



AUTHOR(S):

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Publisher citation:

OpenAIR citation:

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FORTHCOMING IN ENVIRONMENTAL VALUES (ACCEPTED FOR PUBLICATION)

MEETING THE TARGETS OR RE-IMAGINING SOCIETY? AN EMPIRICAL STUDY INTO THE ETHICAL LANDSCAPE OF CARBON DIOXIDE CAPTURE AND STORAGE IN SCOTLAND.

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ABSTRACT

Preston's (2011) challenge to the moral presumption against geoengineering is applied to carbon dioxide capture and storage (CCS) in Scotland, United Kingdom. Qualitative data is analysed to assess if and how Preston's arguments play out in practice. We argue that the concepts of 'lesser evil' and prioritising human well-being over non-interference in natural processes do bring different value positions together in support of CCS, but that not all people see short-term carbon abatement as the 'least worst' option or a suitable way to prioritise human well-being.

KEYWORDS

carbon dioxide capture and storage (CCS); climate change; environmental ethics; epistemic justice; ethics of science and technology.

1. INTRODUCTION

Carbon dioxide capture and storage (CCS) is a 'clean coal' energy technology that traps carbon dioxide (CO₂) emissions from fossil fuel-burning power stations and industrial sources, transports the CO₂ by ship or pipeline and injects it into underground geological formations. The rationale for this is that CO₂ is the main driver of anthropogenic climate change, a potentially serious threat to humans, animals and ecosystems. Support for CCS has come from both industry and government. Some academic projects and funders too have a stated aim to move CCS towards deployment (CASSEM Project, 2011; European Commission, 2009).

CCS is often described as a vital – in cases like metals production the only – option to reduce CO₂ emissions from fossil fuel sources (DECC, 2014; Shell, 2014). The high proportion of electricity sourced from fossil fuels is cited to justify the necessity of CCS if deep cuts in anthropogenic CO₂ emissions are to be achieved relatively soon (IEAGHG, 2014) whilst avoiding disruption from intermittent renewable energy supply and energy insecurity (GCCSI, 2014). Within this, there can be different grounds for supporting CCS, such as 'dynamics as usual' – preserving existing processes of energy production and consumption as far as possible via technology that captures the end emissions. Another might be a perceived need for deep and urgent reductions in CO₂ emissions, which must be applied to current fossil fuel sources to avoid an 'overshoot' scenario. CCS could even be seen as a more general effort to reduce human pollution of natural environments. We argue that whilst some publics and stakeholders with different standpoints can coalesce around CCS as necessary in the immediate future to respond to energy and climate challenges, others question if a focus on short- to medium-term (5–25 years) carbon abatement neglects deeper reflection on how society makes decisions about the environment and energy.

2. CCS AS ETHICALLY OBJECTIONABLE, OR A LESSER EVIL?

CCS is usually grouped among 'low carbon' energy technologies, perhaps because it is viewed as an 'end of pipe' pollution control added to a means of producing electricity (or to industrial operations such as cement, chemical and metal production). Nonetheless, it is

helpful to look to the emerging literature on geoengineering to more fully understand the ethical landscape of CCS, as CCS shares commonalities with geoengineering. Direct air capture requires a CO₂ transport and storage infrastructure of the kind being developed through CCS (Brandani, 2012), hence at least some geoengineering options are likely to depend on prior CCS research and development. Taking the Royal Society definition of geoengineering as ‘deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change’ (Shepherd et al, 2009: 1), CCS too is deliberate, large-scale, alters the planetary environment (subsurface geology) through injection of ‘captured’ CO₂ and is undertaken predominately as climate change mitigation.

Indeed, some ethical issues already explored for geoengineering are pertinent to the capture, transport and storage of CO₂. Hale and Grundy (2009) express concern at the implications for individuals’ sense of responsibility and respect if previous environmental ‘wrongs’ can be corrected by technologies spatially and relationally removed from the polluter, and the lack of human agency in large-scale electricity generation suggests this concern may well be applicable to CCS – particularly if consumption of extracted fossil fuels is perpetuated without reflection from the end users. Similarly, Borgmann (2012) applies Weinberg’s (1967) concept of a ‘technological fix’ to geoengineering, in particular solar radiation management. Borgmann takes Weinberg’s concern about turning a complex social problem into an apparently simpler technological problem, and cautions that the setting within which people’s actions take place and the vision of the ‘good life’ that this setting supports should not go unchallenged. Borgmann’s apparent worry over geoengineering deflecting attention away from deeper questioning over the ‘good life’ resonates with the way a continuation of fossil fuel energy via CCS may mask bigger questions about what kinds of society we should be aiming for via climate change mitigation.

