste Management

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**ABSTRACT**

In this paper we compare two high-profile strategic policy reviews undertaken for the UK government on environmental risks: radioactive waste management and climate change. These reviews took very different forms, both in terms of analytic approach and deliberation strategy. The Stern Review on the Economics of Climate Change was largely an exercise in expert modelling, building, within a cost-benefit framework, an argument for immediate reductions in carbon emissions. The Committee on Radioactive Waste Management, on the other hand, followed a much more explicitly deliberative and participative process, using Multi-Criteria Decision Analysis to bring together scientific evidence and stakeholder and public values. In this paper we ask why the two reviews were different, and whether the differences are justified. We conclude that the differences were mainly due to political context, rather than the underpinning science, and as a consequence that, while in our view "fit for purpose", they would both have been stronger had they been less different. Stern's grappling with ethical issues could have been strengthened by a greater degree of public and stakeholder engagement, and CoRWM's handling of issues of uncertainty could have been strengthened by the explicitly probabilistic framework of Stern.

**Keywords:** Cost-Benefit Analysis; discounting; Multi-Criteria Decision Analysis; public engagement

## 1. INTRODUCTION

In late July 2006, the Committee on Radioactive Waste Management (generally known as "CoRWM"), which was set up by the UK government in 2003, published its recommendations in *Managing our Radioactive Waste Safely* [1, in chapter 9]. CoRWM endorsed geological disposal as "the best available approach" in principle for the long-term management of the UK's radioactive waste "within the present state of knowledge". Just three months later, Sir Nicholas (now Lord) Stern presented his UK government-sponsored review of climate-change policy, *The Economics of Climate Change* [2]. He recommended "prompt and strong action" worldwide to deal with climate change. Both of these were high-profile exercises in the strategic appraisal of environmental risks and yet they took strikingly different approaches. In this paper we ask why, and whether the differences are justified. Our overarching motivation for this paper is the improvement of decision making in the face of such environmental risks, particularly in relation to the use of formal methods such as Cost Benefit or Decision Analysis.

These strategic policy reviews are of interest as they provide a window on how government can approach the analysis of substantive environmental risks. Contrasting them, as we do in this paper, brings out the particular choices which government makes in framing, and which the reviewer or review team has in undertaking, such reviews. In this analysis we draw on documentary evidence, in particular the reports themselves, but also personal experience, as both the authors were involved in one or other of the reviews. The first author was a full-time member of the Stern Review team in the UK Treasury, and the second author was a member of the team of consultants that facilitated CoRWM's Multi-Criteria Decision Analysis. Despite our personal involvement, we do nevertheless take a gently critical view, arguing that both of these reviews could profitably have drawn on some of the tools of the other.

Both climate-change policy and radioactive waste management centrally involve risk and irreversibility, in each case playing out over very long timeframes. In the case of radioactive waste, the key decision is one of whether to emplace the waste in a permanent geological disposal facility or leave it in temporary storage. The argument for the former is that we can have sufficient confidence in the performance of a suitably designed and located facility to contain the waste, and in any case, no better solution is likely to become available in the foreseeable

future; the argument for the latter is that this confidence is overstated, and we risk losing the flexibility to respond when new information arises. In the case of climate change, the key decision on emissions reductions is whether to take aggressive action now or postpone intervention to the future. The argument for taking action now is that anthropogenic climate change is irreversible, and we already have enough evidence that it is real, and at least potentially catastrophic. The counterargument is that investments to reduce emissions are also costly to reverse, that we are currently too uncertain about the benefits of such emissions reductions, and that we should wait until we have learned more about them.

How best to approach policy problems involving decision under risk has been a source of contention for decades. In this paper we draw on the view articulated by Stern and Fineberg [3] that the process for handling such problems should generally be at least to a certain extent an "analytic-deliberative" one (for clarity, we note that the Stern of Stern and Fineberg is not the Stern of the Stern Review). Drawing implicitly on the thought of Habermas, Stern and Fineberg present analysis and deliberation as distinct modes of approaching problems:

> We use the term *analysis* to refer to ways of building understanding by systematically applying specific theories and methods that have been

> developed within communities of expertise, such as those of the natural science, social science, engineering, decision science, logic, mathematics, and law [disciplines] (p 97).

> *Deliberation* is any formal or informal process for communication and for raising and collectively considering issues. In deliberation, people confer, ponder, exchange views, consider evidence, reflect on matters of mutual interest, and attempt to persuade each other (p73).

Stern and Fineberg argue that these modes are mutually strengthening and that organisations concerned with risk-related decisions should acknowledge the relevance of analysis and deliberation and give conscious attention to how they are integrated. Stern and Fineberg also acknowledge that analysis and deliberation are often closely intertwined in existing practice (for example, academic peer review is a form of deliberation deployed within scientific disciplines): nevertheless, their synthesis provides a basis for good practice, and we see this current paper as amplifying their main themes in the context of the strategic policy review.

There were striking differences between CoRWM and Stern both in the nature of the analytic techniques used (Multi-Criteria Decision Analysis versus a range of economic and probabilistic approaches to support Cost-Benefit Analysis), and also in the form which deliberation took (broad- versus narrow-based). We ask three central questions:

a) How did the reviews' approaches differ?
b) What explanations can be given for why the reviews differed?
c) Should the reviews have been less different, and what could they learn from each other?

