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It's the Society, Stupid!

Communicating Emergent Climate Technologies in the Internet Age

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Abstract Emergent or unproven technologies occupy a central role in post-Paris debates about climate change goals and their feasibility. New technologies have often faced major political and social challenges and the way they are communicated is changing as technical experts and scientists play a greater role in communicating directly online. We review the scope and key characteristics of communications on carbon dioxide capture and storage (CCS) technologies presenting data from a comprehensive survey of websites compiled to assess the state of global CCS communications. Our key empirical finding is that existing communications are techno-centric in their framing, overlooking economic, political and institutional aspects of CCS as a societal arrangement. We also find an overrepresentation of traditionally less trusted actors from business and government (resulting in a pro-CCS bias), rather than by independent academic researchers or NGOs. We offer some recommendations for how CCS and similarly emergent climate technologies might be better communicated in the age of the Internet, not just in terms of their technical features but also in terms of their societal impacts and the role they might play in a wider social and political context.

Keywords Emergent technologies, carbon capture and storage (CCS), climate change, public communications, epistemic community

JEL Classification M38, Q40, Q54, Q58

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Communicating Emergent Climate Technologies in the Internet Age

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1. Introduction

In the 2015 Paris climate agreement countries of the world agreed the target of limiting global temperature rises to 2°C – or preferably 1.5°C – above pre-industrial levels. This level of ambition has brought the issue of unproven or emergent technologies such as net negative emissions technologies (McLaren 2012; Fuss et al, 2014; Sanchez et al. 2015; Anderson, 2015) to the forefront of global climate politics. The IPCC Fifth Assessment Report (IPCC, 2014) place great emphasis on the need for net negative technologies to place the world on a trajectory towards 2°C, whereas for others the Paris agreement 'relies on emerging technologies that are barely proven, yet to be successfully commercialized, or downright illusory' (Martin 2015). New – or unfamiliar – technologies often face major social acceptance challenges and the history of energy technologies in particular is littered with controversies – 'fracking' and 'oilsands' being only two of the latest examples (Boudet et al, 2014; Axsen, 2014). Emergent technologies not only have to be accepted (or rejected) by key audiences, they also have to be constituted in the public mind: i.e. what matters is as much about *what kind of thing* technologies are deemed to be as it is about how or whether they actually work (Druckman and Bolsen 2011). Narrow focus on technical efficacy is therefore likely to be insufficient, especially if the aim is engagement rather than convincing an audience (Buhr and Wibeck 2014).

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At the same time, technical experts are often the ones who 'know' the technologies and find themselves doing the communicating, not just to decision-makers but also to sceptical publics and NGOs. But other bodies, including companies, governments and NGOs, also increasingly communicate to mass publics about new technological options via new online media. Most studies of communication of emergent technologies focus on either reception of messages or on communications via printed or electronic mass media.

A case that can illustrate the wider question of how publics are being introduced to emergent technologies is carbon dioxide capture and storage (CCS), an arrangement whereby CO_2 is captured at large point sources such as fossil fuel fired power stations and then transported to geological storage sites (Reiner, 2016). Indeed, the most commonly cited net negative emissions technology is BECCS or biomass energy with carbon capture and storage. For the purposes of our discussion, however, we focus more broadly on CCS since far more work has been done (both technically and in terms of communications) on CCS than on BECCS, which is still largely at the conceptual stage.

For the past decade, CCS has been touted by international institutions and national governments as having an important role to play in achieving greenhouse gas emissions reduction efforts at least cost (IPCC, 2005; IPCC 2014; IEA 2009; IEA 2013; DOE 2010, HM Government 2010). The IEA declared: "Given current trends of increasing global energy sector carbon dioxide (CO2) emissions […] the urgency of CCS deployment is only increasing" (IEA, 2013: 5). However, CCS remains relatively unknown amongst national publics (Reiner et al., 2006; Ashworth et al., 2007; de Best-Waldhober et al., 2009; Eurobarometer, 2011). Moreover, there is also a strong link between CCS and the saliency of climate policy and the need for action (Ashworth et al, 2015). With CCS not yet operating on a commercial basis, the images and presentation of CCS – more than actual CCS infrastructure or experiences with CCS – make up what CCS means to most people at the present time (Hammond and Shackley 2010; Reiner, 2015). Yet while there is a growing literature on the *reception* of CCS communications, which examines how CCS is viewed and understood, much less has been done on the 'supply side' (ter Mors et al, 2011; Ashworth et al, 2011; Upham and Roberts, 2011) apart from studies of

media coverage. How is CCS actually being communicated and by whom in the age of the Internet?

We review the scope and key characteristics of CCS communications, exploring systematic tendencies in the communication of a novel (or little known) technology. Presenting a global survey of web sources and non-web sources including books, articles, media reporting of CCS, educational materials and museum exhibits, we provide qualitative and quantitative analysis of who is communicating CCS electronically and how they are doing it. We find that CCS communications is strongly techno-centric, dominated by business and government actors (with limited coordination between these) who generally come over as 'optimistic' and pro-technology, while broader public questions about the economic and societal purposes and implications of adopting CCS are sidelined. Our recommendations for how CCS and similar emergent climate technologies might be communicated could be summed up as 'it's the society, stupid!': instead of focusing just on the technical features and feasibility of CCS, communications should tackle how the technology is perceived and how CCS, as a social arrangement, fits into or otherwise affects wider societal structures and values (Wibeck et al. 2015).

The remainder of our study is structured as follows: in section 2 we present our understanding of what communicating emergent technologies involves and then review the existing literature on CCS communications. Third, we present the methods used for the comprehensive review of public communications about CCS, and present the overall scope of the survey of global CCS materials. Fourth, the main findings are presented relating to how CCS is being communicated and framed and by whom. Finally, we discuss lessons to be learned for communicating emerging technologies – regardless of whether the message is intended to positive, neutral or negative – before concluding.

2. Communicating emergent technologies.

The 'deficit' theory of communications held that social conflict over technologies was down to ignorance of the science or technology in question (Nesbit 2009:41). Others have used a deficit theory to explain inaction on environmental issues (Eden 1996). However, this theory has been challenged, particularly in the politics and sociology

literature concerning social conflict over new technologies where the prevailing view has been that science, just like other areas of politics, depends on strategic framing and communication that engages with the values and perspectives of a target audience (Brossard and Lewenstein 2009). Studies beginning with Kempton (1991) have that found that the general public conceptualizes global climate change very differently from scientists and experts (Wibeck et al. 2015) and use a variety of heuristics or mental models to understand what is a complex problem (Bostrom et al 1994). On the question of climate change, therefore, the importance of 'framing' both the climate 'problem' and associated emergent technologies designed to tackle it are crucial (Hulme 2009; Nisbet 2009; Druckman and Bolsen 2011, Corry and Jørgensen 2015).

