A LOOMING RHETORICAL GAP: A SURVEY OF PUBLIC COMMUNICATIONS ACTIVITIES FOR CARBON DIOXIDE CAPTURE AND STORAGE TECHNOLOGIES

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Abstract

The major communications efforts to the general public on carbon dioxide capture and storage (CCS) technologies are reviewed and found to be lacking across all countries and initiatives surveyed, driven primarily by a lack of resources and coordination. Given claims by government and industry that CCS can be a major low-carbon energy source and that public acceptance is critical, the minimal allocation of resources to communications is striking. Little effort seems to have gone into developing a baseline understanding of public attitudes or into understanding how different actors will respond to information on CCS. Outlets reviewed include websites, multimedia presentations, museum displays, educational materials and technical diagrams. The internet is the major focus of the analysis as it has become the major source of information for specific science and technology issues and internet users are more likely to pay attention to science and technology issues. Materials are developed but accessibility is often poor and many websites are rarely updated. Some useful resources are available but no examples that meet current best practice standards found and successfully implemented in other areas of public communications on science and technology, which are the product of deliberate design, requiring time, resources, and imagination.

Keywords: Public communications, carbon dioxide capture and storage (CCS), outreach, science and technology education, climate change

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1. Introduction

What role should public communications play in the development and deployment of a new technology? Some advocates point to past controversies such as those over nuclear power and genetically modified (GM) foods and argue that there is a need to anticipate potential problems by monitoring public opinion, building trust and designing effective communications materials. Carbon dioxide capture and storage (CCS) is a relatively new concept, not only to virtually all of the general public but also to many of the key stakeholders that will be making decisions on siting and deployment. Capture technology requires detailed knowledge of engineering and storage requires familiarity with geology and both subjects lie outside of the domain of even those laypeople with good scientific and technological literacy. The concept of taking carbon dioxide and pumping it across great distance in pipelines and then storing it under the seabed or in geological reservoirs one or two kilometers underground draws comparisons to 'science fiction' (BBC News 2005) and the proposed scale of perhaps billions of tons being stored for many centuries creates further challenges for the lay public.

The most basic question that will be examined here is how, when and if information should be presented to the general public. One view of public engagement is primarily reactive, responsive to attacks or a crisis, but which does not draw attention to an issue by unnecessarily engaging the public. Another approach is proactive – taking action, developing materials and taking an expansive view of interested parties whether or not any obstacles ultimately arise. There are several potential problems with a proactive approach. One concern is that the public communications campaign itself will raise concerns that the technology is hazardous. Moreover, especially at the early stages of development, studying public perceptions and developing communications materials and engaging in outreach will divert (or be seen as diverting) resources needed for technology development. Others may feel that engagement is premature given the early stage of technological development. Finally, a critical question for public communications is determining whether the issue is primarily (or purely) of local interest, or whether it has broader political and public interest. As a largely unfamiliar concept, but one which fits into existing debates over energy and which may be subject to siting controversies, CCS can offer a useful case study in public communications over an emerging technology.

To begin, an analysis of the gaps in studies of public attitudes and in public communications efforts is presented, i.e., we seek to identify those areas that, relative to their importance, have been largely ignored or understudied. The analysis in Section 2 grows out of

a larger gap analysis conducted as part of the ACCSEPT project, a project funded by the European Commission's Sixth Framework Program (FP6), which also deals with the legal, regulatory, and economic acceptability of CCS technologies (de Coninck et al 2007).

As part of the wider analysis conducted under ACCSEPT, several gaps associated with the social and public sphere were identified. Key gaps identified include the need for:

- Better geographic coverage and time evolution of public attitudes;
- Interaction between awareness and perceptions of climate change and energy policy upon support for CCS;
- Studies of the effectiveness of different types of educational materials, methods of communication and messengers; and
- Case studies of public reaction to actual storage sites.

In this report a slightly updated assessment is offered, which identifies the main gaps, and then extends the analysis to cover some of the main challenges remaining to begin to bridge some of the gaps, in particular, the "communications" gap, namely the lack of educational materials, methods of communications and credible messengers. The view of the need for communications on CCS is widely accepted and its role in fostering public acceptance is well stated by van Alphen et al (2006), who describe the need for clear and understandable language on both climate change and CCS and argue that:

> communication to society is a joint responsibility of all organizations involved… To create societal acceptance at large, open, clear, two-way and well-timed communication is needed, clearly putting CCS in the broader context of climate change and the range of possible solutions for a more sustainable future. A greater understanding of the urgency and severity of the climate change problem will make CCS more acceptable. (van Alphen et al 2006: 4378).

Our analysis of the current state of communications that follows is not, however, restricted to Europe and includes other major regions where, arguably, efforts at outreach and communications are, at least slightly, more advanced including Australia, Canada, and the United States. Section 3 discusses the broader context into which communications on CCS technologies fits, including the political environment and broader challenges of communicating science and technology. Then in Section 4 existing materials are reviewed in greater detail, focusing on websites, multimedia, museums, mapping and the use of geological diagrams in public communications. Then, after having conducted a comprehensive review (detailed in greater depth in Appendix 1), in Section 5 current practices in CCS are contrasted against a checklist of best practices in science and technology communications which finds

the current situation badly wanting, other than in a few areas, most notably in the engagement of leading scientists in outreach.

2. Gap Analysis

Despite the fact that some first studies have been done on public perceptions towards carbon dioxide capture and storage technologies, the lack of certainty concerning whether the general public would approve of CCS is still regarded as one of the major barriers to CCS deployment (CSLF 2006). Indeed, some in industry have referred to public acceptability as a "potential show stopper" (Hill, in HoC 2006). In part, this is because these studies all find quite low levels of awareness of CCS, which makes the situation inherently less stable than for other better-known low-carbon technologies such as nuclear power, wind turbines or solar panels.

Other critical questions that might be elucidated by studies of social acceptability include the identity of the messenger and the form of the message, i.e., who presents the case for CCS and how it is presented. To date, most of the outreach on CCS has been conducted by oil and gas firms, the electric power sector, academic and government scientists and to a lesser extent, government agencies and a small number of environmental groups (most notably Natural Resources Defense Council and the Clean Air Task Force in the US and the Bellona Foundation in Norway and the EU). Studies of credibility have found, however, that industry and government are precisely those least trusted by the general public (EC 2005a). Further, as ter Mors et al (2006) find for the specific case of CCS, untrustworthy sources actually undermine the position they advanced. Those considered most trusted are environmental groups and independent scientists. As described in Section 3.2, NGOs have not adopted an overtly hostile stand to CCS in principle, but they still have been skeptical overall and have largely been reluctant to take a stance to actively promote the technology, expecting that those seen to benefit from the technology, namely the energy industries, take the lead. Independent scientists by contrast, notably geologists working for national geological surveys, have been quite visible proponents and as discussed in Section 5, are one of the few examples where best practices in science and technology communications are being employed.

Section 3 describe how the most common source of information for the lay public on general questions of energy and environment are the news media, most importantly television, whereas on specific science and technology questions, it is the internet, which has become the

primary source of information in both the United States and Europe (NSB 2004: 7-5). Although television is the most trusted source of information on science (EC 2007b), there have been no studies of television coverage of CCS. We focus here primarily on the internet since it allows for the widest ranging coverage in both geographic scope and availability of accessible materials.

Local and national environmental groups constitute an important shaping influence upon public opinion, particularly at a stage where the public itself lacks information. Hence, engaging stakeholders in a discussion of CCS is an important element in any effort to determine social acceptability. There have been some efforts by governments and industries to engage with key stakeholders, but such efforts are not always appreciated. In testimony before the CCS Inquiry of the House of Commons Committee on Science and Technology, NGOs in the UK were critical of existing government and industry efforts (HoC 2006, 42).

On the monitoring of public opinion, there are several basic approaches: (1) small focus groups of perhaps a dozen citizens, (2) case studies of local populations in the vicinity of planned CCS activities, for example those living around a storage site or CO_2 pipeline or (3) public opinion surveys of attitudes towards CCS and climate change more generally. All are needed, and various have been employed in different contexts, but to date, there are no instances of either a comprehensive assessment having been taken in any one country at a fixed point in time or the development of a time series for any single approach.

The focus group can offer the richest responses because participants will spend many hours learning about the subject and will begin to develop informed opinions on the subject. Of course, it is easy to question the relevance of such an approach since citizens will rarely, if ever, become well informed on a technical subject such as carbon dioxide capture and storage. Opinions will instead be based on cursory knowledge of the subject that will compete with many other issues for a layperson's attention.

A case study can offer a detailed analysis of local concerns and can provide rich, usually qualitative, data. The dangers are that any local populace will be suspicious of siting a "waste" facility and that there is an inherent selection bias in such surveys since it is often the most strident voices that will be forthcoming and the boundaries of the local community itself is a question of debate. Even further removed is a representative population sample used in public opinion polling. A survey of the general public will suffer less from the selection and information biases described earlier, but the low level of awareness makes it

difficult to ask respondents anything other than the most basic questions regarding CCS, energy technologies and climate change more broadly. In many cases, respondents will offer nothing more than "pseudo-opinions" (de Best-Waldhober and Daamen 2006) or will hold views that are clearly based on incorrect information (Reiner et al 2006).

Although firms developing CCS projects have, no doubt, used focus groups, Shackley and Gough (2004) conducted one of the few focus groups on CCS that is publicly available. Participants discussed the issues surrounding CCS both before and after they had been exposed to detailed information and discussions with experts such as those of geologists from the British Geological Survey. Attitudes were generally found to be more favorable to CCS with exposure to additional information.

Many of the early studies conducted were non-representative of the population at large (e.g. de Coninck and Huijts (2004) study of residents of an area with gas storage, the Shackley, McLachlan, and Gough (2005) survey of some 200 respondents at Liverpool Airport and the Palmgren et al (2004) convenience sample of 126 in Pittsburgh), but they still provide valuable insights into the design of questionnaires aimed at the lay public and identify a number of important concerns. Perhaps even more meaningful would be surveys which are representative of the population of a town or a city where a CCS project was being planned such as Ketzin in Germany or Lacq in France, but too date there have only been media coverage (Kanter 2007), rather than more detailed analysis. There has been some effort at outreach by the companies involved (Vattenfall and Total respectively) and by some independent organizations (such as CIRED in France), but there still has not been any detailed assessment by independent analysts. *Aside from independent qualitative studies in different nations, a necessary first step, it is important to understand cultural and cross-national differences by carrying out identical studies in several different countries.*

Huijts, Midden, and Meijnders (2007) offer one of the few case studies of the attitudes of local residents (n=103) in the vicinity of a potential storage site for carbon dioxide. They found that public attitudes towards CCS in general were slightly positive, but attitudes towards storage nearby were slightly negative. In spite of having little knowledge about CO_2 storage, the lay public showed little desire to learn more. Therefore it is not surprising that trust in those providing information was seen as particularly important. NGOs were found to be trusted most, and industry least by the general public. Trust in different actors appeared to depend on perceived competence and intentions. Moreover, previous experience with the

organizations or actors involved, concerns over accountability and openness can also play important roles in shaping trust (see generally, Lofstedt and Cvetkovich 1999).

With regard to public opinion polls, one obvious gap is the lack of geographical coverage beyond the small handful of nationally representative opinion surveys. Even in those few countries where studies have been carried out, the earliest surveys only date to 2003. Given the lack of popular awareness, it has been deemed essential to monitor the time evolution of public attitudes in response to ongoing developments (ZEP 2006). One might expect that given the early stage in the development of CCS that there is considerable scope for public awareness to grow and for attitudes to shift.

The first representative national surveys were conducted in the US, Japan, UK and Sweden by the University of Cambridge, Chalmers University of Technology and the Massachusetts Institute of Technology (Reiner et al. 2006). The surveys sought to identify basic levels of awareness and understanding of CCS technologies and place it in the broader context of energy and climate change policy. More recently there have been surveys completed in Spain by Ciemat (Solà, Sala and Oltra 2007) and in Australia by CSIRO (Ashworth et al 2007) based on the same questionnaire.

Independently, other public opinion surveys in Canada, France, and the Netherlands have also been conducted which are noteworthy for their differences. The Canadian study (Sharp 2004) tried to develop the term “geological disposal of carbon” (GDC) which was felt to convey a more easily accessible term. The French study (Ha-Duong and Campos 2007) explicitly examines the use of language, particularly comparing the use of the term “stockage” instead of “sequestration” to describe storage. ‘Carbon dioxide capture and sequestration’ is also the more common term used in the United States, which poses a challenge to basic comprehension, but also because both terrestrial sequestration (i.e., aforestation or reforestation) and geological sequestration are grouped together. This need to address two quite disparate issues at the same time also arises from the nature of the DOE regional partnerships, many of which group the two approaches together.

The surveys commissioned to date have been largely funded by academic institutions, with no resources earmarked to carrying out more comprehensive and/or more regular surveys by any of the proponents of action. The effort to survey public opinion has been wholly opportunistic and uncoordinated at cross-national (e.g., European or OECD) level. Only recently has the Eurobarometer asked the first basic question on public awareness of CCS at

the EU level (Table 1). There has been little effort to focus, for example, on either major countries such as Italy or Poland or on conducting serious academic case studies of new projects such as those of Ketzin in Germany or Lacq in France.