The structure of the paper is as follows. To address question a), we outline the differences between the two reviews in Section 2. In Section 3, turning to question b), we note the choices of analytic approach and deliberative strategy were linked, and explore possible reasons for these differences, in terms of (i) the *underpinning science*, (ii) the *scale* of the problem and (iii) the *political context* of the reviews. The structure of these two sections is summarised in Figure 1. In Section 4, we give our answer to the difficult question c), and then in Section 5 we conclude.

*Figure 1 about here*

## 2. HOW DID THE REVIEWS' APPROACHES DIFFER?

On one level, CoRWM and Stern appear to have considerable similarities. Both were commissioned at the highest levels of government to report on a knotty problem. In both cases, the political sensitivity of the issue and its technical complexity generated a perceived need to commission senior figures with credible independence from the heart of government to lead the review. Both were similar in scope with budgets of a few million pounds sterling and lead-times to delivery of about two and a half and one and a half years respectively. Nevertheless, there were substantial differences (table I). In this section we focus on the differences in terms of analytic approach and deliberation strategy.

*Table I about here*

### 2.1. Analytic approach

Both reviews drew on substantial bodies of scientific evidence, although the relevant scientific communities were obviously different: CoRWM had relatively little need to consult atmospheric scientists, just as Stern had for hydrogeologists.

Similarly neither review was a research project in the underlying science – both broadly accepted the consensus view. Both drew on analytic approaches for integrating the scientific information, relating it to value-relevant outcomes, and ultimately trading-off conflicting desiderata. However, the approaches drawn on to do this were quite different – Multi-Criteria Decision Analysis (MCDA) in the case of CoRWM and Cost-Benefit Analysis (CBA) in the case of Stern.

CoRWM's approach, while technically innovative in various ways, and unusually ambitious in scale, is recognisable as an MCDA of a type familiar in the context of environmental appraisal [e.g.4, 5-7]. Roughly, CoRWM's MCDA worked as follows. A long list of solutions was prepared, some of which were eliminated at an early stage to obtain a shortlist. At workshops attended predominantly by scientists and other experts, short-listed options were scored on a number of different criteria. These criteria were then weighted to arrive at overall value scores using a "swing weighting" elicitation procedure [8].

Criteria weights were elicited from the public and stakeholders with standard aims of public and stakeholder consultation in mind – namely democratic legitimacy, substantive insight into the decision problem, and in the hope of smoothing over public opposition [9]. Criteria weighting was chosen as the

vehicle for doing so, in order that public and stakeholder views would be operationally useful and focussed on the key trade-offs at hand. The Committee members themselves deliberated over criteria weighting in a series of workshops or 'Decision Conferences' [10-12]. Extensive sensitivity analysis was done to explore whether the recommended solutions were robust to reasonable changes in weights, on the basis of information garnered from the public and stakeholder engagement. CoRWM also made a holistic assessment of the solution options to tap into the Committee members' overall, disaggregate feel for how the options performed. For further details the reader is referred to Chapters 10 and 11 of CoRWM's report and Morton, Airoldi and Phillips [9].

In Stern's case, the review team followed the standard logic of CBA, comparing costs and benefits with the welfare-economic motivation of only recommending policies that increase some proxy of aggregate well-being [e.g. 13]. This conventionally involves measuring costs and benefits in money units wherever possible. The nature of this exercise places heavy emphasis on expert modelling, and distinguishes it from many MCDAs in the environmental domain in the UK, where the emphasis is on structuring the analysis around stakeholder engagement [7, 14]. Thus Stern built an argument for immediate and strong

cutbacks in carbon emissions on the basis of a wide range of technical modelling exercises to quantify costs and benefits.

In some academic circles, the extent to which Stern's analysis can be considered an example of CBA has been debated [15-19]. This appears to stem from the fact that Stern did not use a single so-called 'integrated assessment model' [see 20] to estimate the monetary costs and benefits of emissions reductions. Rather it made partial use of a variety of models, on the grounds that no single model could be considered adequate for all purposes [21]. This precluded formal estimation of the 'optimal' target for global carbon emissions in welfare-economic terms, which would have been a natural task to undertake if a single model had been used [e.g. in 22, 23, 24]. Another reason why Stern's analysis deviates from the sort of formal model-building exercise one might find in an academic paper is uncertainty. At times Stern built his case on evidence that was not modelled at all [see especially chapter 3 of 2]. This predominantly concerned the estimation of the benefits of emissions reductions (the avoided impacts of climate change), where some of the identified risks were so poorly understood that they had not been incorporated in the relevant models. Nevertheless, the basic logic was to compare costs and benefits and to recommend policies that provided net benefits on aggregate (see chapter 13 of the Review). Indeed, in comparison with previous appraisals of emissions

targets in the UK [25, 26], the Stern Review included explicit monetisation of the benefits of emissions reductions for the first time (chapter 6). More generally, CBA as practised by government rarely, if ever, resembles the sort of purely formal analysis that some commentators had in mind when debating the status of the Stern Review.[1]

As mentioned, a particular feature of Stern was its emphasis on analysis of, and attitudes to, uncertainty. Stern's main point, that immediate and strong reductions in carbon emissions are warranted, was based on reductions in the probability of particular temperature changes 'bought' by progressively tighter climate targets. These probabilities were derived from complex climate-modelling exercises [e.g. 27]. Similarly, the Review's attempt to estimate the benefits of emissions reductions in money units (chapter six) was based on a substantial Monte Carlo simulation procedure, as was its principal attempt to estimate costs [28`, in chapter 9].