A key aspect of the framing of emergent technologies concerns what constitutes the boundary of the technology itself. At one extreme the techno-centric view holds that technologies are discrete devices that can be understood and evaluated independently from the socio-political context of their potential adoption or use. At the other end, a socio-centric view would posit that technologies do not exist or function in abstraction from particular societal contexts and must therefore be viewed as elements within a greater assemblage of other technologies, values, customs and economic and legal frameworks – practices (Latour 1987). The former focuses on the immediate physical or ideational elements of particular devices whereas the latter views technologies as patterns of networked interactions between materials, social actors and infrastructures whereby the exact boundaries of a technology are not necessarily obvious or apolitical (Klein and Kleinman 2002).

Beyond this, the role an emergent technology is envisaged to appropriately fulfill can be contested, leading to different justification strategies. Relatedly, the 'common sense' efficacy question of how well it performs a given function can be communicated in different ways. Often disagreement is assumed to be about efficacy – does something work? – when in fact more foundational disagreement about what the function of the technology is, and (as above) what the technology even consists of, lies at the root of the discord.

Table 1: Dimensions of emergent technology construction

Evaluative dimension	Efficacy	Function/justification	Constitution

Key question	Does it work?	What should it achieve?	What is it?

Although an emerging technology, CCS has already attracted controversy along all these parameters. In terms of function, some environmental groups see it as a tool for achieving a rapid decarbonization of the economy in a race to meet climate targets reaching into the foreseeable future (ENGO Network, 2013) particularly given its potential role in decarbonizing industry, while others view it as a shorter term 'bridge' from a fossil fuel energy system to a renewable future tackling the twin problems of climate change and rising energy costs (WWF-UK 2008, Lynas 2011). Opponents may view it as a way of protecting the interests of fossil fuel heavy industries while others may see it as a form of energy solution maintaining security of supply despite carbon limits. Disagreement even extends to whether CCS involves simply capture and storage technologies (and possibly transportation of pressurized carbon dioxide) or also the legal, economic, political and logistical infrastructures necessary to roll out CCS on a large scale (Corry and Riesch 2012).

In terms of evaluations, a sizeable but assertive minority views it negatively, as a dangerous distraction that they fear will either not work, will never be implemented or regulated effectively, or as something likely to divert precious funding away from other preferred solutions (Eurobarometer, 2011, Wong-Parodi et al., 2008, Corry and Riesch 2012). Even advocates commissioned by the Global CCS Institute have described CCS as having an 'image crisis' (Pragnell 2013), which has precipitated, at least in part, the failure of a number of projects (most notably in the Netherlands and Germany). Given the precarious state of CCS, communication and 'framing' of CCS is potentially critical to its future (Bäckstrand, Meadowcroft and Oppenheimer, 2011). From section 3.0 we examine how CCS has been communicated, considering all three dimensions of emergent technology construction (see Table 1).

So far, however, most academic focus has been firmly on receptions of CCS. Determinants of attitudes to CCS have been explored (Wong-Parodi et al. 2001) and some national and cross-national surveys have gauged emergent public opinion on the technology (Shackley and Evar 2009; de Best-Waldhober et al 2009)). Surveys of stakeholders have been done comparing NGO and different corporate groups' attitudes to CCS or investigating local community attitudes (Huijts et al. 2007,

Johnsson et al. 2010; Shackley et al, 2007). At the level of individuals, the impact of technical knowledge on perceptions of risks and benefits of CCS (Wallquist et al. 2010) and the impact of social factors on attitudes to CCS (Bradbury et al 2009) have been examined. All these in some way measure how the CCS message is being received by different groups.

The studies that do exist of the supply of information on environmental and energy technology policy questions have focused on media representations of climate change and associated politics (Weingart, Engels and Pansegrau, 2000; Boykoff and Boykoff, 2004; Carvalho and Burgess, 2005; Antilla 2005; Boykoff, 2008a) as well as on specific technologies such as biofuels (Sengers, Raven and van Venrooij 2010) or photovoltaics (Heras-Saizarbitoria, Cilleruelo, and Zamanillo, 2011). The vast majority of these studies have focused on media coverage (overwhelmingly print media, e.g Sampei and Aoyagi-Usui 2009) and the interaction between the mass media and various audiences (Boykoff 2008b) using a 'one-size-fits-all' approach rather than tailoring messages to offer an explanation of technical details and social and political context appropriate for different audiences (Kasperson et al, 1988; Pidgeon, Kasperson and Slovic 2003).

By contrast the internet has allowed for the possibility of narrowcasting and offering a level of technical detail that would be impossible in traditional outlets. This offers the opportunity for more direct engagement with 'audiences' (Web 2.0) but also favors specialists, who are focused on conveying the technical content, over science journalists (Brossard and Scheufele, 2013; Powell 2013). Such internet communications have not been systematically studied. Gavin and Marshall (2011) examine web and television media coverage in the two weeks surrounding the Copenhagen Climate Summit in December 2009 while Kirilenko and Stepchenkova (2014) analyze a year's worth of Twitter microblogging on climate change. However, this leaves a gap in analysis of how technologies are actually communicated to publics in the age of the Internet. Since the public does not generally have access to the peer-reviewed literature, aside from the media, online communications now offers one of the only ways to obtain more technical scientific information from independent or academic scientists who also enjoy higher levels of trust than the mass media (Lorenzoni, Nicholson-Cole, and Whitmarsh, 2007: 452)

In terms of communication of CCS in particular, similar to the issue of climate change and energy technologies in general, there have been a number of studies examining the coverage of CCS in the press or mass media (Asayama and Ishii, 2013; Boyd and Paveglio, 2012, Dowd et. al 2012, de Best-Waldhober et.al 2012, Boyd et.al 2012, Buhr and Hansson 2011, Feldpausch-Parker et al. 2011, Weiler et al 2012). One study that does shine the spotlight on the communicators rather than those being communicated to, found an emerging international community of CCS experts, a so-called 'epistemic community' promoting CCS (Stephens et al. 2011).[3] However, the epistemic community turns out to be defined as the authors of peer-reviewed journal articles and all presenters, co-authors, session chairs and conference committee members at recent specialist conferences on greenhouse gas control. In so doing, the study excludes CCS communications generated outside the scientific community. As such, it does not measure CCS *as projected into the global public sphere*. The study hypothesized that networks of specialists with a shared knowledge base and policy agenda and would be naturally inclined to play up benefits and downplay risks but was "unable to confirm or deny whether or not a bias of over-optimism exists within the CCS community" and called for "an improved understanding of whether and to what extent perspectives within the CCS community incorporate and address broader public concerns about the technology" (Stephens et al 2011: 389).

