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Developing communications about CCS: Three lessons learned.

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To curb the risks of climate change, the Intergovernmental Panel on Climate Change (IPCC, 2014) posits that global carbon dioxide emissions from the energy supply sector must be reduced to 90% below 2010 levels between 2040 and 2070. Electricity generation is the largest contributor to energy supply section emissions (IPCC, 2014). Carbon capture and storage (CCS) holds the promise of helping to reduce electricity sector CO_2 emissions from coal-fired power plants, as part of a low-carbon portfolio that could also include energy efficiency, natural gas, renewables, and nuclear power. However, as with any emerging technology, such benefits come with potential risks. If people believe that the risks outweigh the benefits, the resulting public opposition may prevent the widespread adoption of CCS.

Löfstedt (2014) identifies key messages from the risk communication literature so as to inform people's decisions about the siting of CCS facilities. Here, we discuss our own communication efforts aimed at informing people's decisions about whether or not to include CCS as part of a low-carbon electricity portfolio (rather than at any specific sites) for the U.S. state of Pennsylvania.. Our main lessons learned are in agreement with Löfstedt's (2014) recommendations.

To inform people's decisions about whether or not to support the implementation of CCS, our team created brochures that aimed to facilitate systematic comparisons of the risks, benefits and costs of ten low-carbon technologies (Fleishman, Bruine de Bruin, & Morgan, 2010; Fleishman-Mayer & Bruine de Bruin, 2014), as well as a computer tool that supported users in developing technically realistic low-carbon portfolios (Mayer, Bruine de Bruin, & Morgan 2014). All materials are publicly available at <http://cedmcenter.org/tools-for-cedm/informing-the-public-about-low-carbon-technologies/>.

We recognized that effective risk communication uses comprehensible wording to cover the facts that experts wish to convey as well as additional content non-experts deem

relevant for making more informed decisions (Bruine de Bruin & Bostrom, 2013; Fischhoff, 2013). To this end, our risk communication materials about CCS were developed with input from diverse experts, stakeholders and members of the public. Specifically, we used the systematic 'mental models' methodology, which aims to create a shared understanding or 'mental model' about the topic under consideration (Bruine de Bruin & Bostrom, 2013; Morgan et al., 2002). This methodology has previously been applied to topics such as nanotechnology, vaccines, sexually transmitted infections, and smart meters (e.g., Cousin & Siegrist, 2010; Downs et al., 2004; Downs, Bruine de Bruin, & Fischhoff, 2008; Krishnamurti et al., 2012). Below, we highlight three of the main lessons we learned in developing our materials about CCS.

1. People want to know about alternatives to CCS

Our initial work on public perceptions of CCS revealed that our participants were relatively uninformed about CCS, and focused on the risks when first learning about it (Palmgren et al., 2004). Similar findings were reported in follow-up studies conducted in different countries (Huijts et al. 2007; Shackley, McLachlan, & Gough, 2005; Sharp, Jaccard, & Keith, 2009; Wallquist, Visschers, & Siegrist, 2009, 2010). These findings are in line with psychological theories of decision making, which posit that people tend to pay more attention to the negative (loss) attributes than to the positive (gain) attributes of decision options (Kahneman, Slovic, & Tversky, 1982). Such tendencies may be exacerbated when initial impressions are negative (Finucane et al., 2000). We found that CCS tended to evoke negative initial impressions, including associations with 'nuclear waste' (Palmgren et al., 2004). It should therefore not be surprising that people preferred to consider CCS in comparison to low-carbon technologies, such as wind and solar (Palmgren et al., 2004).

To give people the comparison information they wanted, we developed carefully balanced brochures about the risks, benefits and costs of ten low-carbon technologies (Fleishman et al., 2010). We designed our materials to facilitate side-by-side comparisons of technologies across a number of attributes (DeKay et al., 2001), because such comparisons make less familiar attributes easier to evaluate (Hsee, 1996). For each technology, we created a fact sheet with information about a set of attributes deemed relevant by both experts and non-experts. In an evaluation study with Pennsylvania residents, we found that our materials informed lively group discussions, and actually led to the reluctant acceptance of CCS as part of a larger portfolio for reducing CO2 emissions (Fleishman et al., 2010, Mayer et al., 2014).

2. Using simple wording improves understanding, even about complex technologies

Effective risk communication requires plain wording, recognizing that reading levels in the general population tend to be at elementary-school levels (Neuhauser & Paul, 2011). Readability tests have demonstrated that texts with shorter words and shorter sentences are easier to read (Neuhauser & Paul, 2011). Tests of health communications have found that such simplified wording enhances recipients' comprehension (McGaw & Sturmey,1989; Overland et al., 1993), independent of whether the mode of delivery is written or oral (Bradshaw et al., 1975).

Creating simple communications is no easy feat. Many outreach materials and websites are written at the university level (Daraz etal.,2011; Davis et al.,1996; Neuhauser & Paul, 2011; Paashe-Orlow et al.,2003), possibly because many experts fail to realize that their preferred wording is more difficult than that of non-experts (Bruine de Bruin & Bostrom, 2013). We have also encountered experts who expressed concerns about simple words making them sound less knowledgeable, or about seeming to 'talk down' to their audience.