**2.2. Deliberation strategy**

[1] We are grateful to Michael Spackman for this point.

We regard both CoRWM and Stern as having a strong deliberative aspect. However, they differ both in terms of the *internal composition and dynamics* of the review team and the extent to which they availed themselves of broader *mechanisms of public and stakeholder engagement*.

We deal first with *internal composition and dynamics*. CoRWM was set up as an independent committee outside the Department for Environment, Food and Rural Affairs (DEFRA), the central-government department with responsibility for radioactive waste management policy, and the team had a diverse membership, both by discipline (including economics, law, politics, and relevant science and engineering disciplines) and by profession (including academics, a lawyer, a lay member and a prominent environmentalist). This contrasts with a traditional advisory committee, with highly focussed and directly relevant expertise. Members of CoRWM were senior and in some sense equal in rank; most had several decades of relevant experience. While some members had spent a large portion of their working lives in the nuclear industry, others were opponents of UK policy, both on radioactive waste management and nuclear matters more generally. By contrast, the Stern Review was undertaken 'in-house' by a team of civil servants either directly in the employ of the Treasury or on secondment from other central-government departments with a policy interest

(e.g. DEFRA, the Department for International Development, and the then Department of Trade and Industry). The review team sat within the Treasury and contributions from independent experts such as academics were invited either on an informal, advisory basis or on a consultancy basis. While by all accounts the Review was produced by a team, it contrasts with CoRWM in being deliberately structured around a significant public figure.

In addition to its status and composition, the two processes differed in terms of the use they made of formal *public and stakeholder engagement mechanisms*. External parties were extensively involved in CoRWM's formulation of the problem and in various stages of CoRWM´s decision process from long-listing to option assessment, as well as commenting on the recommendations. Indeed, both CoRWM's members and outsiders such as its Independent Evaluator regarded its public and stakeholder engagement as ground-breaking in the UK [29]. Central to its engagement were three separate fora for ongoing dialogue with external interests: a National Stakeholder Forum of various interest groups, which met four times over the course of the review; eight Nuclear Site Stakeholder Round Tables comprising stakeholders from nuclear communities, which met three times; and four Citizen's Juries [30, 31], which each met three times. CoRWM took particular care to feed its deliberations back to these various fora, so that while

there was a recognition that not everyone would agree with the Committee's emerging view, there was no doubt that all expressed opinions had been considered. This intensive engagement exercise was complemented by a broader exercise in disseminating information and soliciting views, including the circulation of a discussion guide to many hundreds of stakeholder groups across the UK.

The Stern Review on the other hand did not bring external parties into the process so formally and so intensively. A call for evidence was opened in early October 2005 and was closed by mid January 2006. Shortly afterwards, at the Oxford Institute of Economic Policy ('Oxonia') Distinguished Lecture in Oxford on 31st January 2006, Stern tested out his initial views [32]. Many of the ultimate findings of the Review were presaged here. Further responses to the Oxonia lecture were invited until March. Both prior and subsequent to the Oxonia event, Stern and his team also engaged in an extensive programme of consultation with academics, policy-makers and non-governmental actors, both at home and across many of the countries seen to be important in international climate negotiations, such as Brazil, China, India and the United States. Yet these were typically one-off and informal, either in the nature of fact-finding or of dissemination of emerging conclusions. While views were diligently and extensively sought, there

was no formal provision for the consultees to monitor whether and to what extent their views were impacting on decisions, which is the defining characteristic of the 'consultation' mode of public and stakeholder engagement, as famously set out by Arnstein [33] in her 'ladder of citizen participation'. There was little if any engagement with lay members of the general public; these myriad consultations tended to be restricted to academic and policy networks. This is not to deny that the Stern Review process was deliberative. Rather, the point we seek to make is that Stern's public and stakeholder engagement was informal and inward looking (towards established nodes of influence in domestic and international climate policy), while CoRWM's was formal and outward looking.

## 3. WHY DID THE REVIEWS DIFFER?

While there were real and stark differences between the two reviews, we would caution the reader against interpreting them as polar opposites. The CoRWM members, for example, were very aware that their role was not simply to reflect back public opinion, but to take responsibility for recommending to government, and the substantial amount of intellectual work which CoRWM put in, assembling and cross-checking facts and weighting judgement and argument, is

evident in their final report, just as was the case for Stern. And just as CoRWM was at pains to point out that the MCDA – as the decision-analytic literature consistently stresses – was a tool to support decision making, not an attempt to automate it, Stern also rejected the identity that might be constructed between policy analysis and formal modelling, in the conviction that the application of economic tools to policy must be done with careful attention to underlying (and often implicit) assumptions and value judgements embedded in these tools.

Nevertheless, as we have emphasised above, CoRWM and Stern, despite their similarities, differed substantially in terms of both their choice of analytic method, as well as their deliberation strategy. To some extent, these choices were linked: insofar as Stern is an *economic* review, it is also technical, requiring familiarity with economic theory and methods; CoRWM's diverse team, on the other hand, produced a report which has no specific disciplinary allegiance. CBA, although it draws on public values through surveys and market studies, is not an instrument for consultation, while MCDA has been promoted by opponents of CBA as a form of analysis which is more inherently democratic, participative, and multiperspectival [(e.g. 34, 35)] (while on the other hand proponents of CBA sometimes present MCDA as supine or vacuous, doing nothing more than reflecting back to decision makers their own beliefs).

