Exploring perceptions of climate engineering

Arbetstext, sprid och citera ej.

Victoria Wibeck, Anders Hansson, Jonas Anshelm

1. Introduction

Climate engineering (CE) refers to large-scale intentional technical manipulations of the Earth's climate system, either via technologies for sunlight reflection or for carbon dioxide removal from the air. Examples include stratospheric sulfur particle injection, marine cloud brightening, space mirrors, ocean iron fertilization, biochar, or direct engineered capture of carbon dioxide from the air. There are large variations between these technologies, in terms of their scope in time and space, environmental risks, and the legal, ethical and governance challenges that they pose. Some of them exist only as theoretical constructs, while others have been researched e.g. through computer models (Royal Society, 2009).

Until 2006 CE was more or less considered as taboo on both the climate change policy arena and within science. In 2006 the Nobel laureate Paul Crutzen initiated a special issue in *Climatic Change* and called for active research on CE. He claimed that "the very best would be if emissions of the greenhouse gases could be reduced so much that the stratospheric sulfur release experiment would not need to take place. Currently, this looks like a pious wish" (Crutzen, 2006:217). This is a perspective that is still valid in both the public and scientific debates. CE is reluctantly supported because the measures that are preferred, i.e. global political agreements on emissions reductions and a breakthrough for mitigation, seem less likely. However, this stance is also heavily contested (e.g. ETC 2012, Hamilton, 2012). Furthermore, the global and likely far-reaching environmental consequences of CE are poorly understood and invoke both ethical and governance concerns and raise questions on these options' technical feasibility.

Consequently, CE is currently assessed for the first time in the forthcoming IPCC main reports. The first working group presented its results in the autumn of 2013: "Modelling indicates that SRM [solar radiation management] methods, if realizable, have the potential to substantially offset a global temperature rise, but they would also modify the global water cycle, and would not reduce ocean acidification. If SRM were terminated for any reason, there is *high confidence* that global surface temperatures would rise very rapidly to values consistent with the greenhouse gas forcing. CDR [carbon dioxide removal] and SRM methods carry side effects and long-term consequences on a global scale" (IPCC Summary for policy makers, WG1, 2013). The inclusion of CE, which actually was deemed as "largely speculative and unproven" only a few years ago (IPCC, 2007), can be seen as a sign of normalization of these options. This opens up for the possibility that CE may constitute an additional and potentially complementary category of options to address global warming, besides strategies to mitigate greenhouse gases and adapt to climate change. However, the general awareness of this potentially radical shift in climate change politics is still very low. Surveys in the UK, USA and Canada, which are the countries with the most vivid public mass media debate on CE, show that only a few percentages of the public know about CE (e.g. Mercer, Keith & Sharp, 2011). This notion has become a motive for emerging social science research in public deliberation, public perceptions and engagement. Sikka (2012:109) argue that a critical take on these perspectives are urgent and "particularly necessary with respect to climate engineering since most discussions surrounding it have taken place far removed from public scrutiny".

This paper aims to explore early social representations of climate engineering among lay people in Sweden. Sweden is an example of a country with limited scientific, policy and public debate on CE, and the geographical scope is also a widening in relation to the present dominance of Anglo-Saxon research in this field. For example Porter and Hulme (2013) have stressed the importance to explore aspects that are central for assumptions and discourses of CE in wider cultural contexts. Our case constitutes an appropriate case for exploring "upstream" public reactions to the idea of engineering the climate, and for analyses of how sense-making on emerging and controversial technologies is shaped. The data consists of eight semi-structured focus group interviews with Swedish laypeople, conducted in May-September, 2013. The following research questions have guided this paper: What are the focus group participants' initial responses to CE? How stable are these responses? What aspects are the most crucial for the sense-making processes? What aspects were contested and controversial within the focus groups? We will also more tentatively discuss what this limited empirical material can say about CE, and also more specifically discuss our analysis' contribution to previous research on public engagement and CE.

2. Public understanding of climate engineering: an emerging research field

The previous research on the public understanding of CE can broadly be divided into two categories. The first category is primarily quantitative and maps opinions or perceptions. A few survey studies have been conducted focusing on quantitatively estimating laypeople's knowledge about GE (Kahan et al. (fc?);NERC, 2010; Pidgeon et al. 2012, see also Poumadere, Bertolde and Samadi, 2011). These studies showed that despite its profound social and ethical implications, only a few percentages of the respondents had heard of CE and that even less knew about the basic principles of the technologies. Mercer, Keith & Sharp (2011) found, in the largest international survey (United States, Canada and the United Kingdom) of public perceptions of CE, that no more than 8% of the respondents were to some extent familiar with CE – they correctly defined the term climate geoengineering. The researchers concluded that public opinions are in their formative stage and are sensitive to changes in framing and future information on risks and benefits.