	Nuclear fusion	**CCS**	Hydrogen energy & cars (H2)	Fuel cells	Geo-thermal energy	Ocean energy (tidal/ wave/ marine)	ITER	4th gen-eration nuclear reactors	**Clean Coal**	Nega-watt & Sustain-able decrease	None of these
EU-25	58%	21%	53%	41%	44%	43%	9%	31%	24%	7%	19%
BE	68%	28%	68%	41%	29%	38%	3%	29%	25%	6%	13%
CZ	39%	16%	55%	51%	33%	42%	5%	18%	22%	8%	21%
DK	72%	32%	88%	62%	35%	**80%**	1%	30%	15%	7%	3%
D-W	71%	32%	67%	**68%**	77%	49%	14%	44%	13%	12%	8%
DE	71%	33%	66%	**68%**	78%	49%	14%	44%	13%	11%	7%
D-E	74%	35%	61%	67%	85%	50%	14%	43%	14%	10%	4%
EE	30%	15%	36%	38%	19%	28%	2%	33%	16%	5%	36%
EL	32%	17%	38%	*14%*	37%	*24%*	14%	37%	34%	6%	37%
ES	47%	15%	43%	23%	24%	27%	4%	17%	19%	3%	38%
FR	69%	30%	66%	58%	65%	59%	23%	**49%**	22%	8%	9%
IE	45%	10%	34%	21%	*17%*	38%	3%	*15%*	41%	3%	27%
IT	47%	*9%*	40%	16%	29%	*24%*	*1%*	21%	17%	2%	29%
CY	*20%*	*9%*	43%	*14%*	23%	29%	10%	24%	20%	4%	**40%**
LV	38%	12%	35%	16%	*17%*	32%	8%	25%	18%	3%	29%
LT	37%	11%	*28%*	32%	21%	29%	*1%*	22%	*9%*	2%	35%
LU	66%	32%	76%	58%	42%	50%	3%	40%	31%	10%	9%
HU	30%	15%	34%	20%	34%	30%	*1%*	17%	22%	3%	39%
MT	46%	22%	40%	26%	19%	33%	3%	19%	33%	12%	34%
NL	86%	**45%**	**80%**	48%	29%	53%	3%	29%	33%	13%	5%
AT	31%	*9%*	38%	34%	32%	25%	**32%**	31%	24%	4%	30%
PL	40%	12%	36%	24%	30%	26%	10%	28%	42%	10%	23%
PT	46%	20%	34%	32%	31%	44%	4%	18%	33%	4%	29%
SI	39%	18%	52%	27%	34%	43%	13%	28%	28%	14%	25%
SK	30%	*9%*	39%	36%	35%	26%	3%	17%	24%	9%	28%
FI	69%	33%	62%	44%	**86%**	48%	16%	26%	**49%**	11%	3%
SE	**99%**	20%	70%	65%	32%	76%	31%	26%	26%	**15%**	*0%*
UK	68%	17%	54%	44%	36%	62%	2%	30%	31%	4%	15%

Table 1. Awareness of Energy Technologies across EU-25
(Question QD3: In the context of energy production, which, if any, of the following have you heard of?) Source: European Commission (2007), p 13.

The most comprehensive national effort to create a comprehensive national research effort has been that of the CATO project in the Netherlands, measured in terms of funding (€6m), level of effort and coordination. There have also been significantly smaller efforts to integrate across disciplines in other countries such as the UK through the UK Carbon Capture and Storage Consortium (UKCCSC) and in Germany through a project coordinated by Forschungszentrum Jülich, Fraunhofer Institute ISI and the Wuppertal Institute.

Around the world, different groups such as the CO_2 Capture Project (CCP), Carbon Sequestration Leadership Forum (CSLF), United Nations Environment Programme (UNEP),

Intergovernmental Panel on Climate Change (IPCC) and various national governments and multinational firms have put together a range of different types of educational materials and methods of communication, and many more are examining the possibility of developing such materials. There has been incidental consultation across projects, but no sustained effort to coordinate these many different activities, nor are existing materials often put to good use. *To date, 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.*

A number of firms including Statoil, Vattenfall, BP, Total and other firms have engaged in project development, development of promotional materials and community outreach as part of their current or planned projects. Although there may have been some internal corporate efforts to assess these projects, *no published case studies have been found of attitudes towards these first novel projects including the response of the community as well as coverage by local, national and international media.*

The eventual acceptance of CCS as part of a portfolio of options would logically seem to depend on the awareness and perceptions of CCS as well as the perceived urgency and challenge of addressing climate change more broadly. Unlike other measures such as energy efficiency or renewables, which might have other sources of support, CCS is entirely linked to climate change. Assuming tough carbon constraints, then the critical question is how CCS is perceived in comparison with other low and zero-carbon technologies such as renewables, nuclear power, and to some extent, natural gas. An additional consideration would be fuel poverty and equity – if electricity prices go up, how are the fuel poor to be protected? CCS will therefore be affected by the level of concern over energy security, climate change and price and its relation to other generation technologies, but *there have been few widely accessible studies of how CCS fits within the broader energy, environmental, economic and security context.*

There are a wide range of siting problems that firms or governments encounter when trying to site a new facility ranging from a high-level nuclear waste storage facility and incinerators to wind turbines, solid waste facilities and new factories. There has been no work to determine whether CCS is perceived as an industrial process or waste and thus a largely local issue or as a decision that draws broader national level attention akin to the case of nuclear power. Huijts and de Coninck (2004) have put forward the concept of NUMBY or "not under my backyard" to reflect the potential anti-siting attitude of many local residents opposed to a CCS project, especially the storage component. There are, of course, local

benefits from CCS projects which will dampen opposition, but most of the disputes over siting would concern storage and transport, which have relatively few local benefits as compared with a new power station. Since the benefits of CO_2 storage or transport accrue primarily globally but the costs, however slight they might be, are imposed on the local community, there will be understandable concern about even low-level risks and the impacts on property prices in the vicinity.

Determining where on the spectrum of siting of different types of facilities CCS falls would require greater public familiarity with the technology and so should be studied as part of the first projects. For some projects, where storage is offshore, it is likely that CO_2 pipelines may elicit the greatest concern, whereas for onshore storage, it may be the storage site itself that emerges as the focal point for opposition. Indeed, *there is little clarity as to even which stage of the process (capture, or more likely, transport or storage) is likely to elicit greater opposition and what could explain the sources of that opposition.*

Apart from siting issues associated with storage and transport, the broadest implications of CCS might well be the impact that CCS will have on electricity prices. Recent Eurobarometer studies (EC 2006, EC 2007a) have found relatively low willingness to pay for renewable energy – roughly half of Europeans did not want to pay anything additional for renewables in spite of its popularity. If CCS is perceived as being responsible for rising consumer electricity bills, then one might expect that CCS will be perceived more negatively (which is equally true for other low-carbon technologies that drive up electricity prices).

Another serious gap is the lack of information regarding CCS in many languages. The Summary for Policy Makers of the IPCC Special Report on Carbon dioxide Capture and Storage was translated into the major languages of the United Nations (i.e., French, Spanish, Russian, Chinese and Arabic). In addition, there are several sources of more popular information on CCS including various industry consortia and governmental organizations including the United Nations Environment Program (UNEP), the Carbon Sequestration Leadership Forum (CSLF), International Petroleum Industry Environmental Conservation Association (IPIECA) and the CO_2 Capture Project (CCP). Specific projects in individual countries such as Germany and France have begun to see the development of materials in those languages.

In spite of the small fraction of fossil energy in France's electricity sector, French is the only language besides English where it could be said that there exists a number of high-

quality communication outlets and many of them, such as the BRGM and Club CO_2 sites, are among the most professional. In terms of the number of high-quality sites, one might even make a case that the average French speaker is more likely to come across accessible information than a native English speaker. As discussed in Section 4.1, although only recently launched, IZ Klima, a new German site, is one of the better sites reviewed.

To increase access to the ACCSEPT stakeholder survey, CCS fact sheets were translated into 16 European languages with the support of Shell International. CO2-Net East has taken the fact sheets in Eastern European languages and is utilizing them for its own purpose and is also translating other material into their own languages (see Appendix). Nevertheless, information in major languages such as German, Italian, Spanish and Polish is relatively scant. *Virtually all the public communications material related to CCS has been developed in English and the first materials are only slowly being developed or translated into other key languages.*

A more basic question is whether public perception itself is relevant to the development of CCS. There is evidence that some NGOs, for example, do not believe that the public has a well-articulated view or that the organization that could influence the technology development process (Shackley & McLachlan 2006). *The relationship between public acceptability and adoption of a technology by the political process has not been adequately explored.*

Although research into public perception does not by itself enhance social acceptance it does serve as an important first step towards understanding potential concerns of members of the public and other interested parties. Studies of public perception can also provide insight in the strategies that can best be followed to design risk assessment and regulatory schemes, which are more likely to build trust and acceptance. Given the absence of adequate study it should not be surprising, but *there is no mechanism by which studies of public acceptability might inform regulatory design.*

3. Moving from Public Perception to Implementation

CCS is hardly the first new technology to be evaluated. There is much to be learned from the wealth of experience in other fields such as with genetically modified (GM) foods (Bernauer et al 2004), and nanotechnology (Doubleday. forthcoming). The institutional innovations in

biotech field seem to be the most interesting analogs, but were stimulated by a determined opposition. What is not clear is whether such 'radical' approaches would be adopted without a groundswell of public protest.

Based on this analysis, several social field issues emerge as major gaps that need to be addressed and which are currently lacking:

- Better geographic coverage and time evolution of public attitudes;
- Interaction between awareness and perceptions of climate change and energy policy upon support for CCS;
- Effectiveness of different types of educational materials, methods of communication and messengers; and
- Case studies of public reaction to actual storage sites.

With respect to geographic coverage, although no country is covered adequately given the claimed potential of CCS, there have at least been some efforts made in the US, UK, Australia and the Netherlands and to a lesser extent in Japan, Canada, France, Germany, Sweden and Spain to investigate public opinion. A number of European countries that have been identified in the ACCSEPT study as being of critical importance (e.g., Norway, Italy, and Poland) have seen little or no assessment of public acceptance. For example, in spite of the longstanding Sleipner project, the Norwegian government notes "There have been little public discussions regarding the ongoing storage of CO_2 at the Sleipner field in the North Sea and the coming storage of CO_2 from the Snohvit field from 2007" (Government of Norway 2007). One reason the government gives for the lack of public discussion is that both projects have had "broad support from the main environmental organizations, which may have had a positive effect on the general public's acceptance of these projects." Instead, there is little reason to believe the public is actively engaged on an offshore project.

Absent a directed program of research, studies have inevitably been piecemeal, opportunistic and uncoordinated. The gap analysis focused on studies of public perceptions, which could help establish a baseline for assessing changes over time. The most obvious recommendation in this regard is to provide the necessary funding for coordinating and surveying attitudes on a regular basis.

The remainder of this report therefore focuses on the last two key suggestions, namely a focus on communications and the gaps between perceptions and implementation of projects and programmes. Also, unlike public perceptions, there have been few if any studies of the current state of communications with respect to CCS.

To move forward, some evidence of international best practice is sought. Given the dearth of available materials, the search for best practices is not restricted to Europe, but insofar as possible, is global in scope, looking to efforts by individual projects, firms, national governments and international institutions and consortia. We examine the current offerings and shortcomings across a range of communications resources.

One can break down the available materials into several categories: websites; pamphlets, leaflets and other short summaries; technical materials, especially diagrams of the capture, transport and storage processes designed for wider accessibility; multimedia material and outreach by CCS professionals. For practical purposes, most of the analysis that follows focuses on written materials and especially those available on the internet. As a rapidly evolving issue area, it is impossible to do much more than offer a snapshot that may not reflect the reality at a later date and there are many initiatives underway (but not yet final) that have not been included in the current report. Moreover, it is difficult to properly represent outreach that has been conducted on a one-on-one or small group basis or that has not been documented in a publicly available form. A fuller analysis would also include interviews with communications practitioners as well as with potential funders such as governments and industry and more attention to the response of individuals to the materials themselves.

Given the rapid growth in CCS as an issue and the vast expanse of the internet, one cannot claim to be truly exhaustive in assessing all the available materials. Moreover, language poses an additional barrier, so we cannot claim to have identified every major site in every major European language. Nevertheless, here and in Appendix I, we have sought to review the websites of many of the major organizations involved in CCS, who would also therefore be expected to be at the vanguard in developing materials.

We begin with the internet, since a comprehensive website ideally can serve as a repository and 'one-stop shop' for all the materials. Moreover, the internet is also increasingly the main pathway by which the public seeks to access science and technology information. According to studies by the US National Science Foundation and the European Union, the most common means of investigating a specific scientific issue in greater detail is the Internet and its importance has grown over the last few years. From 2001 to 2004, that number increased from 44% to 52% while books declined as the primary source from 24% to 12% and television increased from 6% to 13%. {NSB 2006) Reliance on the internet relative to television as the primary source of information rises with education. Moreover, internet users

also tend to be those more likely to pay attention to science and technology issues (18% vs 13%) (Pew 2004).

Aside from the internet, other obvious sources for the public to learn more about a technical issue such as CCS include: various media outlets including television, newspapers and popular science magazines; libraries and books; educational institutions; and museums and other resource centers. Although there have been a number of studies of print media coverage of CCS (IEA GHG 2006; Bradbury and Dooley 2004; Mander and Gough 2006), there are no studies of coverage of CCS in either the most trusted and widely viewed media (television) or the media most used by the scientifically aware and attentive and for specific technical questions (the internet).

We will review the presentation of CCS in various contexts, but first it is helpful to understand how different groups are engaged with science and technology and their interests in learning more about a technical issue such as CCS and understand the role CCS can play in the wider political over energy and environment. The most attentive portion of the public will use any and all of these resources and may seek out information long before the issue becomes salient, driven by curiosity more than self-interest. Those less interested in science and technology in general will only seek out information in direct response to a specific project, will generally be more suspicious of science and technology and will be less versed in seeking out such technical information.

3.1 Attentive, Interested and Inattentive Publics

Miller and Pardo (1999) have divided the public into three categories based on their interest in and understanding of science and technology: an attentive public, an interested public and a residual public. The attentive public (AP) includes those who: (1) express a high level of interest in a particular issue; (2) feel very well informed about the issue; and (3) read a newspaper on a daily basis, regularly read a news magazine or a magazine relevant to the issue. By contrast, the interested public (IP) consists of those who claim to have a high level of interest in a particular issue but do not feel very well informed about it. This group is usually far larger than the AP. Finally, the residual public (RP) consists of those who are neither interested in nor feel very well informed about a particular issue.

