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Public perceptions of climate engineering

Laypersons' acceptance at different levels of knowledge and intensities of deliberation

Over the past years, new options for addressing global warming and atmospheric CO_2-concentrations – such as bioenergy carbon capture and storage – have been included in computer models that estimate how much more can be emitted before the global mean temperature increase surpasses 1.5 °C. While the public in general remains mainly unaware of these, similar proposals in the past have triggered public protests. The prospect of public opposition therefore calls into question the use of these options in the models.

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Abstract

Even if societies decarbonized rapidly, it is unlikely that they will achieve the 1.5 °C target without also resorting to CO_2 removal, by means, for example, of bioenergy carbon capture and storage (BECCS). Such methods were included in the special report *Global Warming of 1.5 °C* published by the Intergovernmental Panel on Climate Change in 2018. This report also discusses solar radiation management, such as stratospheric aerosol injection (SAI) which might be used to change global temperatures. However, public debate about the acceptability of these methods remains absent. We look at laypersons' perceptions of BECCS and SAI at three stylized stages of increasing knowledge and deliberation. We found a high level of uncertainty among survey respondents as to whether to accept the use of these methods, which decreases when additional information is supplied by stakeholders. When comparing survey participants to members of a citizens' jury, we found lower levels of acceptance for SAI and similar levels for BECCS among jury members who had deliberated the methods intensively. Despite fears of distracting from the aim of reducing emissions, decision-makers should publicly discuss these methods to avoid planning based on incorrect assumptions about the political feasibility of CO_2 removal. People want to be informed about both approaches and the threat of SAI makes them focus their attention on mitigation.

Keywords

bioenergy carbon capture and storage, citizens' jury, climate engineering, public perception, stratospheric aerosol injection

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Climate change experts' attention currently focuses on the potential role of climate engineering to limit global warming. A vivid sign is the special report *Global Warming of 1.5 °C* of the Intergovernmental Panel on Climate Change (IPCC) (2018) (see box 1 for an explanation of the technologies). Already in its *Fifth Assessment Report* the use of CO_2 removal technologies – mostly in the form of bioenergy carbon capture and storage (BECCS) – was part of the majority of ambitious mitigation pathways (IPCC 2014). Four years later, it is clear that the 1.5 °C target cannot be met without CO_2 removal, even if societies decarbonized rapidly (Van Vuuren et al. 2018). This means that the *Paris Agreement* to limit global warming to 1.5 °C implies the use of at least some CO_2 removal method in the future. The latest IPCC report (2018) discussed solar radiation management, especially in the form of stratospheric aerosol injection (SAI) which might be used to change global temperatures. Without assessing societal, legal, technological, and resource constraints on research and deployment of the technologies, their costs might be underestimated and their future contribution to climate change mitigation overestimated (Löschel 2014, Schäfer et al. 2013, Fuss et al. 2014); especially strong constraints on CO_2 removal have thus implications for the level of ambition necessary to keep global warming below 1.5 °C. The public perceptions of these technologies are one of these constraints.

Climate engineering – underexposed in public discourse

While CO_2 removal technologies are included in the IPCC assessments on which decision-makers base their climate policies, a public debate on their desirability is still missing (Luokkanen et al. 2013). Among the public, few have heard about climate engineering yet (for overviews see Burns et al. 2016, Merk et al. 2015). For example, in the US, 57 percent indicated in a representative survey in 2016 that they were not at all familiar with SAI and ten percent were very familiar with it (Mahajan et al. 2018); in a survey in 2013 in Germany 78 percent of respondents had never heard about SAI before (Braun et al. 2018). When asked about climate engineering in general, including CO_2 removal, 26 percent of a UK sample said that they had heard about it before (Corner and Pidgeon 2015). There is a strong discrepancy between the debates in expert circles, that is, the pivotal role of CO_2 removal in 1.5 °C scenarios, and the low awareness in the societal discourse.

It is still unclear how the public, that is, people in different countries, will react to the various proposals when they become more widely known. Looking at past climate-engineering research projects like *Lohafex* or *Stratospheric Particle Injection for Climate Engineering (SPICE)* (Pidgeon et al. 2013, Oschlies and Klepper 2017, Rickels et al. 2011) suggests that there is the potential for considerable public protest against research and deployment of the technologies. In surveys of public perceptions, participants are hesitant to embrace the technologies and the range from opposition and acceptance is broad. In the above mentioned German survey, for example, only 26 percent of the respondents would at least somewhat agree to the use of SAI (Braun et al. 2018), while in the US survey of 2016 about two thirds of respondents would agree to the use of SAI (Mahajan et al. 2018). In the light of past protests, there is a risk of taking especially optimistic survey results literally and taking public acceptance of climate engineering for granted. Mahajan et al. (2018) cautioned against this and pointed out the occurrence of acquiescence bias which could introduce a systematic overestimation when support in contrast to objection is elicited. This is especially important as research points toward a decrease in acceptance of SAI, when people's level of information increases (Braun et al. 2018, Sütterlin and Siegrist 2016).

