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Evaluating global Carbon Capture and Storage (CCS) communication materials: A survey of global CCS communications

A report for CSIRO

Work Package 1

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Executive summary

This report reviews the scope and key characteristics of carbon dioxide capture and storage (CCS) communications and primarily builds upon a comprehensive Global CCS Communications Database that was compiled for this project. We also draw upon investigations of non-web sources, including books, articles, media reporting of CCS, educational materials and museum exhibits, to provide as varied and comprehensive an overview as possible of CCS communication practices to date.

Drawing upon this comprehensive review, the key questions that we seek to answer are:

- What types of institutions are behind the communication of CCS?
- From which countries and in which languages CCS is communicated?
- How is CCS communicated in terms of the technology and stage of the process?
- Whether, or to what extent, is CCS portrayed from a supportive, neutral or critical perspective?
- To what extent CCS communication efforts are evidence-based?
- In what ways are CCS communications fragmented or coordinated across institutions and sites?
- Which forms of media are being used (reports, video, animations, etc.)?
- How is CCS taught in educational settings, if at all?
- How is CCS communicated in the context of existing and future economic structures and climate strategies?
- Where might further efforts be needed and how could CCS communication be developed?

When comparing the state of current CCS communications to those reviewed in Reiner (2008), CCS communications appear to be more extensive today, are somewhat better linked together and make greater use of a variety of media while also aiming for a wider and more varied audience. However, CCS communications remain in need of a greater diversity of languages, approaches and substantive focuses. Of course, at least some progress is to be expected insofar as three years have passed since the last such large-scale review and, if anything, the ambitions of governments and other leading institutions have grown steadily, as have commitments to funding CCS technologies and specific CCS projects (IEA, 2009).

In particular, CCS communication is found to be heavily oriented towards explaining the technological and engineering processes involved. Socio-economic questions about costs, burdens, policy alternatives and wider social implications all receive much less rigorous coverage. How developing CCS would affect other long-term problems apart from climate change, and how CCS compares to other options, requires greater attention and priority.

In short, communication concerning CCS and society is very much in the shadow of what CCS technology is and how it works.

The headline findings are:

1. *Overall, progress is slow and spotty but gradually building in scale and scope*. A mix of government, industry, NGO and research institutions now communicate CCS as an integrated technology, and links between different key sources of information on CCS are growing stronger. More sources are appearing and their content has been improved, but some, especially NGO and research sites can stagnate or disappear.
2. *The focus is still on how CCS works, rather than how it might be made to work.* Overall, there is significantly more information and communication effort going into explaining technical issues associated with the process of CCS rather than the economic, legal, social and political aspects.
3. *Transport is the 'invisible' technology*. Perhaps because of the much greater level of effort placed on capture and storage in research, transport has been relatively neglected in terms of communications; as significant potential exists for people to be impacted by the transportation of carbon dioxide, particularly where carbon dioxide (CO_2) storage is offshore.
4. *There is a heavy reliance on climate change as the sole rationale justifying CCS.* Comparisons to other low-carbon technologies are surprisingly rare and potential uses of CO_2 such as enhanced oil recovery (EOR) are often underplayed.
5. *A large majority of CCS communications material is overtly positive*. The most prevalent communications comes from less trusted sources such as business and governments which often are advocates. More trusted sites, such as research institutions, established media or NGOs, are less strongly positive, less exclusively technically oriented but much less common.
6. *Communications by research institutions are usually narrowly technical, but more critical sources tend to focus on a wider set of issues, especially social concerns.* Critical sources of information on CCS tend to be hosted by NGOs and media outlets with a greater focus on cost, burdens and social implications of CCS. Only a fraction of independent technical experts and research organisations develop communications materials aimed beyond narrow technical audiences.
7. *The Internet remains the main focus for CCS communication.* CCS is also the subject of full length books, animations/films, popular science exhibits and educational materials, but even many of these alternate routes have a web presence as well.
8. *English remains the primary language of CCS communication*. The bias arises in part because English is the scientific language but also because researchers and corporations based in English speaking countries are among those most engaged in CCS development. However, good German, Norwegian and French examples of CCS communication were also identified and more research is still required into the availability of information in non-Western (primarily Asian) languages.
9. *The 'one-size-fits-all' approach limits potential usefulness to many groups*. Different target audiences need different messages, types and levels of information that are currently not always available.
10. *Educational materials are being developed but only slowly.* The distribution of educational materials is very limited and gaps in educational age-groups remain. A few examples of pedagogical models of CCS and computer games made for CCS purposes have also been identified.

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Introduction

Carbon dioxide capture and storage (CCS) is a relatively recent arrival on the energy and climate policy scene. It received little attention in the first three assessment reports of the International Panel on Climate Change (IPCC) before publication of the Special Report on CCS (IPCC, 2005) in preparation for its Fourth Assessment Report and was viewed cautiously by the International Energy Agency (IEA) until well into the 2000s. CCS is now projected to play an important role in future global emissions reduction efforts (IEA, 2009), but CCS technologies remain a relatively unknown quantity amongst national publics and as well as in some policy circles (Reiner et al., 2006; Ashworth et al., 2007; de Best-Waldhober et al., 2008; Fischedick et al., 2008; Eurobarometer, 2011).

In general, people have indicated a basic awareness and appreciation of wind, solar power, hydro-electric power and nuclear power, having seen windmills in the countryside, solar panels on rooftops, waterfalls, or television footage of nuclear power stations with their ubiquitous cooling towers. By contrast, CCS remains for most members of the public, an obscure acronym or at best a series of perhaps unproven engineering processes involving capture, transportation and storage of CO_2.

The low levels of awareness should not be seen only as a problem: the situation presents an opportunity for anyone with an agenda for (or against) CCS to influence public views far more than would be possible on issues where opinions have already been formed. Views on its precise future role vary among researchers, between NGOs and across international policy arenas. Some see it as a tool for achieving a rapid decarbonisation of the economy in a race to meet climate targets reaching into the foreseeable future, others 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. A sizeable but assertive minority view 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).

For these reasons, CCS communications are likely to play a crucial part in determining what kind of role CCS eventually ends up playing in the energy and climate infrastructures currently being planned and built around the world. With CCS not yet operating on a commercial scale, CCS communications via media coverage, visits to science museums, and especially websites, make up a significant part of the 'CCS' that most people will experience. As Hammond and Shackley (2010) point out, 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. The importance therefore of questions about how CCS is being communicated becomes imperative, specifically, how such communication is, and may be, developing and where it might be enhanced and improved in the future.

The main reference point for this analysis is the overview of communications efforts conducted in early 2008 (Reiner, 2008). In this report, global communications materials on CCS are reviewed in a more comprehensive manner via database analysis and compared to the state of affairs in 2008. The earlier study was fairly critical of the state of CCS communications at the time and concluded that "the major communications efforts to the

general public on CCS technologies are (…) found to be lacking across all countries and initiatives surveyed, driven primarily by a lack of resources and coordination" (Reiner, 2008).

Before assessing how effective CCS communications is in educating and communicating CCS to its many publics, a more comprehensive treatment is needed to understand how CCS is presented and what are the styles, methods and sources of those communications materials. Drawing upon a comprehensive review of existing communications materials and the resulting database, the main objectives of the report are therefore:

1) To provide a comprehensive overview of global CCS communications materials, and
2) To compare findings with those of the earlier review to assess the direction and pace of developments in CCS communication.

In particular, the review seeks to determine:

- The types of institutions that are behind the communication of CCS;
- The languages in which CCS is communicated;
- How CCS is communicated:
  a) in terms of engineering technologies; and
  b) in terms of its place within economic structures and climate strategies;
- Whether, or to what extent, CCS is portrayed from a supportive, neutral or critical perspective;
- The extent to which CCS communication efforts are evidence-based;
- The ways CCS communication is fragmented or linked across institutions and sites;
- The forms of media being used (reports, video, animations, etc.);
- How CCS is taught in educational settings, if at all;
- Where further efforts might be needed and how CCS communication could be developed.

Overall, although still evolving in many areas, CCS communications appear now to be more extensive, target a moderately wider audience, are somewhat better linked, and make use of more diverse media formats to convey their messages. Key institutions such as the European Commission's Zero Emissions Platform (ZEP) are sourcing, producing and making information on CCS available worldwide, or are beginning to provide a platform for debates around CCS and its place in the energy-climate policy mix. One example of this, although for members only at this time, is the discussion site hosted by the Global CCS Institute (the Institute), which hosts a wiki-style 'OpenCCS' forum for sharing ideas, best practices and viewpoints.

However, 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.

Areas where more work is needed include: 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.

The remainder of the report is structured as follows: we first present the methods used for the review of public communications about CCS, and the overall scope of the survey of global CCS materials that underpin this report. Next, the issue of language and countries of origin is discussed. The content of CCS communications is then surveyed, asking what aspects of CCS are generally covered and how, and which are not. In Section 4, the sources of CCS communication are investigated. The various approaches to CCS communication are then assessed, including the direction and inclination of difference sources. Public opinion and communications is summarised in Section 6, followed by a review of some indicators of the integration and fragmentation of CCS communication, Information on the types of multimedia and education materials available relating to CCS (and to some extent the broader topic of 'clean coal') is presented in the last section. The conclusion draws upon the main findings and identifies where additional work and resources are needed to improve the usefulness and applicability of the communications. There are lessons to be learned regardless of whether the message is intended to positive, neutral or negative.

1. Methodology: Surveying CCS communications

The information sourced for this report was assembled over a period of a year (from mid-2010 to mid-2011) during which CCS communications resources were collated for a global CCS database. During the collection process, communications were coded and analysed to gain an overview of the key characteristics of and gaps in the information provided and the sources of that information.

Definition

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 for climate change purposes*. In this study, a total of 194 online sources of CCS communication were chosen from a wider corpus of over 300 internet-based representations of CCS. Only websites judged to be covering CCS systematically in some way, i.e. from more than one angle or perspective, were included in the survey. Sites simply covering one element of CCS or 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.

Those communicating CCS in order to promote the technology account for a large majority of CCS communication sources (see Figure 10). Critically oriented sites were also included in the survey where such sites raised issues about CCS according to the above definition, even

though many often lacked systematic CCS-specific information. More critically oriented sites 'communicate CCS', but not to promote it, which in part explains why they do not devote the resources to explaining the technology in detail. They often focus on the larger political and social context into which CCS fits. For example, the 'Bury Coal'[1] project covers primarily issues raised by unconventional fossil fuels such as oilsands ('tar' sands); but, also includes commentary on CCS and links to other articles about the technology expressing concern about a possible prolongation of fossil energy and the perceived negatives associated with it. CCS is thus treated sceptically but not rejected outright and any attempt to understand and evaluate CCS applying, to some degree, a systematic approach therefore falls within the selection criteria.

Sources

Understood in these terms, CCS is communicated in the public sphere in multiple ways including via websites, official reports from governments and international organisations, books, museums, schools and the media. In this report the main source of information has been internet websites. This reflects the thesis that the majority of individuals actively seeking information on CCS would appear to take a web-based approach, at least initially. Also, many non-web based sources also have web representation. While books tend to contain the most comprehensive examples of CCS communications, their reach is generally limited to specialist audiences and niches, compared to websites that are readily available globally. Search engines render most CCS communications readily accessible even using broad catch-all search strategies, although CCS communications materials were also sought out in a targeted fashion amongst CCS stakeholders and organisations officially associated with CCS organisations such as the Institute and using a snowballing approach whereby the links and resources on one site provide additional suggestions and links to many other sites.