The second category of studies applies qualitative approaches and has primarily a public engagement perspective with the explicit aims of contributing to the research, development or governance of the technologies in focus. In general that perspective can be justified of several reasons, e.g. : 1) people have the right to receive information and influence the technologies that will have an effect on their lives, 2) increased awareness about the technology and trust in the stakeholders responsible for the development, 3) to improve the quality of the decisions by also incorporating lay knowledge and additional perspectives in the governance processes, and 4) challenge taken for granted problem-definitions and explore how proposed solutions may be received by the wider community (Carr et al. 2013; Macnaghten and Szerszynski, 2013; Pidgeon et al. 2012). We agree that these aspects are of great importance when assessing and developing novel large scale technologies, but addressing those issues are not of primary concern in this study. Contrary to the public engagement field we take the low awareness of CE as starting point to study emerging social representations among lay people concerning something they most likely have never heard of. However, exploring social representations of CE obviously contribute to opening up the assumptions and concerns that laypeople have concerning CE, and the low degree of guidance by us as moderators in the focus groups can also contribute to the understanding of meaning making processes.

Even though this is not a public engagement study the previous research in that field provides important insights for this study – both regarding methods and the analysis. For example Carr at al. (2013) and Pidgeon et al. (2013) claim that it is not a prerequisite that participants in public engagement studies have extensive knowledge of the technology that is at hand. Also lay-knowledge, commonsense knowledge and limited input of basic knowledge from an expert can lead to well-reasoned argumentations and positions. Pidgeon et al. (2012) maintain that lay people tend to draw on a range of cultural narratives and other personal experiences that can be related to the scientific topic being discussed in order to construct an understanding. In the present study we pay particular attention to that phenomenon. Daamen et al (2006) have contested the argument that positions taken very quickly and based on very limited knowledge input concerning technologies are stable or provide valuable insights concerning public acceptance. In a simple experiment they demonstrated that laypeople's opinions, in this case regarding the technology carbon capture and storage, could easily be changed by even letting the respondents perform irrelevant and annoying tasks for a few minutes. Well aware of this objection to investigating laypeople with low awareness of a specific technology we paid attention to the dynamics in the groups, e.g. how the respondents reacted to new information and other respondents' counter-claims. We will also return to this issue in the discussions.

Pidgeon et al. (2012, p. 4177) have performed both a qualitative interview study and a survey in the UK in order to study how "public perceptions and responses to geoengineering are shaped by, and in turn shape, the public debate about CE." 41 in-house interviews were conducted in 2009 in the UK, which was prior to the topic received attention in the massmedia. In the interviews Pidgeon et al (2012) gradually approached the topic of CE by first discussing climate change and energy security, and then introducing more and more detailed information about CE. In total they spent five minutes in each interview on CE. The structure of the interview and questions are similar to those applied in our study, however we spent considerably more time on discussing CE and closely related issues, thus providing an opportunity to bring the analyses further, for example on the topic of "naturalness" that was highlighted by Pidgeon et al. (2012) as a significant theme for understanding CE.

In a related study Pidgeon et al. (2013) applied a deliberative method in order to embed a public dialogue already in the innovation process. For two days they discussed CE (SRM) in three workshops with informants, both in general terms and in relation to the proposed SPICE project in the UK. The informants had the possibility to formulate questions day one in order to pose them to experts the following day. The main concerns were ordered into four categories: safety and unintended impacts; methodology and justification; knowledge limitations; and governance and communication, which also are concerns partly overlapping those found in the present study.

Compared to the mentioned studies Macnaghten and Szerszynski (2013) claim to have a more critical stance concerning the role of social science in public engagement (c.f. Stilgoe, 2012). They also applied a deliberative focus group method in the UK (in 2011) using a similar approach as Pidgeon et al. (2012) when gradually introducing CE (SRM), i.e. aiming at not only reproducing dominant framings, but instead understanding responses and what shaped them. Most importantly, which is also the critical dimension, the researchers also tried to interpret the responses' implications for governance. In contrast to previous studies the participants in Macnaghten and Szerszynski (2013:472) were claimed "to arrive at more consistently skeptical positions about the prospect of geoengineering", which may partly be explained by the moderators' intentional avoidance of the emergency framings. One of the main arguments is that CE was perceived to likely "create a particular kind of world, one with an increased probability of geopolitical conflict, a new condition of global experimentality, and major threats to democratic governance. (p. 465)".
.

3. Methods and material

This paper is inspired by a dialogical interpretation of the theory of social representations (e.g. Moscovici, 1984; Marková et al, 2007). This theory concerns lay sense-making through the formation of shared representations of the surrounding world (Moscovici 1984) – or in other words "how people make sense of unfamiliar information" (Smith & Joffe, 2012:2). When given a dialogical interpretation, which focuses on how representations are formed and negotiated in social interaction between individuals (Chaib and Orfali, 2000; Wibeck, 2012), the social representations theory is especially helpful in analyses of how abstract science-based knowledge with time becomes common sense knowledge. This theoretical perspective has informed our choice of focus group methodology, since focus groups provide a means of getting insight into processes of "joint meaning-making in action" (Wilkinson 1998: XX). Moreover, we opted for focus group methodology, since this method is recommended when the object of study is new to the participants and when social representations have still not become conventionalized (Marková et al. 2007). We had good reason to believe that CE would be largely unknown to the focus group participants, since there had been virtually no media debate about this topic in Sweden at the time when the interviews were conducted. Under such circumstances, focus groups may provide a setting where participants in interaction try out understandings and arguments, thereby providing opportunities to observe joint formation and negotiation of social representations (ibid.).