However, it is possible to convey information in simple words without undermining trust or the perceived quality of the communication (Wong-Parodi, Bruine de Bruin, & Canfield, 2013). Even recipients with higher literacy levels prefer materials that are easier to read (Davis et al., 2006; Smith et al., 2008). Although the benefit of simplifying communications may depend on the complexity of their original content (Wong-Parodi, Bruine de Bruin, & Canfield, 2013), we were able to create materials about CCS that improved knowledge and perceived understanding (Fleishman et al., 2010; Mayer et al., 2014).

To ensure that our simplified wording could be understood, we conducted one-on-one read-aloud interviews in which we asked members of the public to improve our materials. Such participatory design processes are critical for creating effective communications (Neuhauser & Paul, 2011). Interviewees helped us to better explain several complex topics, including how the intermittency of wind power limits the production of electricity "because sometimes the wind is not blowing" (Fleishman-Mayer & Bruine de Bruin, 2014). As noted above, they also asked us to explicitly address specific attributes that experts had not explicitly addressed. For example, our interviewees wanted to know about the life span of specific technologies, which experts had implicitly incorporated in the technology costs. They also noted that we presented too much information at once, which led us to present brochures one at a time. Our evaluation study found that the resulting materials improved understanding and were perceived as useful for decision making (Fleishman et al., 2010).

3. The time to communicate about CCS is now

Outreach activities about CCS remain largely non-existent (Ashworth et al., 2010), perhaps in part because of the concern that people may like CCS less as they learn more about it (Palmgren et al., 2004). However, as noted above, people may be willing to accept

some CCS if it is presented in comparison to, and as part of a portfolio of, other low-carbon electricity generation technologies.

Any reluctance to communicate may promote distrust, as it can fuel the suspicion that important facts are being held back from the public (Fischhoff, 1995). Pro-active risk communication and early involvement of stakeholders will also help to address concerns about procedural fairness (Bradbury et al., 2009). We discovered that another reason for communicating now is that, while CCS remains relatively unfamiliar in most countries (Pietzner et al., 2011), people will likely be open to receiving information and approach it with an open mind. That may change after people form their first impressions about CCS, perhaps based on limited facts. Indeed, psychologists have long recognized that first impressions can be formed on the basis of little to no information, guide the interpretation of new information, and are therefore difficult to change (Finucane et al., 2000; Zajonc, 1980). Classic psychological research has found that first impressions are difficult to change, even after it is revealed that they were actually formed on the basis of false information (Anderson et al., 1980; Johar & Simmons, 2000).

Moreover, people who perceive themselves as having attained knowledge about an issue become less open to learning new information (Gino & Moore, 2007), find it harder to consider alternative points of view (Koehler, 1991), and are more likely to interpret new information as confirming what they think they know (Klayman, 1995). Confidence in knowledge may increase even with repeated exposure to ambiguous statements (Arkes, Boehm, & Xu, 1991), and thinking more extensively about one side of the argument (Petty & Cacioppo, 1986; Koriat, Lichtenstein, & Fischhoff, 1980).

Outside of the psychological laboratory, people's first impressions also shape how they interpret subsequent information. For example, people who have grown to distrust a technology tend to perceive new information about it more negatively than those who have

grown to trust it (Cvetovich, Siegrist, Murray, & Tragesser, 2002; Poortinga & Pidgeon, 2004). Proponents of nuclear power interpret near-accidents as evidence of effective safety procedures, while opponents see evidence of risky practices (Plous, 1991). Individuals who worry about a hazard may feel alarmed when learning new information that experts view as neutral or positive (Levy et al., 2008).

Perhaps more importantly, we found the same troubling pattern in studies of public responses to our CCS communications. Exposure to one-sided appeals that included little to no factual information about CCS influenced participants' subsequent responses to our so carefully balanced risk communication materials (Bruine de Bruin & Wong-Parodi, in press). Specifically, they interpreted the content of our risk communications in light of their manipulated first impressions, such that those who had received positive one-sided appeals interpreted our materials more positively than those who had received negative one-sided messages. As a result, first impressions about CCS can linger and solidify, even if they are initially feeble and easy to influence (de Best-Waldhober, Daamen, & Faaij, 2009; Pietzner et al., 2011).

These findings suggest that risk communications will be more likely to reach their goal of informing public debate if they are disseminated while people still have an open mind. Of course, there is no guarantee that communicating in a timely manner will promote public support or prevent conflicts in public debates. However, it should lead to fewer disagreements, and reduce the likelihood that they are based on misunderstandings (Fischhoff, 2013).

In conclusion, we highlighted three main lessons we learned when communicating about CCS to Pennsylvania residents: (1) in learning about CCS people also want to know about its alternatives; (2) using simple wording improves understanding, even about complex technologies; and (3) the time to communicate about CCS is now. We hope that these

lessons, in combination with the Löfstedt's (2014) recommendations, will promote the development of effective risk communication efforts so as to inform people's decisions and public debate about CCS and other emerging technologies.

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