The reliance of conventional CCS on coal and gas may also leave it open to contestations over the deleterious effects of fossil fuels. Markusson et al. (2012) warn CCS could lead to society being ‘locked in’ to ongoing fossil fuel use. This is not morally objectionable unless one believes that continued use of coal and gas is intrinsically bad; however Ha-Duong and Loisel (2011) suggest several hundred fatalities per year should be expected if CCS is deployed at large scale, mostly from (a) having to do more inherently dangerous coal

mining to fuel new CCS power stations and (b) transporting this coal by ship or train to the power stations. Environmental injustice claims have also been raised against some corporations involved in extractive industries (Boele et al., 2001). Intergenerational justice challenges too may arise from storing CO₂ over thousands of years. The difficulty of gauging values and preferences of future generations, and in conceptualising the fairness of putting future generations at risk of exposure to negative effects from climate change, are well covered in climate change ethics (Gardiner, 2006; Jamieson, 2010). Similar questions may thus be asked about the fairness of leaving future generations with a large quantity of sequestered CO₂ when uncertainty still exists over the level of maintenance (in terms of both costs and skills involved) this CO₂ could need in the very long term (Evar, 2014).

There are therefore several reasons why environmental ethicists might object to CCS deployment. However, if (a) deep and rapid cuts in anthropogenic CO₂ emissions are required to avert dangerous climate change, yet (b) global fossil fuel usage for energy is unlikely to radically decrease in the near future (Scott et al., 2013), then ethical claims against CCS may become somewhat less clear-cut. Preston's critical exploration of the presumptive argument against geoengineering in environmental ethics (2011) is thus a useful vehicle for evaluating the ethical challenges raised by CCS. Preston suggests two grounds on which the presumption in environmental ethics that geoengineering is inherently 'bad' may be open to scrutiny. One is the 'lesser of two evils' argument – that geoengineering could in certain contexts (such as severe warming posing a danger to humans and ecosystems) be seen as a serious attempt to make amends and lessen both human and non-human suffering. Preston's second linked argument is prioritisation of human well-being, a view that if refusing geoengineering would involve knowingly letting people die in order not to interfere with the earth's fundamental processes, then the obligations humans have to each other would likely trump values for natural processes.

Strands of both Preston's arguments appear in CCS debates. In the United Kingdom (UK), moderate environmental non-governmental organisations (NGOs) such as the World Wide Fund for Nature and the Royal Society for the Protection of Birds cautiously support CCS (Littlecott, 2012), acknowledging the continued short-term role of fossil fuels and viewing CCS as preferable to nuclear power. The position on CCS depends in part upon opposition to

nuclear – which in Britain is the only other reliable baseload low-carbon energy source available at present. In the UK context at least, the ‘lesser evil’ argument comes through here, for whilst many NGOs oppose fossil fuels in principle because of the adverse impacts on landscapes and communities, they accept carefully-managed carbon capture can provide a realistic non-nuclear trajectory away from fossil fuels.¹ Similarly, debates continue over the effects on near-term consumer energy prices of a rapid introduction of renewable energy (Timilsina et al., 2013), which has potential to magnify issues of fuel poverty. Given the profound effects of rising energy costs on less economically advantaged sections of society (Ekins and Lockwood, 2011), managed use of fossil fuels with CCS could be seen as prioritising human well-being if it helps to mitigate fuel poverty.

There is thus potential for a range of perspectives on whether CCS is ethically ‘good’ or ‘bad’. Exploration of these competing viewpoints is a useful exercise in understanding how to negotiate the more ethically challenging dilemmas we may face as demanding low-carbon targets are implemented or as energy security concerns intensify, yet it is only relatively recently that CCS-specific literature has explicitly addressed values and ethics. Brown (2011) and Medvecky et al. (2013) survey the ethical landscapes of geological CO₂ storage and CCS respectively. De Groot and Steg (2011) and McLaren (2012) explore potential for claims to injustice in CCS implementation. Gough and Boucher (2013) make one of the first attempts to map out the real-world ethical landscape of CCS, analysing statements on CO₂ storage released by a range of developers, governmental bodies and NGOs to identify areas of potential ethical conflict. Gough and Boucher identify ethical ‘faultlines’ (areas of potential or actual ethical contention) around environmental justice, preventing harm, techno-scientific competence and managerial and regulatory competence. We use these topics – justice, preventing harm and competence in CCS – as a point of departure.