In this paper we are particularly concerned with the content of early social representations of emerging, contested CE technologies, while a forthcoming paper will explore processes of formation of such representations through anchoring the new in well-known categories or through objectification of abstract science-based knowledge (cf. e.g. Höijer, 2010; Smith and Joffe 2012; Wibeck, 2012).

The analyses presented in this paper are based on eight focus group interviews with Swedish lay people, involving a total of 45 participants. A focus group discussion is a facilitated discussion between a relatively small group of participants (in this study 5-7 in each group), on a predetermined topic (e.g. Morgan 1997). The basic idea of a focus group is to take advantage of the interaction between participants in a group discussion to explore in depth their recurrent and differing arguments, standpoints and opinions (Kitzinger 1994; Morgan 1997; Wibeck et al. 2007).

The focus groups were internally homogeneous with respect to the age and educational background of the participants. Variation between the groups was sought for, to achieve as broad a "map of opinions" as possible and allow a wide range of perspectives on climate engineering (see Table 1). The age range of the participants was 16-88 years, and they had shifting educational and occupational backgrounds. All groups included both women and men, although some more women than men in total participated in the study.

A research assistant recruited the participants, employing a topic-blind recruitment strategy (cf. Macnaghten & Szerszynski, 2013) which meant that CE was not mentioned in the invitation. We did not want the participants to prepare for the discussions by searching information, but wanted to investigate whether they were familiar with CE and to explore their spontaneous reactions and associations. Therefore we chose to invite the participants to participate in a group interview on global environmental problems and how these could be handled. We acknowledge that the focus on global environmental problems might have affected the composition of the groups, in that people interested in environmental issues might have been more inclined to participate. However, in analyzing the data, we found that the participants varied greatly in whether they claimed to be interested in environmental issues or not.

Each focus group met once, and the discussions lasted 40-90 minutes. The focus group discussions were audio recorded and transcribed verbatim. The discussions were conducted in Swedish, but for the purposes of this paper all quoted examples have been translated into English and adapted to written language conventions. The names of participants have been changed into pseudonyms to ensure confidentiality.

The approach we chose to focus group interviewing implied a low degree of moderator involvement. We constructed a semi-structured topic guide with open questions which we posed if the participants did not bring them up spontaneously. The topic guide started from a broad discussion on global environmental issues, via climate change, to climate engineering technologies. We also allowed the participants to bring up additional aspects, which were not in our topic guide, but which related to the broader topic of the focus group.

The approach taken in this study is open-ended, in the sense that it explores lay people's spontaneous reactions to CE, while largely trying to refrain from imposing preexisting frames of CE, such as a climate emergency frame or an insufficient mitigation frame (cf. Bellamy et al. 2012). Nevertheless, since the climate emergency frame has had large impact on the climate engineering discourse so far (REF), and it has been suggested to have a strong impact on people's understandings of CE (REF), we found it appropriate to introduce this particular frame in the later parts of the focus group interviews, to be able to scrutinize how the participants would react to them.

The data were analyzed through thematic content analysis (Marková et al., 2007; Wibeck et al., 2007). All transcripts were categorized and coded, with the purpose of constructing recurrent "big themes" (Marková et al, 2007; ch. 6).

Focus group	**Group characteristics**	**Participants**
H	High school students (natural science)	3 women, 4 men
G	University students (economy)	4 women, 2 men
E	Young parents (university education)	4 women, 1 man
F	Young parents (high school education)	5 women, 1 man
C	Middle aged citizens (university education)	3 women, 2 men
D	Middle aged citizens (high school education)	2 women, 3 men
A	Senior citizens (university education)	4 women, 2 men
B	Senior citizens (high school education)	1 woman, 4 men

4. Results

4.1 Climate change and climate engineering

The focus group discussions started with the moderator asking the following question: "What comes to your mind when you hear the words 'global environmental problems'? The different environmental issues mentioned included e.g. climate change, pollution, and ozone depletion. Nevertheless, it was evident that all focus groups perceived climate change as the largest

environmental risk in contemporary society. When further discussing their spontaneous associations to climate change, a recurrent pattern across the groups was that the participants highlighted dramatic climate change effects which are distant in time as well as space. They mentioned for instance melting glaciers and floods. This is well in line with broader media and popular culture representations of climate change, both in Sweden (Olausson 2009) and elsewhere (O'Neill & Nicholson-Cole 2009). Similar prototypical examples were also found in previous Swedish focus group studies of social representations of climate change (Gammelgaard Ballantyne et al. fc; Wibeck, 2012). In the present study, when discussing climate change in general, the focus group participants expressed high confidence in science to explain the causes and predict future impacts of climate change. Overall, the participants perceived climate change as a serious threat to human societies and ecosystems, and they expressed considerable pessimism about the future of the environment. To mitigate climate change, the participants emphasized the need for individual life style changes along with societal transformation and limits to growth. However, the role and ability of politicians to respond to the challenges of climate change, e.g. through international negotiations, was repeatedly questioned in the focus groups, and the participants claimed to have low trust in politicians in this respect.