Apart from the internet, other sources of information such as NGO publications, popular science books and video material were taken into account in the analysis and non-English sources have also been sought in certain languages including German, Scandinavian languages and French. Beyond the database of CCS websites providing the main basis of analysis in this report, CCS has now made its way into energy policy analysis, popular science books as well as policy manifestos 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. Rackley, 2009; Meadowcroft and Langhelle, 2010; Wilson and Gerard, 2007), films and animation as well as information CD-ROMs (e.g. almost 14,000 pages in US Government, 2009).

CCS has also been presented in a small number of science and technology museums (such as London's Science Museum[2]) and at festivals such as *SCI-FUN,* The Scottish Science and Technology Road Show, which features a working desk-top model of CCS processes (Figure 1) 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. CCS is now treated as a standard policy option in the organs of climate change governance such as the IPCC (2007) and the IEA, which declared it

[1] http://burycoal.com/blog/2010/02/15/carbon-capture-and-storage/

[2] http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/Exploringourfuturechoices/3point3/3point3point4.aspx

"an important part of the lowest cost greenhouse gas (GHG) mitigation portfolio" (IEA, 2009: 4).

Figure 1. Scottish Science and Technology Road Show Desktop CCS Model

Source: SCI-FUN http://www.scifun.ed.ac.uk/downloads/ccs/CCSI-side.jpg

Nonetheless, 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.com or Google Books). It is the preferred channel NGOs, research institutions, major firms and governments use to communicate and distribute information, whether the message is positive, neutral or negative.

Coding

Each of the sites selected for inclusion in the database drawn upon for the report were coded according to country of origin, language(s), the technological processes covered (any combination of capture, transportation and storage of CO_2) and any socio-economic aspects covered (legal, economic, role in relation to climate change, comparisons to other technologies). Each site was then classified depending upon its level of development: 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 communication. Of the 194 sites, some 20% were of limited scope while only just over a third were rated 'highly developed', covering CCS from multiple angles and in depth, while 4 percent are single paper sources [3] (Figure 2).

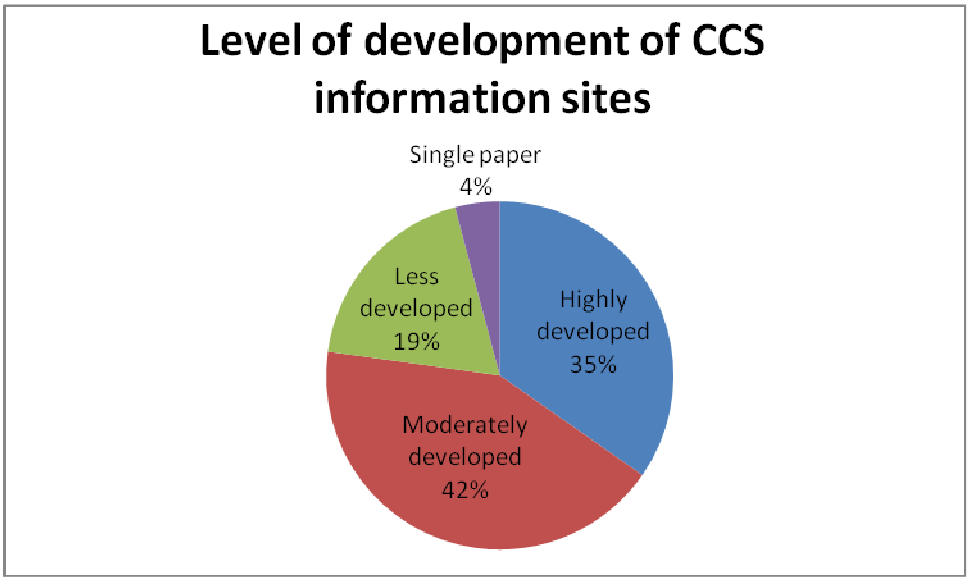

Figure 2: A large majority of the sites reviewed show at least moderate development

The evaluative stance of a website was judged to be 'pro' when it "explicitly or implicitly came across as trying to further CCS" while 'neutral' and 'critical' sites were classified accordingly.

[3] That 80% of the sites included are at least moderately developed should not be taken as a general expression of the maturity of CCS communications sites since the basis for selecting the sites is precisely that they sought to communicate CCS deliberately and from more than one angle. Many other sources of information on CCS, notably research papers or research groups working on CCS were excluded from the dataset in the first place if they did not seek to engage in communications.

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. To gauge the balance between different evaluative stances to CCS, each site was classified according to whether it was judged to be basically positive, neutral or critical in relation to CCS. Finally, information was also gathered on what kind of media the sites used including videos, animation, newsletter or links to other sites.

In analysing and evaluating the data, most of our effort focused on web-based CCS communications since this is the forum where people new to the subject or policy-makers looking for reliable information on CCS and its potential place in a future society are likely to look. A survey of environmentalists showed that over 80 percent used or would use internet sources for their information on CCS. However, other CCS communication sources are taken into account where relevant.

2. The language of CCS communications

The earlier survey of CCS communication concluded that virtually all public communications material related to CCS has been developed in English and that the first materials are only slowly being developed or translated into other key languages, with French cited as the "the only language besides English where it could be said that there exists a number of high-quality communication outlets" (Reiner, 2008).

The current survey showed that English is still by far the most dominant language on the internet[4] (see Figure 3), although a number of fairly comprehensive CCS communications websites now exist in German, French and Norwegian. Again, this roughly follows the languages of the countries working most on CCS. Books about CCS are overwhelmingly in English (although see Ha-Duong and Chaabane, 2010). The overall dominance of English in CCS communication is not surprising. English is of course the *lingua franca* of the scientific community (both in publications and scientific conferences) and the dominant language in international policy communities. In addition, many of the leading nations in terms of developing CCS are English-speaking (Australia, United States of America (USA), United Kingdom (UK), Canada).

[4] Internet searches were conducted in other languages but the conclusions must of course be seen in the light of the survey of global communications materials conducted primarily by English speakers.

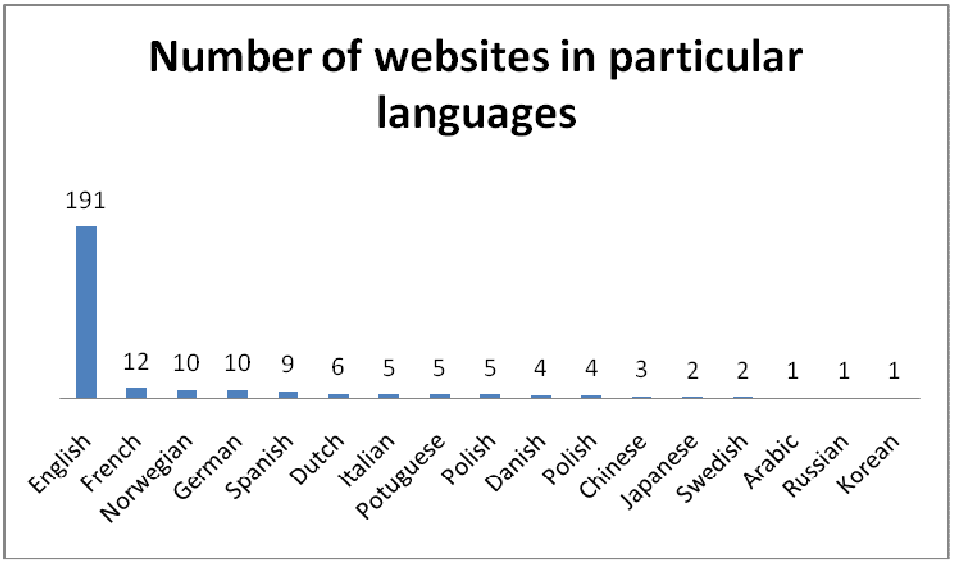

Figure 3: English is the lingua franca of CCS communications

The existence of high quality French-language CCS sites, despite the low share of fossil fuels in the French electric power sector relates to the significant oil and gas expertise in France (such as that of the French Petroleum Institute IFP[5] and the French Geological Survey, BRGM[6]) and most notably the French oil company Total's Lacq project[7], Europe's first full chain CCS demonstration project. The most comprehensive German site (and one of the most comprehensive in any language), provides reports, multimedia artefacts, conference proceedings, speeches and lectures, up-to-date databases on CCS projects worldwide and pedagogical materials on all stages of CCS, is still run by IZ Klima, a German information clearinghouse on CO_2 technologies[8]. The German Research Centre for Geosciences (GFZ) also has useful information in German on CCS[9]. Other German language material is mostly corporate (e.g. the German energy companies RWE[10] and E.on[11] have sections on CCS on their websites). For multiple European languages, there are explicitly multilingual sites such as those of the European Commission (which translates material as a matter of policy). Most sites, whether based in Germany, France, Japan, or China will be bilingual with at least a partial presentation in English. The survey itself was inevitably biased towards English, but audiences not proficient in English still appear to be at a distinct disadvantage. In particular, further research needs to be done into communications in non-Western, Indo-European languages, notably Chinese, Korean and Japanese.

[5] http://www.ifpenergiesnouvelles.com/developpement-industriel/co2
[6] http://www.brgm.fr/brgm/CO2/presentation.htm
[7] http://www.total.com/fr/dossiers/captage-et-stockage-geologique-de-co2/le-pilote-industriel-de-lacq-200816.html
[8] http://www.iz-klima.de/
[9] http://www.gfz-potsdam.de/portal/gfz/Struktur/GeoEngineering-Zentren/CO2-Speicherung (includes detailed information on technologies such as Oxyfuel combustion as well as underground coal gasification in both English and German)
[10] http://www.rwe.com/web/cms/de/2688/rwe/innovationen/stromerzeugung/clean-coal/
[11] http://www.eon.com/de/businessareas/35247.jsp

3. What is being communicated?

Overall, there is significantly more information and communication effort directed at explaining technical issues associated with the process of CCS although the target audience is not just fellow experts, but in many cases extends to the wider public or at least the interested publics. However, substantially less information is provided on the economic, legal, social and political aspects of CCS. CCS is many different things and can be approached in multiple ways. By definition CCS is a collective term for a number of discrete technical processes such as capture and storage. In addition, CCS as a policy tool is something that involves an existing energy system, e.g. coal fired power stations, and particular societal contexts involving economic, political and legal constraints and infrastructure such as carbon markets, liability legislation and government backing. Each communication of CCS involves a choice of what precisely to communicate, from flue gasses to carbon quotas to local planning laws and enhanced oil recovery (EOR).

Firstly, CCS is communicated, not necessarily in expert terms, but mainly as a unified technological system. Although CCS is a collection of distinct technologies such as CO_2 capture and injection into geological storage sites, it is often presented in terms of an integrated singular CCS process. Thus, over half of the websites surveyed presented material on all three engineering processes of capture, transport and storage together (Figure 4).

Secondly, some aspects of the technology are covered more than others. CCS applied to power generation infrastructure is by far the most common way of presenting CCS, possibly because energy sector actors are among the most active in developing CCS. Cement production, steelworks and other large point sources of greenhouse gasses in industry generally receive much less attention. Furthermore, transport is covered much less than capture and storage. 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. In contrast, transport is the CCS process given the least amount of attention, either in the context of specialised websites, or relative to capture and storage when the entire CCS chain is being presented. As described by one blogger on the Institute website: “Transport 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 commercialised technology” (Hegan, 2011, see also Global CCS Institute, 2011). Indeed, 28 sites included in the database left out transportation entirely while concentrating on capture and storage. None communicated only transportation of CO_2. This may reflect the view that transportation is a generic process familiar 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 process 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. An earlier study found that on-shore transport and storage were the processes regarded with greatest scepticism by the general public (Reiner et al 2010).