3. A survey of CCS communications

The global CCS communications for this study were first assembled over a period of a year during the high-water mark period of CCS communications (from July 2010 to August 2011) during which electronic CCS communications resources were collated in a database and then updated. CCS communications was defined operationally as any *deliberate attempt to convey technical, social, legal, economic issues directly or indirectly related to the capture and storage of* CO_2 *on a large scale to reduce greenhouse gas emissions*. Online sources provided the main focus of the survey. A total of 194 online sources of CCS communication were eventually included in the database chosen from a wider corpus of over 300 internet-based representations of

[3] On epistemic communities more generally, see Haas 1992 and Adler and Haas 1992.

CCS gathered from web search-engine searches, an earlier preliminary survey (Reiner 2008), and consultations with CCS stakeholders. Search engines were used using English, German and French keywords as well as in Scandinavian languages, targeting languages of some major (western) CCS nations. CCS communications materials were also sought out in a targeted fashion amongst CCS stakeholders and organizations associated with the Global CCS Institute. From there, a snowballing approach was used whereby the links and resources on one site provide additional links to other sites. This process was continued until no or few new sites were being identified.

Only websites judged to be covering CCS systematically in some way, i.e. from more than one angle or story, were included in the survey. Sites simply covering peripheral material, such as press releases simply mentioning CCS, were excluded on the grounds that 'CCS communications' implies a systematic and deliberate attempt at conveying a particular message or set of messages about CCS. Critically oriented sites were also included in the survey where such sites raised issues about CCS according to the above definition. These were often the ones focusing on the larger political and social context into which CCS might fit.

Beyond the database of CCS websites, CCS has also made its way into energy policy analysis, popular science books as well as policy manifestos, typically ones debating how to 'save the planet' (e.g. Goodall, 2010), or in plans to make the transition to a low carbon energy system (Smil, 2010). CCS is the sole subject of numerous books (e.g. Meadowcroft and Langhelle, 2010; Wilson and Gerard, 2007; Markusson, Shackley and Evar 2012) though usually aimed at narrower audiences, films and animations[4], as well as information CD-ROMs (e.g. US Government 2009). CCS was also found to have been presented in a small number of science and technology museums (London Science Museum, n.d.) and at festivals such as *SCI-FUN,* The Scottish Science and Technology Road Show, which features a working desk-top model of CCS processes and 'educational' on-line CCS games can also be found, e.g. on the website of The Science Alberta Foundation and at The Science Museum in London which has an 'Energy Ninjas' game that includes a section on CCS.

[4] E.g., the animated CCS movie produced by the Norwegian-funded BIGCCS International CCS Research Centre: http://www.youtube.com/watch?v=eTBnuU8BSew Accessed 29th January, 2016.

These non-web-based resources provided background information for the analysis but are not included in the statistics describing CCS communications websites presented later in this article because of their incommensurate nature and the difficulty of doing a more comprehensive study of such resources. Further, the internet remains the main avenue for the dissemination of web-based, as well as non-web-based, CCS communications (e.g. books that primarily exist in hard copy but have a web presence on, for example, Amazon or Google Books).

Each of the sites selected for inclusion in the database were coded according to key variables. In particular, the coding sought to determine:

- The types of institutions that are behind the communication of CCS (NGO, Corporate, Government or Research/education);
- The level of development of the website (highly, moderately, less developed sites and single papers);
- The languages in which CCS is communicated;
- The country of origin (or, in a number of cases, the origin was based in an international organization);
- How CCS is communicated:

a) in terms of engineering technologies (any combination of capture, transport and storage)
b) in terms of its place within economic structures and climate strategies (legal, economic, social, climate related issues);

- Whether, or to what extent, CCS is portrayed from a supportive, neutral or critical perspective;
- The ways CCS communication is fragmented or linked across institutions and sites;
- The forms of media being used (reports, video, animations, etc.);

A ‘highly-developed’ website was required to “communicate CCS in multiple ways and from multiple perspectives”, a ‘moderately–developed’ website covered CCS “from more than one perspective but not in a comprehensive way, usually as a part of a wider discussion of technologies or climate change”, while a ‘less-developed’

communication website provided only “rudimentary explanation of CCS, or of only part of the process, and used simple and non-systematic presentations” of the issues. Single page or idiosyncratic information on CCS was excluded unless it could be interpreted as engaging in a deliberate effort at CCS communication.

To gauge the balance between different evaluative stances to CCS, each site was independently classified by each author according to whether it was judged to be basically positive, neutral or critical in relation to CCS. The evaluative stance of a website was judged to be ‘positive’ if it was coded as trying to further the deployment of CCS, neutral sites did not take a position on CCS while ‘critical’ sites were classified as those “trying to question or discourage the deployment of CCS”.

To get an idea of the actors behind CCS communication, each site was also grouped according to whether it was predominantly run by researchers, governments, business or NGOs. This was usually straightforward to code although in a very few circumstances there were several types of organizations involved (for example, the Zero Emissions Platform (ZEP), which is a European Commission ‘technology platform’ that is dominated by industry, but which includes representation from NGOs and national governments.

Finally, information was also gathered on what kind of media the sites used including videos, animation, newsletters or other formats, as well as how an individual website linked to other sites or resources. We did not seek to evaluate the caliber of the resources developed although some clearly displayed high production values, whereas others were done in a more rudimentary or cursory fashion.

4. Results: Evaluating CCS communications

4.1. CCS communication is technology-centric

An in-built danger in policy areas where technical or specialist communities are the main advocates of an emerging technology is that communication about those potential solutions becomes overly technical to the detriment of a wider discussion over non-technical issues, such as how the technology will be paid for, what the consequences will be for other technologies and what risks will be borne by whom (Liverman 2008). Our survey found that CCS is communicated overwhelmingly in technical terms, with socio-economic aspects such as economics, legal and

regulatory questions each covered in under half of CCS communication sites. Social issues of acceptance and risk were covered even less.

Firstly, the technology is often presented as a device, de-contextualized from the society it would serve. Although the target audience is meant to include the wider public, there is significantly more information and communication directed at explaining technical issues associated with the process of CCS than societal questions. Virtually all websites surveyed (97%) explained one or several of the technical processes such as capture or storage of carbon dioxide. Socio-economic issues are mentioned much less regularly (Figure 1). While climate change is mentioned on 74% of CCS-communicating websites, the surrounding issues concerning why CCS *in particular* should or should not be an important solution to climate change are seldom covered. Direct comparisons of CCS to other climate technologies were found in only 26% of the websites (Figure 1), but most of these were brief and unsystematic comparisons, often presenting no economic comparisons or other quantifiable variables. The economics of CCS, legal issues and social issues are covered in CCS communicating websites 42%, 40% and 23% of the time respectively. Almost three-quarters (74%) of websites links CCS to global warming and explains its potential role in relation to this problem, but only 26% compare it to another global warming technology (and for the most part these comparisons were rudimentary).

