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Persuasiveness, importance and novelty of arguments about Carbon Capture and Storage

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ABSTRACT

Carbon Capture and Storage (CCS) is a promising technology for reducing carbon emissions, but the public is often reluctant to support it. To understand why public support is lacking, it is crucial to establish what citizens think about the *arguments* that are used by proponents and opponents of CCS. We determined the persuasiveness, importance and novelty of 32 arguments for and against CCS using a discrete choice experiment in which respondents made consecutive choices between pairs of pro or con arguments. We used latent class models to identify population segments with different preferences. The results show that citizens find arguments about climate protection, which is the primary goal of CCS, less persuasive than other arguments, such as normative arguments (for example 'a waste product such as CO_2 should be disposed of properly') or arguments about benefits of CCS for energy production and economic growth. This discrepancy complicates communication that aims to convince citizens of the benefits of CCS for climate protection.

1. Introduction

Climate change mitigation requires substantial modifications to energy production and consumption patterns. Yet, the technologies needed to change these patterns often lack public acceptance (Wustenhagen et al., 2007). Carbon Capture and Storage (CCS) is such a technology. CCS involves capturing CO_2 at a large emission source (e.g. a power plant or factory), transporting the CO_2 to a storage location (e.g. a natural gas field) and injecting the CO_2 into a rock formation for permanent storage (see Reiner, 2016 for an overview of recent CCS developments). CCS is a critical component of climate change mitigation strategies as fossil fuel consumption is increasing and carbon-intensive industries remain prominent (IPCC, 2014). If CCS is to become a viable option policy makers and industry must encourage its development (IEA, 2013; Scott et al., 2012). However, the public is reluctant to support this technology (De Best-Waldhober et al., 2012; L'Orange Seigo et al., 2014b; Upham and Roberts, 2011). This discourages stakeholders, such as energy or industrial firms, policy makers and NGOs, from moving toward large-scale implementation (Markusson et al., 2012). Stakeholders need to communicate with citizens to build support for CCS (Ashworth et al., 2010).

Existing studies offer comprehensive guidelines for effective communication processes (see Brunsting et al., 2011; L'Orange Seigo et al., 2014a) for a review of CCS communication studies). Yet, citizens' reactions to the *content* of stakeholder's messages are partially understood. This hampers communications efforts (Reiner, 2008). Studies into message content focus primarily on neutral, descriptive information. Examples are studies into monitoring information (L'Orange Seigo et al., 2011), storage terminology (Ha-duong et al., 2009), figures (L'Orange Seigo et al., 2013), labels (Van Rijnsoever et al., 2015), natural analogues to CO_2 storage (Tokushige et al., 2007a), entities responsible for managing risk (Sharp et al., 2009), basic properties of CO_2 and CCS (Dowd et al., 2014; Tokushige et al., 2007b; Wallquist et al., 2011) or different sets of CO_2 capture and storage technologies (De Best-Waldhober et al., 2012, 2009; Wallquist et al., 2012). Such information is unlikely to foster substantial support for the stakeholder's opinion, unless it is reinforced with arguments that resonate with the values of citizens (Kahan et al., 2012). Recent studies tackled this issue by also showing which *positive* or *negative* characteristics of CCS significantly affect citizen's attitude toward CCS (De Best-Waldhober et al., 2012,2009; Kraeusel and Möst, 2012; Oltra et al., 2012; Tokushige et al., 2007b; Wallquist et al.,

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2011). Despite this progress, three issues remain largely unaddressed.

First, positive or negative characteristics comprise only a *subset* of the arguments communicated by stakeholders (see Boyd and Paveglio, 2014; Buhr and Hansson, 2011; van Egmond and Hekkert, 2012) for an overview). Stakeholders also use counterarguments (e.g. CCS is *not* necessary for climate change mitigation), analogies (e.g. CCS is safe, just as natural gas storage is safe; see Tokushige et al., 2007a), or arguments that appeal to norms (e.g. a waste product such as CO2 *should* be disposed of properly; see Cialdini, 2003). None of the existing studies investigated this broader range of CCS arguments.

Second, existing studies often ignore heterogeneity among citizens by only presenting average opinions (see Allenby and Rossi, 1999) for an overview of the concept). Citizens have diverse reactions to communication about energy technologies (Van Rijnsoever et al., 2015). Arguments that most citizens find irrelevant might be important to a particular population segment. Understanding heterogeneity facilitates the design of segmented communication materials.