In general, the AP makes up perhaps 10-20% of the public on most science and technology issues. This group is also most likely to be using existing resources such as

libraries, museums, and seek access to public officials. Thus, there is a relatively small, informed audience for many policy questions and who will actively seek out information on technical issues. Researchers have concluded that less than one-fifth of U.S. residents meet a minimal standard of civic scientific literacy (Miller, Pardo, and Niwa 1997). Looking across a range of policy issues, the National Science Foundation found that roughly 10 percent of a representative sample of the U.S. population could be categorized as "attentive" on both science and technology and on energy and environmental issues. Unsurprisingly, the public pays more attention to matters that they perceive as affecting them directly. New medical discoveries score slightly higher (14 percent), but local issues such as schools registered the highest levels of attention (31 percent) (NSB 2002: Appendix Table 7-7). Even among those with graduate or professional degrees, less than 25 percent are considered attentive to science and technology issues. Only 15 percent of those with a "high" level of education in science and mathematics (those having taken 9 or more high school or university level science or math courses) are considered attentive, although this percentage is still three times the level for those with "low" levels of science and math education. (NSB 2002: Appendix Table 7-8).

The US National Science Foundation and the European Commission have also tracked public understanding of basic scientific concepts for most of the last decade. In the 2006 study, a number of other countries were also reviewed, primarily from Asia (NSB 2006). In general, there were some common misconceptions (such as whether electrons are smaller than atoms) whereas most could say the center of the earth is very hot and that the earth revolves around the sun. Energy and environmental issues fare no better. Coyle (2004) and NEETF/Roper (2006) find poor performance across both energy and environmental questions. Reiner et al (2006) find that whereas respondents in the US, UK, Japan and Sweden understand that coal plants and automobiles emit CO_2 and that trees absorb CO_2, on other issues such as nuclear power there are persistent misperceptions and that CCS in addition to being largely unheard of, is often confused as a solution to other environmental problems including ozone depletion, air pollution and even water pollution and toxic waste.

There has been concern about the dangers of less attentive publics including less government support for research, greater public susceptibility to miracle cures, get-rich-quick schemes, and other scams and less trust in the benefits of science and technology. Moreover, those within society who are less knowledgeable about science and technology are also less trusting of scientific elites and do not believe in the benefits brought by science and technology (NSB 2004). Of course, addressing public disinterest or disengagement in science

and technology in society is a far broader subject that will require a concerted, long-term effort to create a more scientifically literate populace that involves fundamental cultural and educational shifts. Nevertheless, one would expect that depending upon the audience it would be necessary to include different levels of technical detail, and to develop engagement strategies appropriate to the audience.

3.2 NGOs and the Role of CCS in the National Energy Debate

Most major studies of the technologies needed to carry out an ambitious climate change policy will emphasize the imperative of a portfolio of options including all available low or zero carbon options, but the politics and perceptions of the need for portfolios can be quite different. There are several ways in which the tradeoff across CCS, nuclear and renewables play out. Media coverage often portray decisions on CCS as having an influence on other decisions such as with regard to siting additional capacity in either nuclear power or wind.

Of course, there is significant national variation. In France, there is little hope (or concern) that CCS will influence French nuclear policy and some concerns that CCS may adversely affect increased penetration of renewables, but support has primarily been led by French organizations interested in the deployment of CCS globally. In the UK, CCS is largely seen as acting as a bulwark against nuclear power, for example, by the Liberal Democratic Party which strongly opposes nuclear power and has even played into debates over Scottish nationalism (BBC News 2007). In other countries such as the Netherlands, Germany, and Norway, CCS plays into broader national debates over both funding for research into renewables and over the future of nuclear power and renewables deployment (e.g., Fischedick et al 2007). In the US, the focus has primarily been on IGCC technologies, which may be used in the near term to meet targets for local and regional pollutants, and can lead to confusion with IGCC with capture and storage in spite of the lack of any longer-term incentive to cover the significant extra cost needed to capture carbon dioxide emissions. In most other countries, there is virtually no debate on the potential for CCS.

One critical question for NGOs in deciding on a position with regard to CCS is whether there is, effectively, a zero-sum game between nuclear and CCS in bulk power production or between CCS and renewables on research funding. This may also reflect the low current level of funding for energy technologies overall, which exacerbates the perception that there will be winners and losers.

Stefan Singer, head of the WWF European Policy Office made this clear at a recent ECCP stakeholder meeting, when he stated that WWF support for CCS was contingent on the move away from nuclear (Singer 2006). Many other European NGOs, as seen from the ACCSEPT survey (Shackley et al 2007), were more concerned (than other stakeholder groups) at the possibility of increased focus on CCS diverting public resources away from renewables. NGOs were also far more likely to take many of the associated risks of deployment quite seriously.

There are a small handful of national programmes that actively engage with the NGO sector, for example, the Dutch CATO project currently involves almost all of the major Dutch NGOs including Greenpeace, but there are few other examples where active engagement is the norm. In most countries, the attitudes of the major NGOs can be characterized as ranging from cautiously supportive through neutral to mildly negative. The nuanced positions arise from greater concerns over the risks of nuclear power balanced against a presumption that if properly monitored and regulated, CCS in countries such as China would be far preferable to uncontrolled combustion of coal. Nevertheless, in spite of the growing engagement of major national and international NGOs it is still unclear as to whether CCS will emerge as an issue of broader public concern or will only be of passing interest and of primary concern to local communities concerned over standard siting issues.

Moreover, even if most mainstream NGOs will not necessarily lead concerted opposition to CCS, other skeptical voices may rise up. In the UK, the anti-coal demonstrations and "Climate Camp" that were held outside of Drax power station in 2006 was not sponsored by any major NGO such as Friends of the Earth or Greenpeace, but emerged as part of a new coalition of grassroots organizations (Monbiot 2006). A recent advertising campaign in the United States opposed to all coal plants was sponsored by the group Architecture 2030 (http://www.architecture2030.org), which claims, "There is a 'silver bullet' for solving global warming… No More Coal" arguing that all other efforts are meaningless if the US continues to plan for and build coal plants. Although primarily interested in efficiency and not explicitly opposed to CCS, the campaign does not differentiate between conventional coal and coal where the CO_2 is captured and stored.

Another widely cited example of public acceptability concerns over CCS has been the opposition to the BP Carson project in California, which was primarily led by small Environmental Justice (EJ) groups and ultimately led to the withdrawal of a bill on carbon sequestration even though major environmental groups such as the Natural Resources

Defense Council (NRDC) had championed the bill for its potential climate benefits. Ten EJ groups wrote to the California legislature contending, "CO_2 releases are deadly to our communities". One EJ advocate described CCS as "industry manipulation to try to circumvent growing public interest and knowledge and awareness of renewable energy portfolios" (Brown 2007: A548). Another local group in Alma, Michigan argues that a new IGCC plant with CCS planned for their area should not be built unless permission to build is tied to closure of existing coal-fired power plants (Gittelman 2007). In Australia, the grassroots group Rising Tide, based in the major coal port of Newcastle, challenges the need for coal and CCS and has gained prominence for its opposition to coal-fired generation, regardless of whether the CO_2 is stored.

All these examples bring up local, often longstanding and independent concerns, most of which are non-technical, and suspicion of industry and the coal or oil industry in particular, rather than any specific concern unique to CCS. The rise of grassroots opposition also provides clear evidence of the need for broader dissemination of materials appropriate for wider public consumption rather than focusing only on more educated and engaged stakeholders such as the major national environmental groups.

4. Educational and Communications materials

A number of the major projects, industry, government and consortia websites were reviewed but little serious effort to develop a communications effort that could engage most interested stakeholders let alone the public. A description of each of the websites reviewed can be found in Appendix 1. In this section, some of the key characteristics are drawn out and commonalities of the sites reviewed. It is noteworthy that of the several dozen websites reviewed there appeared to be no effort to coordinate across projects; even simply linking across projects on different websites was relatively weak.

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. A few do include links to more general sites on global warming, but there is usually little effort to ensure that those links remain updated nor do many of the linked sites specifically address the issue of CCS, even in a cursory manner.

4.1 Websites

The websites of the two major international efforts, the Carbon Sequestration Leadership Forum (CSLF) and the International Energy Agency (IEA) Greenhouse Gas (GHG) programme are examples of the inadequacy of the existing effort at education and outreach. The CSLF website has a section that is described as 'Education' but which only contains a very basic introduction similar to that which can be found on many small project websites. In 2004, the CSLF Policy Group convened a Task Force on Public Awareness and Outreach led by Canada, which developed an extensive discussion paper with inputs from Australia, Canada, France and the United States (CSLF 2005). Although housed on the website, the 185-page document is not listed under either the Task Forces or the Documents tabs and is only available by searching for the document.

The IEA GHG Programme contains a set of several "Educational Links" including a UK Defra Climate Change education website (broken), the US EPA global warming Kids page (http://www.epa.gov/climatechange/kids/), a site for younger children called *Oneworld: Tiki the Penguin, Global Warming for Kids* (http://tiki.oneworld.net/global_warming/climate_home.html) and a site for students developed by the Cooler Heads Coalition (http://www.globalwarming.org/student.htm), an industry organization promoting skepticism about climate change (the student site itself is longer active).

Nor are the materials developed always put to good use. One of the more ambitious efforts to develop materials aimed at a broader audience was an 18-page brochure that the United Nations Environment Programme (UNEP) created in an effort to synthesize and simplify the outputs of the IPCC Special Report on Carbon Dioxide Capture and Storage released at the end of 2005 (http://www.unep.org/dec/docs/CCS_guide.pdf). Although there was a print run and distribution of the pamphlet, it is no longer easily visible on even the UNEP website nor do any of the other websites surveyed, even those with educational links, reference the UNEP brochure.

A number of sites include a series of Frequently Asked Questions (FAQs) and in the case of the CSLF website, there is even a Glossary. These FAQs are usually quite technical. Some journalists looking for answers to specific questions might find these helpful, but most of these sites are unlikely to be useful to those largely unfamiliar with the subject. Once again, there is little indication that any of the various groups that have developed FAQs consulted any of the other existing FAQs nor is multimedia or interactive techniques used.

One of the biggest challenges is coordination and establishing the mechanisms needed for collaboration. One example, where collaboration has been especially needed is for the US DOE regional partnerships coordinated by the DOE Office of Fossil Energy and the National Energy Technology Laboratory (Wade 2007a). Although each of the US regional partnerships acts independently, coordination and *ad hoc* collaboration is facilitated through an Outreach Working Group (OWG) made up of the respective outreach coordinators. The OWG conducts regular teleconferences and maintains an internal sharepoint website to store interim work products, notes and resources, but there is no publicly available clearinghouse for all of the information generated by the partnerships (Wade 2007b).

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 CO2CRC are highly project-specific showing little effort in conveying information beyond a small circle of those already interested in the subject. In general, 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.

There are a few examples that come closer to best practice. Most notable is an all-German site, IZ Klima (http://www.iz-klima.de), funded by a consortium of major German and European companies including Alstom Power, EnBW, E. ON, Hitachi Power Europe, RWE Power, Siemens Power Generation and Vattenfall Europe. IZ Klima is designed to serve as an "information platform for the interested public, the media and the professional audience and acts as a mediator between business interests and public concerns." The information center is supported by a technical advisory board, which includes representatives from several government ministries, thinktanks and academia. The Association's president Klaus von Trotha is quoted on its website as saying, "The responsible development of these new technologies will take time. We are convinced that an intense exchange between all groups in society will help ensure that the CO2-power plant is a success." In terms of access, the IZ Klima site includes searchable databases of 46 specific CCS projects and 39 studies of CCS and related issues from around the world in English, French and German with short summaries of all projects and studies and links to the appropriate sites.

IZ Klima is a relatively new site compared to many of the others, so it is difficult to judge the resources allocated to maintaining the site over time, but another major challenge is to keep websites current and provide new content that would encourage interested visitors to return in the future. There are few examples of sites being updated on a regular basis either for quality control or to incorporate new materials or modify website design. The UKCCSC

website (www.carboncapture.org.uk) is one of the better sites in terms of providing detailed news updates on a regular basis, but even here roughly one-third of the links reviewed were broken or out of date. Another site that does reasonably well in providing frequent project updates is the MRCSP site, but here too cross-referencing is poor. Details of the Phase II projects are occasionally updated under "Project Snapshots", but these changes are not listed under the What's New section, the last reference to a website update is from May 2006, so there is no easy way to notice the updates (although the site does have a mailing list allowing for contact about routine updates). In most cases, the issue is simply one of resources and creating a dedicated webmaster to maintain and monitor the sites.

Research-oriented sites such as that of MIT are forced to update relatively frequently to include their latest reports, but outreach-oriented sites often neglect the need for frequent updates after an initial spurt of activity, often driven by the lack of funding or personnel to maintain the site. For example, two otherwise excellent sites from a usability and design perspective, those of the Texas Bureau of Economic Geology and Princeton's Carbon Mitigation Initiative have their most recent newsletters posted in 2004 and 2005 respectively. Many other sites, even those intended to be major portals of information on CCS are rarely updated and have few attractions to encourage repeat visits.

Aside from the lack of updating, accessibility is another serious challenge. Even some of the more impressive materials that have been developed such as the Keystone Outreach Plan and the UNEP brochure summarizing the IPCC Special Report on CCS are often hidden or buried on the site and not accessible to most users browsing the website and would only be found if the document was specifically being sought. Other sites with extensive materials, the US NETL site is a good example, present them in such a way as to be difficult to sort through. This can be contrasted with the easily accessible interfaces of the Princeton CMI or of IZ Klima sites.