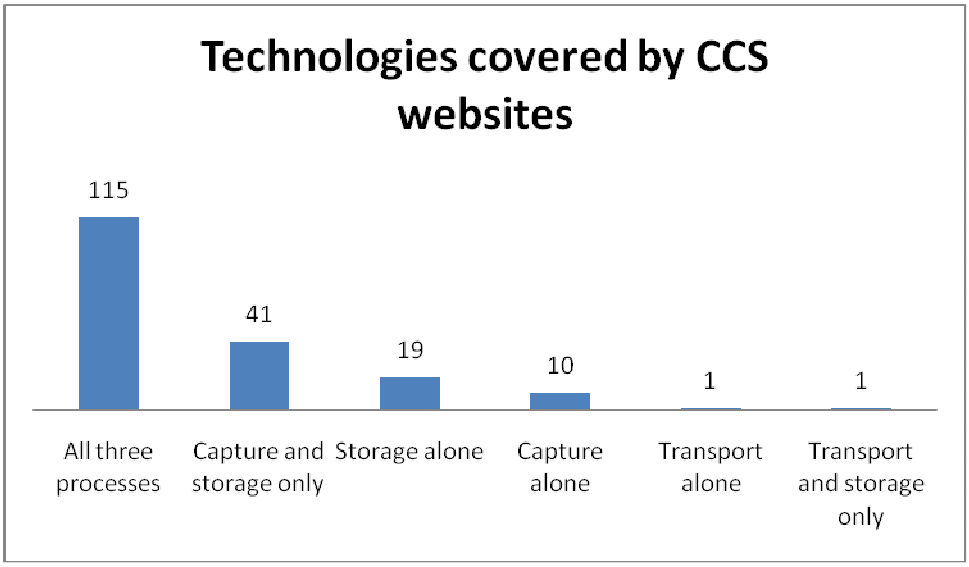

Figure 4: CCS is mostly seen as a combination of capture, transport and storage. Transport is the least visible process.

Although EOR – when CO_2 is used to prolong the life of oil fields by increasing the recovery of oil and gas – is mentioned in some CCS communications it does not tend to figure prominently. While energy companies such as Shell feature EOR in their flash animation "How does CCS work?"[12] Identifying CCS as an existing technology, some otherwise very comprehensive pro-CCS communication websites such as ZEP make few mentions of it, excluding it completely from their leaflet "Capturing and Storing CO_2: The Hard Facts Behind CCS" (ZEP, n.d.). The Institute's presentation 'What is CCS?' does not mention it, although it is mentioned briefly in their FAQs in terms of potential uses of CO_2[13]. The pro-CCS Bellona Foundation likewise does not mention EOR in its factsheet on storage of CCS[14] although EOR gets a mention in their factsheet 'CO_2-capture and storage'[15] as a means of reducing overall costs. The corporate sponsored Norwegian site www.zero.no presents EOR under 'storage'[16]. Critics of CCS point perhaps more readily 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).

Although the engineering side of CCS is given much more attention than the social, economic, political, legal and environmental aspects, socio-economic issues are frequently mentioned, including how CCS compares to and fits in with other competing or complementary technologies or impacts on local communities in terms of safety, risk, employment and overall economic costs and benefits. As mentioned, all the websites were

[12] http://www.shell.com/home/content/innovation/people_planet/ccs/ccs_how_does_it_work/
[13] http://www.globalccsinstitute.com/ccs/what-is-ccs
[14] http://bellona.org/filearchive/fil_Factsheet_CO2_storage_-_english_-_rev_9oct07.pdf
[15] http://bellona.org/filearchive/fil_Factsheet_CCS_-_rev_15Aug07.pdf
[16] http://www.zero.no/ccs/storage/co2-in-enhanced-oil-recovery

surveyed to ascertain whether any of these issues were covered in CCS communication. Although a range of issues are mentioned on many sites, the climate change problem is by far the most common (see Figure 5).

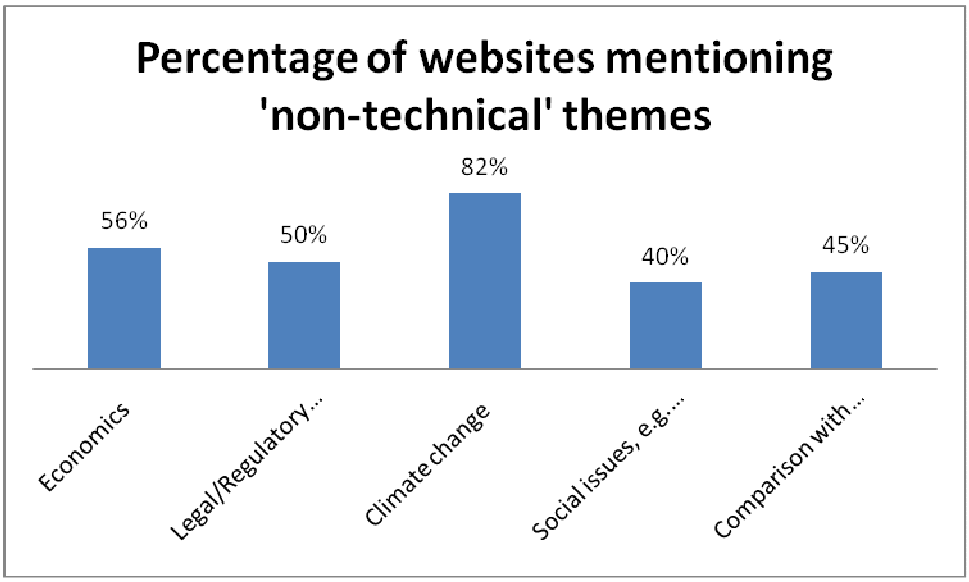

Figure 5: CCS is linked to socio-economic issues but most often superficially and most often to climate change

However, while other issues are mentioned in approximately half the websites, they almost invariably appear 'tacked on' to the technology, often in an unsystematic and less well developed way. If only one 'non-technical' issue is mentioned, it is most likely to be climate change. Economic, legal and social issues are rarely the sole feature next to capture, transport and storage (Figure 6).

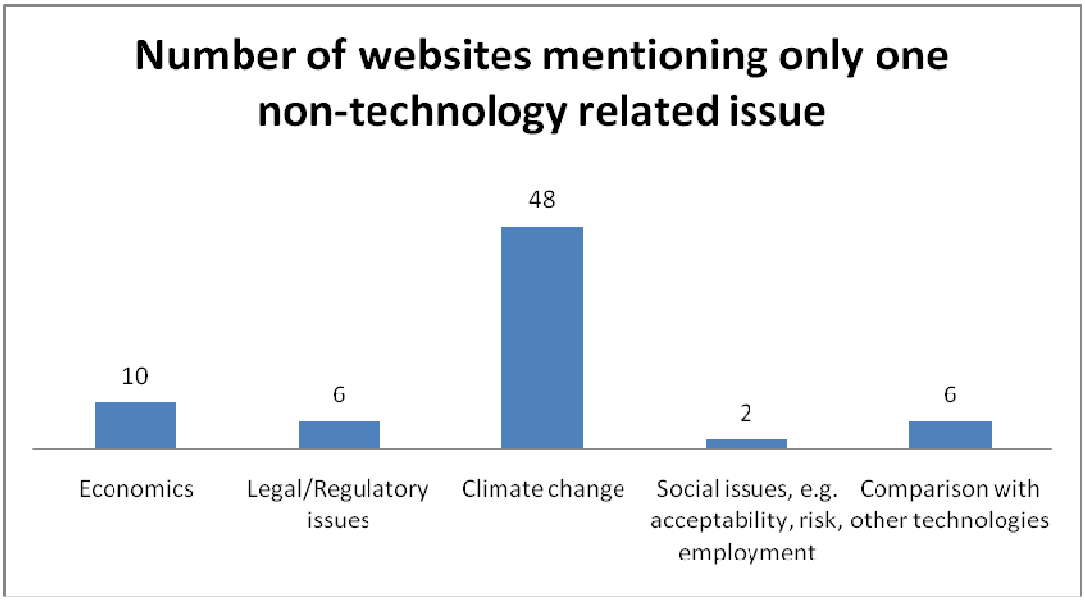

Figure 6: If only one non-technical issue is communicated, it is usually climate change.

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[17] or research projects such as the EC-funded projects ACCSEPT [18]and nearCO2[19]. Websites exclusively dedicated to societal angles on CCS seem unlikely to emerge in the current climate. This reflects the dominance of a technical discourse in general and the prominence of the industry voice in CCS communications (see Figure 7) but also the nature of the enterprise which is – or would be – a considerable additional system of technological infrastructure that would need to be added to the energy system in fossil fuel-dependent societies.

The other major focal point of explanation in CCS communications – besides the engineering of CCS – is that of anthropogenic global warming. In almost all cases, the case for (or against) CCS is made primarily in conjunction with the theme of climate change, reflecting the heavy reliance of CCS on references to climate change as its justifying rationale. CCS animations and videos almost invariably begin with a presentation of the problem of climate change, an explanation of the effect of greenhouse gasses and the high demand for cheap energy before presenting capture and storage techniques. Shell's film 'Carbon capture and storage: a bridge to a low-carbon future'[20] begins with alarming statements on climate change as an urgent and pressing issue. Climate change tends to be presented as a problem in different ways according to the critical stance of the website. CCS proponents thus present climate change in a way that pinpoints CO_2 emissions (rather than fossil fuels, for example) as 'the problem'.

By contrast, opponents tend to go further back in the causal chain to place responsibility on fossil fuels as such, or economic growth, or particular forms of ownership or energy-intensive lifestyles. Focussing on emissions tees up CCS as a solution that tackles 'CO_2 emissions' whereas focussing on the causes of emissions tends to make CCS look less helpful, 'perpetuating' fossil fuels or a particular structure of energy production, which are deemed to guarantee continued or growing emissions.

While climate change is mentioned on over 80% of CCS websites, the surrounding issues concerning why CCS *in particular* should or should not be the solution to climate change are seldom covered. Comparisons to other climate technologies were found in 43% of the websites, but this overstates its coverage significantly as the comparisons were brief, unsystematic and invariably incomplete. Socio-economic obstacles such as low carbon prices and the economic viability of CCS are rarely discussed in any real depth. The best known reference on this point is the IEA 'CCS road map' that concludes that "without CCS, overall costs to reduce emissions to 2005 levels by 2050 increase by 70%" (IEA, 2009: 4). 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[21], and cost analysis[22]. Other issues such as the probable effect of CCS on employment, exports for countries

[17] http://www.ucl.ac.uk/cclp/
[18] http://www.accsept.org
[19] http://www.communicationnearco2.eu/
[20] http://www.youtube.com/watch?v=cohgQZq-I1w
[21] http://www.iea.org/ccs/legal/model_framework.pdf
[22] http://www.iea.org/papers/2011/costperf_ccs_powergen.pdf

reaping first-mover benefits or effects on local environments – remain in the shadow of engineering issues and 'climate change-the problem' in an overwhelming majority of cases.

When 'social issues' are registered this most commonly covers risks (or the minimisation of risks) in relation to storage. Social acceptability and effects on communities, landscapes and social structures are rarely covered. Explanations of necessary legal frameworks and how they are evolving is covered better, 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. Other issues such as employment, when mentioned, are generally covered very summarily and cost-comparisons with other technologies are typically unsystematic. 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. In contrast, CCS communications concerning engineering processes are often thorough and meticulous.

