Institution: Durham University

Unit of Assessment: 17B

Title of case study: Governing science and technology responsibly

1. Summary of the impact

DU research into nanotechnology and geoengineering has used deliberative forms of public engagement involving focus groups with lay publics to explore the complexity of societal concerns about emerging technologies. The results of this research have made a major contribution to the development of a framework of responsible innovation. This framework has been applied to RCUK-funded research, where it led to the withdrawal of the UK's first field trial of a prospective geoengineering technology. This framework has had direct impact on European policy debate and on the UK's Engineering and Physical Science Research Council, which has begun to embed responsible innovation in an operational context.

2. Underpinning research

Decisions about the funding of large research projects in science and technology are normally made on the basis of scientific excellence, as assessed by peer review, and the potential value to business or the nation of the results of the research. A third consideration, the societal acceptability of the proposed research, has often received less or no attention. This neglect has sometimes led to projects becoming controversial, with public disquiet fanned by media reporting and local or national NGO campaigns. An obvious recent example in the UK is trials of genetically-modified crops. Controversies have led major funding agencies to consider how their governance or procedures could be modified to take better account of possible societal concerns, both when making funding decisions and in what is expected of investigators once projects have been funded.

Research in Durham led by **Macnaghten** (2006-) has played a key role in identifying why current approaches to the governance of emergent technologies are problematic. It has developed deliberative processes that aim to embed ethical and societal considerations throughout all stages of scientific practice, and drawn on this research to develop and apply a 'Responsible Innovation Framework'. The specific areas of innovation considered in the underpinning research were nanotechnology and geoengineering, but the proposed governance principles have wider reach.

Core elements of what has become the Responsible Innovation Framework were first developed in the EU-funded Developing Ethical Engagement and Participation in Emerging Nanotechnology project (DEEPEN; 2006-2009), which focused on the ethical challenges posed by emergent nanotechnologies (References 1 & 2). The DEEPEN project was coordinated by **Macnaghten** at DU and also involved **Kearnes** (RCUK Fellow 2006-2011), **Davies** (PDRA 2007-2009), and focus group research with lay publics. The research highlighted the value of cultural narratives to understanding the complexity of public concerns about nanotechnology (Reference 2). It also identified a number of limitations to current efforts to foster the responsible development of nanotechnologies, particularly an impoverished understanding of the complexity of public concerns and an artificial and unhelpful separation between scientific practice and the consideration of societal impacts (Reference 1). In order to overcome this separation, DEEPEN recommended that public engagement should address *anticipation* (the need for science to anticipate its impacts), argued the need for ethical considerations to be built into scientific governance processes via public engagement (Reference 1), and emphasised the importance of encouraging *inclusive deliberation* amongst multiple stakeholders about the potential impacts of scientific research (References 1 & 2).

The practical and policy challenges of embedding ethical considerations throughout scientific governance and practice were explored further in the 2011-2012 Responsible Innovation Project (EPSRC/ESRC: PI Owen, Exeter; CI **Macnaghten**, Durham; PDRA Stilgoe, Exeter). Developing in part from DEEPEN's emphasis on deliberation and anticipation, the Responsible Innovation Project established a framework for supporting decisions about the conduct of innovative but potentially contentious scientific research (References 3, 4, 5). This framework comprises four integrated dimensions: *anticipation* (the need for science to seek to anticipate its impacts), *inclusion* (the need to deliberate and open up reflection to an inclusive array of stakeholders), *reflexivity* (the need for

science to be continuously reflecting on its embedded assumptions), and *responsiveness* (the need for governance mechanisms to ensure science's trajectory is responsive to societal values and concerns). Other definitions of 'responsible innovation' exist (see www.matterforall.org/) so we refer below to what has been styled by others as the Owen/Macnaghten AIRR framework or model of responsible innovation.

The deliberative methodologies applied in relation to nanotechnology in the DEEPEN project have subsequently been extended to the new field of geoengineering (or climate engineering), focusing specifically on solar radiation management and its implications for science governance (Reference 5). In this research, focus groups were asked to anticipate the kinds of world that solar radiation management would bring into being. The findings showed that solar radiation management was anticipated to create an increased probability of geopolitical conflict and major threats to democratic governance, and would be publicly acceptable only under highly specific conditions (Reference 5).

3. References to the research

(**Bold** denotes Durham University researcher at time of research; journal impact factors are from Web of Science as of 31/7/13).