We now turn to discussing explanations for the observed differences. In doing so, we follow recent contributions to the literature on risk regulation [e.g. 36] and on policy appraisal [e.g. 37], which attempt to dig beneath the surface of apparently overarching trends in regulation [e.g. 38, 39] to describe and explain why in fact the style and stringency of regulation often varies from one risk to another. What such contributions have fruitfully asked is whether differences in the nature of regulation, including different methods of gathering information such as, in our case, different approaches to strategic appraisal, are due to differences in the type of risk or differences in the political context, such as public opinion and pressure from interest groups. Here we consider two aspects of the type of risk to be regulated – (i) the nature of the *underpinning science* of climate change compared with radioactive waste and (ii) the *scale* of the problem – before going on to consider (iii) the *political context.*

### 3.1. Underpinning science

In both cases there are considerable similarities in the role of the *underpinning science*. For both climate change and radioactive waste, scientists feel that much of the basic underlying science is well-understood (the role of greenhouse gases

has been understood since Tyndall; North [40] remarks that "there is nothing unusually mysterious to the trained scientist about nuclear energy, ionizing radiation or radioactive isotopes"). This does not, however, preclude uncertainty about the performance of particular systems, for example the climate system, or the behaviour of radioactive waste under the unusual conditions it will encounter in a geological repository, or its movement and impacts in the biosphere. In both cases, such evidence as there is concerning system behaviour comes from the distant past: in the case of radioactive waste the Oklo deposit in Gabon where a naturally occurring nuclear reactor left deposits of radioactive nuclides in a geological setting; in the case of climate change, much relevant evidence comes from palaeoclimatological studies of climate fluctuations. The fact that these events are so long in the past contributes to uncertainty, but in both cases the uncertainty is compounded by the need to extrapolate to situations which do not precisely correspond to any previously experienced. Although radioactive wastes will potentially remain hazardous for tens or hundreds of thousands of years, this profoundly long timescale is not a feature unique to radioactive waste; many of the consequences associated with climate change such as sea-level rise are also not just long-lasting, but effectively irreversible; consequences may be felt not merely for millennia, but forever.

As there appear to be no sharp differences between the role of science *per se*, and as both reviews were scientifically-informed, broadly accepting the mainstream scientific consensus, rather than attempting to commission much in the way of further scientific research, we conclude that differences in the science of the two issues does not explain the difference in approach of the reviews.

### 3.2. Scale of the problem

The *scale of the problem*, in particular how it is reflected in the respective policy frameworks, begins to give a better sense of the reasons for the difference in approach. Radioactive waste is intrinsically a national problem: countries have to manage a stock of radioactive waste produced by activities permitted and regulated by (if not actually carried out by) national governments. The UK, in common with many other countries, has committed to a policy of self-sufficiency in the management of Intermediate and High-Level radioactive waste, meaning that waste should be managed locally within the UK [(41)]. Indeed, radioactive waste is not only national, it is local, in the sense that the waste is produced by a comparatively small set of processes (nuclear power, defence, medical and some industrial processes) in comparatively small volumes (relative to other material flows), and coupled with the fact that the sunk costs of storage/disposal

command a relatively high share of the total costs, a single community has to be found to "host" the waste. As a result, much of the politics of radioactive waste is driven by resistance, or the threat or prospect of resistance, from these host communities, and issues of equity, justice and procedural fairness loom large [42-45].

Conversely, climate change is a truly global, systemic, and transboundary hazard. The effects of greenhouse gases are global, since they are transmitted to the regional and local levels through global changes to the climate system. At the same time, all nations are responsible for greenhouse gas emissions, albeit in different proportions, and in most nations there are numerous sources of emissions. It is beyond the ability of any individual nation, even the biggest, to unilaterally reduce global emissions to low levels. There is also the disincentive to do so arising from the public-good nature of the hazard (i.e. other nations can free ride on these efforts). Thus climate change is an issue for international collective action, and national-level actions are highly contingent on the achievement of an acceptable international agreement. Furthermore, the cost structure of options to reduce emissions points to a wide portfolio of measures, due to the sheer magnitude of emissions reductions that many consider

necessary, which ultimately overwhelms the economies of scale associated with any one currently practicable measure [e.g. 46, 47].

These differences in the scale of the issues, summarised in table II, lead us directly into the policy context and history.

*Table II about here*

### 3.3. Political context

On *political context*, the issues can also be sharply distinguished (see table III). Of course there are again similarities. Both hazards are critically linked with – and linked by – energy policy. Roughly one quarter of global greenhouse gas emissions comes from the power sector; in the UK it is closer to one third [48]. Moreover replacing fossil-fuel electricity generation capacity with nuclear power is considered by many, including the UK government, to be a promising option for reducing emissions. In the UK, there is some urgency surrounding energy-supply policy, because a significant portion of the country's current generation capacity will need to be replaced in the coming decade or two. In both cases, the

issue is contentious, with significant interest groups and pressure groups with strong views on either side of the issue.