Technology is thus currently the main 'route in' to communicating CCS, with climate change as the near-sole source of legitimisation. 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 the deliberate CCS communications.

4. Who is communicating CCS?

Analysis of CCS communication websites indicates that 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 (Figure 7). 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 organisations considered independent of business and government. Media outlets were not of a sufficient number (less than 5, in total) to provide meaningful statistics for an organisational category of their own and so were registered as non-governmental rather than as corporate, governmental or research: they have no direct commercial interest in CCS, no allegiance to state interests and do not claim to provide objective new knowledge. Obviously, this is a limitation and ideally, as the number of media outlets increases it would be worth separating them into a new category.

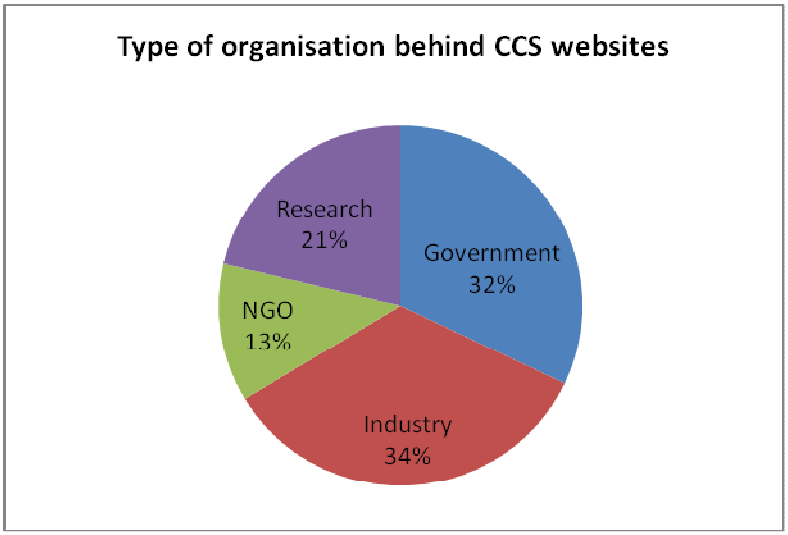

Figure 7: Corporations and governments are most active

In some cases such divisions are somewhat artificial since governments are often involved in corporate enterprises or joined in consortia. Research activities can be both publicly and privately funded and even NGOs are seldom completely free of stakeholder interests or informal connections with other sectors, also overlapping, particularly with research communities. Nonetheless, the self-understanding of a CCS communicator (e.g. as 'a company' or 'independent research institute') is not insignificant as it commits the actor in question to conform to certain practices and norms. Governments like to be seen to act in the public interest promoting 'solutions' and researchers and NGOs might feel bound to provide authoritative and independent information. On the other hand, 'research' and 'NGO' may possibly be over-estimated here if such organisations have business or government ties not generally known or publicised. If other media such as books are taken into account, the government and industry dominance may be marginally weakened in favour of the research and campaigning communities.

This lopsidedness towards government and industry sources is potentially a problem for the CCS message since they are among the least trusted sources of information amongst members of the public, whereas independent or university researchers and NGOs enjoy much higher levels of trust among populations and among environmentalists in particular (Pietzner et al., 2011, Corry and Reiner, 2011).

In terms of countries of origin, the UK, USA, Canada, Australia and websites run by international organisations (such as the European Union (EU) or International Energy Agency) or multinational corporations (such as Shell or BP) dominate heavily. Figure 8 shows which countries host CCS communication websites, whereas Figure 9 is a world map indicating current and planned CCS storage projects. 23 websites were hosted by international institutions or companies and 14 websites in the database (at the time of writing) are co-hosted by multiple countries (without being considered an international organisation as such). Countries involved in collaborative CCS communications were typically the same ones hosting CCS websites alone such as the UK, USA, Norway, Germany, Canada and Australia.

CCS thus appears to be a 'Western' technology and an Anglophone one too. However, more research is needed into debates about CCS in non-Western countries, particularly other oil, gas and coal producing countries such as Russia, India, China and Middle Eastern countries, since this pattern of 'doers' being 'talkers' may not always hold.

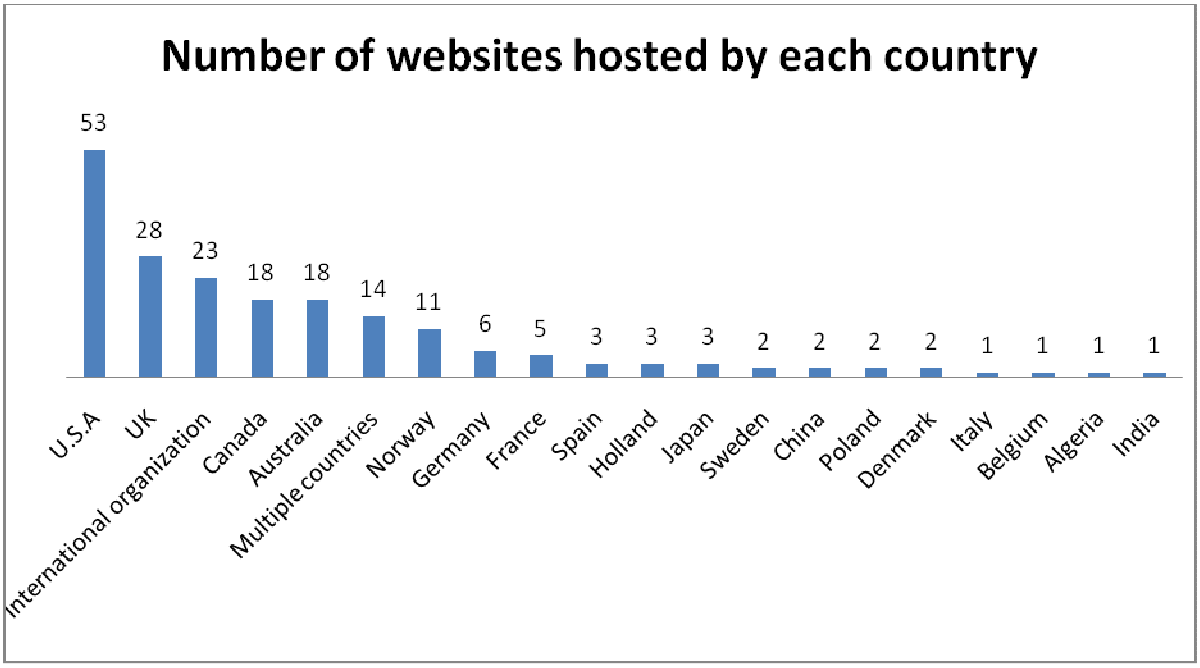

Figure 8: Number of websites hosted by each country

Green = sites currently injecting CO_2, yellow = planned sites, red = cancelled or completed injection sites.

Figure 9: Map of CCS storage projects worldwide.

Source: Scottish Centre for Carbon Storage (www.geos.ed.ac.uk/ccsmap)

5. Is CCS communications positive, neutral or critical?

CCS communications is dominated by promoters of CCS, but the persuasive effect of this is unclear and undocumented, at least in the public domain. Given that CCS communications is closely correlated to countries and organisations involved in developing CCS, it is little surprise that only a small proportion of CCS communications appear to be critically inclined and the vast majority were judged implicitly or explicitly to be promoters of CCS (as Figure 10 shows). Furthermore, the most pro-CCS were also likely to be the most highly developed sites, compounding the pro-CCS effect further.

However, it should be remembered that this large majority of pro-CCS sites does not necessarily say much about the aggregate communicative effect, which may or may not be dominated by the small number of critics. Thus, in the debate about media reporting of the science of anthropogenic global warming, research has shown that reports that feature just a single climate change sceptic have a disproportionately large impact on attitudes, making the participants in the study significantly less convinced of the reality of global warming, less likely to believe in the existence of a scientific consensus and less supportive of measures to counter rises in greenhouse gasses. The study concluded that, although no claims were made about the prevalence of such sceptical views, respondents generalised from a single sceptic to scientists more generally (Malka et al., 2009: 3). Whether this 'sceptic effect' holds for CCS – or whether there is a reverse 'optimist effect' – is open to debate (and further investigation).

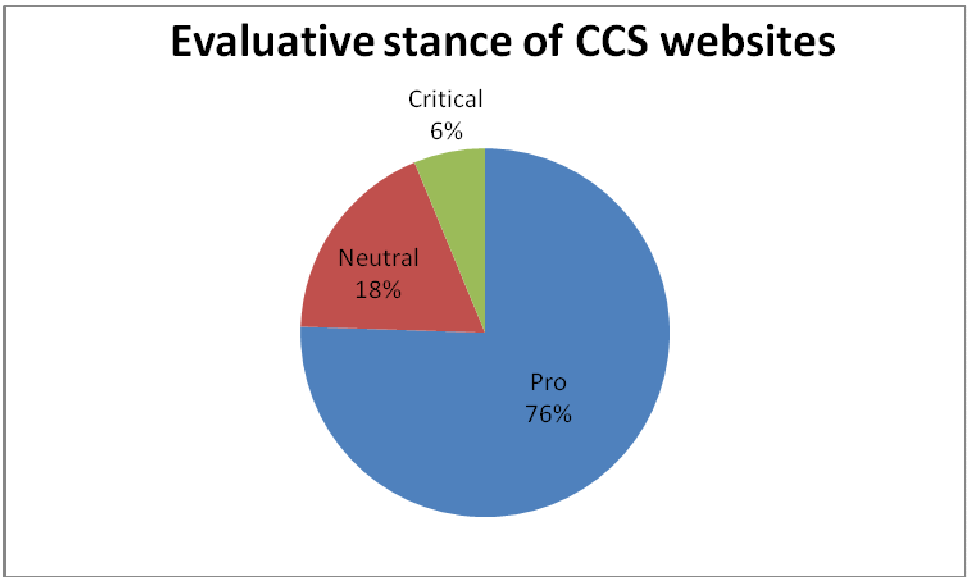

Figure 10: Most sites are positive about CCS

The large number of CCS-positive websites is of course to be expected, since 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"[23]

The relatively small number of neutral sites (18%) is perhaps more interesting, indicating that CCS communication appears perhaps to be in danger of polarisation. Research institutions and news media make up a large proportion of the 'neutrals'. However, the research institutions such as SINTEF and GFZ German Research Centre for Geosciences or public and privately funded research consortia such as the Midwest Geological Sequestration Consortium (MGSC), although neutral, are almost exclusively technically oriented, reflecting their expertise in the techniques 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 optimise risk-related decision-making and maximise 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 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 worry for its supporters. As Figure 11 shows, no industry- or government-led sites are critical (although one corporation, Mantra Energy Alternatives Ltd., views CCS as a competitor to its own product comparing it somewhat unfavourably[24]).