We do not seek to judge whether CCS is ‘ethical’ or ‘unethical’. Rather, building on the rigorous work of Gough and Boucher (2013) and discussions in the wider low-carbon and

¹ We appreciate that in some other countries other alternatives – such as hydro-power in Norway – may be open to consideration; however the ‘clean fossil fuel’ or nuclear baseload dilemma seen in the UK is repeated in numerous other countries such as Germany, Poland and China.

geoengineering literatures, we seek to identify areas where ethical contestations or convergence around CCS may arise in an empirical case study. The aim is thus to explore the landscape of an ethically contentious decarbonisation debate, and to consider how members of society with different value positions may splinter or come together to support a particular course of practical action.

3. METHODOLOGY

This paper uses three related sets of data collected in Scotland, UK. First is the European Union (EU) ECO₂ project, a multidisciplinary study into effects of sub-seabed CO₂ storage on marine ecosystems. Twenty-three in-depth interviews were conducted in Scotland as part of comparative work on the social dimensions of CCS in Italy and the UK. Second is SiteChar, another EU project that characterises sites potentially suitable for CO₂ storage. For the social characterisation phase, fourteen members of the public (reduced to eleven for weekend two) were recruited to attend two weekend-long ‘focus conferences’, hearing presentations, taking part in group discussion and writing their own positioning paper on the desirability or otherwise of CCS and how it should be implemented in Scotland.

Transcripts of the group discussions, and the positioning paper itself, were analysed. Third is the QICS (Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage) project, part of which involved a controlled release of CO₂ into sediments below a rural marine bay in west Scotland over a 37 day period, simulating the effect of leaking CO₂ on marine ecosystems. The authors of this paper attended a public meeting and ‘open day’ held at the experiment site, observed publics’ responses to the project presentation and carried out follow-up interviews with local community members.

The target sample straddled what Shackley et al. (2007) term ‘tier 2’ (peripheral stakeholders such as environmental NGOs, local officials in areas with CCS potential) and ‘tier 3’ (the general public). This focus on peripheral stakeholders and informed publics was because we sought to understand how overarching ethical and moral concepts informed people’s perceptions of CCS. Previous research shows that those within the CCS epistemic community are less open to critical reflection on the technology due to institutional and personal commitments (Stephens et al., 2011), whereas low awareness makes general

public opinions on CCS unstable and subject to frequent change (de Best-Waldhober et al., 2009). Analysis of interview data and recorded discussion followed an adaptation of Doucet and Mauthner's (2008) 'Listening Guide', reading the transcript four times: once for the analyst's own responses; once for where the interviewee speaks about themselves; once for where the interviewee talks about relationships; and once for links to wider themes. This was done to try to avoid 'cherry picking' the most 'exciting' quotes by separating out the analyst's own reactions from the themes the interviewees raised themselves. Written output and notes from ethnographic observation were then evaluated in light of the topics emerging from the voice-centered analysis. The strongest emerging themes were fairness in engagement processes; urgent action versus longer-term thinking; and envisioning a sustainable, low-carbon future. We now discuss how these build on Gough and Boucher's (2013) faultlines of environmental justice, prevention of harm, and techno-scientific and regulatory competence.

4. ETHICAL POSITIONS ON CCS: THEMES FROM EMPIRICAL DATA

4.1 Justice in framing and solving the climate change problem

Gough and Boucher (2013) explore intergenerational, social, environmental and financial justice in CCS, suggesting particular potential for an ethical faultline along environmental justice (which they define as justice for animals and ecosystems). We however focus on faultlines along slightly different conceptualisations of justice: epistemic, procedural and distributional. The Scottish data revealed a range of views on whether CCS could be seen as a just response to climate change.

Distributional and procedural justice are well-rehearsed concepts in energy. Distributional justice refers to disparities in decision-making outcomes (Shrader-Frechette, 2002), whereas procedural justice is a concern about disparities in capability to participate effectively in decision-making processes (Rawls, 1973; McLaren, 2012). To the best of our knowledge, however, epistemic justice has not received such widespread attention in energy and climate change. Epistemic justice is a broader concern with justice in the way society interprets a significant phenomenon or tackles a complex question (Fricker, 2007).