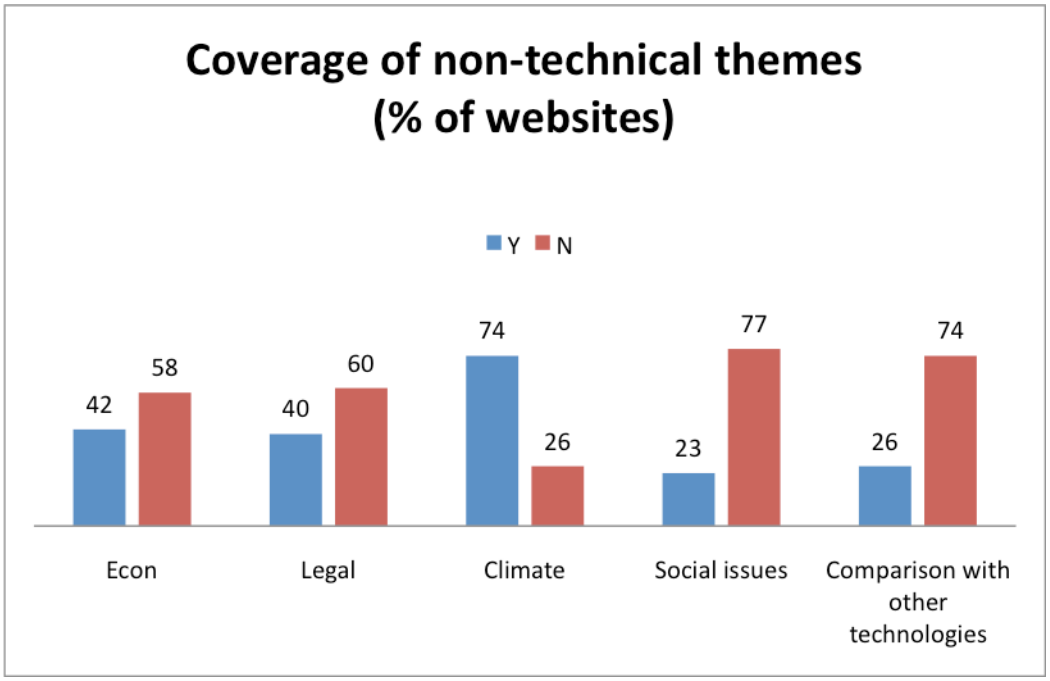

Figure 1: Explanations of socio-economic issues in CCS communication

Even when mentioned, socio-economic issues such as carbon prices and the economic viability of CCS, when discussed, are rarely covered in any depth. This minimalist treatment cannot be explained by the lack of authoritative figures on the economics of CCS. The International Energy Agency (IEA) has done extensive work on the subject, including a 'CCS road map' that concludes that "without CCS, overall costs to reduce emissions to 2005 levels by 2050 increase by 70%" (IEA, 2009: 4) and a follow up road map in 2013, which in spite of delays, still reached similar conclusions about the critical role of CCS in keeping costs down (IEA 2013). The IEA website is one of the most comprehensive statements on the economics of CCS and provides information on legal issues, a model regulatory framework, and cost analysis.

Other issues such as the probable effect of CCS on employment, exports for countries reaping first-mover benefits or effects on local environments are virtually invisible and remain in the shadow of engineering issues. When 'social issues' are registered this most commonly covers risks (or the minimization of risks) in relation to storage and perceptions of risk. Wider effects on communities, landscapes and social structures such as employment are rarely covered.

Explanations of necessary legal frameworks and how they are evolving is covered better (40%) than social issues, although again it is often unclear what remains to be

done and where liability and responsibility for monitoring storage sites in the long term is likely to lie.

Thus, how CCS on a large scale might be paid for, whether costs would be passed on to customers, raised via taxes and so on, is almost never touched upon in CCS communications. By contrast, CCS communications concerning engineering processes are often thorough and meticulous. Where other issues are mentioned, they often appear 'tacked on' to the technology, often in an unsystematic and less well developed way. Websites predominantly dedicated to the social and economic aspects of CCS are restricted to a small handful of research teams such as the legal programme CCLP at University College London UCL, Carbon Capture Legal Programme, or research projects such as the EC-funded project nearCO2[5]. Websites exclusively dedicated to societal angles on CCS are practically non-existent. This reflects the dominance of a technical discourse in general and the prominence of the industry voice in CCS communications. CCS would involve a considerable additional layer of technological infrastructure that would need to be added to the energy system in fossil-fuel-dependent societies, but a more social definition of technology would include necessary social structures in the constitution of 'CCS'.

In a typical introduction to CCS the engineering components and systems are given far more attention than the social, economic, political, legal and environmental aspects. Figure 2 provides a graphic representation of this techno-centric approach (unusually a 'community' is pictured, albeit a very small one).

[5] nearCO2 project website (FP7 project): http://www.communicationnearco2.eu/ Accessed 29th January, 2016.

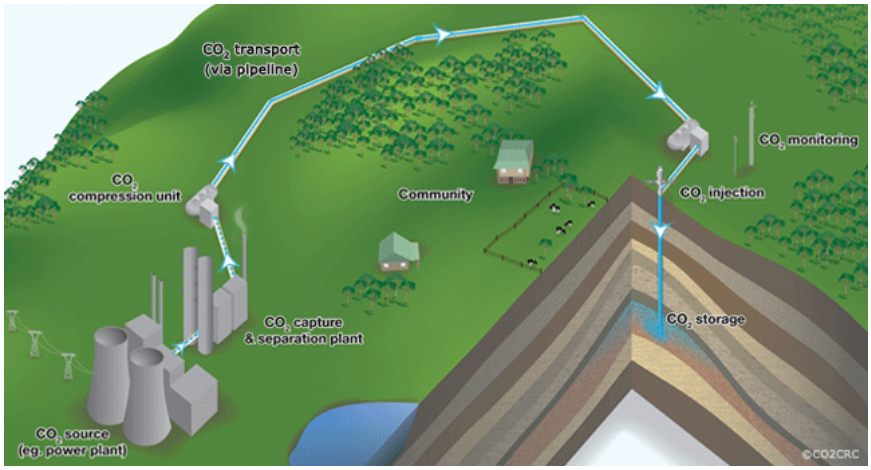

Figure 2: A typical introductory image of what CCS is, taken from The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) website

At the same time, some aspects of the technological devices are communicated more than others. While some sites do present only one process such as CO_2 storage, over half of the websites surveyed presented material on 'all three' engineering processes of capture, transport and storage together (Figure 3). Of the sites concentrating on only one distinct process, storage of CO_2 was most often the sole subject of a communication effort although a few websites were dedicated to the process of capture alone.