*Table III about here*

However, there have been clear differences in the state of, and pressures on, UK policy towards radioactive waste, compared with climate change. Radioactive waste management has been on the policy agenda for several decades and the UK government, through its implementor the Nuclear Industry Radioactive Waste Executive (NIREX), has repeatedly tried and failed to develop solutions [1, 49]. The history of both radioactive waste management in particular and nuclear technology in general has left a legacy of suspicion and distrust of state- and industry-sponsored actors and established science, and their combined ability to deliver solutions in the UK and internationally [50-52]. While the mainstream scientific community has tended to favour geological disposal solutions (or even more politically controversial sub-seabed solutions), this has not been a view shared by the public at large, or by environmental organisations (for example, the Royal Society [53], in its role as the UK national academy of science, noted "We conclude that deep geological disposal is the best available long-term option, but recognise the fact that this is not yet widely accepted."). CoRWM was initiated

against this backdrop, after the NIREX-sponsored programme's application to build an underground laboratory in Cumbria as a prelude to the construction of a repository had been rejected by the Secretary of State. At this point, the radioactive waste management process in the UK had stalled.

With climate change, the position was different. Public concern in the UK about climate change was consistently high in the years running up to the commissioning of the Stern Review, as evidenced by a range of opinion polls. One poll conducted in 2004 found that 63% of respondents supported the proposition "assume the worst and take major action now to reduce human impacts on climate, even if there are major costs" [(54)]. Exactly 63% of respondents in a 1999 poll had supported the same proposition [(54)]. More importantly, instead of actively distrusting the role of the state, similar opinion polling showed that a clear majority (70%) of Britons called for the government to "take the lead in combating climate change, even it means using the law to change people's behaviour" [(55)]. Unlike radioactive waste then, this put UK public opinion in line with the consensus view from the scientific community, and with a political consensus shared by all three of the UK's main parties [(56)].

Yet such a high degree of public support was not matched at the time by concrete policy measures domestically, nor was it always mirrored in other parts of the world. For example, the aforementioned survey was also administered to a sample from the United States, finding that in 2004 only 48% supported the proposition "assume the worst and take major action now to reduce human impacts on climate, even if there are major costs", which was itself only slightly up from 46% in 1999 [(54)]. Indeed, these two observations are related, because it was the lack of progress in the international negotiations on climate change, caused in turn by insufficiently strong domestic constituencies in favour of action to curb emissions in key countries like the United States, which rendered UK politicians reluctant to advance too far.

### 3.4. Weighing up the explanations

The framing of CoRWM's task reflects the pervasive lack of public trust on the nuclear issue. CoRWM's brief was explicitly "to arrive at recommendations which can inspire public confidence and are practicable in securing the long term safety of the UK's radioactive wastes", with the sponsor further noting (to eliminate any residual ambiguity) that the Committee "must therefore listen to what people say during the course of its work, and address the concerns that

they raise" [1, Annex 1]. This is in line with international good practice in radioactive waste management [45]; also UK national commentators, including those with links to the earlier, failed, NIREX process, have come to the view that more transparent, responsive and participatory approaches are essential to meaningful progression [49]. Yet in the light of the essentially national scale of the problem, there was no need to involve and convince an international audience. Although CoRWM was chaired by an economist, there is little direct evidence of an economic imprint on CoRWM's report, albeit CoRWM did commission work on the costs of the various options.

In the case of climate change, facing a domestic public which shared scientists' concerns, but a sceptical international community which required convincing and motivating, the challenge was to garner international support. Jordan and Lorenzoni [56`, p310] argue persuasively that the Stern Review was part of a "much grander geo-strategic plan to convince the rest of the world that 'business as usual' will eventually lead to unacceptable risks". Making the *economic* case for action was a pivotal part of this plan. Indeed, the Stern Review was commissioned against the backdrop of the so-called 'Gleneagles Dialogue on Climate Change', conducted under the auspices of the G8 together with the five leading emerging economies. In this context, we can understand the ministerial

home of the Stern Review in the UK's central government (i.e. the Treasury, rather than DEFRA), its terms of reference to take a global view over the medium- to long-term, and ultimately its choice of CBA for the task. The international imperative to conduct an economic assessment of climate targets was buttressed by certain domestic political dynamics. A report by the House of Lords Select Committee on Economic Affairs [57] had been quite critical of the lack of economic evidence used to form climate policy in the UK. Partly as a response to this and partly in expectation of the likely increasing fiscal importance of climate policy in the future (e.g. through revenues from carbon taxation), climate change rose up the list of priorities for the Treasury. Without the need to win over the domestic public, it is equally clear why much less emphasis was placed on public and stakeholder engagement.

Overall this discussion suggests that the differences in approach taken by the two reviews are much more obviously explained by political context, and in turn by scale, than they are by the scientific nature of the problem: different political pressures and imperatives prevailed at the time CoRWM and Stern were commissioned; and the constituencies or 'audiences' were different. Thus CoRWM's broad-based membership and emphasis on transparency in modelling were well suited to a policy problem characterised by a legacy of suspicion and

distrust. Stern's technically rich CBA, on the other hand, was well suited to a policy problem characterised by a (perceived) lack of economic credibility behind ambitious climate targets.