Claims to epistemic injustice may arise if people feel they have been marginalised in the framing of a question because of their social identity, knowledge and access to accepted cognitive frameworks, or because they do not speak in the dominant language of decision-making (Anderson, 2012). On first inspection, this may sound like procedural justice. Where we see difference is in the way epistemic justice goes beyond the processes of decision-making alone to consider how the whole problem, and range of possible outcomes, are framed. Even if fair *procedures* are in place, claims to epistemic injustice may still arise if people feel marginalised in deciding what questions to ask in the first place, and in accessing the knowledge used to guide the field of questioning and possible outcomes.² We see epistemic justice as particularly important for energy and climate change because the huge uncertainties involved – and potential for profound effects on peoples’ lives – mean governance based on ‘hard science’ alone may struggle to encompass the range of concerns at play.

This notion of the range of potential solutions – and the kind of questions that can be asked – being pre-determined from on high arose in the SiteChar project. Whilst the proposals shown to the participants were indeed hypothetical, they contained considerable infrastructural and geological detail, and were presented by project developers and governments as being underway or imminent. This led some participants to question the value of their involvement:

Eva: For me it’s a genuine question, how likely is our report to make any tangible difference?

Sharon: At this stage especially. I was quite surprised when [the civil servant presenting] said it was, they’ve already been developing this policy for three years, so I’m thinking there’s this policy happening now, three years down the line, so I’m also concerned, sort of wondering, curious to know how much difference it will actually make. (Eva and Sharon,³ SiteChar weekend 2, April 2012).

² See Mabon et al. (forthcoming) for a fuller discussion of epistemic justice in energy.

³ All participant names referred to in this paper are pseudonyms.

And in several cases, feelings turned from curiosity and enthusiasm to despair or outright rage:

One of the very first things you says to us was this was all hypothetical, about the storage site that's out there, and you, we had hypothetical, that's what you said, it's all hypothetical. But where in theory the more we've came and done this and got more information from you, it's more than likely that out there will be a storage site out there considering that it seems to be quite far down the line of going ahead for it. (Billy, SiteChar weekend 2, April 2012).

Claims to epistemic injustice could arise from the way the engagement process is part of a bigger narrative in which the assumed end-point is CCS deployment – an end-point that people like Billy, Eva and Sharon feel they cannot influence. The publics taking part in this CCS 'consultation' have little sway over how the 'problem' of climate change is conceived and how the range of possible 'solutions' is framed. By the time publics are brought into engagement processes for CCS and other low-carbon technologies like it, many of the big decisions *appear* to have already been taken. A power station may have been chosen, rough pipeline routes determined and a site earmarked for geological storage. Billy's concern that he had no opportunity to influence this framing of the whole problem seems to chime with the epistemic justice concerns of Fricker and Anderson. In Eva and Sharon's discussion, there may be claims to both procedural and epistemic justice – procedural in that engagement is too late and too narrowly defined to give participants capability in decision-making, and epistemic in that some actors feel excluded from the process of defining CCS as a fitting solution to climate change.

It is important to note that not everyone participating in the citizens' conference felt so despondent. Many respondents, particularly in north-east Scotland, were satisfied that appropriate procedures were in place to deal with issues that could arise from CCS deployment. When asked about other activities in the North Sea, a representative of the

Scottish fishing community described the network of oil and gas companies likely to be responsible for offshore CO₂ storage thus:

[Fishers] have worked with them from the start, and there's very little conflict there now, there's a process where people are advised as to what's going on, there's a recognition of loss or damage to gear, that if that's easily proven then people are compensated for that immediately. (Callum, ECO₂ interview, October 2012)

The long relationship of cooperation between oil and gas companies and fishing communities is discussed very positively – the presence of a process for dialogue, lack of conflict and speed of compensation all suggest potential for claims to procedural injustice to arise is minimised. Contrast this to concerns over the proliferation of both on- and offshore wind development in the north-east, raised by a local councillor and retired fisher respectively when discussing energy:

Very controversial one particularly in Aberdeenshire is wind power, we had the, the concern we've had more applications for wind turbines in Aberdeenshire as a councilled area than all the other local authority areas across Scotland put together, and that's, it's a heated debate. (Peter, ECO₂ interview, October 2012)