4.2 Diagrams

Many sites include a diagram that seeks to explain graphically how carbon dioxide is captured from a source, transported and then stored, usually in an underground saline aquifer. The most common diagram used is that of the Sleipner field done by Statoil and has become almost iconic of CCS given its prevalence. As a technical diagram, it is quite elementary, but for a broader audience the diagram could be quite problematic. Few members of the public

understand how oil and gas are recovered and few would they have any sense of dimension other than perhaps the ship. If the goal is to allay concerns that the CO_2 was not being injected into the ocean, considerable confusion could arise over the similarity between the blue of the (unlabelled) North Sea with the blue of the Utsira formation. There would also be little sense of direction of flow along the various lines nor would there be any understanding of the link between the gas in the Sleipner East field (confusingly indicated in red) and the CO_2 being pumped back down into the Utsira formation.

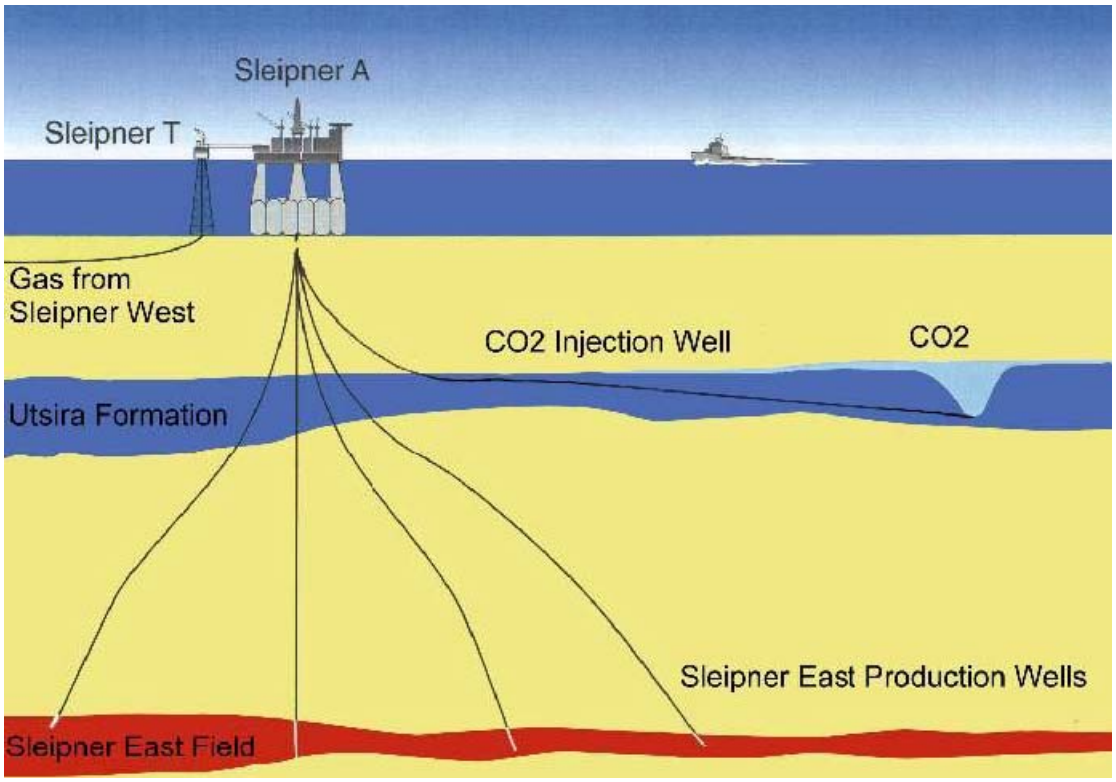

Figure1. Diagram of Sleipner Field (Statoil)

The second image is a cartoon, also developed by Statoil, which attempts to convey the nature of the entire CCS value chain. Included in the diagram are fossil fuel sources, the needed transport infrastructure and storage facilities. Again, this image has been widely reproduced on everything from printed materials to mouse pads. Compared with the Sleipner diagram, this cartoon has some advantages and disadvantages. The greatest positive element is that it seeks to convey the context for CCS by incorporating it into the infrastructure needed to supply the nearby city. Beyond that basic point, however, the diagram is quite complicated to follow with no less than three colored sets of arrows to denote natural gas pipelines, hydrogen pipelines and 'geological storage' (which is intended to convey the transport of CO_2 to the geological storage site). There is actually a fourth transport in the form of the electricity

transmission lines and upon close inspection a hydrogen filling station to describe a fifth vector for energy transport.

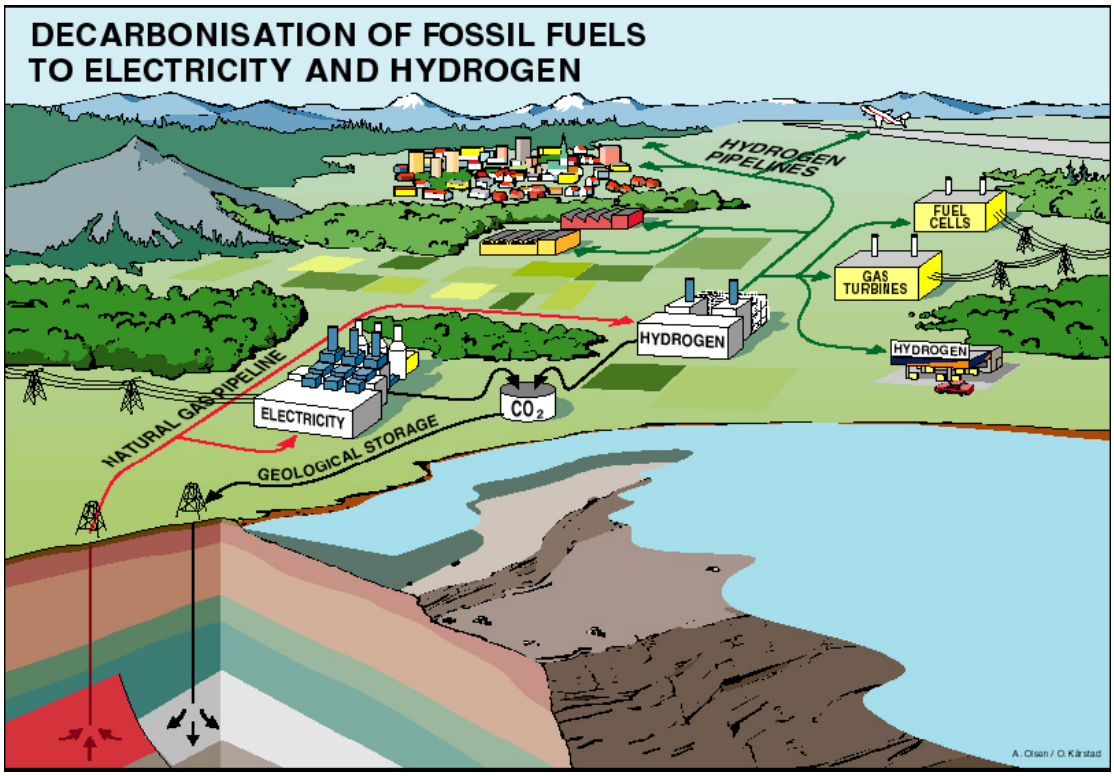

Figure 2. Diagram of a Decarbonized Energy System

Other diagrams developed by BRGM in France, CO2CRC in Australia, GEUS in Denmark and the industry-led CO_2 Capture Program (CCP) and the US DOE Plains Partnership (PCOR) can be found in Appendix 2 and are only a sampling of many similar diagrams that have been developed. The major challenge of all these diagrams is the difficulty of portraying complicated geological information to an audience, including not only the lay public, but most government, NGO and even electric power sector representatives, that is unlikely to have had even a basic introduction to geology. The GEUS, CCP and CO2CRC all focus primarily on illustrating the technical aspects of the problem. Few stakeholders, let alone members of the public, would understand rock porosity or that CO_2 would (or could) be stored in, what appears to the naked eye, as solid rock. Some, such as the Sleipner visual presented in Appendix 2 attempt to offer a striking visual depiction. Others, such as that developed by PCOR seeks to clarify the US DOE-imposed confusion between terrestrial and geologic sequestration. For some purposes, it may be better to avoid detailed geological images entirely. The Battelle Pacific Northwest Laboratory figure, for example, does not

even attempt to include any details of the subsurface and simply uses a heuristic to illustrate the hub-and-spoke nature of storage sites.

Of the geology-rich diagrams, the BRGM effort is by far the most impressive in highlighting and zooming in on specific elements of the CCS value chain and by framing the issue and the diagram in a broader context of energy and climate change that is likely to be more resonant with the general public. The single static BRGM diagram is not much better than others such as that of Statoil, it is only the animation and context that allows it to convey more useful information.

One of the more interesting efforts to produce an interactive diagram was developed by Carolyn Preston at Natural Resources Canada on behalf of the US DOE Office of Fossil Energy/CSLF (see Appendix 2). The Flash-enabled diagram sought to demonstrate how a reservoir would fill up with CO_2 over time depending on the percentage of CO_2 injected into a reservoir. Again, this figure is no longer accessible (Preston 2007).

Mapping activities: There are several sites that attempt to develop various forms of mapping, whether as an interactive tool or a more conventional atlas. The US National Energy Technology Laboratory (NETL) has developed a National Carbon Sequestration Atlas which maps all potential storage sites across the US based on the Phase I research (http://www.netl.doe.gov/publications/carbon_seq/atlas/ATLAS.pdf).

Perhaps the most usable is the IEA GHG Programme's interactive map of CCS demonstration projects. The map is intended for a wider audience than the more detailed project database developed by IEA GHG. Similarly, IZ Klima's interactive map allows for a view of major projects with short summaries (in German) and links to the external websites which can provide greater detail on any specific project.

The Big Sky Partnership in the Western United States also has a readily accessible site that includes a map gallery and the potential for interactive mapping. Several other major efforts to develop GIS tools include those of BGS, MIT, and Ecofys (GIS references). Only BGS has made an effort to make the data accessible on a website as part of the UK Carbon Capture and Storage Consortium project (http://www.bgs.ac.uk/co2/ukco2.html).

4.3 Educational Materials

Apart from materials aimed at the public overall, educational materials are professed to be another main aim of outreach efforts. There are some examples of positive developments in educational programs and materials aimed at CCS; for example, Statoil is in the process of helping to develop a set of educational materials for Norwegian schools (Sundset 2007). The RECS (Research Experience in Carbon Sequestration) programme in the United States has taken undergraduates, graduates and early career professionals from across a range of disciplines and exposed them to different technical and non-technical aspects of CCS. CSIRO in Australia has employed large group engagement and consulted with over a thousand participants in workshops or using computer-assisted telephone surveys (Ashworth et al 2006; Littleboy et al 2006). Other examples of communications and educational materials are discussed in the sections on diagrams and museums. There are good examples of educational materials in the general areas of geology. The British Geological Survey (BGS) (http://www.bgs.ac.uk/education/home.html) offers a wide-ranging set of educational resources on various aspects of geology, although in spite of the active involvement of BGS in major British, European and international CCS projects, there appears little on CCS itself.

One site that attempts to explain CCS in an engaging and straightforward, if somewhat skeptical, fashion is the Why Files, a site devoted to "science behind the news". The site is largely aimed at science teachers and based at the University of Wisconsin. Each article uses outside external, usually academic, advisers for generating content and reviewing technical details (http://whyfiles.org/256carbon_storage/index.php).

One of the few organizations to have developed targeted educational materials on CCS is the Keystone Centre based in Colorado and with offices in Washington, D.C. The Keystone Science School Curriculum trains teachers and gives detailed lesson plans and information on environmental issues and climate change in particular (http://www.keystonecurriculum.org/). The Keystone Center also developed an outreach plan, or at least a scooping study for such a plan on CCS for the Office of Fossil Energy within the US Department of Energy and the National Energy Technology Laboratory in 2004. The 2004 study has not been extended nor has its impact or usage been assessed.

The Keystone (2004) study is one of the few to actually segment target audiences and, at least briefly, analyse the pathways by which different stakeholders might be engaged. The report divides up stakeholders into regulators, elected officials, business leaders, NGOs and

the general public. NGOs are further distinguished according to various types of national environmental groups, state groups, and organizations dealing with environmental justice, energy, land-use, and farming. For the general public, brief descriptions of the interests and outreach pathways are given for students, abutters, clubs and churches and involved citizens. The CCP2 Study (Wright et al 2007) offers a detailed analysis of stakeholder perceptions and potential barriers and opportunities by country for major developed and developing countries, and by stakeholder group (industry, NGO, government, and general public). Again, in both cases, little use seems to have been made of the analysis.

Multimedia: There have, to date, been 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 CO2CRC, NETL in the US and the Dutch CATO project. Whether the videos have the intended effect is, however, a separate matter. Focus groups in Manchester and Cambridge done as part of the ACCSEPT project using the CCP video as a case study, chosen for having higher production values than most, found the video to be unsuccessful in conveying the intended message. The videos alienated the audiences by being seen as too technical (even by audiences with a strong technical background) or in being likened to industry propaganda. Production quality was also criticized. As noted earlier, 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.

Another good example is the 28-minute Smithsonian Institution video on "energy challenges", half of which focuses on geological storage as a major technology to reduce emissions, available at: http://www.learner.org/resources/series209.html. The video, accessible for free after registration, describes the First Energy project being run by Battelle for the Midwestern Regional Carbon Sequestration Partnership (MRCSP).

4.3 Museums

Surveys show that science and technology (S&T) museums are more popular in the United States than in other countries. In 2001, 30% of NSF survey respondents said they had visited such a museum in the last 12 months, compared with 16% of Europeans (in 2005), 13% of Japanese, 14% of Chinese, and 1% of Russians (2003). Although the rate of S&T museum attendance in Europe seems to be about half that in the United States, the 2005 rate for Europe was about 50 percent higher than that recorded in 2001 (EC 2005b). When Europeans who

had not visited an S&T museum were asked their reasons, about one-third said they “don’t understand” S&T, and an approximately equal number said they “did not care” about S&T (EC 2005b). Within Europe, Sweden, Norway, Switzerland, Luxembourg, and Iceland have the highest rates of S&T museum attendance.