To develop this point in more detail, we now turn to the question of 'how', as opposed to 'why', the respective approaches of the two reviews were chosen. In both cases, it is evident that the approach was framed to a large extent by the terms of reference that were drawn up, and hence the choice was indeed made at an early, political stage. As we have mentioned, CoRWM's terms of reference placed heavy emphasis on public and stakeholder engagement, and they also arguably anticipated that MCDA would be the analytic approach most suited to structure this engagement, since they required the identification of "criteria" for assessment (but not, for example, "scenarios", which might have led to a greater focus on uncertainty). At the same time, Stern's terms of reference, which were after all drawn up by the Treasury, called *inter alia* for an examination of the evidence on "the costs and benefits of actions to reduce the net global balance of greenhouse gas emissions" (2, p ix). Elsewhere in Stern's terms of reference, the Review is charged with the task of "taking into account the risks of increased climate volatility and major irreversible impacts".

From this point of departure, any further choices to be made appear to have flowed largely from the individuals appointed to carry out the reviews, and the methods with which they were familiar. This is perhaps most obviously true of Stern, one of the UK government's most senior economists at the time, who brought with him decades of experience in welfare economics in general and CBA in particular. But it is also true of CoRWM. Key documents (both internal and from outside experts) from the early stages of developing CoRWM's methodology show that prior experience with MCDA played a role in its choice, in particular in connection with the 'Best Practicable Environmental Option' procedures for radioactive waste disposal at UK nuclear sites, and the NIREX waste disposal site selection processes of the 1980s and 1990s [58, 59]. This is despite the fact that the problem CoRWM faced was different, being larger in scale and much more challenging (in that it was asked not to recommend a site, but a way forward more generally). In this sense CoRWM's approach can be thought of as creatively making use of an approach which already had a track record in the UK radioactive waste context.

To turn around the question of how the review's approaches came to be chosen, we can also ask what was ignored in the process of making this choice. Neither review made its choice of approach on the basis of a comprehensive survey of

methodological possibilities. While it is clear that Stern thought reflectively about the strengths and limitations of formal CBA [see e.g. chapters 2 and 6 of 2], there is no evidence to suggest that this thinking extended to considering whether methods could be borrowed from the tradition of MCDA. Turning to CoRWM, probabilistic methods are mentioned in a peer review of an early methods document by a prominent international decision and risk analyst [60], but this does not seem to have been taken up by CoRWM. Equally, formal economic methods are dismissed in a single line in a Review of Options Assessment Methodologies commissioned by CoRWM [59] ("Simply using economic models has been widely questioned: for example, 'how can you value a feeling of well-being?'", p 1). To summarise, neither review appears to have seriously engaged with the possibilities offered by methods from outside the relevant discipline and tradition. In the next section we will consider whether that was a mistake.

## 4. SHOULD THE REVIEWS HAVE BEEN LESS DIFFERENT, AND WHAT COULD THEY HAVE LEARNED FROM EACH OTHER?

We are left with a more normative question; could and should the two reviews have been less different? It is worth highlighting at the outset that both reviews were, on the whole, well received. CoRWM's public and stakeholder engagement

is regarded as an outstanding achievement by, for instance, the Independent Evaluator [29], and its substantive conclusions have also been well received by, for instance, the Royal Society [61], and by the House of Lords Science and Technology Committee [62]. The Stern Review's conclusions were also well received in many quarters, with, for instance, an impressive range of endorsements published with the book version of the review report [2], and the Review has stimulated and focussed public and political attention both in the UK and internationally. We personally regard both reviews as substantial achievements and "fit for purpose", although acknowledging that our respective roles mean that we may not have been entirely unbiased.

Nevertheless, both reviews have generated ongoing controversy. Without seeking to canvass all views on the two reports (which would require a paper, or perhaps a book, by itself), we focus on two issues of particular interest for our current comparison. One is the role of uncertainty and the recommendation of an intensified R&D programme in the case of CoRWM. The other is the handling of benefits accruing to future generations in the case of Stern.

Turning first to uncertainty in radioactive waste management, one reading of the case proponents make for geological disposal is that, while neither disposal nor

storage are risk-free, the probability of any given level of environmental degradation is lower under the disposal option than under the storage option. Equally, a key question in deciding the form of the waste management strategy is the scheduling of events, including the timing and conditions under which construction would begin on a repository, and the timing and conditions of the closing of the repository. Indeed, it has been argued that properly understanding the meaning of the concept of retrievability is pivotal in interpreting the feedback from the public and stakeholder engagement [63]. It follows that the suitability of a particular analytic approach rides to a significant extent on its capacity to deal with these issues.

In the MCDA, CoRWM's approach was to try to formalise these aspects of the decision problem in criteria, such as "public safety" and "flexibility". In the particular variant of MCDA it used (a multi-attribute value model), performance on one criterion was then traded off against performance on the other, and so on against performance on a wide range of other criteria. Elsewhere, the CoRWM report (chapter 18, p 147) makes an extensive qualitative survey of the uncertainties surrounding the options, noting that scientists have expressed confidence in geological disposal as a generic concept, but also that new uncertainties may arise in moving from a generic concept to a specific facility

design. It further discusses possible concerns about the bias of the same scientific community, due to institutional links to the nuclear industry. In the light of this uncertainty, CoRWM made a formal recommendation that there should be an "intensified programme of research and development into the long-term safety of geological disposal". However, because the report relies heavily on qualitative statements of uncertainty, the degree of uncertainty is unclear, as is the extent of the expanded R&D programme. The government's response to the recommendation on R&D is equivocal and falls short of committing new money to relevant R&D; effectively, the issue is thrown back to the technical establishment, in the shape of the regulators and to the Nuclear Decommissioning Agency [64]. One of the CoRWM members has subsequently expressed his disappointment at this aspect of the government's follow-through [63].