There is a societal and political imperative for development of renewable energy, we accept it, but it's got to be, got to be remembered that we are an industry that has been operating in the marine environment for as long as human beings have been here and it doesn't quite chime that fishermen are getting pushed out of the way for new ideas where, with a bit of planning and cooperation both could co-exist. (Jimmy, ECO₂ interview, October 2012)

Both respondents acknowledged the reality of climate change and the need to renew energy

systems during their interviews, but were anxious about the rapid deployment of wind energy in their area. The implication from the councillor's comment seems to be that the area he represents is somehow being 'used' to provide renewable energy for the rest of Scotland, taking more than its fair share of new infrastructure. The concern about fisheries getting 'pushed out of the way' suggests potential for claims to procedural injustice, in that the respondent feels it is the lack of procedures for planning and cooperation that give rise to the potential for conflict rather than the mere presence of renewable energy infrastructure in the sea.

Even for renewable sources that seem more inherently 'good' than fossil fuels, there is thus still potential for claims to distributional, procedural or epistemic injustice to arise – even among people who acknowledge the need to decarbonise. Likewise, the data suggests that more ethically contentious outcomes like CCS *can* return economic and infrastructural benefits to host communities,⁴ and implement sound procedures to allow different stakeholders to co-exist. A possible avenue of enquiry for future research may be to see whether perceptions of procedural or epistemic fairness can translate into outright support for a technological option that at first glance seems less ethically clear-cut, and whether this could help facilitate rapid mitigation deployment.

4.2 Preventing harm: urgent action versus a more considered response?

Gough and Boucher identify a second ethical faultline over preventing harm. That is, taking into account the possibility of future leakage, does CCS on balance put society at a lesser or greater risk of negative effects than other courses of action? Underneath this, we believe there is an even deeper faultline along the question of whether deploying CCS now is necessary to stave off the most dangerous effects of climate change, or whether focusing on a short to medium-term technological fix could ultimately put society at an even greater risk of harm, by both delaying the transition away from a fossil fuel economy and introducing psychological implications.

⁴ Alistair, another interviewed councillor, did however point out that the economic benefits of oil and gas have not been felt evenly throughout north-east Scotland.

Gardiner (2006) argues not only that failure to act now increases the level of mitigation or adaptation required in future⁵ but also that inaction by current generations may reinforce a carbon intensive infrastructure and limit the potential of future generations to act. CCS is challenging in this regard. If one believes its proponents, CCS is relatively close to technical readiness for full-scale deployment and can deliver significant emission reductions in a relatively short time frame – thus reducing the burden on future generations to take action. Bioenergy CCS may (if developed) arguably reduce existing atmospheric CO₂ concentrations, extracting energy from biomass combustion while capturing and storing CO₂ fixed in plant matter by the conversion of atmospheric CO₂ during photosynthesis. Yet as Markusson et al. (2012) explain, climate change mitigation from conventional CCS could lead to society being ‘locked in’ to ongoing use of fossil fuels, reinforcing a carbon intensive infrastructure and limiting capacity of future generations to act outside of this infrastructure. Hammond et al (2013) even suggest that CCS is likely to deliver only a seventy per cent reduction in full-cycle CO₂ emissions under credible energy system scenarios.

This perpetuation of a fossil fuel energy system and economy was troubling for some. There was a sense that investment in the research and development of CCS technologies merely delayed the inevitable need to move away from a fossil fuel-based society, at worst diverting funding away from development of renewable energy. As a researcher with a policy background working closely with the QICS experiment explained when asked about his views on CCS more broadly:

[CCS is] something that society might well have to do but it’s a temporary fix while we try to turn the supertanker around ... Until we can wean ourselves off heavy use of fossil fuels then we’re going to have to do some clever fixes. It’s a sad situation really, because we’ve known about the effects of fossil fuels, climate change, for quite a long time and slightly more recently things like ocean acidification, and the response time is incredibly slow, and in fact what we’re looking now at are all sorts

⁵ We would suggest that ‘acting now’ may also include investing in research and development in the present so that solutions deployed in future may be cheaper and technically superior.

of schemes to accelerate the production of fossil fuels rather than sensible means of reducing it. (Brendan, ECO₂/QICS follow-up interview, October 2012)

Brendan does not oppose CCS outright, acknowledging its pragmatic value in buying time for larger systemic changes. Rather, the ethical concern is the potential for misappropriation of CCS, that the technology will be used to allow society to continue indefinitely on its current trajectory – perhaps even speeding up fossil fuel use – instead of facilitating more gradual technological and structural changes. The argument that knowledge about the negative effects of fossil fuels has existed for a long time is used to further emphasise how the uncritical adoption of technologies like CCS that continue fossil fuel use could be seen as morally irresponsible behaviour.