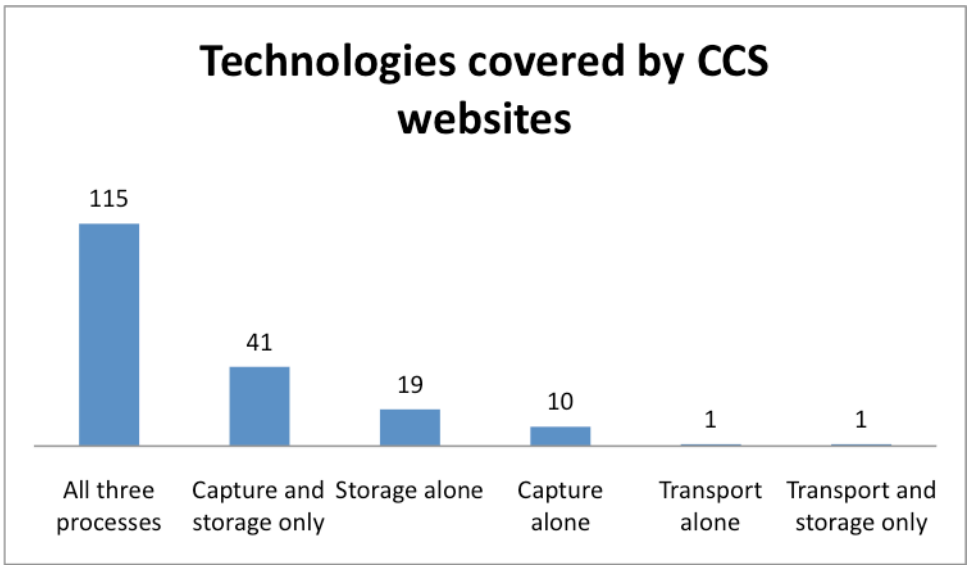

Figure 3: CCS is mostly seen as a combination of capture, transport and storage. Transport is the least visible process.

In contrast, transport is the CCS process given the least amount of attention, either in the context of specialized websites, or relative to capture and storage when the entire CCS chain is being presented. As described by one blogger "(t)ransport is often perceived as the forgotten cousin in the CCS chain (it doesn't even warrant a letter in the acronym). Unlike capture and storage, CO_2 pipelines are considered a 'proven' and commercialized technology" (Hegan, 2011, see also Global CCS Institute, 2011). 28 sites included in the database left out transportation entirely while concentrating on capture and storage. None communicated only transportation of CO_2. Possibly the only working portable model of CCS, the Scottish Science and Technology Road Show Desktop CCS Model, leaves out transportation (presumably for practical reasons).[6]

This omission may reflect the view that transportation is a familiar and generic process as a result of the analogous transport of natural gas via pipeline around the world and therefore needing little explanation compared to the less familiar processes of capturing CO_2 from flue gases or storing liquid CO_2 in underground sites. On the other hand, placement of transportation pipelines is a controversial issue and concerns around transportation could become more serious as and when CCS is implemented on a larger scale (Gough, O'Keefe and Mander, 2014). An earlier study found that on-shore transport and storage were the processes regarded with the greatest scepticism by the general public (Reiner et al 2010). These omissions reinforce the societal deconstextualisation prevalent in CCS communications.

4.2. Justifications for CCS

Apart from constituting the content and borders of a technology, communications of an emergent technology also have to establish what role it should play. Although a range of issues are mentioned on websites, climate change is by far the most common non-technology related issue described, covered in 74% of CCS communication websites. As described, views differ as to what role CCS would have in relation to climate change mitigation: a cost-effective form of decarbonization, a

[6] More information on the model can be found at SCI-FUN http://www.scifun.ed.ac.uk/

temporary ‘bridge’ to 100% renewables, or a distraction leading to a false sense of security and end in continued fossil fuel use (Stephens 2014). In addition, CCS is nearly always described as a technology applied to power production rather than other major point sources. Cement production, steelworks, chemicals and other large point sources of greenhouse gases in industry generally receive much less attention.

Furthermore, despite the general focus on technical details, the role of enhanced oil recovery (EOR) – when CO_2 is used to prolong the life of oil fields by increasing the recovery rate – did not originally feature prominently. Some otherwise very comprehensive pro-CCS communication websites such as ZEP made very few mentions of it, even excluding it completely from their leaflet “Capturing and Storing CO_2: The Hard Facts Behind CCS” (ZEP, n.d.). The Global CCS Institute’s presentation ‘What is CCS?’ did not mention EOR, although it is mentioned briefly in the associated fact sheet (Global CCS Institute, n.d.). The pro-CCS Bellona Foundation likewise did not mention EOR in its factsheet on storage of CCS (Bellona, n.d.) although EOR gets a mention in their factsheet ‘CO_2-capture and storage’ as a means of reducing overall costs (Bellona Foundation, n.d.).

Critics of CCS perhaps more readily pointed to EOR as a ‘negative’ because they claim it is counterproductive in relation to climate change mitigation. Others consider it a way of potentially making CCS more economically viable and hence a net benefit to cutting CO_2 emissions (POST, 2005, 3). Greenpeace claims that EOR sites are ultimately “too few and too geographically isolated to accommodate much of the CO_2 from widespread capture operations” (Rochon et al., 2008: 22).

More recently though, EOR and other technologies that use CO_2 have featured more prominently since some proponents of the technology, notably in the U.S. and China, have sought to emphasize the non-climate benefits. Many advocates have now opted for a revised term for the technologies as ‘carbon capture, utilization and storage’ or CCUS. For example, the large annual U.S.-based conference in Pittsburgh renamed itself as the annual CCUS conference in 2012 after ten years of having been the CCS conference (Greenwald, 2012). Concurrently, the former Assistant Secretary for Energy at the U.S. Department of Energy wrote prominently of “making the business case for CCUS technologies” (McConnell, 2012). The official Chinese description of carbon capture also referred exclusively to CCUS to emphasize the non-climate benefits of proceeding with NDRC, 2013). Prominent

industry groups ranging from the US Energy Association to the World Coal Association have relabeled their communications to focus on CCUS, often with detailed technical descriptions of the utilization options (e.g. Southwest Partnership 2012).

Technology is thus currently the main 'route in' to communicating CCS, with climate change as the near-sole source of legitimization. The reliance on climate change in making a case for the desirability/necessity of CCS means that other issues such as potential employment opportunities, or the wider implications of continuing fossil fuels (e.g. mining) that also cause concern regarding CCS, are neglected. Thus, the six-country FENCO-ERA project, found that "communication of CCS is also communication about the use of coal" (Ziogou et al., 2010:17), yet this is rarely reflected in deliberate CCS communications materials.