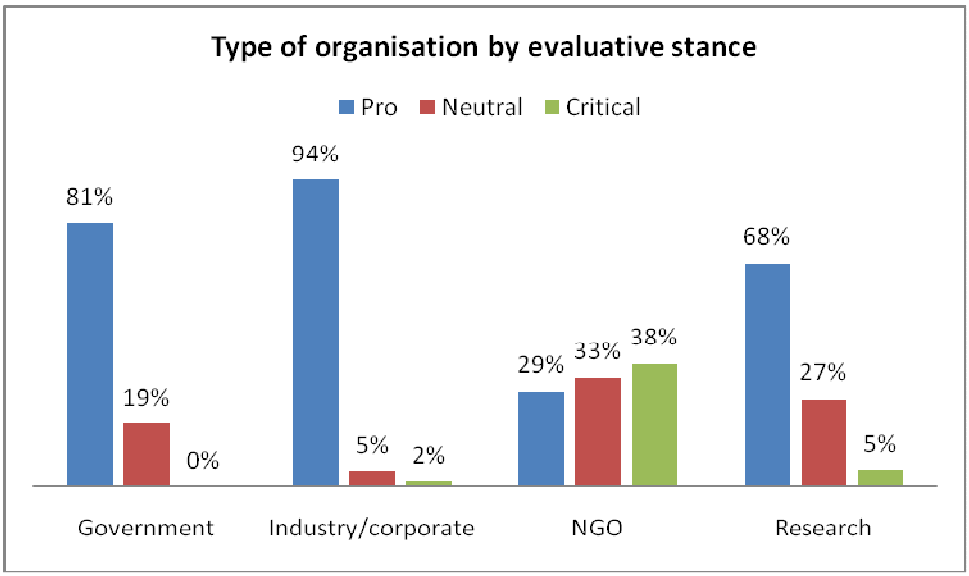

Figure 11: The least trusted communicators are also the ones most likely to be pro-CCS

[23] http://www.worldcoal.org/carbon-capture-storage/
[24] http://www.mantraenergy.com/Economics/ComparisonwithCCS.aspx

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 scientific 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" (DoE, 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 conundrums.

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, forthcoming). 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. In part, the very nature of CCS as a relatively novel technology and the uncertainties means that as actors continue to develop their views, in the German context, "opens up space for dialogue and moderates confrontation" (Fischer and Praetorius, 2008: 176)

There are also differences based on 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 delaying tactic. NGOs can also differ from one project to the next. WWF-Scotland has been generally supportive of CCS proceeding at Longannet in Fife, which is a retrofit of an existing coal-fired power station, but strongly opposes a new build coal plant at Hunterston in Ayrshire (WWF-Scotland, 2010). Categorisations such as 'pro' and 'neutral' necessarily involve simplifications that conceal such differences.

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*[25] 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). Similarly, the *United States Carbon Sequestration Council* is pro-CCS but describes itself as "a **non**-profit coalition of scientists, engineers, academics, environmentalists, and leaders from the business and the public sectors" (USCSC, 2011). In fact, the 'members' of

[25] http://ccs-education.org/

the Council include the seven DoE-funded regional sequestration partnerships, two large coal companies, one major oilfield services firm, the US Energy Association, which represents the interests of the US energy sector, one consultancy, one research institute, one thinktank and one university (Stanford), although the regional partnerships themselves include a range of actors including numerous universities. It is difficult to identify a single environmental group among the many organisations involved.

Boundary problems aside, judging by the relationship between the overall evaluative stance of a website and its focus on different parts of the technology (Figure 12), most critical content seems to be associated with issues of storage. Those preoccupied with CO_2 capture alone tend to be less frequently 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.

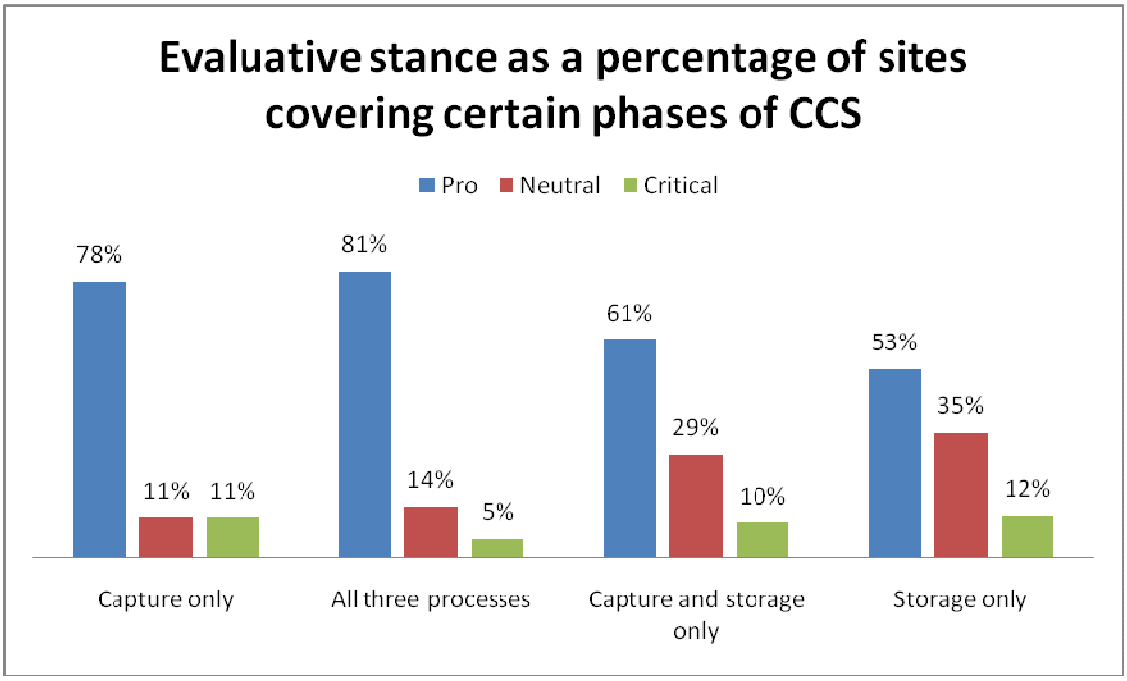

Figure 12: Communication of storage is the type of CCS communication most likely to be of a sceptical nature.

This raises the larger question of what animates opposition and support for CCS (Corry and Reiner, 2011), a question which seems only partially to be worked into CCS communication efforts by those not aiming to provide a neutral view.

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 even engage in humour, 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 recently taken down. One animation from the site, http://www.ev-eon.com, can still be found archived on YouTube (http://www.youtube.com/watch?v=K5lSgkmQWAg) but the rest of the content is now lost. Several of the websites that arose in opposition to the proposed CO_2 storage site in Barendrecht in the Netherlands have also disappeared.[26] Such critical sites are more likely to disappear over time as the project that motivated the development of the critical site either succeeds or fails. Indeed, it is unusual to find a local group, such as the Greenville, Ohio based opposition site Citizens against CO_2 Sequestration[27], which sought to actively oppose other CCS projects even after the project of local interest has been resolved. Even though the DoE project in Ohio was cancelled in August 2009, the group kept active supporting opponents of projects including several US projects as well as the Dutch Barendrecht project. Nevertheless, even for this group, there have been no further posts since July 2010, reflecting the difficulty of maintaining an interest in communications once the issue that motivated action has disappeared.

There is a similar problem with many research projects, which might be funded for a fixed period of, say, two or three years, and after the project funding runs out there is no dedicated funding to maintain the website, so that even if the project website continues to remain available to the public as an archive, there is no further updating of content. This is true for projects such as the ACCSEPT[28] and FENCO-ERA[29] projects, which covered European stakeholder and public attitudes and communications respectively over the duration of the project, but which have not been updated since the projects terminated. In other cases, projects will contain dead links, so that CO2Geonet still refers to the 11 languages that their brochure appears in, but the actual brochures do not appear to be available.[30] Thus, communications efforts by those NGOs and research institutes that are the most trusted and already the least represented are also those least likely to maintain a continual presence for reasons of both funding and topicality.

6. CCS communication and surveys of opinion

Reiner (2008) concluded that "education and dissemination activities have all been carried out independently and there have been no studies of the effectiveness of different forms of educational materials". This touches on the wider question of whether CCS communication is evidence-based in terms of being tailored to different audiences, the characteristics of

[26] Two of the 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 (different variants of "No to CO_2" are no longer available. The site www.co2isnee.nl is still available, but the last entry is from 30 August 2010.
[27] http://citizensagainstco2sequestration.blogspot.com/
[28] http://www.accsept.org
[29] http://www.ccs-communications.gr
[30] http://www.co2geonet.com/Sections.aspx?section=268.355 provides a link to the website http://co2geonet.promoscience.com/ which no longer exists.

which are researched or documented in some way. Although a small number of scientific studies of the effect of information about CCS on public acceptance do now exist in scientific journals, education and dissemination activities still appear to be carried out largely independently of such studies.

Recent studies from Europe have compared different methods of CCS communications (Daamen et al., 2011) and evaluated the effect of information in different forms about CCS on perceptions of risks and benefits, finding that "the provision of comprehensive information aimed at resolving prevalent misconceptions about CCS can decrease perceived risk and increase perceived benefits"(Wallquist et al., 2011: 83). But the findings also show that some specific types of information can result in the perception of higher risks and lower benefits. Researchers at Carnegie-Mellon University found that "informed members of the general public preferred diverse portfolios that contained CCS and nuclear over alternatives once they fully understood the benefits, cost, and limitations of each" (Fleishman et al., 2010: 1399). A Dutch study found similarly that informed respondents "were likely to base their option evaluations on this information, though not entirely" (de Best-Waldhober et al., 2009: 322). In the US, a Batelle PNNL report emphasised that public awareness was low but that stakeholders should be provided not just with an explanation of what CCS is but ideally also "a context that includes a realised scenario of a world that undertakes GHG mitigation, the range of technologies with advantages and risks of both established and new technologies, and alternative options for policy" (Malone et al., 2010: 424). This idea of presenting a "realized scenario" of mitigation with "advantages and risks" of CCS with "alternative options" for policy is very rarely found in communications of CCS.

However, public opinion surveys have developed somewhat since Reiner (2008) concluded that "the effort to survey public opinion has been opportunistic and uncoordinated at cross-national (e.g. European or OECD) level". There have been some first steps taken towards coordination such as the study of public opinion towards CCS carried out in six European countries (Pietzner et al., 2011). Among the report's recommendations: CCS education materials should be targeted towards women, older and younger audiences and differently according to national context. Further, Eurobarometer (2011) has recently produced a survey of attitudes towards CCS in 12 EU member states that were deemed, the furthest along in considering CCS. In fact, the CCS Eurobarometer did not include some member states, such as Denmark and Ireland, where projects have been proposed or at least discussed. It is notable that it is rare for a Eurobarometer *not* to cover the full EU-27, which speaks to the very low level of awareness of, and interest in, the technology in many countries. Nor has there been any formal effort to coordinate national surveys outside of Europe, although researchers have sought to undertake comparable surveys (Reiner et al., 2006; Ashworth et al., 2007).

That CCS is primarily communicated as an isolated technology indicates that this kind of evidence has not been taken into account in the production of such communication. Some of these conclusions such as the idea of comparing different policy-mix options could already be worked into CCS communication. However, ways of communicating CCS and local differences in frames or worldviews still need to be researched more if CCS communications are to be generated systematically in an evidence-based way, with the purpose of gaining acceptance (or mobilising opposition) to the technology.

Thus, 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 recent 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.

7. Linkages and cross-referencing

Reiner (2008) concluded that there appeared to be no effort to coordinate across projects; even simply linking across projects on different websites was relatively weak. He also concluded that "even the best project sites from a usability perspective (and in terms of budgets), such as that of the Dutch CATO project or the Australian CO_2CRC are highly project-specific showing little effort in conveying information beyond a small circle of those already interested in the subject".

Links to other projects are now more common and 71% of the websites in the dataset did have at least some such links, but industry-run sites are less likely to make readers aware of related projects and information.