Another implication of Brendan's account is that, given society's less than impressive track record to date in being able to change course in response to climate change, there is little to suggest it should be any better from now on. Under this rationale, it may make sense to develop ways of limiting anthropogenic CO₂ emissions within existing infrastructure, particularly if the alternative is runaway climate change from continuing unabated fossil fuel use. This is the view encapsulated by environmental impact assessor Scott, who rationalises the need for CCS thus:

I think there is an end goal, particularly in Scotland and the western world of trying to move to renewables, but that's not going to happen any time soon, so to reduce the potential effects of global warming we need a sticking plaster or bridge to enable us to reach that destination, and to be able to do that in my opinion, in the relatively short term CCS is the only opportunity because we have the infrastructure and capability, technology and some of the knowledge to be able to do that. (Scott, ECO₂ interview, April 2012)

Scott's position is that the speed of development of renewable energy infrastructure is too slow to be able to mitigate the most dangerous effects of climate change. The use of words

like 'infrastructure' and 'technology' suggests that the kind of outcome Scott is aiming for is one where present social arrangements continue as much as possible, the ethical concern being that failing to deploy CCS would put society at greater risk of exposure to negative effects from either climate change or an inadequate and prematurely-deployed renewables network. Whilst facilitating a smooth transition to a renewed energy network within existing social structures was for some a suitable trajectory, others wondered about the future implications of CCS (and technology more generally) diverting attention away from the cumulative effects on humans' collective well-being:

How much damage are we doing to ourselves by internalising the knowledge that we are hiding CO₂ out of view? In the same way that buried personal emotional issues tend to resurface with upset (until acknowledged, processed and resolved); so burying rather than dealing with the cause of excessive CO₂ may be damaging to our collective psychological wellbeing.

This extract, from the positioning paper the Moray citizens produced on CCS (in Brunsting et al., 2012) implies that fitting extra technology onto existing fossil fuel power systems to capture the emissions, and subsequently injecting these emissions into the ground, could be seen as an acknowledgement of the failure of economically developed societies to curb their carbon dioxide emissions in the first instance. The concern is that this could leave a psychological legacy for current and future generations, passing on a risk of psychological malaise to future members of society as a result of failure to imagine more sustainable ways of living.

4.3 Are we competent enough to do CCS? Do we even need competence in CCS?

The third ethical dimension we consider relates to how CCS fits into differing visions of an appropriate low-carbon future. Gough and Boucher (2013) identify two separate faultlines along techno-scientific competence and managerial and regulatory competence, albeit both focused on whether there is sufficient knowledge for the effective, safe and reliable

operation of CCS (and what happens if there is not). For our purposes we take this notion of ‘competence’ as one entity, as many participants in our study questioned whether society even *needs* competence in CCS in the first place. What we are getting at here is that there are multiple visions of what a sustainable low-carbon future might look like and what society needs to do to get there, with CCS fitting well into some but certainly not into all of these. Indeed, Gough and Boucher suggest further enquiry is needed into how CCS relates to human values and ideas of ‘appropriate’ progress for society.

The tightly-bounded rationale for CCS when it is communicated to publics, stakeholders and opinion-formers is challenging. As outlined in Section 1, this is often a linear narrative of CCS as the only way to reduce CO₂ emissions in the time-frame available, due to the relative immaturity of renewables and the requirement for a baseload energy source (GCCSI, 2014; IEAGHG, 2014). Typically, the narrative then goes on to dispel a range of ‘myths’, ensuring people are aware that CO₂ cannot explode, that stored CO₂ is very unlikely to leak, that the risk to human health is virtually non-existent. Proponents of CCS often argue that, if publics can come to ‘accept’ this rationale via good communication, then support for deployment can be garnered (CSIRO, 2010).