1. **Davies** S, **Macnaghten** P, **Kearnes** M (ed.) 2009. *Reconfiguring Responsibility: Lessons for Public Policy* (Part 1 of the report on Deepening Debate on Nanotechnology; funded by EC Framework VI programme). Durham: Durham University. Available at http://www.geography.dur.ac.uk/Projects/Portals/88/Publications/Reconfiguring%20Responsibility%20September%202009.pdf .
2. **Macnaghten** P (2010) Researching technoscientific concerns in the making: narrative structures, public responses and emerging nanotechnologies. *Environment & Planning A.* 41: 23-37 (JIF 1.89, 8 citations).
3. Stilgoe J, Owen R, **Macnaghten** P (2013) Developing a framework for responsible innovation. *Research Policy,* http://dx.doi.org/10.1016/j.respol.2013.05.008 (published online in June 2013) (JIF 2.850).
4. Stilgoe J, Owen R, **Macnaghten P** (2012) *Taking care of the future: a framework for responsible innovation*. Report to UK Engineering & Physical Sciences Research Council.
5. **Macnaghten** P, Szerszynski B (2013) Living the global social experiment: an analysis of public discourse on solar radiation and its implications for governance. *Global Environmental Change* 23: 463-474 (JIF 5.24).

4. Details of the impact

Our research into the governance of emerging technologies has had direct impact in two ways: (1) through the application of the Owen/Macnaghten framework for responsible innovation to the UK's first field trial of a prospective solar radiation management technology, resulting in the withdrawal of the trial, and (2) by embedding the dimensions of this model of responsible innovation in European public policy debate and EPSRC research policy.

Applying the framework for responsible innovation: the case of geoengineering

The Owen/Macnaghten framework for responsible innovation was first trialled in relation to the Stratospheric Particle Injection for Climate Engineering (SPICE) project. SPICE is one of two projects funded by EPSRC, NERC and STFC in 2010 in response to a 2009 Royal Society report which urged RCUK to support investigations of the potential of geoengineering as a third response to global warming, along with emissions reduction and adaptation. One geoengineering approach is solar radiation management, which seeks to alter the balance between incoming solar radiation and outgoing radiation. SPICE aimed to investigate the feasibility of doing this by delivering large quantities of sulphate aerosol to the stratosphere to mimic the cooling effects of volcanic eruptions. A test was proposed of a one-twentieth scale delivery system: a 1-km high hose supported by a tethered balloon. Although this so-called test bed would not be geoengineering as such – it would spray only a small amount of water – the experiment was highly symbolic as the UK's first field trial of a technology with solar radiation management potential (Reference 3).

In order to ensure that the project proceeded in a responsible manner, the funding agencies adopted a 'stage-gate' model of innovation governance. Funding for the test bed was conditional

on the project team passing the stage gate in respect of five criteria which are tabulated in Reference 3. One criterion was a risk management plan for possible malfunctioning of the test, but the others were about the wider implications and were directly modelled on the dimensions formalised in the Responsible Innovation project described in Section 2: the SPICE team was asked to anticipate, reflect, and deliberate with publics and stakeholders on the purposes and possible impacts of the research and what it could lead to. Macnaghten was invited by EPSRC to chair the stage-gate panel in recognition of his role in the Responsible Innovation project and his previous research on upstream societal engagement in potentially controversial science and technology, including the DEEPEN project (Source 1). EPSRC briefed him as follows for the panel meeting: "The purpose of this panel is to ensure that the SPICE research team can demonstrate their preparedness and ability to execute the test bed work package safely and responsibly. They should demonstrate that they have considered both the proximal (i.e. operational) issues, and the future applications and impacts of their research. We are also looking to ensure that the research team can be responsive to concerns arising and the evolving landscape external to the project". The responsible innovation framework thus provided a decision support tool for the panel to consider the wider risks, uncertainties and impacts surrounding the SPICE test. The panel discussed the SPICE team's response to the five criteria in June 2011 and asked for more work in relation to three of the criteria: developing a communications plan to inform public debate, reviewing the risks and uncertainties of solar radiation management, and ensuring more inclusive engagement with stakeholders.

In September 2011 the SPICE team issued a press release announcing that they would be going ahead with the test bed within a few months. A vocal media debate ensued in the following three months, with polarised views about geoengineering as a response to global warming (Source 2). This was fuelled when EPSRC and the UK Secretary of State for Energy and Climate Change received a letter signed by 50 NGOs which demanded that the project be cancelled (www.handsoffmotherearth.org/hose-experiment/spice-opposition-letter/). Following consultation with Macnaghten as chair of the stage-gate panel, EPSRC took the decision to delay the test bed to allow the project team to undertake the additional wider responsible-innovation engagement work requested by the stage-gate panel. Further discussions between RCUK and the SPICE team led to the eventual withdrawal of the experiment in May 2012. EPSRC's announcement of this (Source 3) explicitly states that "as a result of the stage gate and the responsible innovation approach, the SPICE team was also encouraged to explore issues connected to the potential future use of geoengineering technologies".