Third, existing studies rarely examine message effectiveness beyond persuasiveness or attitude change. Yet, attitude change can be unstable and short-lived or stable and long lasting. Dual processing models suggest that stable attitudes require elaborate or systematic processing (see Chen and Chaiken, 1999; Petty and Wegener, 1999 for an overview). Citizens will process information in depth if they are motivated and knowledgeable about the topic in question. They will therefore likely not scrutinize unimportant or new arguments, but will resort to cognitive shortcuts instead, leading to less stable opinions. A communicator attempting to encourage the audience to adopt a specific, stable opinion should select arguments that the audience perceives as *persuasive*, *important* and are not completely *novel* to them. It is therefore important to include importance and novelty in studies into message effects.

We address these shortcomings by eliciting the *perceived* persuasiveness, importance and novelty of 16 pro and 16 con CCS arguments for different population segments. To this end, we asked citizens to make eight consecutive choices between two arguments in a discrete choice experiment (DCE). By exploring the persuasiveness, importance and novelty of arguments we advance understanding of citizens' reactions to the content of stakeholder's messages. Our results help to improve communication strategies for CCS. They are also insightful for energy technologies with similar public acceptance issues.

2. Methods

We elicit the *perceived* persuasiveness, importance and novelty of arguments by asking a sample of citizens to make eight consecutive choices between two arguments in a discrete choice experiment (DCE) (see Amaya-Amaya et al., 2008) for an overview of DCEs) that was included in an online survey. Other CCS studies used DCEs to identify the importance of technological or economic characteristics of CCS, such as price and amount of CO_2-emission reductions (Kraeusel and Möst, 2012; Sharp et al., 2009; Wallquist et al., 2012). To the best of our knowledge, DCEs have not yet been used to study arguments.

Table 1
Pro and con CCS arguments.

No.	Pro arguments	Label
P1	The climate problem cannot be solved without CO_2 storage	Climate problem
P2	CO_2 storage is needed to honor international climate agreements	International climate agreements
P3	CO_2 storage requires fewer lifestyle changes	Lifestyle changes
P4	The Netherlands should set an example when it comes to CO_2 storage	Set an example
P5	CO_2 storage reduces the need for nuclear energy	Reduces need for nuclear
P6	CO_2 storage can be used in industries where there are no other options for reducing CO_2 emissions	Industrial applications
P7	CO_2 storage makes it feasible to use large supplies of coal for cheap energy	Cheap coal
P8	The development of technology for CO_2 storage contributes to employment and economic growth	Economic benefits
P9	CO_2 storage is cheaper than solar or wind energy in the medium to long term	Relatively cheap
P10	The Netherlands has a good starting position because of its experience with natural gas	Natural gas experience
P11	Other countries have used technologies for CO_2 storage safely for many years	Used in other countries
P12	CO_2 storage is already being used to recover more oil from oilfields	Enhanced Oil Recovery
P13	CO_2 storage is safe. CO_2 is stored in natural gas fields where natural gas was stored for millions of years	Safety of natural gas fields
P14	CO_2 storage uses less space than solar panels or wind turbines	Space requirements
P15	Gas or coal plants with CO_2 storage are a stable supplement to the inconsistent supply of solar and wind energy	Stable energy supply
P16	A waste product such as CO_2 should be disposed of properly	Dispose of CO_2 garbage
No.	**Con arguments**	**Label**
C1	The climate problem can be tackled without CO_2 storage	Unnecessary for climate problem
C2	CO_2 storage promotes the use of new coal-fired power plants	Promotes coal
C3	CO_2 storage is more expensive than solar or wind energy in the long term	Relatively expensive
C4	It is not certain that there will be a return on large investments in CO_2 storage	Investment uncertainty
C5	Storage sites for CO_2 have to be monitored indefinitely	Indefinite monitoring
C6	Real estate prices near CO_2 storage facilities may fall	Falling real estate prices
C7	CO_2 storage detracts from the development of renewable energy	Detracts from renewables
C8	Electricity bills will be higher because of CO_2 storage	Higher electricity bills
C9	CO_2 storage is new and has never been applied on a large scale, so the risks are not fully understood	Risks not fully understood
C10	It is better to avoid generating CO_2 than to store the CO_2	Avoid generating CO_2
C11	If a lot of CO_2 leaks on a windless day, a suffocating cloud of CO_2 could be created	Suffocation
C12	Groundwater might become acidified if CO_2 were to leak out of an underground pipeline	Groundwater acidification
C13	CO_2 storage can cause small earthquakes, comparable to those caused by natural gas extraction	Earthquakes
C14	Hazardous chemicals are used in the capture of CO_2.	Hazardous chemicals
C15	Power plants with CO_2 storage require 10–40% more energy	Energy requirements
C16	There is little public support for CO_2 storage	Lack of public support

Note: The arguments refer to 'CO_2 storage', because the Dutch media use this term instead of 'Carbon Capture and Storage'.