There have been few non-computer based models of an operational CCS system that might be used for public display. One model has been developed by Instituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS in Italy which reproduced Statoil's diagram (see Figure 2) into a fully interactive "Exhibition Model". This model is made available to CO2NET member companies. Another example is a physical model developed by the Midwestern regional consortium (MGSC) in the US for use in outreach.

A good example of a well-designed educational site that seeks to explain energy issues that might be considered as best practice is that of the ‘Energy Zone’ at the Science Museum in London, which is a much larger website that addresses many different aspects of energy (http://www.sciencemuseum.org.uk/on%2Dline/energy/). Although BP is the major sponsor, the content and design of the exhibit is independent. The site (and the exhibit itself) offers an excellent example of the best in engagement with a wide age range (the target group is 7-14).

Attendance at major museums, almost by definition, targets attentive publics that would be expected to be most interested in learning more about a technology such as CCS and many are successful at attracting large numbers of visitors. The Cité des Sciences in Paris attracts 2.5 million per year and the Chicago Museum of Science and Industry attracts 1.9 million. But attendance at science museums is not the only measure of their influence. Increasingly, many science museums have become an important resource even for many that never set foot in the museum. The Science Museum in London attracts 2.5 million visitors but 6.5 million visitors to its website. More remarkably, the Exploratorium in San Francisco attracts 550,000 visitors a year but has 20 million visitors to its website (various museum websites 2007). The Exploratorium also has, for example, a well-designed Global Climate Change Research Explorer site at: http://www.exploratorium.edu/climate/primer/.

On the specific question of CCS, there is much less available. At the Science Museum exhibit there is a short case study (alongside 40 others on different aspects of energy) which includes several photos and diagrams of a project similar to Sleipner http://www.sciencemuseum.org.uk/on-line/energy/site/EIZCaseStudy26.asp. Of twenty animations on a variety of topics including fusion, fuel cells, tidal and biomass power is a

short (45 second) narrated animation using a diagram similar to that of Sleipner: http://www.sciencemuseum.org.uk/on-line/energy/site/EIZInfogr16.asp Otherwise, there is no other reference to CCS in the broader exposition of energy and energy policy.

4.4 Outreach vs Communications

To date, most effort has focused on what is often referred to as 'outreach'. These usually consist of stakeholder meetings where NGOs are invited to voice their opinions and concerns. These have been conducted by the CSLF, CCP, ECCP, and many other national and international efforts with varying degrees of engagement, but there is little by way of sustained dialogue. Some communications activities have even been conducted in developing countries such as South Africa (DME 2006) and Korea (Shin 2006) although others such as India (Goel 2006) claim to be doing outreach, but have largely confused broader public engagement with purely technical discussions within the scientific community.

Stakeholder engagement has largely been viewed as a static process with a view that holding occasional stakeholder meetings is sufficient. Futuregen lists "communications efforts ongoing" as one of the three "accomplishments" to date and the efforts consist of "media and stakeholder outreach" and establishing the website. The CSLF goes as far as vetting its stakeholders by requiring that stakeholders register on a database and be 'approved'. The stakeholder list itself numbers less than 100, comprise only a subset of the stakeholders actively engaged in CCS (over 500 stakeholders responded to both the ACCSEPT survey and EU consultation in Europe alone) and many of those represented are minor players. Moreover, virtually all of the stakeholders listed on the registry were drawn from industry, government or research institutes. The only NGOs included on the stakeholder registry are three US based organizations, Environmental Defense, Bellona-USA and Natural Resources Defense Council, all of which are generally favorably disposed towards CCS. The attitude has largely been to treat stakeholders as a variable to be 'managed' and a potential obstacle to be overcome rather than an actual dialogue. Indeed, there has been vocal disagreement over the appropriate level for engagement. The European Commission argued against the inclusion of stakeholders in the CSLF because there are national mechanisms for stakeholder engagement, whereas other supported identifying key national stakeholders and involving them in the CSLF process.

At the European level, the Zero Emissions Platform has taken communications seriously at least at the level of the organizational chart. The five original working groups included a group on Public Acceptability that offered input into the development of the documents, the Strategic Research Agenda and the Strategic Deployment Document. The ZEP SDD Action Plan offers a clear and effective path to improving public communications, but the ultimate test will be whether the plan itself is actually pursued and the necessary resources allocated.

ZEP SDD Communications Action Plan

Plan an information campaign - now

It is very clear that in order to implement CCS on a larger scale, it must be done with full public support – and soon, if it is to have an early impact. This should take into account research into current public perceptions of CCS and climate change (see Strategic Research Agenda). Groups such as national and European parliamentarians, journalists, environmental pressure groups and representatives of civil society are particularly important targets.

Ensure communication is a dialogue, not one way

Establishing an information campaign about CCS is not without danger, and we must use professional agencies to help define the message, the messenger, the medium used and the target public. We therefore need to start planning for such a campaign in the next few months, with a focus on providing clear scientific information as part of a dialogue that encourages all voices to be heard and involved.

Assign a significant budget

A well-organised outreach campaign is not cheap – around €250k per country – and funds must be set aside. Timing is also critical – in some countries CCS is moving onto the policy agenda relatively quickly, whereas in others, there is still virtually no recognition of CCS, even in policy circles.

Regularly monitor the public reaction and respond when necessary

Both before and after the launch of any campaign, we will need to gauge public opinion, and listen to it regularly (we could use the Eurobarometer, supplemented by focus groups in different countries), in order to watch the evolution and catch objections early. We must then respond to these objections, thoroughly and honestly, using the right messengers.

Source: The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) 2006. *Strategic Deployment Document,* Final report, 24 November

Since 1 December 2006, the working groups were abolished and replaced with a current structure that includes a Task Force on Communications. Although the group has grown in size, to date, no funds have been forthcoming from either the Commission or from any of the participant firms. Representatives of industry have therefore overwhelmingly dominated the taskforce, making up over two-thirds of the membership. Whereas the Working Group on Public Acceptability included Greenpeace as co-chair, the only NGO actively involved in the Task Force on Public Communications has been Bellona, a

Norwegian NGO which has been dismissed by some in the NGO community for being a strident advocate of CCS (although WWF is also a nominal member of the Task Force) (ZEP TFCom 2006). With few incentives for either academics or NGOs to participate, the task force has been overwhelmingly dominated by those with a vested interest in promoting the technology.

There have been a number of positive though minor efforts undertaken by the Task Force with minimal resources. Green Facts, a non-partisan group which develops short, readable summaries of major scientific reports, has been commissioned to 'translate' the IPCC Special Report on CCS into a more understandable synthesis. The ZEP Task Force participated in Green Week, the major environmental event in Brussels. Nevertheless, the Task Force has not been engaged in the broader communications efforts of the ZEP overall nor have there been any serious efforts to develop communications materials. In large part, efforts have been delayed as a result of the lack of funding from either the European Commission, member governments or any of the multinational firms involved.

Some would argue that before one can engage in outreach of any form, there is the need for greater internal communications within the relevant disciplines such as geology and engineering. Here, progress is more palpable, although again, far from uniform. For example, recent activities run by the CO2GeoNet Network of Excellence include an Open Forum, a Training and Dialogue Workshop, a CCS School, a Field School, and CCS Geochemical training courses. It is true that developing a cadre of future communicators is essential, but as described in Section 5, the engagement of the professional community such as geologists is actually the one area of clear success and so one might expect that the marginal benefits from additional resources would be greater in areas where current arrangements are furthest from best practice.

Moreover, it is not just the professions that require training, the NGOs have also needed to develop their own materials on CCS. Climate Action Network-Europe (CAN-Europe) put together a set of materials and workshops in 2003-4 for its member NGOs across Europe on CCS and hydrogen (http://www.climnet.org/CTAP). In the United States, two NGOs in particular, Environmental Defense and the Clean Air Task Force (CATF) have conducted extensive outreach within the NGO community at the state and regional level.

5. Comparison to Best Practices in Science & Technology Communications

Are there dangers in pushing forward with CCS technologies without monitoring public opinion or mounting an effective communications effort? There are cases where new technologies have been generally accepted after a short debate and many others where there has been little public debate or interest. But there are also the well-known cases where ignoring risk perceptions and failed communications efforts have led to hostility. Public concerns over a range of technologies from nuclear power to genetically modified (GM) food have undermined the spread of these technologies that were heralded by their proponents as major breakthroughs with enormous societal benefits. In both cases, the only efforts to assess public attitudes or develop effective communications materials occurred long after public opinions had been shaped by opponents.

Of course, one can list the large number of nuclear power plants and annual growth in GM crops worldwide as evidence that public relations disasters can still produce major globe-spanning, multi-billion dollar technologies. The real question though is the counterfactual and what might have happened otherwise, were it not for the moratoria and bans in major countries over the last few decades. A glance at the time profile of nuclear construction or a geographic distribution of GM crop planting tells the story of missed opportunities and begs the question of whether a more successful public communications effort would have mitigated some of the hostility these technologies have faced.

CCS is heralded by advocates in much the same terms as a major contributor to mitigating climate change and where billions of dollars are expected to be invested in the technology in the coming decades. To date, CCS has enjoyed the benefits of at least a small window in time where communications materials might have been developed and public attitudes assessed *before* the wide-scale launch of the technology. As governments and firms prepare to initiate major projects in different corners of the world, that period of grace when public opinions could be assessed and communications materials developed before CCS enters the public eye is rapidly drawing to a close.

It is quite possible that CCS will ultimately be viewed in much the same manner as any number of industrial processes that are seen as technical, opaque and largely uninteresting to the general public although there may be occasional local fights over siting. On the other hand, given the low level of awareness and mixed initial reactions to CCS, there is no reason to be especially confident in such an outcome, particularly if CCS is caught up in the politics

of already politically salient technologies such as nuclear power and renewables and an increasingly politicized debate over energy and climate change policy. As Malone and Bradbury (2006) note "the issue is not just the acceptability of individual projects but rather the acceptability of the whole idea and class of technologies." Efforts to understand social and political forces can also act as an early warning of potential problems and also serve as a guide to the design of more effective communications efforts but these studies would need to be conducted well in advance so that the findings can usefully be incorporated and a baseline developed over time.

In 2002, the US National Institute of Standards and Technology (NIST) conducted a workshop on "Best Practices for Communication of Science and Technology to the Public". (NIST 2002). The workshop offered some dozen key recommendations with regard to public communications including to:

- Illustrate both process and product of project development: presenting the scientific process and unresolved scientific questions can be more compelling than simply showing results based on a black box model

- Involve scientists in a substantial way: with greater exposure, scientists can become experts in public education for a range of audiences from children to adolescents to adults

- Avoid parochialism by bringing in the work of others: rather than only describing the research or projects of the sponsoring organization, useful content from any source should be covered which will demonstrate broader national and international consensus of support.

- View the issue from the audience's point of view, not the institution's: listen to, acknowledge and incorporate approaches suitable for the targeted audience(s)

- Develop a baseline – "ideally before putting it on the evening news": take advantage of the often long period time before media coverage and wider discussion to conduct surveys, focus groups and assess how project announcements or communications efforts change perceptions.

- Use face-to-face methods whenever possible: two-way communication can improve public trust

- Reach out beyond the science-attentive public: choosing unconventional venues (such as shopping malls) or target audiences (such as disadvantaged youth) have been successfully employed in other science communications efforts

- Use multimedia and illustrations: interactivity can bring science & technology to life
- Provide information to the media in easily usable form: making information accessible will encourage time-pressured journalists to draw on the material in their reports
- Avoid perceptions of environmental injustice or backroom deals: even the appearance of bias, conspiracy or less than full disclosure can stall or kill a project
- Avoid a situation where there are charges that "you haven't told us" or "you're sneaking up on us": include the public and interested stakeholders from the start
- Avoid letting the project become a political "football": create vocal supporters of the project within the community thereby making it unpopular to be against the project leading policy-makers to defend the project and marginalize opponents

The list is not some idealized view of public communications, but rather every single one of the best practices can be found as real world examples where such best practices approaches have been implemented successfully. As detailed in NIST and other case studies of best practices in communications, successful efforts are not arrived at accidentally, but are the product of deliberate design, which requires time, resources and imagination.

Almost every one of the dozen issues highlighted is directly relevant to CCS. A current assessment would find some good progress on one or two issues most notably in the involvement of the scientists in outreach. Many of the national geological surveys, such as the British, French, Australian, German, Czech and Danish Geological Surveys have been deeply involved with international efforts on CCS. Overall, however, there remain many serious shortfalls such as in the development of a baseline, reaching out beyond the most attentive segment of the public, and developing high quality explanatory materials for use by the media and the general public. Documents such as the ZEP SDD Action Plan recognize many of these issues, but there is little evidence that the needed resources have been forthcoming. In response, some would claim that CCS is still at an early stage given the lack of broader public awareness, but as the NIST guidelines note, that is precisely when one wants to act in order to be able to assess changes if the expected growth in CCS as a major generating technology were to materialize.

The virtual absence of best practices should not be construed as reflecting poorly on the few professionals currently involved in CCS communications activities, but is symptomatic of the resources dedicated. With sufficient resources, there is little doubt that

they (and the many others needed) would be able to design the materials needed to engage the public and target key stakeholder groups. The reality is that there are remarkably few communications professionals involved in the field. Most materials developed have been the work of in-house web designers or academics or consultants contracted to provide support on a part time basis. The sum total of the disparate activities might have been pooled across any number to produce a serious, professional effort. Divided across some 50-100 independent efforts, the products have been as described – sparse, repetitive, self-referential, and on the whole, quite poor.