Against this backdrop, we believe that a formal probabilistic modelling approach [65], of the sort undertaken by Stern or as exemplified in other approaches such as decision trees [66] and real options [67], would have had the advantage of making key uncertainties explicit and discussable, and could have helped clarify both the meaning of the nature of the solutions on the table, in particular with respect to

the conditions for undertaking particular actions (such as sealing the repository) and expectations about the scope of an expanded R&D programme.

For its part, the Stern Review received some heavy criticism from those who took issue with a number of features of the Review's CBA, especially its choice of an unusually low discount rate to compare the future benefits of emissions reductions with their present costs [18, 68-71]. The discount rate captures a key ethical trade-off between burdens on the present generation and burdens on generations in the far-off future. It has long been known that the results of a CBA of climate targets are very sensitive to the discount rate [compare 22, 72]. What many commentators found disappointing about the Stern Review was the lack of sensitivity analysis to demonstrate the contingency of the overall recommendations on the discount rate: in other words, the Review was seen to be trying to impose a particular view on intergenerational equity, and to be doing so without openness [73, 74]. This was self-defeating, as in certain quarters it diminished the Review's capability to persuade people into support for curbing greenhouse gas emissions.

Hence, just as CoRWM could have benefitted from Stern's explicitly probabilistic approach, we consider that Stern could have benefitted from CoRWM's intensive

use of public and stakeholder engagement. As Stern notes repeatedly, at the core of climate-change policy is an ethical problem. It could be that the public at large feel a strong sense of obligation to future generations; however, Stern did not seek evidence that this was the case, nor did they seek to probe exactly what is the nature of that obligation. Such an engagement would have given Stern ammunition to deal with its critics. Moreover, in times of economic difficulty, a real danger is that national publics may lose the will to incur the very concrete costs of action. Some level of prior public engagement might well have strengthened public resolve to see through the necessary sacrifices – in Yankelovich's [75] terms, to "come to public judgement", and accept the necessary tradeoffs.

Reflecting on the comparison, we argue that CoRWM could have benefitted from some formal uncertainty analysis, just as Stern could have benefitted from some extra public engagement – although of course all reviews operate within a fixed budget envelope and delivery date and any additional activity must be counterbalanced by cuts elsewhere. One possible objection, however, is that Stern's analytic approach and its deliberative strategy were bound up together, as were CoRWM's; and that attempts to be at the same time intensely technically analytic and extensively participative are bound to fail. The reasoning behind

this goes beyond the simple observation that both analysis and participation represent competing demands on resources. Rather, the thought is that the proliferation of technical detail makes meaningful lay participation impossible, and discussion fora become dominated by those with technical expertise. Obviously there may be an element of truth in this, but we see the challenge for future strategic reviews not as deciding where they want to position themselves on an analysis-deliberation frontier, but as pushing forward that frontier, developing new and better ways to combine analysis and deliberation, as both Stern and CoRWM, in their different ways, attempted to do. For example, CoRWM's use of longitudinal engagement mechanisms (the citizen's juries and roundtables which met multiple times following a roadmap leading to decision, with feedback between rounds of consultation) provided a way to help nonexperts build specialist knowledge and contribute more meaningfully. Stern's modelling, to take another example, captured key value judgements within a small number of parameters governing the discount rate, thus potentially providing a way for concerned parties without a background in the underpinning theory to understand the implications of their moral intuitions about obligations to future generations.

## 5. CONCLUSION

In this paper, we have attempted a comparison of two quite different strategic policy reviews commissioned by the UK government on issues of environmental risk. We have expounded the differences in the ways in which the two reviews attempted to incorporate both analysis and deliberation in their working through of the respective issues. We have explored reasons for the differences, and argued that much of the difference can be explained by the political context in which the reviews took place, rather than the intrinsic nature of the risk decision itself. There is an argument that the subject matter and overall context of these reviews is so different that little can be learned from the comparison: that we are comparing apples and oranges. We would strongly contest this: as we have rehearsed throughout this paper, although there are dissimilarities, the similarities between the underlying risk decisions are pronounced, making the differences in the analytic and deliberative approaches taken, if anything, still more surprising and worthy of comment.

The overarching motivation of this paper is the improvement of risk-related decision making, in particular the use of formal techniques such as CBA and MCDA. We find it disconcerting that policy reviews in the environmental domain should take such dissimilar forms. Ultimately these reviews are intended

to provide government with a reasoned basis for undertaking action. While we recognise that the study methodologies chosen, and the mode of presentation of results, will be influenced by political context, we would like to feel that there is a core of argumentation underpinning policy which is method-independent. Otherwise, the question naturally arises: were the conclusions reached determined by the methods used?

This is not to say that different people may not take quite different views on the same policy issue. In dealing with complex environmental risks such as radioactive waste and climate change there are critical questions of time preference, risk attitude, attitude to distributional equity, responsibility to the non-human natural world, and confidence in the ability of the scientific establishment to deliver reliable predictions. Such questions are inherently judgemental. However, the role of methods such as CBA and MCDA should be to help decision makers structure and clarify these judgements; as their proponents repeatedly stress, they should not make the decision, and insofar as key value judgements are implicitly embedded in the methods, they fail.