Embedding responsible innovation in European policy debate and UK research policy

Our research has informed European public policy debate about how research innovation might be governed responsibly. The initial pathway to impact was the DEEPEN end-of-award event in Brussels in September 2009. This involved speakers from seven European countries, officials from three European Commission directorates and two European government departments, and representatives from three industry associations and two civil society organisations. DEEPEN's emphasis on deliberation and public engagement in the governance of new technologies informed the report *Understanding Public Debate on Nanotechnologies: options for framing public policy* (2010; Source 4). This report was published by the Governance and Ethics Unit of the EC's Directorate General for Research & Innovation, which has a budget of €10 bn/yr. It aimed to stimulate public debate on the development of nanoscience and nanotechnologies. Its co-author (Source 5) states: "An EC publication of this nature is quite unusual" and further confirms that "DEEPEN helped the EC to reflect further on issues of responsible development of nanotechnology and to think about new ways of public engagement and further initiatives within and beyond the Science in Society programme". Findings from the Responsible Innovation project provided a key input to the European Commission (2012) report *Options for Strengthening Responsible Research and Innovation: report of the Expert Group on the state of art in Europe on Responsible Research and Innovation* (Source 6). The definition of Responsible Research and Innovation, as set out in Annex 1 of the report, employs the four dimensions of the Owen/Macnaghten AIRR framework (anticipation, inclusion, reflexivity, responsiveness) as set out in References 3 & 4. It further states that these dimensions are "points of reference [which] should be reflected in the design of research and innovation processes and products" (Source 6, pages 56–58).

In parallel with the impact on EC policy debate there has been direct impact on UK EPSRC

research policy. The initial pathway to impact here was SPICE. A senior EPSRC policy officer (Source 7) confirms that the experience with the SPICE project showed the value of the responsible innovation framework in navigating potentially controversial emergent technologies. The EPSRC Delivery Plan 2011-2015 contains a commitment to promote responsible innovation. Testimony stresses that this commitment provided an imperative "to develop a coherent approach [to responsible innovation] that can be embedded in a day-to-day operational context but in a way that is acceptable, practical and proportionate" (Source 7). The Owen/Macnaghten responsible innovation project (as described in Section 2) was funded to "help the research councils understand the broader context of responsible innovation and to develop a responsible innovation framework for implementation across the research councils" (Source 7). Testimony states that the [Responsible Innovation] project's findings had a "direct impact" and were "an integral factor" in shaping a set of specific recommendations for "implementing a responsible innovation approach" (Source 7).

EPSRC has begun to implement the recommendations across its £800m/yr portfolio of funded research (Source 7). Testimony confirms that "Since the completion of the [the Owen/Macnaghten responsible innovation framework] paper we have continued to work towards a more practical approach to Responsible Innovation and the core elements of your paper [i.e. Reference 4] are at the heart of this – particularly your approach to framing responsible innovation around the Anticipation – Reflection – Deliberation – Responsive approach" (Source 8). As an example of implementation, applicants to EPSRC's 2013 Doctoral Training Centre competition were encouraged to include training in responsible innovation in their bids (Source 9).

5. Sources to corroborate the impact

Source 1: Email from Senior EPSRC policy officer (EPSRC) to Phil Macnaghten, 15/3/2011 [participant].

Source 2: Examples include BBC R4 Material World 17/11/2011: Engaging with Geoengineering (www.bbc.co.uk/programmes/b0175293), 1'40" to 12'07" and especially 5'15"; Ruz C (2011) Scientists criticise handling of pilot project to 'geoengineer' climate (http://www.guardian.co.uk/environment/2011/nov/17/scientists-criticise-project-geoengineer-climate?INTCMP=SRCH); Brumfiel G (2012) Controversial research: Good science bad science *Nature* 25 April 2012 (http://www.nature.com/news/controversial-research-good-science-bad-science-1.10511) [all reporters]

Source 3: Update to EPSRC's SPICE web pages on 22/5/2012 (www.epsrc.ac.uk/newsevents/news/2012/Pages/spiceprojectupdate.aspx)

Source 4: von Schomberg R & Davies S (2010) *Understanding Public Debate on Nanotechnologies: options for framing public policy*. EC Directorate-General for Research – Science, Economy and Society. Available at http://demo.intrasoft.be/ssc/document_library/pdf_06/understanding-public-debate-on-nanotechnologies_en.pdf (especially pp 6 - 8).

Source 5: Testimony email/letter from Project Officer, DEEPEN; European Commission DG Research & Innovation, 16/5/2013. [Reporter].

Source 6: van den Hoven J *et al* (2013) *Options for Strengthening Responsible Research and Innovation: report of the Expert Group of the state of art in Europe on Responsible Research and Innovation*. European Commission, Directorate-General for Research and Innovation. Available at ec.europa.eu/research/science-society/document_library/pdf_06/options-for-strengthening_en.pdf (see especially pp 56-58).

Source 7: Testimony letter from Senior Business Manager, Strategy and Planning, EPSRC, 21/5/2013. [Participant/Reporter]

Source 8: Testimony email/letter from Head of Impact EPSRC 17/7/2013 [participant/reporter].

Source 9: http://www.epsrc.ac.uk/SiteCollectionDocuments/Calls/2013/CDTcallfinal.pdf (see p.17).