The more interesting question, of course, is why the outcomes with regard to public dissemination have been so disappointing, particularly given the involvement of actors with the means to support communications activities and the avowed interest in the success of CCS technologies. It is possible to identify a number of possible reasons why public communication activities are in the state described:

1. Competition. Firms, governments, research groups and even international consortia have independent agendas, timetables, and circumstances. Language may act as an additional barrier to cooperation. To a lesser extent, they may also perceive that those differences warrant competing messages and communications campaigns, but the perfunctory efforts across the board would indicate that the lack of cooperation reflects a lack of forethought rather than active competition. There is also little incentive for contributing to the provision of a public good. Most actors, whether public or private, want to demonstrate their own initiatives and so coordination of resources may be impossible. Shell would not want the first project highlighted on a common website to be a BP project, nor would the American government want an Australian or French project highlighted at the expense of one of their own. Others may feel constrained by resource availability and fear the transactions costs involved in any international consortium.

2. Speed. The rapidity with which CCS has risen up the agenda may also have taken industry and government by surprise and may account for the seemingly slow reaction to engage the public and inability to divert resources to an issue that had seemed primarily technical only a few years ago. Of course, it has been industry leaders (e.g., van de Veer 2006) and governments that have been the ones that have heralded the possibilities of CCS, for example, after withdrawing from the Kyoto Protocol, President Bush declared “We all believe technology offers great promise significantly reduce [greenhouse gas] emissions … especially carbon capture, storage and sequestration technologies” (US DOE 2002).

Moreover, while some governments and pro-CCS groups may be seriously resource-constrained and need to deal with longer budget cycles, it is hard to make the same argument for the energy industry, where oil and gas supermajors and many electric utilities have been enjoying record profits. Rather, the lack of funding would seem to indicate a clear prioritization.

3. Exclusive focus on Technical Solutions. Although a concern for independence or a benign neglect of cooperation may offer some explanation for the halfhearted response, the weak effort from the major inter-governmental consortium (CSLF), inter-firm consortium (CCP) and pan-European platform (ZEP) all indicate that a more compelling reason for inaction is the low priority placed on understanding public attitudes and the emphasis on technical issues. As witnessed from the long history of public communications in the nuclear power industry (Bier 2001) or the brief history of the Ocean Carbon Sequestration Experiment, technocratic elites may under-invest in both basic social science and in public outreach and communications efforts because they believe it leads to a diversion of resources from "productive" to "non-productive" uses.

As de Figueiredo, Reiner and Herzog (2002) describe in their analysis of the failure of the Hawaii ocean sequestration project, little effort was made to assess public attitudes in advance, the general public learned of its existence through the local newspaper, and the project was reluctant to divert resources from technical issues and spend any funding on either social science or on communications. As a result, the project, which was first announced in Kyoto in 1997 was endlessly delayed and ultimately sought to move to Norway. In Norway, a permit was issued, but ultimately was withdrawn after Greenpeace sailed the Rainbow Warrior to Oslo to meet with the minister. As a result, there has not been a single ocean carbon storage project conducted worldwide (IPCC 2005).

4. No news is good news. In spite of cautionary tales from ocean sequestration, nuclear power and GM foods, a subset of the technocratic elite may be actively or passively discouraging initiating wide-ranging communications on CCS out of fear it may backfire by drawing attention to the issue and thereby generating opposition. From this perspective, CCS would ideally be viewed as any number of other industrial processes such as underground storage of liquids (Reiner and Herzog 2002; Keith et al 2005) rather than a technology comparable to nuclear power in terms of public attention. This view is generally more of a hopeful view than one based on analysis.

5. Lack of political will. Until such time as actors can reasonably expect that climate change policy will produce a carbon price of a level sufficient to encourage CCS, there will continue to be considerable uncertainty as to whether CCS will be as important as some advocates hope or anticipate. Justifying technical research can be justified years in advance of widespread commercialization, whereas there may be the perception that public communications materials will only be necessary if and when the technology is deployed.

6. Conclusions

To date, after a relatively positive start in the form of an early recognition that communications and surveys of public attitudes are essential to the development of a new technology, the progress in actually developing any sort of communications effort has been remarkably slow when compared with the aspirations of its proponents and projections that CCS will form a major part of the electricity infrastructure within the next two decades (IEA 2006). There have been a few first efforts, the Canadians have recently organized the first communications workshop under the auspices of the International Institute for Sustainable Development (IISD), Climate Change Central and the University of Calgary (CCC 2007) and there have been early efforts in Australia as well. Although this would only be a start, even such a basic event as this has not yet taken place in Europe or the United States, other than virtual meetings among DOE partnership outreach teams. Much like the infrastructure itself, there is a significant lead-time associated with any major effort to develop effective communications tools or a significant outreach effort. To be useful in assessing changes over time, a mechanism for monitoring would need to be instituted in the relatively near future. In spite of the large number of multinational corporations involved and government rhetoric on ambitions of carbon-free electricity, the commitment has been quite small, again when measured against the claims of supporters of CCS.

Minimal national and industry efforts to coordinate have also led to a wasteful duplication of effort and expenditure of resources. An organization such as the CCP, ZEP or CSLF could serve as an important means of bringing together resources from the public and private sectors, but to date the pooling of resources has been decidedly modest. Again, this is not a specific criticism of the individuals involved in developing these materials, but reflects the significant sums that would be needed to develop web, multimedia and educational materials that are professional, regularly maintained and tested. Some degree of independent

effort is, of course, beneficial in encouraging experimentation, but at least in communications materials the result has been dozens of basic introductions to the subject and no single example of a professional, high quality effort.

The highest-level international effort, the CSLF, has, to date, done fairly little to engage stakeholders in other than a cursory manner and has neither created a venue for engagement nor has it developed educational materials or other communications resources. The CSLF is already viewed with great skepticism by NGOs who see it as a US-inspired effort consistent with the Bush Administration's technology strategy that is seen more as a "diversionary tactic than as an honest effort" (Anderson 2005). As such, the CSLF undermines NGO attitudes towards CCS by its very association with a climate-sceptic US Administration. Individual national governments and projects have made some efforts at communications that might be characterized as ranging from poor to mediocre, with no clear evidence that any government, firm or project has met virtually any of the NIST best practice guidelines.

CCS has benefited from *not* being nuclear power, which continues to be viewed much more negatively by stakeholders, especially NGOs as seen in the ACCSEPT stakeholder survey (Shackley et al 2007). Insofar as CCS is perceived as being involved in a zero-sum game for resources with renewables then there will be opposition to the needed investment in research and development that would lower the costs and risks of CCS technologies.

Even governments that have been relatively advanced in acknowledging the nominal importance of CCS at least rhetorically have been criticized for the lack of effort and resources devoted to public communications. The UK has been one of the few European countries to conduct parliamentary hearings on carbon dioxide capture and storage. The Science and Technology Committee hearings focused specifically on the question of public acceptance and communications and concluded in early 2006:

> The Government has done little so far to engage the public in a dialogue about CCS technology. We accept that it is early days for the technology but previous experience has emphasised the value of early engagement. (HoC 2006, I: 42-43)

In response, the UK government had promised that such a communications strategy would be available by mid-2006 but as of mid-2007, no strategy was even being planned in spite of a national consultation on CCS commercialization conducted by the Treasury and the announcement of a major competition for funding that was expected to amount to hundreds of millions of pounds (H.M. Treasury 2006). Even the Dutch CATO project, which is probably

the best coordinated and best funded European project, provides far less than 10% of its overall budget to public perception and engagement issues and as a research-led initiative has devoted relatively few resources to communications efforts (Daamen 2007).

Direct outreach to stakeholders has been somewhat mixed and there is little evidence of anything approaching real engagement. The overwhelming dominance of major energy firms creates the impression to those less charitably inclined that CCS technologies are simply "bolt-on adjustments to the fossil-fuel status quo" (Leggett 2007). Many major NGOs such as WWF have offered support that is contingent on the specific outcome of national debates over nuclear power. If countries such as the UK decide to expand nuclear power or countries such as Germany or Sweden change course then reluctant NGO support for CCS may dissipate.

Traditional media outlets such as newspapers and television may still come to dominate once (or if) the issue becomes newsworthy, but at this stage of development the internet remains overwhelmingly the most important resource for most. Offering clear, trustworthy sources of information on the internet will be vital for those using it as their first port of call when they hear about a new technology.

In spite of the weak overall state of communications and the lack of assessment of the current condition, there are worthwhile blueprints for next steps available. Although not yet acted upon, the ZEP SDD Action Plan on public communications does in fact encompass many of the NIST best practices and offers a clear path forward. The real test will be in the allocation of resources, which to date have been both lacking and lagging. The experience of other CCS projects and efforts does not bode well. Public communications and public acceptability are rarely if ever allocated either the budget or personnel appropriate to the task. Even so, the efforts to date have been too narrowly focused, uncoordinated, duplicative and insensitive to the needs of potential consumers and to the trust in the purveyors of the information. The persistent neglect may not matter if CCS does not grow as quickly as anticipated or if no serious opposition ever arises, but if not, then the opportunity to provide for the signal from the proverbial canaries will have been missed.

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APPENDIX 1. WEBSITES

Major national or international CCS websites with a significant education or public outreach element:

Bellona Foundation (Norwegian/English)
Short basic introduction to CCS, news and reports
http://www.bellona.org/subjects/CO2_sequestration

Bureau of Economic Geology / Gulf Coast Carbon Center
Detailed project description, general geology resources for teachers and students and the general public, including targeted outreach materials, links, short project-specific FAQ on carbon storage and EOR.
http://www.beg.utexas.edu/environqlty/co201.htm

BRGM (primarily French)
One of the best sites reviewed offering a detailed representation of the individual elements in the CCS chain.
http://www.brgm.fr/brgm//CO2_animation/animlong.swf

Canadian CO_2 Network (English/French)
News, introduction to CCS and climate change overall, roadmap, projects, events, links, success stories
http://www.co2network.gc.ca/

Carbon Mitigation Initiative (CMI) at Princeton University
Image library with photos of capture plants and especially storage diagrams (from US or Canadian sources). stabilization wedge game and resources, events (exclusively CMI annual meetings), newsletters and press releases (from 2004/5), "CMI in the news" (current), annual reports, basic links
http://www.princeton.edu/~cmi/

Carbon Sequestration Leadership Forum (CSLF)
Basic introduction, FAQ and glossary listed under "Education Center"
http://www.cslforum.org/education.htm

Climate Action Network (CAN) Europe
Background information on CCS technologies aimed at member NGOs but likely to be useful to wider audience
http://www.climnet.org/EUenergy/CCS/index.htm or http://www.climnet.org/CTAP/

Club CO_2 (French/English)
Industry-government organization includes glossary, good set of links to national, European and international projects, useful background information of different aspects of CCS
http://www.clubco2.net

CO_2 Capture Project (CCP)
26 minute Video for Phase I, plus reports, brief review of technologies
http://www.co2captureproject.org/phase1index.htm

CO2CRC (Australia)
7 fact sheets+ FAQ + video that does not work on all platforms (also linked to WCI): http://www.co2crc.com.au
Simple animation available at: http://www.co2crc.com.au/ANIMATIONS/rpc.html

CO2Net
Events calendar, research database, and Information Centre with newsletters, multimedia (CO2CRC, CCP and CO2Net videos) and a 4 page fact sheet is available in many EU languages (English/French/Spanish/Italian/ Portuguese/Czech/Slovak/Hungarian/Romanian/Polish/Russian/Estonian/Croatian):
http://www.co2net.com/home/index.asp
See also CO_2 Net East developed especially for Central & Eastern Europe: http://www.energnet.com/co2neteast.

French Ministry of Industry (French)
Condensed on a long, single page, but provides a good overview including short descriptions of most major CCS projects in France, Europe and internationally
http://www.industrie.gouv.fr/energie/prospect/textes/sequestration.htm

Euractiv
European news and information on CCS, with a primary focus on decisions made in Brussels
http://www.euractiv.com/energy/energy/carbon-capture-storage

Futuregen
Provides project specific news and FAQs. Industry alliance: http://www.futuregenalliance.org/
US DOE: http://www.fossil.energy.gov/programs/powersystems/futuregen/index.html

Green Facts (English/French)
Nonpartisan summaries of detailed scientific studies includes IPCC Special Report on CCS. Offers three levels of increasing depth: 'highlights', 'details' and 'original source', links to international sources and news stories with a strong EU focus. Level 1is also available in French, with separate links to French sites. Buttons for German, Spanish and Dutch are not currently operational. http://www.greenfacts.org/en/co2-capture-storage

ICO2N
Canadian industry consortium with themes and 2-page fact sheets on "Understanding the Basics", "Safety" and "Vision", FAQs, good set of links to primarily Canadian and American sites including NGOs and academics.
http://www.ico2n.com

IEA GHG Programme
Basic introduction to climate change, emissions, international dimension, CCS and "educational links". Regular newsletter is aimed primarily at practitioners but which does offer short summaries of international activities. Most publications and technical reports are inaccessible to outsiders: http://www.ieagreen.org.uk/
IEA also offers databases of CO_2 emissions, "risk scenarios" (using features-events-processes common in the nuclear industry), an interactive design tool in choosing the appropriate monitoring techniques for CCS, and a database which offers short project descriptions by region. As of mid-2007, the project database includes 68 from North America, 41 from Europe and 21 from elsewhere: http://www.co2captureandstorage.info/co2db.php

IZ Klima (German)
German industry consortium site includes a project database describing 46 projects around the world with short summaries in German and links to external sites. Projects can be sorted by title, project focus, maturity or country and displayed on an overview map. Database of CCS reports includes 39 studies (12 in German and 3 in French) and is searchable and sortable by title, topic, publisher, year or country with a short German description of each study. FAQ section provides answers to 16 basic questions on CCS. Summary of media coverage, focusing exclusively on coverage of the center itself. List of upcoming international meetings.
http://www.iz-klima.de
Interactive project map: http://www.iz-klima.de/index.php?id=34&pleon_project_id=4

Massachusetts Institute of Technology (MIT)
Brief introduction to CCS, technical reports some of which are readily accessible to a wider audience, good list of links
http://sequestration.mit.edu