Wynne (2006) is critical of over-emphasis on communication in science, arguing that this misses the point that publics may evaluate technologies in terms of values, morals and ethics. Douglas (1992) likewise suggests that what people actually weigh up are contesting notions of the ‘good life’ rather than the minutiae of risk assessment. Indeed, in our study CCS was often evaluated not in terms of potential to reduce emissions, but rather how it connected with the wider values and principles of a sustainable future society. Proving that CCS is safe and viable may thus do little to engender support among people whose vision of the future lies outwith the parameters of the CCS rationale – such people may see no need for competence in CCS. For instance, technology like CCS that keeps society on a trajectory of reliance on large-scale infrastructure was perceived by some as a missed opportunity for more profound societal change. As a farmer in Argyll reflected when moving from CCS to discuss the role of energy in society more widely:

Meat, we produce huge amounts of it, but it goes elsewhere, we don’t eat it,

somebody else down south eats it ... Energy's the same, you know, why are we not doing little domestic things, how do they really work, why don't they, you know? We keep looking and wind, wind and solar and what have you, yes there's the big stuff, but so many other countries they do little, tiny setups, but every time you talk to anyone, oh they don't work, well why would people, other people keep using them if they didn't work? (Gail, ECO₂/QICS follow-up interview, October 2012)

For Gail, what comes to the fore is not climate change mitigation but the longer-term sustainability of a rural community, which large-scale technological solutions conceived within existing governance structures alone are unlikely to attain. Gail presents the challenge of reflecting on the inefficiency of processes embedded in current social organisation, here food logistics and centralised energy networks, and using this opportunity to imagine more sustainable ways of doing things. It is not techno-scientific competence that is required to reach the kind of future society Gail envisions, but competence in imagining new ways of living and governing. There are here clear parallels to Weston's (2009) challenge to imagine possibilities for different kinds of social organisation that may lie outwith the constraints of existing social structures.

Even accounts that were more focused on the nearer-term effects of climate change reflected on the kind of society that would be produced as a result of mitigation or adaptation measures. When asked how decision-making processes could be improved, a conservation officer for a major British NGO raised the possibility of wildlife or ecosystems suffering negative effects from humans' narrow attempts to control CO₂ levels by deploying widespread low-carbon energy:

Marine renewables again, you know, very welcome as a response to the problem of climate change, but ... this can obviously have a nature conservation impact, but those impacts are not very well characterised because it's an emerging industry, which I guess would be the same thing with carbon capture under the seabed. (Simon, ECO₂ interview, July 2011)

This links to the possible psychological effects of the geological storage of carbon dioxide raised in Section 4.2. Whilst CCS may be an effective way to keep CO₂ levels in check, concern was expressed by some that focusing too narrowly on meeting targets may lead to side-effects that could reduce quality of life in other ways. Loss of biodiversity is presented here as exactly one such potential side-effect, illustrating how, for many stakeholders and informed publics, CO₂ emission reduction was just one factor among many to be considered as part of their imagination of a sustainable, low-carbon future. CCS may thus not be viewed as a proper or appropriate technology if it is perceived to have potential disruptive effects on the wider natural environment.

A final question is whether CO₂ storage/disposal could even be seen as not making full use of society's competences in technological innovation. Some participants suggested CO₂ was a potentially valuable resource that ought not to be thrown away. In the SiteChar citizens' conference, one participant in particular took a keen interest in alternative uses for carbon dioxide as opposed to mere storage (in Brunsting et al., 2012) and a technical consultant interviewed for the ECO₂ project objected right from the start to the very basic principle of CCS:

I actually think it's a waste of a resource, but that's because I'm technically aware that it's possible to do something with that carbon rather than inject it into the ground, there are possibly preferable technical options. So I, I very much view it from a technical point of view, but it seems to me to be a very, very, very expensive way of trying to continue to do an old-fashioned system. (Murray, ECO₂ interview, October 2012)

The idea of 'storage' as wasteful, and 'innovation' as a more appropriate trajectory, came across in a number of interactions. As can be seen through language like 'waste of a resource' and 'old-fashioned system', there is an associated sense in which CO₂ storage is somehow a lazy or less intrinsically good use of the captured material. In this regard,

competence in CO₂ capture is seen as part of the future, but there is also a view that society could do better than merely storing CO₂.