After discussing environmental issues in general, and climate change in particular, the participants were briefly introduced to the topic of climate engineering. We will now proceed to analyzing how they reacted to the prospects of large-scale deliberate engineering of the global climate. We will first present three general observations about recurrent standpoints expressed in the focus groups. Thereafter, we will analyze recurrent themes in the data more in depth and illustrate turning points and dynamic tensions in the focus group discussions, which helped shape participants' representations of climate engineering.

First, it was obvious that CE was largely unknown among the focus group participants. When asked if they had heard of CE, only six participants answered in the affirmative. However, when explaining to the other participants what CE technologies they were familiar with, they all either hesitated to provide an answer, or they described technologies which fall outside the wide variety of CE technologies identified in the scientific literature (e.g. Royal Society 2009; IPCC 2013). Public unawareness about CE was expected, since there had been virtually no media debate in Sweden prior to the focus group sessions. In addition, as noted in Section 2, similar results were found in the UK, the US and Canada, where there has actually been some debate in the media (Macnaghten & Szerszynsky 2013; Mercer, Keith & Sharp, 2011; Pidgeon et al. 2012).

Second, despite the widespread unawareness about CE, when provided with some more detail as outlined in Section 3, the focus group discussions largely ended up in a skeptical view on CE. In this respect our focus groups display a different pattern from the study conducted in the UK by Pidgeon et al (2012), which suggested a correlation between concern about climate change and favorable attitudes to climate engineering (Pidgeon et al. 2012). As noted above, in our focus groups, the participants expressed great concern about climate change. Nonetheless, skeptical views were expressed towards both CDR and SRM technologies, particularly to stratospheric aerosol injection and ocean iron fertilization. Admittedly, skeptical reactions could be a reaction to the simple fact that CE technologies were unknown to the participants and therefore seen as frightening. This could of course be a partial explanation, but the fact that participants' scepticism to CE was in most cases qualified, and various arguments were used to back up the skeptical viewpoints, as further explained in the following, speaks against this interpretation. Moreover, it was apparent from several passages of the focus groups that even though no such claims were made by the moderators, since the participants saw the moderators as representatives of the scientific community, they perceived

them to be proponents of CE research. Still, however, they withheld their skeptical stance towards CE. In some of the groups (FG D, E, F, G, H) a few participants raised arguments in favour of CE research. These arguments were of two types. Either participants claimed that large-scale CE technologies "sound cool" (FG H) and that it is good to "think outside the box"(FG D, G) to address the challenge of climate change, or they voiced the argument that CE research is needed as a "plan B" in case other responses would fail (FG C, F). The plan B argument (the "climate emergency frame"), however, was deliberately introduced by the moderators towards the end of the focus group session, and it was only after that that some participants picked it up. However, more often this argument was contested and after some discussion, participants tended to discard it.

Third, although the moderators' questions were open-ended and not much guidance were given to the participants as to which aspects of CE to discuss, similar arguments recurred in the different groups. Since the study was designed to include a broad selection of participants, with different backgrounds and different degree of interest in environmental issues, this was somewhat unexpected. In particular, it is worth noting that arguments frequently voiced in the social science and the media discourse on CE also came up in the focus groups, although the participants had not heard of CE before attending the focus group session.

4.2 Environmental risks and the limits of science

In all focus groups the spontaneous, consensual and almost totally unquestioned reaction to CE was that deploying such technologies would result in unpredictable side effects in the form of self-generated mega risks. The climate engineering technologies and their foreseen side effects were primarily described as dangerous, brutal, and frightening, but also as strange and weird – or in the words of one participant: "it feels like something from a science fiction movie" (E69). When presented with a brief description of CE technologies, many participants reacted with expressing their fear of unintended consequences, as illustrated in the following example:

Medelålders gymnasium

153	L	Lite science fiction (flera skrattar)
154	I	Ja och vad gör det i nästa steg då?
155	L	Ja just det
156	S	Kan det också ge någon negativ effekt?
157	J	Hur gör man för att få dem här filtrera tillbaka då? Det är ju nästan som..
158	T	Men att reflektera tillbaka känns inte som om det skulle kunna vara någon negativ effekt..
159	J	Jaa. (flera:mmm)
160	L	Men om man skulle lägga något pulver..
161	I	Eller filter? (flera:mmm)
162	L	Det kanske blir för mycket..
163	S	Det kan ju vara lika hemskt som det var med kärnkraft. (I:ja) (paus) Det tror jag.. (paus)
164	I	Ofta manipulerar man en sak och då blir det fel någon annan stans.. rubbar balansen (flera:mmm) fast nu är ju den redan rubbad
165	T	Ja nu är den ju redan rubbad..
166	I	Frågan är ju hur mycket är den rubbad och blir den rubbad ännu mera? Eller.. skulle det här verkligen hjälpa. Men har dem gjort någon studie i sån där sluten..