4.3. Communicator of CCS

Another potential danger of communities of experts doing the communicating is that, particularly with large-scale technologies, corporate and government actors inevitably play a large part. They are generally not trusted as much as researchers and NGOs and can, like all social groups, suffer from group-think tendencies (Toke 1999, Nader 2002). Environmental activists have been found to be particularly skeptical of such actors (Corry and Reiner 2013).

Our analysis of CCS communication websites backs up these hypotheses in so far as the largest identified group communicating CCS is the industry sector (34%), comprised primarily of energy sector firms or joint ventures across sectors sponsored by corporate actors. However, government (32%) and research institutions (21%) are not far behind in terms of total number of CCS websites. NGOs are the smallest of the four groups accounting for only 13%, even though this includes media organizations considered independent of business and government.

If other media such as books are taken into account, the government and industry dominance may be marginally weakened in favor of the research and campaigning communities.

The prevalence of government and industry sources is potentially a problem for the CCS message since these are among the least trusted sources of information

amongst members of the public, whereas independent or university researchers and ENGOs enjoy much higher levels of trust whereas companies are at or near the bottom of the trust scale for most of the public (Eurobarometer 2014: 46) and among environmentalists in particular (Corry and Reiner 2013).

4.4 Over-optimism in CCS communications?

Another feature of epistemic community communication is that it can suffer from a 'bias of over-optimism' (Stephens et al. 2011). CCS communications is dominated by promoters of CCS, with the vast majority were judged implicitly or explicitly to be supporting CCS. Over three-quarters (76%) of sites were coded as pro-CCS, 18% were deemed neutral and only 6% were viewed as critical. Furthermore, the most pro-CCS were also likely to be the most highly developed sites, compounding the pro-CCS effect further.

The large number of CCS-positive websites is, of course, to be expected, since communications are dominated by CCS-investing countries and stakeholders have an interest in furthering their own causes. For example, the World Coal Association site on CCS begins:

"Carbon capture and geological storage (CCS) technology is the only currently available technology that allows very deep cuts to be made in CO_2 emissions to atmosphere from fossil fuels at the scale needed" (World Coal Association 2016).

The relatively small number of neutral sites (18%) is perhaps more interesting, indicating that CCS communication appears to be in danger of polarization. Research institutions and news media make up a large proportion of the 'neutrals'. However, public research institutions such as SINTEF and GFZ German Research Centre for Geosciences or mixed public and private funded research consortia such as the Midwest Geological Sequestration Consortium (MGSC), although judged to be neutral, are almost exclusively technically oriented, reflecting their expertise in the technical domains of capture or storage rather than in economics, policy or risk analysis. The International Risk Governance Council is an exception to this rule as they focus heavily on risk analysis from a socio-political angle and aim to foster improvements in risk governance that will ultimately optimize risk-related decision-making and maximize public trust in governance processes and structures (IRGC,

2011). However, they concentrate on the risks associated with engineering aspects of CCS such as storage, rather than engaging in debates about socio-economic risks, for example about whether funding for CCS would crowd out funding for renewable technologies, or whether there would be a 'moral hazard' to developing CCS such that alternatives to fossil fuels were not pursued.

Given that corporations and governments are among the least trusted communicators, the fact that government and industry are by far the most keen to promote CCS (rather than give a neutral or critical account of it) should be a source of deep concern for its supporters. As Figure 4 shows, no industry- or government-led sites are critical (although one corporation, Mantra Energy Alternatives Ltd., views CCS as a competitor to its own focus on "utilization" and compares CCS unfavorably, Mantra Energy n.d.).

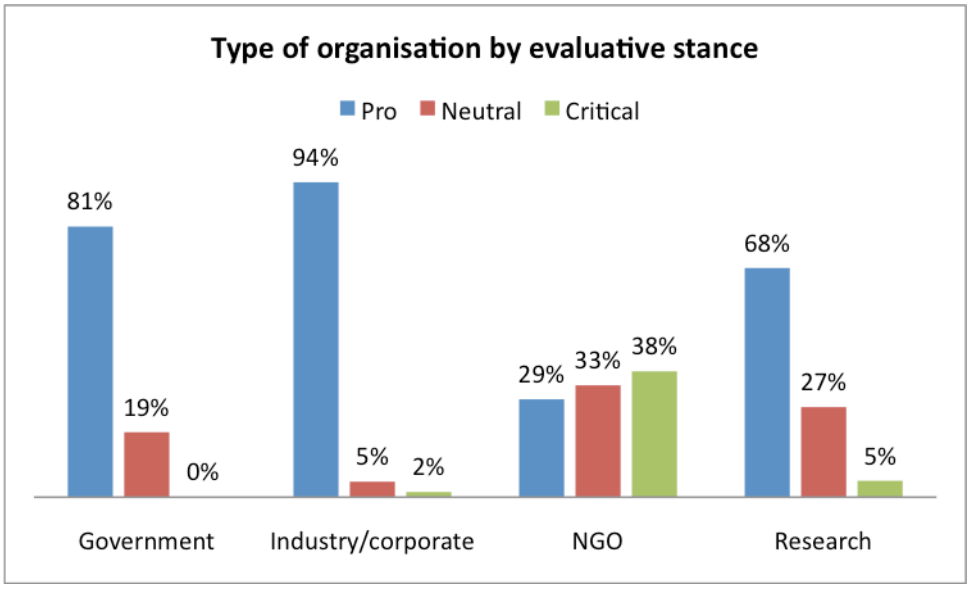

Figure 4: The least trusted communicators are also the ones most likely to be pro-CCS

Logically, governments and corporate actors have no obvious incentive to be critical about CCS, although governments are more likely to appear to be neutral. Research institutions appear to be the most balanced, which also presumably follows logically from their institutional identity as suppliers of objective information. About a quarter of government run sites were deemed neutral. Thus the US Department of Energy (DOE) communicates CO_2 sequestration in terms of its potential advantages but also recounts the probable costs and problems:

"The Clean Coal Program is addressing the key challenges that confront the wide-scale deployment of CCS technologies through research on cost-effective capture technologies; monitoring, verification, and accounting technologies to ensure permanent storage; permitting issues; liability issues; public outreach; and infrastructure needs" (USDOE, 2011).

Although balanced, such government websites usually, if anything, lean towards being pro-CCS and problems with the technology are presented as 'key challenges' to be overcome rather than genuine obstacles.

Perhaps more surprising is that a majority of NGOs are registered as either neutral or positive towards CCS. The largest and best-known environmental NGOs vary in their evaluative stance with Greenpeace generally critical, Bellona strongly positive and WWF and Friends of the Earth somewhere in between (see Anderson and Chiavari 2009, Corry and Riesch, 2012). Moreover, some international NGOs such as Friends of the Earth (FoE) have adopted different stances with regard to CCS from one country to the next. For example, FoE Denmark (NOAH) adopts a more overtly negative view of CCS than FoE in the UK or Germany, but this is a relatively unusual position.