5. DISCUSSION AND CONCLUSIONS

A range of ethical and value positions emerged around CCS in Scotland, largely reflecting the faultlines of justice, prevention of harm and techno-social competence identified by Gough and Boucher (2013). In fact, the faultlines in the Scottish study ran even deeper to encompass how CCS did or did not fit into different visions of a low-carbon future. Publics and stakeholders to varying extents enacted Preston's (2011) critique of the moral presumption against geoengineering. A number of people in our sample did conceptualise CCS as a 'lesser evil'. This included not only those who might gain financially from ongoing fossil fuel use, but also others (councillors, fishers) who felt good relationships with oil and gas developers engendered trust in implementing bodies and reduced potential for conflict, and NGOs who accepted the need for a short-term baseload energy supply and viewed 'clean' coal and gas as preferable to nuclear power. Others cautiously acknowledged the embeddedness of fossil fuels in society and the pragmatic need to reduce emissions, but were concerned that CCS deployment could become an end in itself rather than a bridge to a non-fossil fuel future. This group included academics interested in historical processes of change and entrepreneurs viewing fossil fuels as finite. A third group perhaps saw CCS as the 'greater evil' – people with more environmentalist and/or egalitarian leanings who felt an imperative to imagine more harmonious relationships with nature outside of technological 'fixes' and meeting targets, and a minority who viewed CO₂ storage as somehow a failure of humans to think innovatively and put captured CO₂ to good use.

A breadth of positions also emerged along Preston's (2011) second argument: prioritising human well-being. Many who felt CCS did prioritise well-being believed the transition to renewables is happening too slowly, hence several decades of controlled fossil fuel energy are needed to reduce risks to society from unabated climate change or volatile energy prices and supplies. In north-east Scotland at least, CCS could also be perceived as having low potential for claims of injustice, given the long and largely positive relationship with the hydrocarbon industry that will be responsible for CO₂ storage. However, another coalition

warned against overstating the positive benefits of fossil fuels in Scotland, citing distributional injustices and exclusion from the bigger project of framing the climate change problem and its potential field of solutions. A third group, with strong environmentalist leanings and/or knowledge of the scientific uncertainties of CCS, objected to imposing financial, techno-scientific and psychological risks on future generations.

In this small-scale study, publics and stakeholders acknowledging the severity of climate change and the need for deep and urgent cuts in anthropogenic CO₂ emissions were often prepared to entertain the possibility of a solution that might seem less inherently 'good' than renewable energy. Actors with seemingly different world views had potential to coalesce around the idea of CCS as the next stopping point on the road to decarbonisation, even if their ultimate visions of a low-carbon future were very different. This suggests that ideas such as 'lesser evil' and the prioritisation of human well-being do inform decision-making around climate change mitigation. However, we caution that others felt excluded from the process of defining the 'problem' of climate change and the field of potential 'solutions'. Our sample also included nobody openly sceptical of anthropogenic climate change, so the question remains of how someone who did not buy in to the tightly-bounded rationale for CCS from the outset might engage with the technology.

We finish with two overarching observations. One concerns not underestimating the ability of members of society to tackle spatially, temporally and ethically complex issues. Carr et al. (2013) argue that publics are capable of engaging in complex social and ethical discussions on solar radiation management, even with minimal technical knowledge. Many respondents in the ECO₂ project spoke not of the ability of CCS to reduce emissions or ensure public safety, but of what they thought a fitting and appropriate vision of the future looked like. The discussion of the SiteChar participants on potential psychological impacts of 'hiding' CO₂ underground also demonstrates how public conceptions of social well-being under conditions of climate change can extend far beyond discussing 450 parts per million CO₂ in the atmosphere or 2°C warming.

Second is the need for broad-based rationales when addressing climate change. The case of CCS – where, for many long-term issues like CO₂ migration and induced seismicity, scientists are unable to provide unequivocal answers – exemplifies very well the centrality

of values to interpretations of the science underpinning environmental change. Communication of risks and probabilities alone may not be effective for those who do not engage with this scientific rationale, or whose world view leads them to evaluate uncertainties differently. In cases like this, the most fruitful course of action may be to allow open discussion over what leads different people to understand environmental science and technology differently, but all the time keeping a check on finding pathways which head in the common direction of mitigating environmental change.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the European Union Seventh Framework Programme [FP7/2007–2013] under grant agreement n° 265847: ECO₂ – Sub-seabed CO₂ Storage: Impact on Marine Ecosystems. Use of data from the EU FP7 SiteChar and NERC QICS projects was possible due to respective Memoranda of Understanding between ECO₂ and these projects, and we thank both for permission to use the material herein. Presentation of an earlier version of this paper at the Seventh International Conference on Applied Ethics in Sapporo, Japan was possible via an international travel grant from the UK CCS Research Centre and a bursary from the Center for Applied Ethics and Philosophy, Hokkaido University.

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