The general implication of this line of reasoning is that choice of study method in such reviews should be, as far as possible, reflective, informed by an awareness

of a range of methods and an understanding of their strengths and weaknesses. Others have suggested criteria which may be used to guide methods choice: for example, Fischoff, Lichtenstein, Slovic, Derby and Keeney [76] suggest approaches to supporting decisions should be: comprehensive; logically sound; practical; open to evaluation; politically acceptable; compatible with institutions; and conducive to learning; Dietz and Stern [77] consider that science has the best chance of being integrated with public participation if the methods used ensure that: decision-relevant information is accessible to all parties; explicit attention is given to both facts and values; analytic assumptions and uncertainties are explicitly described; and there is independent review and learning as new information comes to light.

We also consider that that reviews should draw on multiple methods, deploying and combining them in creative ways in order to best meet the needs of the study in question. In the specific case of Stern and CoRWM, our conclusion is that the two reviews could have learned from each other: some of Stern's analytic approaches, particularly around the explicit handling of uncertainty, could profitably have been used to strengthen CoRWM's case; and some of CoRWM's public and stakeholder engagement would have added robustness to Stern's discussion of the ethics of climate change. Irrespective of whether the reader

accepts this view, what seems harder to dispute is that frameworks for the design of strategic appraisal of environmental risks are lacking. In settings such as routine appraisal, there are detailed technical guidelines about how problems are to be modelled (e.g. in the UK there is the so-called Green Book [76]), and one can expect that appraisers will follow the guidelines and justify when they depart from them. However, in the context of these "strategic appraisals" as we have called them, there seems to be no way of learning from previous practice in other domains, and little in the way of systematic guidance for taking methods decisions. We hope this paper will provide a spur and foundation for the development of such guidance.

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**Figure 1. Appraisal of policy problems involving decision under risk. Choices in appraisal, and factors influencing those choices.**

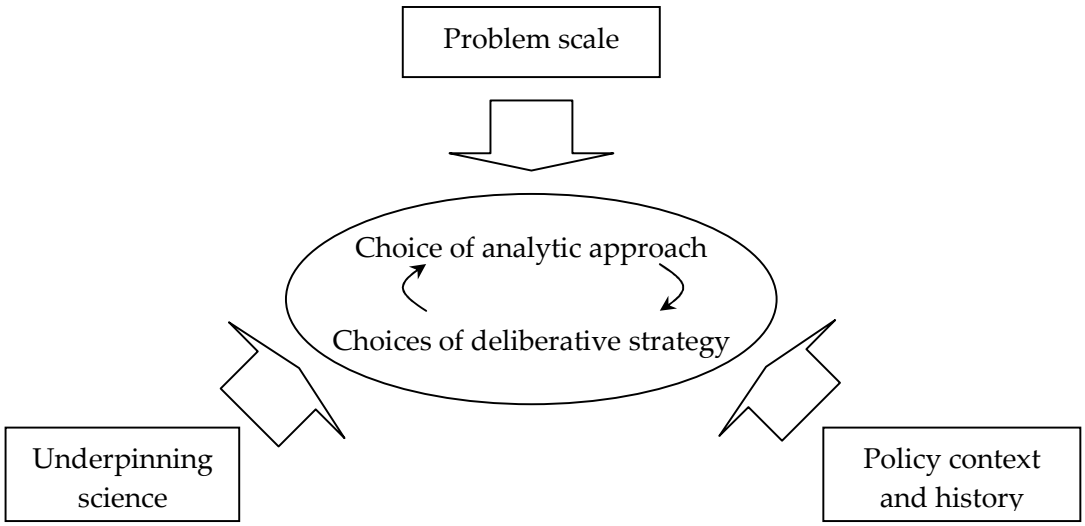


**Table I. Differences between CoRWM and Stern.**

| | *CoRWM* | *Stern* |
|---|---|---|
| *Analytic approach* | Multi-Criteria Decision Analysis – scoring and weighting of options, structured around stakeholder participation | Cost-Benefit Analysis – extensive technical modelling to enable Stern to make comparison of costs and benefits under uncertainty |
| *Deliberation strategy – internal composition and dynamics* | Independent committee; diverse membership including both insiders and outsiders | Undertaken within a government department; led by senior civil servant from that department, supported by a team of more junior civil |

| | | |
|---|---|---|
| | | servants |
| *Deliberation strategy – public and stakeholder engagement* | Extensive arrangements for deliberation throughout process; focus on civil society | Standard, 'light-touch' consultation (publish consultation document – invite responses); focus on national and international policy networks |

**Table II. Differences in the scale of the radioactive waste and climate change problems.**

| | *Radioactive Waste Management* | *Climate Change* |
|---|---|---|
| *Scale and international-isation* | Nation states manage own waste – host community required to shoulder the burden | Transboundary in causes and consequences – impacts spread across many social groups |
| *Cost structure of solutions* | Small number of management strategies | Many, diffuse solutions |

**Table III. Differences in the policy context of CoRWM and the Stern Review.**

| | *Radioactive Waste Management* | *Climate Change* |
|---|---|---|
| *Public attitudes* | Nuclear industry has longstanding public-relations problems | Goodwill towards action (though public resolve untested) |
| *Policy situation* | National policy process stalled by failure of 'decide, announce, defend' | International community (G8(+5)) unconvinced of the economic case for action |