Firstly, in this review it appears that most sites - approximately three quarters - do have links to other CCS sites of some kind now, but the extent and relevance of links varies greatly. Some, such as European CO_2 GeoNet, provide extensive links to factsheets, key climate change and greenhouse gas-sites, a 'kids corner' and CCS maps and videos. The website of the research project 'The politics and policy of carbon capture and storage' similarly has a substantial links[31]. However, both these examples have governmental backers and most sites are of a more limited nature. Links are in reality often very limited. For example, on the Southeast Regional Carbon Sequestration Partnership (SECARB) website there are factsheets concerning SECARB's own ongoing CCS demonstrations projects[32] but, as is not un-common, no links to other similar projects. Gassnova, set up to manage the development of CCS solutions at Kårstø and Mongstad, present information on these two projects in Norwegian and English and link extensively on the Norwegian site, but they do not link to other sites on the English language version[33].

Conversely, it is striking that over one-quarter (26%) of sites (chosen by virtue of them clearly communicating CCS), do not have *any* links to other CCS projects. West Virginia Carbon Sequestration presents CCS and carbon to liquid (CTL) technology and local projects, but has no links to other sites[34]. American Electric Power has a short explanation of CCS but does not link to other CCS sites either[35]. The same is true for American Power's presentation of CCS[36] as well as Shell's[37].

[31] http://www.ccs-politics.se/links.html
[32] http://www.secarbon.org/
[33] http://www.gassnova.no/?language=UK
[34] http://www.wvcarb.org/index.php
[35] http://www.aep.com/environmental/climatechange/carboncapture/
[36] http://www.americaspower.org/carbon-capture-storage

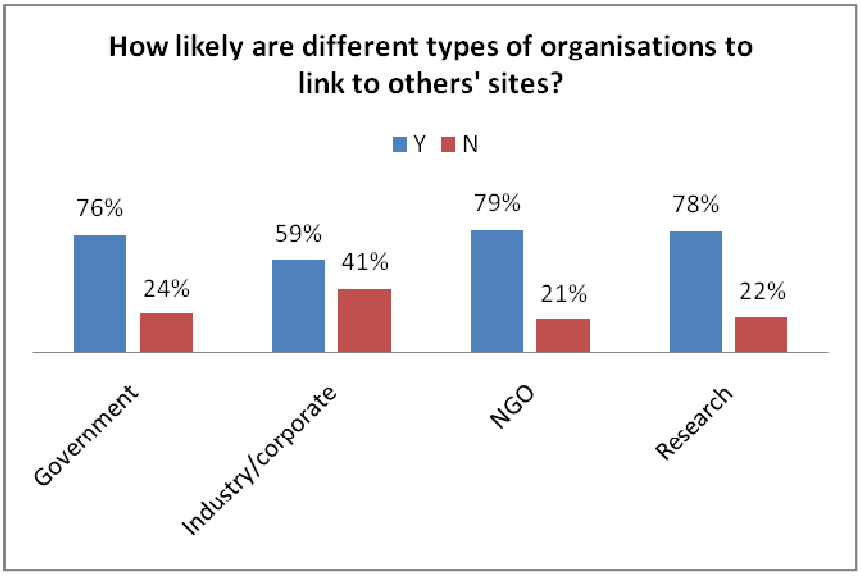

Figure 13: Propensity of types of organisations to link to other CCS communication websites

Compared to NGOs and research institutions in particular, businesses and corporate/public consortia are more likely to exclusively communicate the progress of their own projects rather than to promote knowledge of CCS in general. This would explain why they have a lower propensity to lead readers on to other (perhaps competitors') sites. NGOs and government sites such as the Norwegian Ministry of Petroleum and Energy and European projects such as Geonet on the other hand, are more likely to provide relevant links to global or 'hub' sites such as the Institute's and other commercial and governmental institutions. Governmental sites are often collaborations with industry or regional governments promoting their area. One example of this is the North Sea Basin Task Force which aims to develop broad, common principles that could form a basis for regulating the storage of CO_2 under the North Sea and to provide a consistent basis for managing this activity. It describes the activity of four nations in the North Sea but has no links to other CCS projects worldwide.

CCS-promoting NGOs such as Bellona, on the other hand show a greater interest in communicating CCS in general rather than a particularistic interest in specific storage sites or demonstration projects. Hence, Bellona provides links to articles on ECCO (a European project to recommend standards for CCS) and a Spanish project[38]. International organisations such as the Carbon Sequestration Leadership Forum (CSLF) that exist to coordinate and promote CCS are amongst the most comprehensive, linking to all their 32 currently certified CCS projects[39]. Still, it is striking that CSLF, which began in 2002 as the main international ministerial-level initiative on CCS has not even done any rudimentary communications on the technology itself in almost a decade of existence.

The Institute's website is virtually unique in providing a central point of information and news as well as a global platform for debate and 'wiki'-activity about CCS on the 'OpenCCS'

[37] http://www.shell.com/home/content/innovation/people_planet/ccs/ccs_how_does_it_work/
[38] http://www.bellona.org/factsheets/1191916470.85).
[39] http://www.cslforum.org/projects/index.html?cid=nav_projects

site, advertised as "an open, collaborative area for sharing methodologies, best practices and lessons learned in relation to the implementation of Carbon Capture and Storage"[40]. It provides access to datasets as well as publications and allows users to search for projects, information and best practices not only on all three stages of CCS (capture, transport and storage) but on different stages of project life cycles ('identify', 'evaluate', 'define', 'execute', 'operate', 'closure'). While openly promoting CCS, the Institute's site comes across as a relatively open and interactive space for communicating not only the successes but the challenges of developing CCS. It links to research institutions as well as 'CCS in the news'.

Overall, the conclusion in Reiner (2008) that there is "minimal effort to link across projects so that, for example, someone reading about a project in Canada might easily learn about a project in France" seems outdated. Links to other CCS communications sites are found in a majority of all types of organisations, although organisations committed to CCS as such, rather than to specific projects, were much more likely to link and generally seem to have much more comprehensive links. In any case, the existence of hub-sites such as that of the Institute makes the problem smaller than it otherwise would have been since this provides easy access to other projects.

8. Uses of multi-media

Reiner (2008) suggested that "there is little indication that (…) multimedia or interactive techniques [have been] used" and there has been no effort to analyse television coverage of CCS. Nor have there been any efforts to use past television reports as part of a communications campaign or on a CCS website.

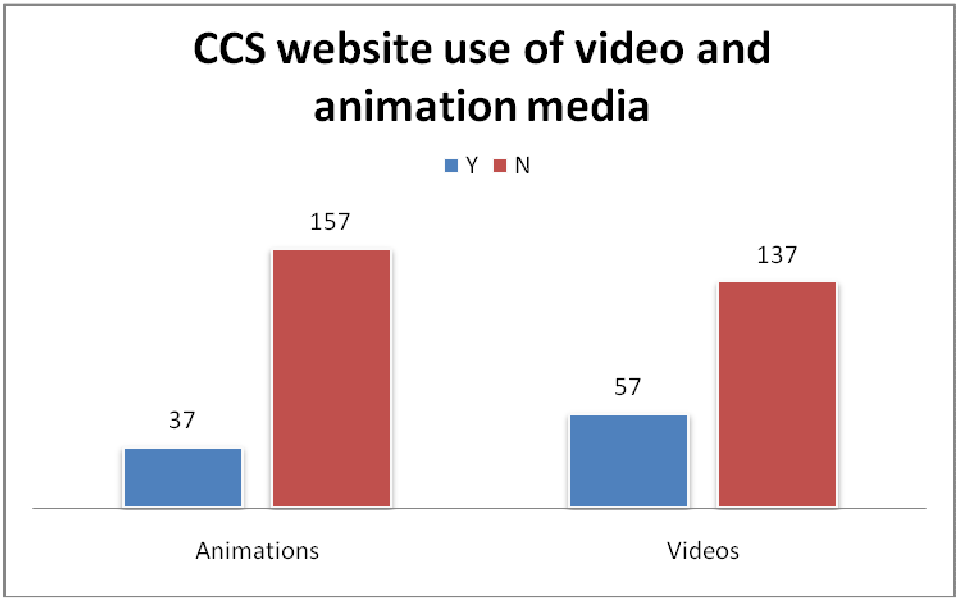

Figure 14: Videos and animations are more common but still not the norm

[40] http://www.globalccsinstitute.com/community/openccs/openccs

Our survey reveals that multimedia are still used to only a limited degree but are now not uncommon. They are heavily represented at the 'campaigning end' of CCS communications. Those that are not of a polemical nature focus heavily on technical explanations of CCS, except for material produced by media outlets which tends to debate potential costs and benefits of CCS as well as discussing CCS in relation to alternative low carbon technologies. As Figure 14 indicates, video films or 'mini-documentaries' (usually consisting mostly of interviews with experts, normally relatively low-budget) exist on 57 out of 194 (29%) sites while 37 (19%) display animation films. Animations explain CCS using graphics in some way.

Did the site have an animation?	Did the site have a video?	
	No	Yes
No	64%	16%
Yes	6%	13%

Figure 15: The use of multimedia

Over one-third of sites had at least one video or animation (Figure 15). Thus, while at the time of Reiner (2008) there were only "a small handful of short videos developed to present projects including the CO_2 Capture Project (CCP), BP on its In Salah project, the Australian CO_2CRC, NETL in the US and the Dutch CATO project", almost sixty sites now offer videos according to the survey. These include videos by CCS proponents such as Bellona and corporate actors such as B9 Coal, Shell and American Electric Power.

Satirical or campaign videos about CCS and videos communicating concern or criticism of CCS also exist, e.g. those from the so-called 'Reality Coalition', a coalition of environmental organisations including The Sierra Club, Natural Resources Defense Council and the Alliance of the Climate Protection who launched an advertising campaign against the idea of clean coal called 'This Is Reality'[41]. The basic message is that 'clean coal' is a fiction[42] or 'simply green-wash'[43]. A similar initiative is the 'Coal is Dirty' group backed by The DeSmog Project, Rainforest Action Network and Greenpeace USA (which includes a satirical spoof page 'Coal is Clean'). They have published an animation satirically depicting solar and wind power as dangerous sources of energy, praising 'dirty is clean' coal[44]. These match campaigns in favour of clean coal, for example those produced by Americaspower.org[45] depicting coal as 'an American resource' that powers 'our way of life'[46] that can be made clean via CCS. The US industry Coalition for Clean Coal Electricity produced a video of carol-singing lumps of coal with an aim to go 'viral' and thus be self-proliferating to draw attention to the idea of 'clean coal'[47]. The goal of this is not to promote CCS directly but to maintain and emphasise the benefits of coal, paving the way for CCS or 'clean coal'. Videos are thus a favourite medium at the more polemical end of the CCS communications spectrum.

[41] www.thisisreality.org
[42] e.g. http://www.youtube.com/watch?v=PdHuB7Ovl2o&fmt=18
[43] http://www.youtube.com/watch?v=uFJVbdiMgfM&NR=1
[44] http://www.youtube.com/watch?v=PLZ-hvVVGmY&feature=player_embedded#at=61
[45] e.g. http://www.youtube.com/watch?v=0bcRgnIcntI&NR=1
[46] http://www.youtube.com/watch?v=ZmVDu_gIpc4&NR=1
[47] http://www.youtube.com/watch?v=x8Gy-kgL8yA

Animations explaining the CCS process itself are less commonly found, especially among critics, corporations being the main suppliers of such artefacts. A good example is a group of three animations developed by the Zero Emissions Platform (ZEP), the EU's technology forum on CCS. ZEP's animations have titles such as 'Inside CCS, the workings of CO_2 capture, transport and storage' and 'Safe storage: closing the carbon loop'[48]. However, government sites including some regional and local government authorities with stakes in CCS also produce animations of CCS processes. For example, the Government of Alberta has animations and films hosted on its website[49]. Critical sites such as Sinkswatch and Greenpeace have also recently produced more critical video material concerning CCS[50].