There are also differences linked to substantive issues and technology. Even relatively pro-CCS NGOs are very sceptical of efforts to claim any benefits from making plants 'capture-ready', which is seen largely as a climate action delaying tactic. NGOs can also differ in their support from one project to the next depending on the technical details and the context. For example, WWF-Scotland was generally supportive of CCS proceeding at Longannet in Fife, which would have been a retrofit of an existing coal-fired power station, but strongly opposed a new build coal plant at Hunterston in Ayrshire (WWF-Scotland, 2010). Categorizations such as 'pro' and 'neutral' necessarily involve simplifications that conceal such differences, including in the financial and organizational independence of 'non-governmental' communicators. The overall characterisation of NGOs may, in part, be a question of database categorisation, since websites were coded as belonging to NGOs when they were judged to be "predominantly or functionally autonomous of industry and government", but this can be difficult to ascertain when 'NGOs' are rarely funded purely through small donations or membership. For example, *The CCS Education Initiative* (CCS Education 2016) appears at first sight to be an NGO or independent.

But on closer inspection it enjoys corporate funding (possibly from Hydrogen Energy, a joint venture between BP Alternative Energy and Rio Tinto).

Judging by the relationship between the overall evaluative stance of a website and its focus on different parts of the technology (Figure 5), most critical content seems to be associated with issues of storage. Those preoccupied with CO_2 capture alone tend to be less consistently critical than those preoccupied with storage such as Sinkswatch, BuryCoal and CorporateWatch. In crude terms, the optimists seem to focus on capture while the pessimists set their sights on the storage problem.

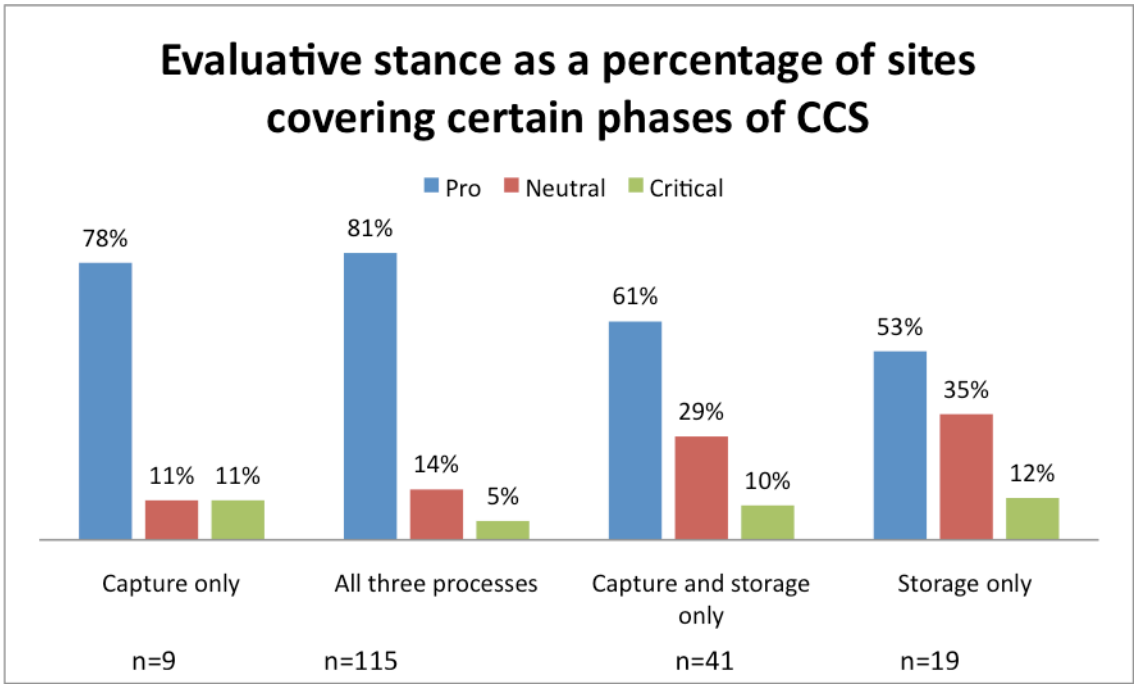

Figure 5: Communication of storage is the type of CCS communication most likely to be of a sceptical nature.

This raises the larger question of what animates opposition and support for CCS, a question which seems only partially to be worked into CCS communication efforts by those aiming to influence opinion.

Whereas the supportive or neutral sites are largely dedicated to explaining the basics of CCS technology, the critical sites often take a broader perspective and sometimes engage in humor, such as Greenpeace's various anti-coal campaigns, which are discussed in greater depth below in the section on multimedia.

Although there were numerous additions to the set of those providing information, there were also a few actors that disappeared. Since critical sites are often driven by opposition to a single project and some are created by smaller community groups with no dedicated funding to a wider communication effort, unlike established institutions, whether industry, government or mainstream NGOs. For example, one notable critical (and satirical) site that was put up by opponents of a proposed new coal-fired plant Kingsnorth in Kent, south of London was taken down after several years. One animation from the humorous "Ev-eon" website, http://www.ev-eon.com (now defunct), can still be found archived on YouTube (http://www.youtube.com/watch?v=K5lSgkmQWAg) but the rest of the content is now lost. Most of the websites that arose in opposition to the proposed CO_2 storage site in Barendrecht in the Netherlands have also disappeared.[7]

Media coverage potentially provides a balanced range of coverage – balanced both in terms of also taking non-technical angles and critical as well as positive stances. Ashworth and Quezada (2011) found that media coverage portrayed CCS in a positive, neutral and negative light in roughly equal measure. The media's CCS coverage also tends to link to multiple CCS projects and related sites, e.g. *The Guardian* newspaper website provides predominantly coverage of the politics of CCS, its financing, surrounding issues such as unconventional fossil fuels (e.g. shale gas and tar sands) as well as linking to technical explanations of what CCS is (The Guardian n.d.). Media coverage is often trusted (Eurobarometer 2014: 46) but typically not so technically focused. Ashworth and Quezada (2011) found that only 20% of media articles on CCS explain technical details of CCS instead concentrating on the costs and political choices associated with adopting it. TV coverage is typically more fleeting and more project-specific (perhaps because of a need for pictures and the ephemeral nature of the TV medium).