Example 1 illustrates a recurrent pattern in the focus groups. The most common fear expressed by the focus group participants was related to the risk of changes in ecological systems. In all groups but one (FG8???) the participants expressed their concerns that deployment of CE would alter ecosystem balance and thus further deteriorate the global ecologic state. Moreover, in one of the focus groups (FG B), one informant claimed that the CE technologies will bring about "pollution on the macro-scale". In comparing CE with pollutants such as DDT or dumping of waste in the Baltic Sea, the participants brought forward the argument that deployment of CE technologies is a shortsighted solution. One of the participants voiced his skepticism towards stratospheric aerosol injection by stating that "I don't believe in dirtying with powder and stuff". Along similar lines, participants in other groups (FGs XXX) stated that deploying CE technologies will not be sustainable in the long run.

In discussing the ethical, legal and social implications of CE, Corner and Pidgeon (2010:32) argued that "/c/oncerns about whether scientists and engineers have the capacity to safely mitigate the unintended technical and environmental consequences of geoengineering will play a central role in the debate". Such concerns were highlighted as key issues in our focus groups, where the risk of unforeseen consequences and the threat to ecosystem balance often led the participants to raise epistemological objections against CE. As noted in Section 5.1, when discussing global environmental problems in general and more particularly climate change, the focus group participants expressed a high level of trust in the scientific community to produce relevant and credible knowledge. As the discussions shifted to CE, however, the level of trust expressed in science diminished. The participants then rather expressed their views of the limits of science in being able to foresee negative side effects. The ecosystems were seen as too complicated, making it impossible to produce satisfactory knowledge or in advance calculate the ecological consequences of engineering the climate. No individual researchers were perceived to be able to judge the ecosystem effects. Moreover, in several of the groups (FGs XXX) the participants raised doubts whether it is by principle impossible to get enough knowledge to justify the deployment of CE technologies. Along similar lines, some participants assumed that scientists cannot possibly know the long term effects of ocean iron fertilization or stratospheric aerosol injection, and that this ignorance constitutes an enormous and insuperable problem of climate engineering (FG A, B, C, D). Others pointed to the fact the climate engineering technologies are untested and maybe even impossible to test before deployment (FG G, H). This leads again to the conclusion by some participants that climate engineering is speculative and compared to science fiction, i.e. scientifically based fantasies hardly deserving consideration in a discussion about the growing seriousness of global warming (FG B, C, G, H).

4.3 Treatment of symptoms rather than causes of climate change

Another recurrent theme in the focus groups was the participants' view of climate engineering as a shortsighted solution. The fundamental problem of CE was in several of the groups claimed to be that development and deployment of CE technologies would be a way of addressing the symptoms rather than the causes and therefore will not contribute to solving the problem of climate change (FG C, D, E, F, G, H). Rather, the participants feared that CE will enable business-as-usual, and preserve or increase contemporary high level of green house gas emissions. Along similar lines, some participants interpreted CE research and deployment as a "sign of surrender" (FG C, 12:96), or a "panic action" (FG C) for a society which is unwilling or unable to reduce greenhouse gas emissions. By contrast, in all focus groups, continued and increased emissions reduction was seen as key to tackling climate change.

Some participants (FG A, B, C) assumed CE research and deployment to lead to a false sense of security based on the misrepresentation that necessary transformation of systems for energy production, transports, production and consumption will not be necessary. Other participants feared that CE will lead to undesired "upscaling" rather than "downscaling" of consumption (FG B), and one participant raised the question when humanity will realize that "we will do with much less" (FG B:328). Another example illustrating this line of reasoning comes from one of the focus group consisting of middle aged citizens, where a participant said:

Example 2:

> "This is starting at the wrong end. If it's an emergency it's great that you could… that there are ways to cool the Earth, but that doesn't take away the need of cutting emissions. That is what creates a chimera that you could just keep going like before" (Middle aged citizens)

In this and other similar sequences of the focus group discussions, the participants addressed the "moral hazard" argument, which has been discussed at length in social science analyses of CE (e.g. Bellamy et al., 2012). This argument basically means that "major efforts in geoengineering may lead to a reduction of effort in mitigation and/or adaptation because of a premature conviction that geoengineering has provided 'insurance' against climate change" (Royal Society 2009:37). In the words of one focus group participant, the same argument can be expressed as follows: "/T/hen we don't need to do anything. If we do like this [i.e. deploy CE technologies] we don't have to do anything, because then it will be fixed anyway" (Retired citizens). The social science literature on CE argues that it is an empirical question whether CE research would bring about these types of reactions, or if the mere idea of large-scale engineering of the climate would rather lead people to prioritize conventional mitigation harder to avoid deployment of CE technologies. In the words of Bellamy et al. (2012:601), "it has been argued that even considering geoengineering could, in point of fact, galvanize mitigation efforts rather than harm them" (Bellamy et al., 2012:601).