Internet traffic volumes and directions

While interesting as a window on the state of campaigning on CCS, the numbers of viewers for CCS videos is moderate in YouTube-terms. Indeed, the most visited English language sites do not involve CCS explicitly, but are a product of the politicised battle over 'clean coal', many of which originated as television advertisements in the United States. Among the other popular – and somewhat more educational – videos is 'Clean Coal Technology' produced by the American Coalition for Clean Coal Electricity promising the realisation of CCS allowing 'abundant' coal to be utilised for 'energy independence' (shown over 16,000 times)[51]. Consulting the statistics available through YouTube reveals that most of the seminal referrals to the video (what YouTube describes as "significant discovery events") are, in fact, efforts to expose green-washing. The most viewed videos are actually spoofs or those taking a critical view of "clean coal". The series of videos produced in the "This is Reality" series amassed several hundred thousand hits. The first video in the series garnered 80,000+ hits and the two other widely viewed videos "Smudge" (over 100,000 hits) and "Get clean coal clean! (NEW Air Freshener)"[52] directed by the Coen Brothers (who directed Fargo, O Brother, Where Art Thou?, etc.) had over 240,000 hits.

The other anti-coal video with a large number of viewings is the product of Greenpeace's campaign to have Facebook 'unfriend' coal, which had over 475,000 views. This video had the widest geographic distribution (ranging from India to South America to all of Europe as far as Russia, in addition to North America and Australia). Viewers were skewed towards younger males and the referring sites were from Facebook itself and mobile devices rather than any political or news-oriented websites. Other Greenpeace videos such as Coal Story (created by Ogilvy and Mather, Beijing and aimed at Chinese coal use)[53] and Coalfinger (a James Bond parody starring well-known British actors Brian Blessed and David Mitchell)[54] had amassed over 50,000 views on YouTube and over 91,000 views on the coalfinger.com website.

Most of the other efforts explicitly on CCS pale by comparison in terms of viewership. The government of Alberta's CCS animation has been viewed 13,000 times to date, explaining

[48] http://www.zeroemissionsplatform.eu/ccs-animations.html
[49] http://www.energy.alberta.ca/Initiatives/1905.asp
[50] e.g. http://www.youtube.com/watch?v=ukBOzpz0z-E&feature=player_embedded
[51] http://www.youtube.com/watch?v=0bcRgnIcntI
[52] http://www.youtube.com/watch?v=uFJVbdiMgfM&feature=channel_video_title
[53] http://www.youtube.com/watch?v=mEd7YHKhF4U
[54] http://www.youtube.com/watch?v=G9HsU9X1CYM

global warming and greenhouse gasses and how CCS could be a solution[55]. Shell's video about CCS is also relatively popular, again angled on the possibility of CCS preventing 'dangerous climate change'[56]. The most viewed NGO video on Youtube with 'carbon capture' in its title is Bellona's at over 4000 views (just above The US Department of Energy's video[57]). The most viewed 'carbon capture' video with a critical stance towards CCS is made by the Australian Green Party, clocking up around 4000 views[58]. This video suggests that CCS will not work and associates a blue and red party (Labor and Conservatives) with a 'dirty' and failed technology.

YouTube's statistics function reveals that these CCS videos are watched primarily in their countries of origin. The 'Americas Energy' and 'This is Reality' adverts are viewed mostly from the US, whereas Canadian users dominate in the case of Alberta, although the Coen Brothers' video does have considerable viewing in Australia as well as South Africa and parts of Europe. Shell's video is also watched more evenly in geographical terms, also showing take-up in Europe and Asia, perhaps reflecting its global brand. Critical sites again compose an unusually large number of the 'feeding' sites. The Australian NewGenCoal's video about climate change and CCS has been viewed less but over 8000 times, mostly from Australia[59]. The British Geological Survey (BGS) video[60] is similarly viewed most heavily from the UK, but also to some degree from the rest of the world.

This indicates that CCS communication is not totally globalised, users seeking locally generated information products. However, the Australian Greens' video has been viewed most from the UK, so there is no simple rule on this. In terms of age and gender, these videos are most commonly viewed by males in the 35-64 demographic. The Coen Brothers video was picked up by leftish-oriented, but generalist, sites such as the US-based news and blog website *The Huffington Post*, the American political blog site *Daily Kos* and the UK broadsheet *The Guardian's* website, whereas virtually every second video is reached via manual searches, campaigning or specialist sites. This indicates that CCS communications (in video form, at least) is not always tied to the media sites users use habitually. Although people are searching world-wide for material, local sites are preferred.

Overall, CCS communication on YouTube is quite polarised and propagandistic, perhaps reflecting the nature of the video medium which is less well suited to more sober approaches such as that taken by the National Energy Technology Laboratory's 'Carbon Capture and Storage: Myth or Reality?'[61] which has around 30 views, rather than more 'campaigning' videos such as the clean coal carol singers or the 'Clean coal technology' spoof[62]. However, BGS's video with nearly 7000 views, shows that it can be done in a scholarly way while reaching a larger audience[63].

[55] http://www.youtube.com/watch?v=R0i6dhEPSwU&feature=related
[56] http://www.youtube.com/watch?v=cohgQZq-I1w
[57] http://www.youtube.com/watch?v=9Cqi4SHqewQ
[58] http://www.youtube.com/watch?v=-4mrjNetc9U
[59] http://www.youtube.com/watch?v=lyEt3lGQVWw
[60] http://www.youtube.com/watch?v=7M2fhOGz0-o
[61] http://www.youtube.com/watch?v=J7Rk6uSV0e4
[62] http://www.youtube.com/watch?v=PdHuB7Ovl2o
[63] http://www.youtube.com/watch?v=7M2fhOGz0-o

Video and animation content

All groups portray CCS mainly from a technical point of view (either how it works, or what it does not achieve) often following a general presentation of the challenge of climate change and energy scarcity (or the abundance of coal). The exception to this rule is recordings of public debates about CCS which tend to focus on cost and comparisons to other climate solutions such as renewable, energy conservation or nuclear. The televised debate most often viewed was posted by a company called FORA.TV which specialises in publishing recordings of live events at top universities and features a debate[64] between a representative of the Sierra Club and advocates of coal on the funding of new generating capacity. Material put together by media outlets appears again to be the most discussion-oriented and the least technology-focussed. Indiana University Television (WTIU) provides one example[65], as does the business channel Bloomberg TV, focussing on the costs and subsidies associated with CCS[66]. Other collections of videos on CCS also exist such as on Carbon Capture Journal's website[67] though mainly from corporate actors such as Alstom but also from media outlets such as the BBC[68].

Furthermore, the relatively small audiences for CCS videos cannot be blamed solely on the technical nature of the issue, since educational videos on closely related topics such as how coal-fired power stations work garner much greater views. For example, two videos[69] on this topic, neither of which is produced by a major organisation generated over 100,000 views each (although interestingly the main audience for both videos was in India).

Mass media coverage appears to be a growing source of CCS communication and to the extent media outlets leave their archives accessible, it is a cumulative resource. TV programs such as *60 Minutes* have taken up CCS for analysis[70] and news reports on CCS can be found, e.g. on *BBC News*[71] and *CNN*[72] indicating that CCS is periodically communicated to a wider audience. TV-material was found to typically be related to political decisions concerning CCS (thus making the issues 'newsworthy' on occasions) and to discuss possible benefits and risks associated with particular (planned) CCS projects. Print media coverage of CCS such as that provided have also proliferated although *The Guardian*[73] is the rare exception insofar it has made its coverage on CCS easily accessible.

In spite of the many articles written on the subject, media outlets rarely compile or provide a clearinghouse of their articles on the topic even if there have been numerous articles published on the subject. This lack of effort should not be surprising, since any media outlet could, of course, do the same on any hundreds of subjects. Rather, it should be for organisations with an interest in CCS to consolidate and distribute press coverage. Websites such as *IZ Klima, ZEP* and the Institute do have RSS feeds of national or global press

[64] http://www.youtube.com/watch?v=bLYUImV6cQ0).
[65] http://www.youtube.com/watch?v=N56cA7PSbF0&feature=related
[66] http://www.youtube.com/watch?v=mcN1Cl4X5UM
[67] http://network.carboncapturejournal.com/video
[68] http://network.carboncapturejournal.com/video/carbon-capture-storage-ccs-to
[69] http://www.youtube.com/watch?v=SeXG8K5_UvU and http://www.youtube.com/watch?v=e_CcrgKLyzc&NR
[70] http://www.huffingtonpost.com/david-roberts/60-minutes-on-coal-dancin_b_191664.html
[71] http://news.bbc.co.uk/1/hi/uk_politics/8015676.stm
[72] http://edition.cnn.com/video/#/video/tech/2009/12/07/quijano.capturing.carbon.cnn?iref=videosearch
[73] http://www.guardian.co.uk/environment/2011/mar/09/carbon-capture-and-storage?INTCMP=SRCH

coverage, but this is mostly designed to present the news from the past few days rather than being able to make use of the coverage in any more useful way to someone less familiar with the subject, such as by being able to search through media coverage on a particular topic of interest.

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[74]. Media coverage is 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 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.

One common feature is that the distance from the surface of the Earth to the storage site is usually depicted as much smaller than would be the case in real life. For example, the one depiction used in the Wikipedia site is drawn from a 2000 article where the depth of the CO_2 being stored looks to be at the height of several of the trees (i.e. tens of meters or a factor of perhaps 100 less than the actual depth of a geological reservoir) (Figure 16). Moreover, the saline formation is described as a 'deep aquifer' and depicted in blue, which may lead some to assume that the CO_2 is being injected into potable water. The Wikipedia site is also the number one site that appears when one searches for 'CCS' or 'carbon capture and storage' on Google. Whether this impacts on perceptions of the safety of CCS is the subject of on-going research (notably with regard to depth in the nearCO2 project), but far more research is needed in this area.