CCS communication websites generally do not to link to media sources despite them being a potentially valuable source of information and debate, perhaps as these are

[7] The main opposition sites, www.co2nederland.nl (from the group CO_2 NE(E)DERLANDS) and www.neetegenCO2.hyves.nl of the Nee Tegen CO_2 group and www.co2isnee.nl (different variants of "No to CO_2") are no longer available. By 2011, the archives of the CO2 is Nee Foundation had been transferred to the local Barendrecht archive: http://www.historischbarendrecht.nl/nieuwsbericht/co2isnee-archief-overgedragen.html Accessed 29th January, 2016.

not seen to be authoritative or scientific. This seems to be an underused resource by those wishing to communicate CCS and its related issues to a wider public.

Finally, diagrams and pictures are used, but in a very uniform, largely unimaginative, way. Many diagrams (and videos) about CCS follow the same template and even replicate the same graphic style, typically illustrating a power plant and a cross section of the Earth with CO_2 being pumped down into geological formations (see Figure 1).

5. Discussion

CCS is primarily communicated as an isolated technological device, with most emphasis on capture and storage of CO_2 from power stations. CCS is justified almost exclusively through references to mitigating climate change without serious efforts at comparison with other low-carbon policy options such as nuclear power or renewables. Reference to EOR and other ways of using the CO2 capture was at first largely avoided by embraced and then embraced, in both cases with minimal There has been minimal consideration of related issues such as employment, mining, resource constraints and unconventional fossil fuels such as shale gas. Many of these issues are, of course, ‘complicated’, but so too is the technical nature of capture and storage, so avoiding complication hardly seems an adequate justification for this neglect.

The most common providers of information are corporate and government sources in CCS-investing nations, which means, unsurprisingly that positive views of CCS dominate. By contrast, non-technical issues are not communicated systematically and a diverse set of sceptics or critics are the ones most committed to communicating CCS as a social arrangement rather than as a discrete technology. With the function narrowed to climate change mitigation and a techno-centric notion of CCS, the impetus is to evaluate efficacy in a narrow sense, without considering societal fit or socio-economic repercussions.

English remains the dominant language of communication and a technical, engineering-oriented focus is at the core of communications largely in terms of the science of CCS technologies. This bias would be unproblematic were it not that the

engineering is often presented with minimal context, without grasping the nettle of how CCS might (or might not) interact with the varied contexts of different energy systems, political systems and other factors that are critical to widespread deployment of CCS such as risks, carbon markets, local communities, and employment impacts. Even some technical issues such as transportation remain largely 'invisible'.

Further, most CCS communication appears remarkably similar in focus, style and tone. Many diagrams and videos about CCS follow the same template and replicate the same graphic style. The growing evidence base concerning how CCS is understood and how different communication strategies work on different target audiences is limited, but what does exist is not yet being harnessed. The one-size-fits-all approach leaves subgroups, regions, language communities, age groups and perhaps females largely un-catered for.

The consistency (or uniformity) in communicating CCS, on it own, as *capture, transportation and storage of CO_2 for the sake of the climate* can be seen as a problem in itself. Different target audiences need different messages, types and levels of information that are currently not available. A study has shown that the socio-political conditions for deploying CCS can differ greatly between national contexts (Wilson et al., 2011). CCS communication needs to develop further beyond a 'one-size-fits-all' model. It is difficult to escape the conclusion that the CCS community is similar to many other epistemic communities insofar as it communicates more effectively internally than externally.

Most corporate-run sites appear not to see it as part of their remit to communicate the logic of the technology more widely or link to other similar projects. The most trusted messengers such as research institutions, serious media outlets and international advocacy groups are the least represented in the dataset.

Educational materials for schools and in tertiary education remain a particularly serious gap in the CCS communication picture and the work of building a societal coalition for (or against) CCS is clearly only in its infancy in this respect.

Although the database of CCS communication is now established we still know too little about how CCS is being communicated in 'rising CCS powers' such as China,

India, Korea, Russia and Brazil and what materials exist (or should exist) in languages such as Mandarin, Hindi, Korean, Russian and Portuguese.

The economics of CCS and the debate about it needs to be documented and explained better, as do the many issues relating to regulatory frameworks, liability and employment. Just as there is a consensus of sorts about 'capture', 'transportation' and 'storage' and the contours of a concerted effort to explain this trio of engineering processes, so there needs to be a well-understood and communicable paradigm or 'narrative' for communicating socio-economic processes connected to CCS (Dahlstrom, 2014). An equivalent trio of 'planning', 'financing' and 'monitoring' could perhaps be envisaged, roughly corresponding to the political, economic and legal aspects of CCS that so far have remained underexposed. If this were communicated as consistently, systematically and graphically as CO_2 capture and CO_2 storage, the debate about CCS may assume a different nature.

Comparisons of CCS to other low-carbon strategies need to be done transparently and clearly communicated, recognizing that CCS is not being chosen or discarded in isolation from the wider debates about energy prices, business models, energy market and institutions, climate change governance and social priorities and values.

CCS communication needs to build more on a growing evidence base from research into how political actors and publics in diverse settings reach decisions about whether, or how, an emergent technology such as CCS should become a part of the energy-climate mix. Questions of how a particular technology fits into a given society or a desired future social constellation will strongly affect the criteria and outcome of subsequent evaluations.

6. Conclusions

Over the past five years, CCS has come under increasing pressure due to cost pressures and local public opposition (Reiner 2016). There would be many different effects from embarking upon a full-scale global programme of CCS in terms of how economies, societies and energy landscapes would look, and the debate about CCS could be framed in broader terms than simply 'reducing CO_2 emissions' (cost effectively). CCS is either a technology, a set of technologies or in broader terms an

arrangement involving a certain kind of society. Yet the job of communicating the debate about whether or how to get there appears to have only just begun. Given the stakes involved and the scale of the task to facilitate a genuine and well-informed public debate on the future of CCS, serious gaps still exist in terms of themes, languages, material for target audiences, teaching materials and new media. In particular, there is near-exclusive emphasis on communicating the *technical feasibility* of CCS, specifically the processes of capturing and storing CO_2. This focus on engineering processes is necessary but clearly not sufficient since CCS is situated within a wider debate about uncertainties, priorities, policy choices, alternative technologies and societal values. If enlightened debate and sound decisions about CCS are to be made, then this part of the equation needs to be communicated more effectively and systematically (see Ashworth et al. 2010).

Emergent technologies have to convince not only in terms of technical efficacy but also in terms of appropriateness (in relation to a wider social context) and most fundamentally in terms of what they even are as technologies. Communicating an emergent technology means not just transmitting knowledge of something pre-existing but constituting the technology in social terms. In practical terms this means that areas where more work is needed include: societal 'fit', issues of cost, comparison with other energy and climate technologies, legal frameworks and the concerns of key constituencies that CCS would need to address. These more critical stakeholders include environmentalists, lay-opinion shapers interested in the economic and legal aspects of CCS, and educational institutions involved in educating future generations of citizens, decision-makers, and scientists and engineers.

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