US National Energy Technology Laboratory (NETL)
Newsletters, project portfolio, roadmap, "bookshelf", 8 min video introduction to CCS
http://www.netl.doe.gov/technologies/carbon_seq/
http://www.netl.doe.gov/coalpower/sequestration
Basic Introduction at: http://www.netl.doe.gov/technologies/carbon_seq/core_rd/storage.html

Petroleum Technology Research Centre (PTRC)
Information on Weyburn Project, FAQs on EOR and CCS, Press releases, token links
http://www.ptrc.ca

Total:
Good overview and background in English and French on both Lacq project and CCS
http://www.total.com/en/corporate-social-responsibility/special-reports/capture/

UK Carbon Capture and Storage Consortium (UKCCSC)
Brief introduction, International roadmaps, Q&A, News roundups
http://www.ukccsc.org.uk or http://www.co2capture.org.uk/

US DOE Regional Partnerships

Big Sky
Presentations, partnership news, notable for Carbon Atlas
http://carbonatlas.bigskyco2.org

Midwest Geologic Sequestration Consortium (MGSC)
Basic facts on CCS, project-specific information, geology and news. Uses www.sequestration.org domain name
News: http://www.sequestration.org/news.htm

Midwest Regional Carbon Sequestration Partnership (MRCSP)
Mailing list, basic information on climate change and CCS, 18 fact sheets, the majority on geologic sequestration, news stories and press releases on the partnership, what's new (new story every 3-4 months on average), phase I report, periodic updates to Phase II demonstration project descriptions for geologic and terrestrial, presentations, basic set of links and members area.
http://www.mrcsp.org

Plains CO2 Reduction Partnership (PCOR)
Basic partnership materials, Kids Site has information on climate change but not CCS. Also includes basic links, FAQ, events and brief description on "What I Can Do".
http://www.undeerc.org/pcor/
Separate section on 'Documentaries" includes a 28 min "Nature in the Balance" video, of which last half is on CCS. A documentary on geologic sequestration is scheduled for 2008.
http://www.undeerc.org/pcor/documentary/

SECarb
Very basic introduction and materials
http://www.secarbon.org/secarbprogrambackground.html

SWCarb
Brief introduction and animation, carbon capture blog (empty)
http://southwestcarbonpartnership.org/GeoSeq.aspx

WESTCARB
Basic introduction, brief section on outreach, interactive GIS viewer: http://www.westcarb.org/outreach.htm
Interactive GIS: http://atlas.utah.gov/co2wc/viewer.htm?Title=ArcIMS%20HTML%20Viewer

United Nations Environment Programme (UNEP)
24-page pamphlet providing basic introduction to CCS and guide to IPCC special report, but the pamphlet itself is not easily accessible. http://www.unep.org/dec/docs/CCS_guide.pdf

Vattenfall
Interactive Climate Map looking at reduction potential by sector and region
http://www.vattenfall.com/climatemap/?WT.ac=advertise

World Resources Institute
Introduction to CCS, working groups on liability and regulation, technical reports and media coverage
http://www.wri.org/project/carbon-capture-sequestration

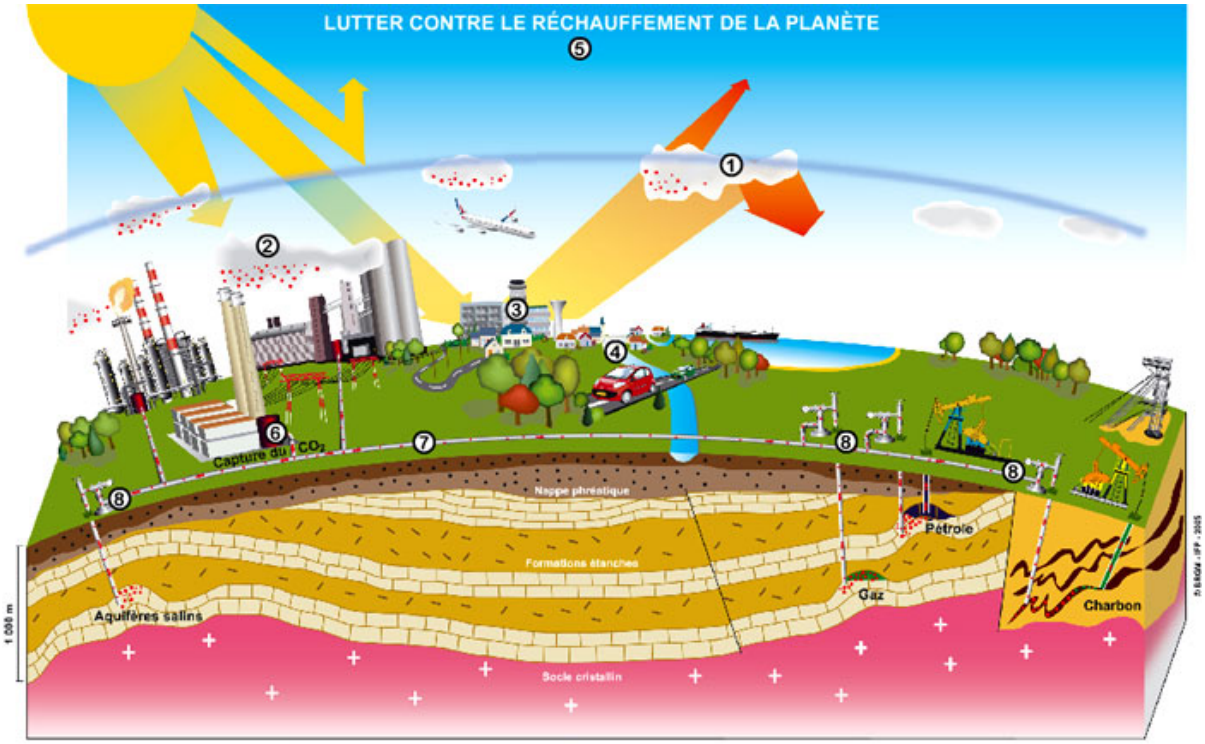
Zero Emissions Platform (ZEP)
Project intro -- little on CCS itself, other than fact sheets (in English, French and German) buried on site, e.g.,
http://www.zero-emissionplatform.eu/website/docs/ETP%20ZEP/ETP%20ZEP%20Roll%20fold%20English.pdf
ZEP Newsletters: http://www.zero-emissionplatform.eu/website/library/index.html#etpzepnewsletters

Other Project and Organization websites

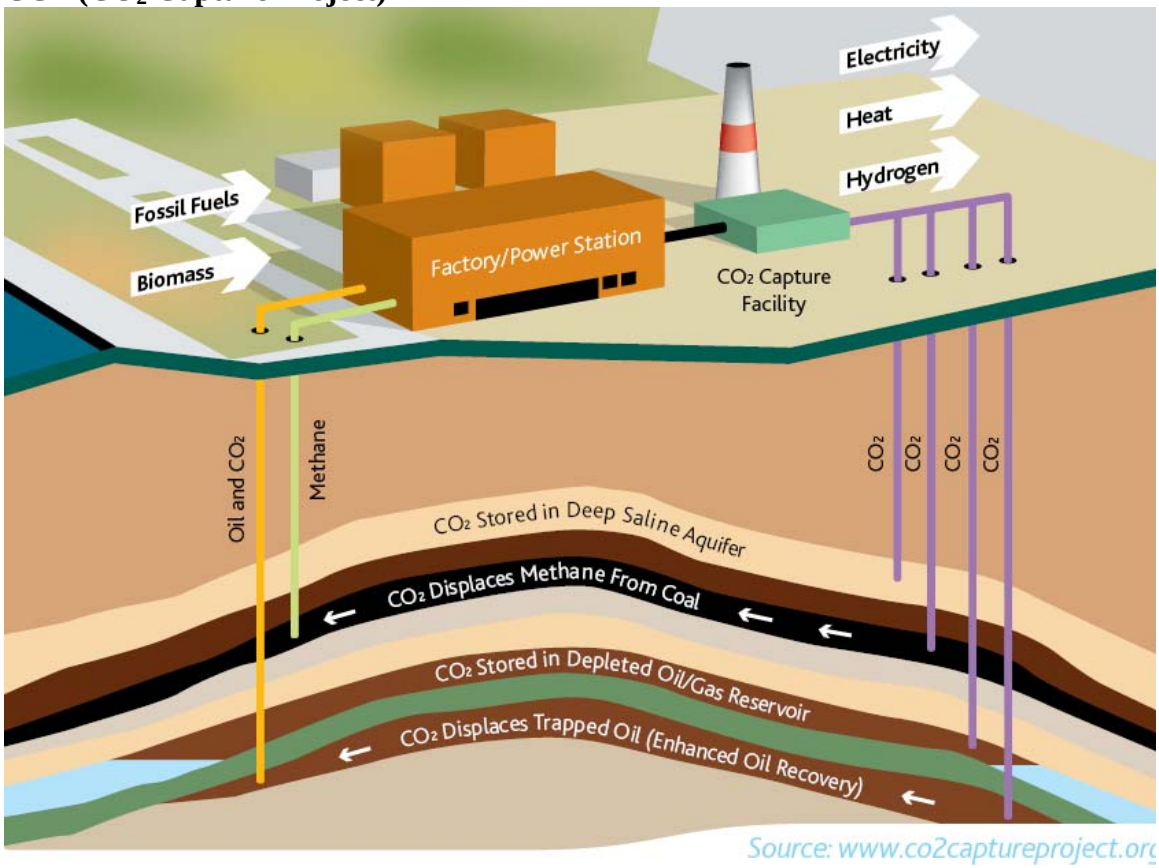
ADECOS: http://www.adecos.de
Alberta Research Center: http://www.energyinet.com/PDFs/GunterCCSprimer.pdf
BP: http://www.bp.com/sectiongenericarticle.do?categoryId=9015794&contentId=7030648
CACHET: http://www.cachetco2.eu/
CASTOR: http://www.co2castor.com/
CATF: http://www.catf.us/projects/power_sector/advanced_coal/background.php
CATO (Dutch/English): http://www.co2-cato.nl/modules.php?name=CATO&page=21
CCS Association (UK): http://www.ccsassociation.org.uk
CO2Geonet: http://www.co2geonet.com/
CO_2 Net East: http://www.energnet.com/co2neteast
CO_2SINK: http://www.co2sink.org/
Coal21 (Australia): http://www.coal21.com.au
COORETEC (German/English): http://www.cooretec.de
ENCAP (Enhanced Capture of CO_2): http://www.encapco2.org/
Enel (Italian/English): http://www.enel.it/azienda_en/sostenibilita/stakeholder/ambiente/zero_emiss/#N10049
Frio Brine: http://www.utexas.edu/research/projects/frio.html
Futuregen for Illinois: http://www.futuregenforillinois.com/
Futuregen Texas: http://www.beg.utexas.edu/futuregentexas/index.htm
GASSNOVA (Norwegian/English): http://www.gassnova.no/sw1003.asp
GEUS (Danish/English/brief description in German and French): http://www.geus.dk/index.htm
Global Climate and Energy Project (GCEP) at Stanford University: http://gcep.stanford.edu/
Gorgon: http://www.gorgon.com.au/01gp_project.html
Greengen (Chinese/some English): http://greengen.com.cn/index.asp
International Test Centre for CO_2 Capture: http://www.co2-research.ca/
Nanoglowa: http://www.nanoglowa.com/Project.html
NASCENT: http://www.bgs.ac.uk/nascent/home.html
Natural Resources Defense Council (NRDC): http://www.nrdc.org/globalWarming/solutions/step4.asp
nZEC (UK-China near Zero Emission Coal): http://www.nzec.info (placeholder site)
UK Parliamentary Office of Science and Technology (POST): http://www.co2capture.org.uk/Post238.pdf
Powerfuel: www.powerfuel.plc.uk
Recopol: http://recopol.nitg.tno.nl/index.shtml
Rising Tide: http://www.risingtide.org.au/cleancoal (Australian NGO)
RITE (Japanese/English): http://www.rite.or.jp/English/lab/geological/geological.html
SenterNovem (Dutch): http://www.senternovem.nl/CO2-Reductieplan/index.asp
Shell: http://www.shell.com/home/content/envirosoc-en/environment/climate_change/co2_sequestration_and_capture/sequestration_and_capture_000407.html
Sleipner/SACS: http://www.iku.sintef.no/projects/IK23430000/index.html
Snohvit: http://www.snohvit.com
Statoil (Sleipner animation): http://www.statoil.com/statoilcom/SVG00990.NSF/web/sleipneren?opendocument
Texas Bureau of Economic Geology: http://www.beg.utexas.edu/environqlty/co2seq/
Utah Geological Survey: http://geology.utah.gov/emp/co2sequest/
World Coal Institute: http://www.worldcoal.org/pages/content/index.asp?PageID=414 (12 page brochure)
World Energy Council: http://www.worldenergy.org/focus/ccs/367.asp
Wuppertal Institute (German): http://www.wupperinst.org/de/projekte/themen_online/carbon_capture_and_storage/index.html
WWF:http://www.panda.org/about_wwf/what_we_do/climate_change/solutions/energy_solutions/carbon_capture_storage/index.cfm
Zerogen: http://www.zerogen.com.au