[74] http://www.guardian.co.uk/environment/carbon-capture-and-storage

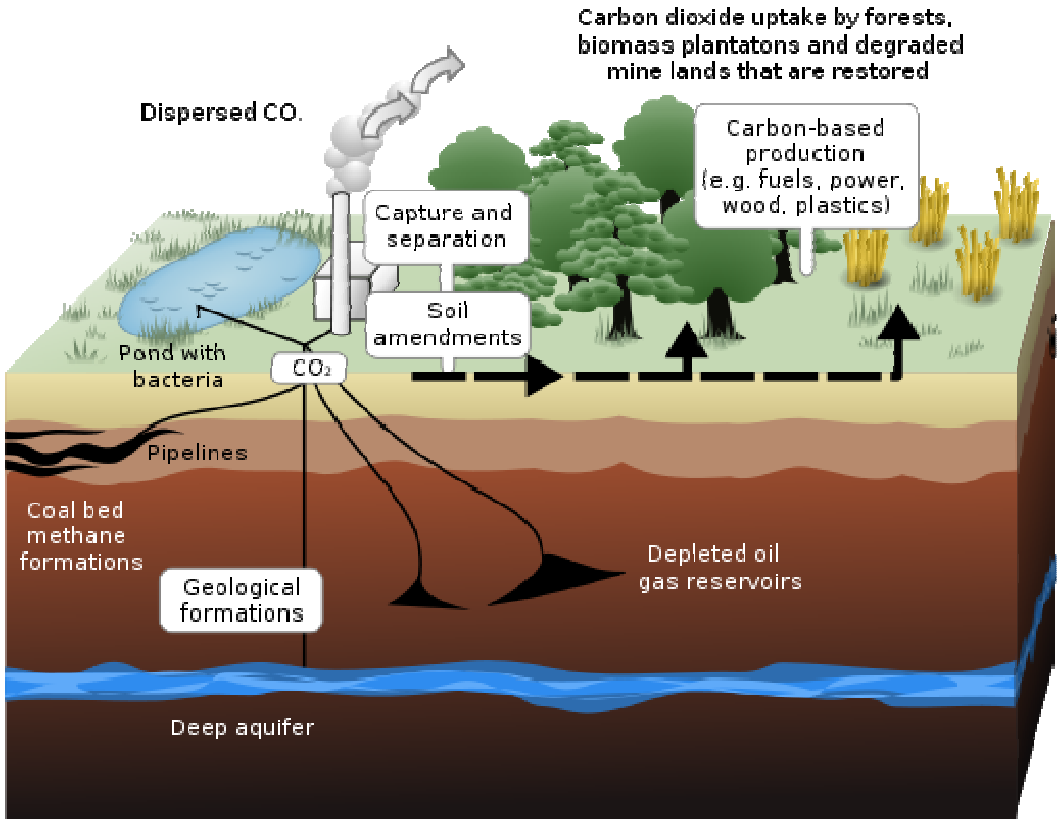

Figure 16: Wikipedia's chosen illustration of CCS

Source: ORNL (2000) drawn from a schematic by Hardin and Payne

9. Educational materials

For Reiner (2008), "The level of effort with regard to educational and communications materials can be described as ranging from token to non-existent. Most project sites make no effort whatsoever to develop educational materials". This appears to still generally be the case, although the increased use of multimedia broadens the age-range of potential users of the CCS communications and some educational materials and teacher training courses have been created.

Beginning with the youngest, one possible development aimed at younger audiences mentioned in Reiner (2008) was a then-proposed Statoil project to produce education materials for Norwegian schools reportedly under way in 2007. This could not, however, be found for this survey. The US Energy Information Agency still has a children's section online which covers energy issues quite well in general, but only one section covers CCS under the broad heading of 'Coal and the Environment'[75]. This is not so much a teaching resource as a simplified version of standard CCS communication material focusing on the processes of capture and storage.

[75] http://www.eia.doe.gov/kids/energy.cfm?page=coal_home-basics

The computer games mentioned above target the younger audience, but these are primitive and very limited. More comprehensively, the Southwest Carbon Partnership has a 'Carbon Bond versus the Greenhouse Gang' interactive 'game', which educates at school level about the basics of climate change and CCS[76]. Similarly the Science Alberta Foundation runs a website for science education of children featuring a 3D CCS game[77].

Indeed, not all materials developed for primary or secondary schools are easily identified. Even some of the leading organisations that develop educational materials and train teachers, such as the Colorado-based Keystone Centre, have little web presence. The main evidence that they have developed such materials is available indirectly, e.g. via the South Western United Sequestration Training Canter[78].

While educational online activities are emerging, it appears to remain the case that there 'have been few non-computer based models of an operational CCS system that might be used for public display' as Reiner (2008) concluded. The educational model and exhibition developed by the Scottish Centre for Carbon Capture and Storage which toured with The Scottish Science and Technology Road Show mentioned above is a notable exception, although again that may also be a result of the difficulty of easily searching for such non-computer based formats (the makers of that interactive model knew of no other examples globally). The British Geological Survey also has a model (see Figure 17) used for explaining the principles of just the storage process involved in CO_2. An online demonstration using this is available[79].

Of potential significance is the development of CCS teaching packages at secondary school level where classes can simulate various stages of CCS in the school lab. One teaching resource is produced in the US by the National Energy Education Development (NEED) Project but could have application throughout the English speaking world (NEED, 2010). It bears the subtitle 'Background reading and hands-on explorations teach students about the properties of CO_2 and about developing technologies that allow CO_2 to be captured from power plants and stored in geologic formations'. This takes students theoretically and practically through issues connected to combustion, carbon auditing, separating gasses, enhanced oil recovery, rock porosity and injection and the range of stakeholders involved in potentially realising CCS. This is imaginatively and thoroughly done, but in line with most CCS communications, concentrates heavily on the scientific processes.

[76] http://southwestcarbonpartnership.org/kids/carbon_mcs.html
[77] Described at http://portfolio.sciencealberta.org/games.html. Game available at http://www.wonderville.ca/asset/co2-connection
[78] http://ccstrainingcenter.org/index.html
[79] http://www.youtube.com/watch?v=C83LCN2G2r0

Figure 17: British Geological Survey model of geological storage

A similar teacher training program run by the Scottish Earth Science Education Forum (SESEF) seeks to enable teachers to teach CCS in schools and offers both teacher training (SESEF, 2011) and webcasts[80]. The SESEF team worked with pupils from four high schools (aged 12-14), delivering a sequence of three CCS workshops that used interactive experiments to introduce the basic scientific concepts of CCS in the context of climate change. As reported by the Institute (April 2011), "pupils built their own model CCS store (using plasticine and marbles) and were helped to take on specific roles required in a CCS consortium (Geo-chemist, Geo-engineer, Geologist and Risk Manager) and research their particular area of expertise to try and tackle the challenges and issues surrounding the new technology" (Anderson, 2011).

At the tertiary education level, the Research Experience in Carbon Sequestration[81] is a large US collaborative program sponsored by the US Department of Energy and several major energy firms to run education programs for future CCS experts, running courses for interested researchers, although is not a source of popular education materials for schools or general consumption (and hence not included in the list). MIT's program on Carbon Capture and Sequestration Technologies covers technical as well as economic and political aspects and, having run since 1989 is the leading academic program in this area[82]. Other universities such as University of Newcastle (Australia) also run courses on CCS or 'clean

[80] http://vimeo.com/16630561
[81] http://www.recsco2.org/
[82] http://sequestration.mit.edu/

coal'[83], as does the University of North Dakota[84] and New Mexico Tech[85]. Of course, the small number is indicative of a relative dearth of such offerings relative to the number of courses in, say, nuclear engineering. This may be because much of the technical content might be included in standard academic offerings in, say, mechanical or chemical engineering, but there is little indication that this is the case.

With potentially more political implications, the British Geological Survey runs various educational activities, most recently a workshop with the UK Department of Energy and Climate Change (DECC) on CCS for NGOs at the Natural History Museum in London[86]. This is the only course run especially for NGOs that the survey registered.

Reaching beyond the world of experts and NGOs, the World Resources Institute (WRI) has developed guidelines for community engagement in CCS projects (Forbes et al., 2010) as has the Scottish Centre for Carbon Capture and Storage (Hammond and Shackley, 2010). The Institute has funded a comprehensive 'Communication/engagement toolkit for CCS projects' (Ashworth et al., 2011). These guidelines document processes of stakeholder engagement, provide resources for analysis and engagement with groups and stakeholders, and all include a list of resources available. However, although the Institute toolkit does point to educational materials regarding CCS, this is limited by the global dearth of such resources.

Finally, outreach for project developers should be distinguished from education materials aimed at students or the general public. For example, the US Regional Carbon Sequestration Partnerships claim to have prepared a manual of "Best Practices for Public Outreach and Education for Carbon Storage Projects"[87]. In fact, it is essentially a manual on how developers should produce outreach and engage the public down to detailed appendices on "sample press release elements" and "conducting a focus group" with little identifiable as "education".

Conclusions

There are some grounds for optimism concerning the development of well informed and policy-relevant CCS communications. A growing body of material from different types of organisations, in web and non-web formats, and with different evaluative stances, is now available, using a more varied set of media formats. Proponents, critics and neutral audiences can find information on ongoing projects and the general principles of CCS, albeit mainly concerning the processes of capture and storage. Non-technical issues and contextual debates such as the nature and scale of the climate change problem, different possible financing models of CCS and regulatory regimes, while still at the periphery of CCS communications efforts, are mentioned more often now than three years ago. Central CCS sites such as that belonging to the Institute provide comprehensive information and work as hubs for less systematic sources of information, as well as, perhaps uniquely, providing a global forum for debate about CCS. Other well-developed sites, such as that of ZEP, provide accessible and informative material in varied formats linking to both specific projects and

[83] http://www.newcastle.edu.au/course/CHEE6200.html
[84] http://www.undeerc.org/centersofexcellence/ccs.aspx
[85] http://ccstrainingcenter.org/index.html
[86] http://www.bgs.ac.uk/research/highlights/ccsworkshopforngos.html
[87] http://www.netl.doe.gov/technologies/carbon_seq/refshelf/BPM_PublicOutreach.pdf

general overviews without being as comprehensive. A third tier of sites is more idiosyncratic, catering for niche interests and individual projects.

There is some information to be found concerning the legal, economic and political debates about CCS, particularly in established media outlets who have taken it upon themselves to communicate CCS to the general public in terms of the policy debates. Compared to the 2008 review, CCS communications have thus undergone some significant developments.

All the same, it is difficult to escape the conclusion that the CCS community is also a community in the pejorative sense of being a group which communicates more effectively internally than externally. English appears to still be heavily dominant as does the technical, engineering-oriented focus that communicates the science of CCS technologies. This would be unproblematic were it not that the engineering is presented without grasping the social science nettle of how CCS might (or might not) interact with the varied contexts of different energy systems, political systems and other contextual factors such as carbon markets. Even some technical issues such as transportation remain largely 'invisible'. CCS is justified almost exclusively through references to mitigating climate change without serious efforts at comparison with other low-carbon policy options or consideration of related issues such as employment, mining, resource debates and 'unconventional' fossil fuels such as shale gas.

Most CCS communication appears remarkably similar in focus, style and tone. The one-size-fits-all approach leaves subgroups, regions, language communities, age groups and perhaps females largely un-catered for. Many diagrams and videos about CCS follow the same template and even 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.

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.

The inherent nature of the field is one that is very dynamic, both in terms of the sources of information and in terms of content. Many new sources of information continue to appear and a few, particularly project-specific opposition sites may appear and disappear quite quickly. As already seen over the past three years, some sources, e.g. the ZEP, have greatly improved the professionalism and quality of the information they provide. It is also worth reiterating that the current analysis is a snapshot. The conclusions derived herein are based on the state of affairs in mid-2011 and should be acknowledged as time limited. That said, the shifts over the course of the past three years have been gradual and largely in established directions rather than displaying any particular innovations or reflecting any significant infusion of resources.

Although the database of CCS communication is now established and this report constitutes a first effort to analyse the information, we still know too little about too many aspects of

the communication of CCS and this is likely to continue to be the case. How is CCS being communicated in 'rising CCS powers' such as Korea, China, India, Russia and Brazil and what materials exist (or should exist) in languages such as Korean, Mandarin, Russian, Hindi and Portuguese?

There is little evidence that the consumers of information have been clearly identified. Analysing how different strategies and styles of communication concerning CCS will be received needs to be expanded and must be harnessed to a greater degree by CCS communicators if many of the gaps identified above are to be filled.

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 kind of consensus about 'capture', 'transport' 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. 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 capture and storage, the debate about CCS may assume a different nature.

Comparisons of CCS to other strategies need to be done transparently and clearly communicated, recognising 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, CCS should become a part of the energy-climate mix.

Finally, the effects that would ensue if the world embarked upon a full-scale global programme of CCS would be multiple 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 a technology, a set of technologies and in broader terms involves a certain kind of society. The job of communicating the debate about whether or how to get there has only just begun.

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