The moral hazard argument was pointed out as relevant in several of the focus groups (FG A, B, C, G). However, their fear did not concern their own behavior, but the risk that other people would be led to believe that lifestyle change is not necessary. Over and again the participants ended up in the conclusion that conventional mitigation, both at individual and collective levels, should be prioritized over climate engineering research and deployment, as well as over adaptation measures. If the prospects of engineering the climate are highlighted in the debate, the focus group participants saw the risk of declined efforts towards reducing greenhouse gas emissions.

4.4 "Messing with nature"

In several of the focus groups (FG A?, D?, G, H) participants expressed their view on climate engineering as "unnatural" or "artificial", which they found problematic. In other words, climate engineering was seen as a way of "messing with nature" (cf. Corner et al., 2013). As shown in previous studies from the UK, whether or not the public perceived CE technologies as implying human interference with "natural" processes strongly determinated whether they were favorable or not (Carr & Palmer 2012; Corner et al. 2013; Macnaghten & Szerszynski 2013). Thus, the view of CE as mankind interfering with nature, could be one explanation for the focus group participants' reluctance to CE.

Conceptualisations of nature are multi-faceted and have varied throughout history and across cultures (Urry & Macnaghten 1998; Corner et al. 2012). An underlying assumption in our focus group

discussions was that what is "natural" is also good. This led some of the focus group participants to state that they saw all manipulation of nature as fundamentally wrong. Some also declared that mankind should realize their limits and refrain from "playing God" (FG A, D).

The focus group consisting of university students illustrates how CE was rejected on basis of the "unnaturalness argument":

Example 3

1.	E:	It feels as if the Earth becomes more and more like a business enterprise… an industry. It won't be as natural as it was before, but it will be made by people. We redesign Earth to become our own little thing which we can manipulate to survive (…)
2.	O:	I have a hard time understanding what it would be like with artificial clouds. It would be really unnatural
3.	R:	Unnatural is not good
(…)		
4.	O:	If you start using artificial means, then you'll need some areas that are free from this. If you for instance walk in the forest, that wouldn't feel special anymore. It would be an artificial forest, perhaps. But then maybe they will turn Sarek [a Swedish national park] into a free area which they seal off and which has real nature, real clouds (University students)

Example 3 illustrates how participants counter posed nature and humanity. CE would according to E in turn 1 constitute a way for mankind to "make" nature, to "redesign" and "manipulate" Earth. Here, cloud seeding is chosen as the prototypical example of an "unnatural" CE technology (turn 2) as opposed to the "natural", pristine nature, which in a future scenario involving CE technologies would need to be preserved in national parks. The emotional value of nature would, according to O in turn 4, be threatened by CE.

A similar line of argument has also been voiced in the popular science literature on CE. For instance, David Keith, well-known climate engineering scientist, highlights that CE would involve '…the end of wildness – or at least our idea of wildness. It means consciously admitting that we live on a managed planet' (D. Keith, quoted in Goodell, 2010: 45). To the focus group participants, such interference with nature would constitute a strong argument against deployment of CE.

However, it is worth noting that technological responses to climate change were not by default seen as a way of messing with nature. In most focus groups the participants expressed skepticism to CE technologies, while instead proposing that a more appropriate response to climate change would be the development of low-carbon energy technologies, in particular technologies for producing renewable energy, such as solar, wind and hydro power. The reason for the positive outlook on renewables was that these technologies were assumed to use nature in an environmentally-friendly way, and to preserve nature, not devastate it.

4.5 Governance and control

In all focus groups except one (FG E), participants highlighted aspects of governance, control and democracy. It has been noted by Preston et al (2011:459) that "/c/oncerns about social justice and geopolitical stability are clearly some of the most important ethical issues that geoengineering faces". In the focus groups, participants raised questions about who would have the power over the

climate engineering technologies and how to regulate its implementation. There was widespread skepticism whether it would be possible to control these large-scale technologies at all, much in line with the skepticism voiced against whether the scientific community would be able to control and predict negative ecological side effects of CE deployment (cf. Section 5.1). This line of reasoning is illustrated by a quotation from one of the focus groups consisting of retired citizens:

Example 4

95	B	Vem skulle ha makten över det?
96	D	Vem skulle reglera det?
97	E	Ofta när människor ger sig och reglerar natur och jord så blir det inte något bra slutresultat.. (De andra instämmer)
98	I	Kan du el du va inne på det här med styrproblematiken då? Ser du någon utväg? Kan man kontrollera globala tekniker?
99	B	Nä jag tror inte det. Det finns alltid någon alltså jag tror att det kan leda till krig likaväl som alla andra dumma saker i krig el det kanske inte är så dumt i och för sig men alla andra händelser och känslor och annat som leder till att man måste kriga och det här vore väl någonting alldeles fantastiskt att ha makten över det. Kunna bestämma att nu får ni frysa ett tag där i hörnet och nu ska vi ha varmt och nu ska vi ha regn och ni får inget regn och om ni är snälla kan ni få köpa mat av oss men jättedyrt.
100	D	Nja det låter inte som nån bra lösning

(Pensionärer universitet)

Example 4 highlights two key questions recurrently posed in the focus groups, i.e. who would have the power over CE and who would control the use of the technologies. It is worth noting that in this example, the moderator did not introduce these questions, but they were brought up by the two of the participants, and followed by joint agreement from the group that attempts to govern nature are seldom successful.

Example 4 further illustrates an argument brought up by the youngest and the oldest participants (FG A, B, G), i.e. that development of CE could lead to conflict, and eventually warfare, over control of the new technologies and their side effects, in particular in a future condition of even scarcer natural resources. Also, in one of the group (FG 7) participants addressed the issue of global (in)justice, arguing that if risky CE technologies will be tested in developing countries, these could become doubly afflicted, both by the impacts of climate change and by potential negative side effects of CE.

4.6 Ways forward?

In all focus groups participants expressed a pessimistic outlook, both on the possibilities of CE as response option to climate change and on mankind's ability to mitigate climate change through conventional means. In several of the groups (FG XXX) participants lamented that in spite of many societal actors' recognition of the seriousness of climate change, short-term interests of growth and profit are still prioritized both at the individual and at the national and international levels.

Some potential solutions were nevertheless identified. As noted above, trust in politicians to deal with climate change was very low. The participants expressed that they wanted politicians to take responsibility for mitigation actions, but still they saw both national governments and international bodies as very slow in taking action. However, when conventional mitigation strategies were counter posed to climate engineering, the former was what most of the participants preferred. When

confronted with the prospects of CE, the participants saw greenhouse gas emissions reduction agreed through international negotiations as the most desirable strategy, despite their general low level of trust in political solutions. This is one of the most notable turning points in the focus group discussions: in the light of CE deployment as consequence of humanity's inability to cope with climate change the UN process which was previously discarded by the participants was now reassessed, with a few exceptions (FG G and H), and described as the best way to counteract global warming. In addition, participants pointed to advances in renewable energy production along with substantial lifestyle changes as solutions to the problem of anthropogenic climate change, instead of putting the global eco-systems at stake through dangerous CE experiments beyond human control.

4. Discussion

It is remarkable that Swedish laymen in only 40 minutes of discussions could problematize and profoundly criticize the technology coherently with most of the central aspects already being brought up in the scientific debate. In line with Carr et al. (2013) and Pidgeon et al. (2013) we maintain that laypeople can lead well-reasoned argumentations even with very limited input from an expert. Only a few years ago, in 2007, the IPCC deemed CE, also without assessing it, as "likely to be ineffective, expensive to sustain and/or to have serious environmental and other effects that are in many cases poorly understood". Since 2007 major modelling efforts have made some progress and are claimed to give a much clearer and more robust view than previous studies (Lawrence & Crutzen, 2013). In 2013 the IPCC made a radical shift and decided to assess CE in order to define its role within the portfolio of responses to climate change. However, the results so far indicate that the uncertainties and environmental risks remain (IPCC Summary for policy makers, WG1, 2013). One could claim that the scientific understanding, in spite of recent progress, still faces the very same fundamental, or even inherent problems, such as: democratic governance (Macnaghten and Szerszynski, 2013), that it is unclear how/if results from field experiments can be scaled up (Robock & Kravitz, 2013; Lawrence & Crutzen, 2013), the uncertainties might preclude meaningful scientific results (Reichwein, 2012) and that these results might be meaningless in informing decision making (Fernow, 2012). We do not aim to address these pressing questions, but we argue that these are dormant concerns also among non-informed laymen. We will elaborate on this issue in the following.

The laymen's critique was surprisingly coherent despite differences in age, gender, educational background and group compositions. The general view was deeply pessimistic, to such an extent that several groups thought they were the most pessimistic one in our sample. Not even the moderators' provocations and introduction of the emergency framing changed the view of the laymen, even though the moderators likely were considered as cautious promoters of CE by the participants and some informants had an optimistic view on the future potential of emerging technologies in general. The lack of trust in the scientific expertise endured, and the growth critique continued to dominate and was also supplemented with far-reaching demands of renewable technologies, lifestyle and system changes. The western materialistic culture was problematized and CE was deemed as making the situation worse. Concerns were raised that CE strengthens, at least temporarily, business as usual. Even though the informants did not consider a risk of self-delusion personally, they saw a risk that politicians, the industry and other citizens possibly could see an opportunity to not respond to the required actions due to the imminent climate crisis. In the light of CE the international political negotiations, which previously were deemed as fruitless, were upgraded and recognized as necessary and the only possible way. How can this pattern be explained, and how does it correspond to previous research, and what insights can this illustration provide to the understanding of CE in a broader sense, e.g. the growing public debate?