APPENDIX 2. DIAGRAMS

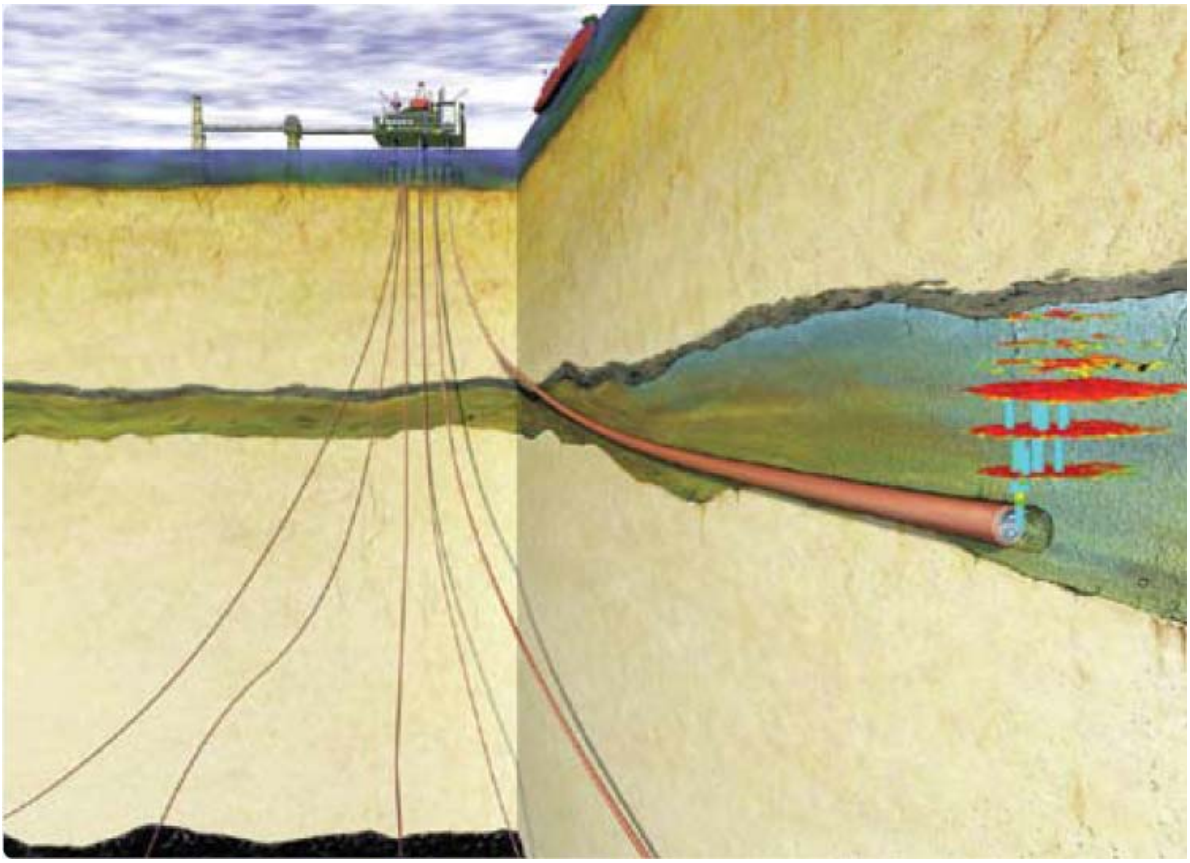
BRGM (Bureau de recherches géologiques et minières)
Animation available at: http://www.brgm.fr/brgm//CO2_animation/animlong.swf



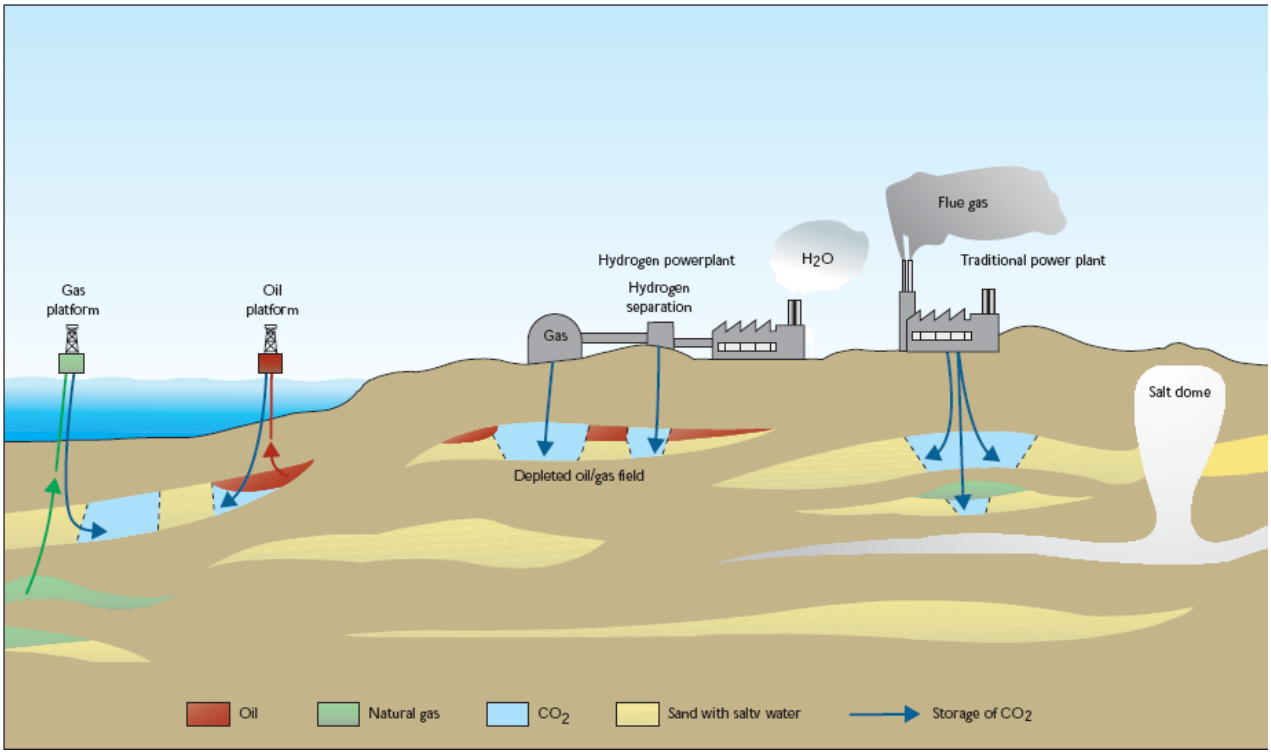
CCP (CO_2 Capture Project)



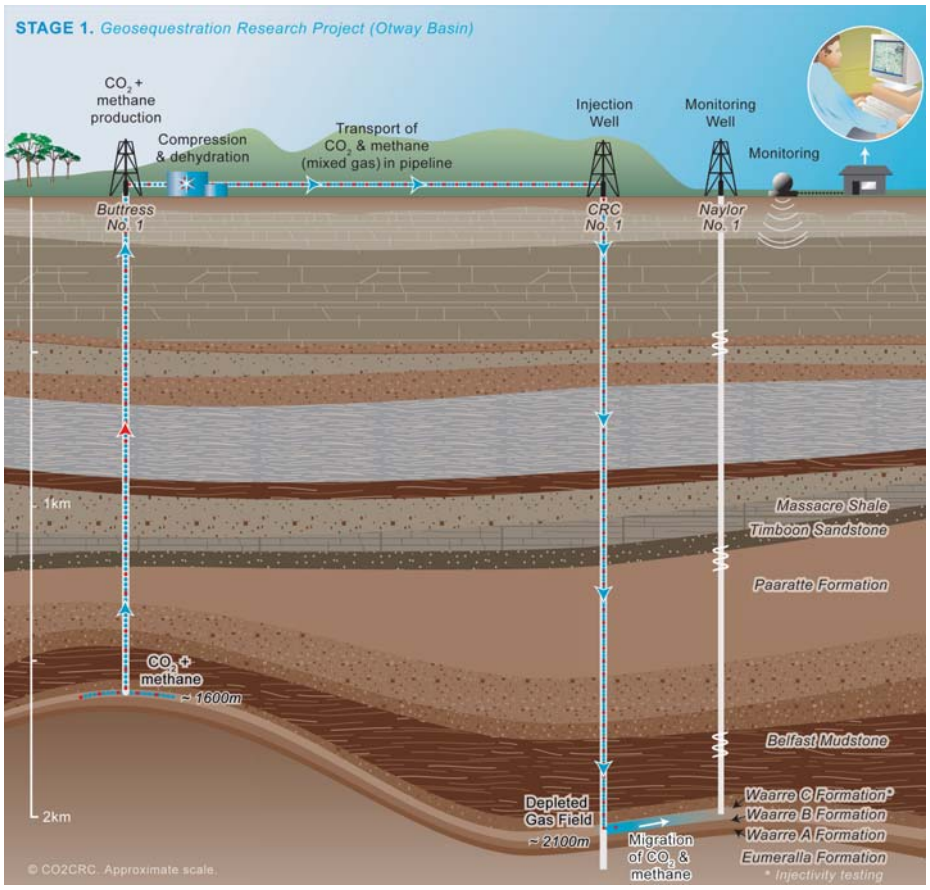
Statoil



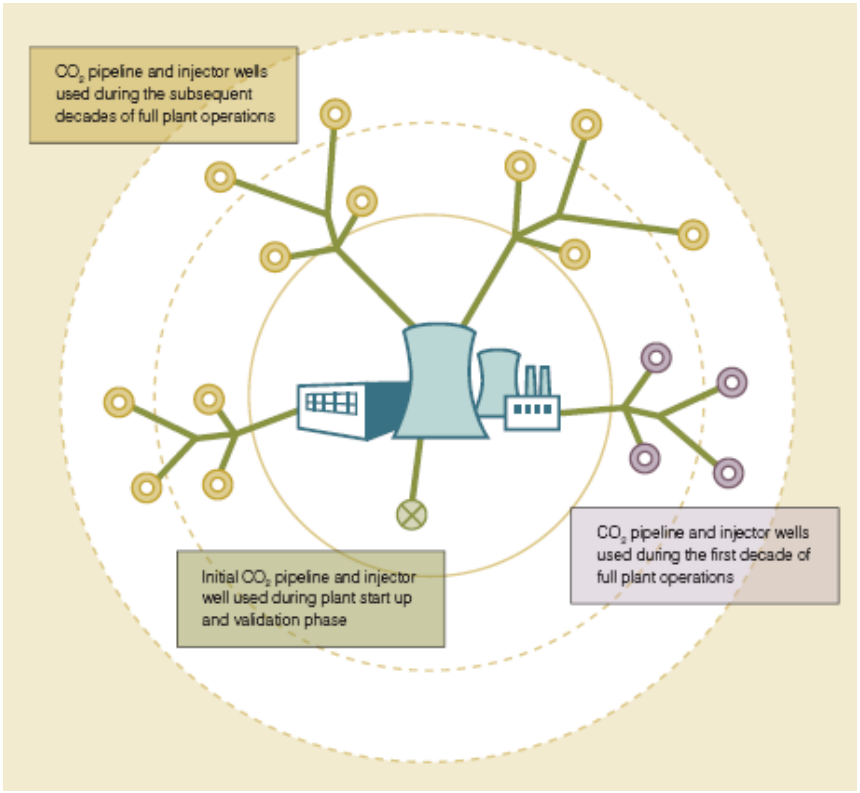
GEUS (Geological Survey of Denmark and Greenland)



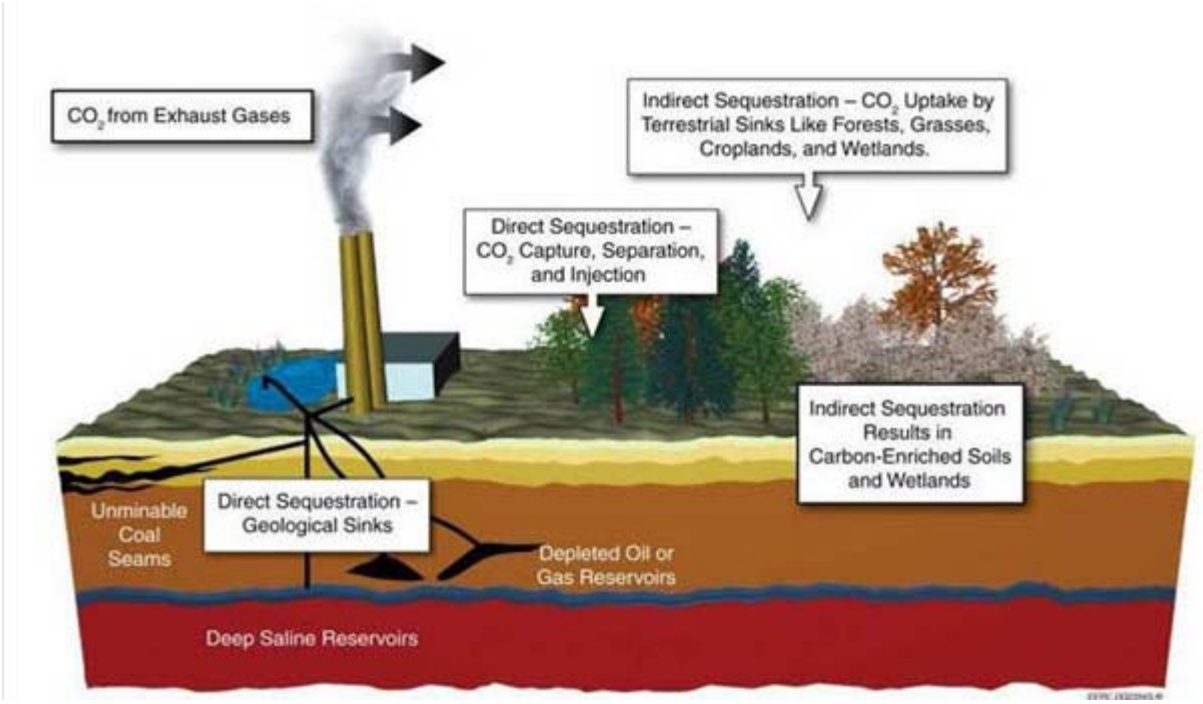
CO2CRC Otway Basin (Australia)



Battelle PNL



Plains CO2 Reduction Partnership (PCOR)
http://www.undeerc.org/pcor/sequestration/whatissequestration.asp



US Department of Energy, Office of Fossil Energy (courtesy of Carolyn Preston, PTRC)