It was not until 2009 the public debate on CE opened up, in the sense that the mass media articles either became more balanced in regards of not primarily positive aspects being mentioned in the articles (Scholte, et al), or an increasing number of articles with the main argument that CE research ought to be halted immediately. The previous years were dominated by claims, intimately interlinked to the emergency framing, emphasizing the pressing need for more CE research or assessments. The proponents of research initially anticipated the problems of CE and presented the risks openly, and not even the critical ENGOs have added any substantial arguments or risks based on technical grounds that had not already been discussed. The problems and risks of CE are probably deemed to be so obvious and severe that not acknowledging these and depicting CE as feasible and a matter of straightforward development cannot be trustworthy (Anshelm & Hansson b, forthcoming). Considering the informants' firm and deeply critical stance, even though they had never heard of CE before, supports this claim. The scientific knowledge base concerning CE is not only very modest, also the scientific endeavor that CE entails is more or less spontaneously considered as stretching the limits of science and moral. No one has the credentials to confirm a better future with CE - and hardly anyone does (Anshelm & Hansson a, forthcoming). So, in the coming years, if the debate continues to open-up to also include more laymen playing active roles, why should these support CE if they in 40 minutes are able to identify the severe problems with CE without any former knowledge about the technology, and their concerns can be easily affirmed by merely taking part of the scientists' argumentation while promoting CE research?

Obviously, a provocative question like this raises validity questions. Is our sample representative for the Swedish population, and if so, is it also representative in an international outlook? Even though it is a qualitative study we claim that our results are fairly representative for Sweden. In spite of the focus groups being heterogeneous and the limited information provided by the moderators, their argumentation and conclusions were strikingly similar. Furthermore, conducting the eighth interview did not add anything substantial to what had already been said or discussed by the previous groups, i.e. empirical saturation. The reliability was also reinforced because the informants' positions on CE seemed to be stable regardless of the moderators' actions; they were no pseudo-opinions in the sense Daamen et al (2006) have experienced.

The previous research has solely been conducted in the UK or US, but looking at these examples may give us a hint on the relevance of our study in an international perspective. Macnaghten and Szerszynski (2013) explain that the skeptical positions found in their focus groups may be explained by the fact that the moderators deliberately avoided to promote the emergency framing, implying that the emergency framing convinces laymen to more easily accept a future with CE. This analysis can be contrasted with ours. The informants were critical both before and after being confronted with the emergency framing, nonetheless the emergency framing had influence. The emergency framing seemed to strengthen the skeptical stance and diverted to re-assessments of arguments for international political negotiations and conventional mitigation options; they were considered to be both more feasible and desirable. Politics was reconsidered in the light of the risks of CE. At least when following the informants' reasoning the moral hazard argument is not prevalent, instead a potential future with CE is so frightening that the feasibility of the alternatives are re-assessed and deemed both more preferable and likely.

Pidgeon et al. (2012) claim that in order to construct an understanding laymen draw on both cultural narratives and personal experiences that can be related to the scientific issue at hand. In our focus group discussions similarities and analogies with the intense and controversial nuclear debate were frequently made. Some informants were even joking about arranging a referendum concerning CE, as was the case with nuclear power. The nuclear debate in Sweden lasted for a couple of decades and is usually seen as a turning point regarding laymen questioning the expertise. During that debate

experts' claims were gradually more and more contested and also confronted with scientifically grounded counterclaims. The nuclear debate can be understood as a broad education of Swedish citizens in sociotechnical matters and the trust in expertise and scientists was profoundly remodeled (Anshelm, 2000). Possibly this skeptical stance is still prevalent, or at least reminded when topics of hazardous large scale sociotechnical systems sharing characteristics with nuclear power are experienced. This might indicate that Swedish laymen are especially aware of the environmental side-effects of grand scale technologies, and therefore more skeptical than citizens in many other countries. Such an assumption would entail that the patterns detected in our study have little to say about the conditions for laymen's engagement in public debates taking place in other contexts. On the other hand there are good reasons for assuming that the same pattern will occur in for example Germany that has had a similar societal reaction to nuclear power, and maybe that the same kind of reactions will at least increase in for example the US and the UK as the public environmental awareness and engagement are enhanced. Maybe the reactions of Swedish laymen can be understood as being in the vanguard in this respect, and our study accordingly indicates what the popular understanding of CE will look like in those countries in the years to come. It could be asked why laymen should have faith in the scientists' capabilities to make the needed major knowledge breakthroughs concerning CE when they will have their fears affirmed as soon as they take an active part in the public debate? Or is it possible that the unique reflexivity among the CE scientists might lay a ground for mutually trustful and open-minded deliberation?