But not only strong public objection could be a reason for concern for climate policy, also an overoptimistic evaluation of the technologies could have negative repercussions on climate protection: experts fear that discussing climate engineering – especially SAI – as a way to counteract climate change could reduce the motivation to cut emissions via mitigation. This concern is called moral hazard (Lin 2013) or mitigation obstruction (Morrow 2014). Public perception surveys and deliberative studies do not confirm this: participants prioritize mitigation when learning about climate engineering (Wibeck et al. 2015, Shepherd 2009) or are even willing to spend more on mitigation compared to others who have not been informed about SAI (Merk et al. 2016). Only for CO_2 removal one survey experiment has found a drop in the stated motivation to engage in mitigation (Campbell-Arvai et al. 2017). It remains unclear whether perceptions of SAI and BECCS could influence each other when presented jointly in studies or in public.

In this paper, we extend prior research on public perceptions by creating three stylized situations with varying amounts of information and varying depths of deliberation of the technologies. We call them stylized because we create these situations instead of observing reactions in real-life when laypersons happen to learn about and to engage with the technologies. These situations represent different stages on a continuum of knowing and deliberating about SAI and BECCS, which we compare: on the first stage, survey 1, we provided respondents only with some technical in-

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BOX 1: Short introduction to climate engineering

"Climate engineering" is a term for various technologies and methods that are large-scale interventions into the climate system to limit global warming. These technologies either aim at changing the radiative balance, most prominently stratospheric aerosol injection (SAI), or at removing CO_2 from the atmosphere and delivering it to long-term storage – called CO_2 removal or negative emission technologies –, like bioenergy carbon capture and storage (BECCS) (NRC 2015, Rickels et al. 2011, Masson-Delmotte et al. 2018):

Stratospheric aerosol injection (SAI) is the deployment of particles into the stratosphere (more than 18 kilometers above ground) where they would reflect sunlight into space before it warms the Earth. This could slow down global warming much faster compared to cutting greenhouse gas emissions. The particle layer would have to be renewed continuously for centuries, until the share of greenhouse gases in the atmosphere will have returned to lower levels. If the deployment of SAI were suddenly stopped, global mean temperatures would rise abruptly within a few years. Little research has been done on the effects and side effects of SAI so far. Injecting sulphate particles could have negative effects on various ecosystems, the ozone layer and the health of animals and people. SAI does not target ocean acidification. Furthermore, political conflicts might arise over deployment itself or the intensity of deployment. It is unclear whether further negative effects would occur during deployment.

BECCS could be used to remove CO_2 from the atmosphere and thus reduce its CO_2 content. As energy crops grow, they take CO_2 from the atmosphere. In the process of generating bioenergy, the CO_2 could be captured. Energy crops need a lot of land, water, and nutrients for cultivation, which would then not be available for humans, animals, and plants. The captured CO_2 would have to be stored underground for centuries. Whether the storage sites are safe, that is, whether no CO_2 escapes, depends on its geophysical characteristics. Storage safety in empty gas fields has already been tested for more than 30 years. The effects of using BECCS on global temperatures, food prices, water availability, and nature would strongly depend on the scale, the regions and the plants that are used.

formation about SAI or BECCS. On the second stage, survey 2, respondents received some technical information and, in addition, the opinion of a societal stakeholder. Finally, on the third stage, in a so-called citizens' jury, participants intensively deliberated on SAI and BECCS on three weekends. They were informed, became familiar with other actors' evaluation of climate engineering, and discussed SAI and BECCS with their fellow participants. Especially the citizens' jury represents a very high level of engagement with the topic, which laypersons will hardly pursue on their own accord. Participants at every stage had to make up their minds in different forms about whether to agree with research and deployment of SAI or BECCS. In the citizens' jury, we also had the opportunity to look more closely at opinion shifts between mitigation, BECCS, and SAI.

Method – varying amounts of information and depths of deliberation

Survey 1

Survey 1 represents a stage where people have just been introduced to climate engineering. Respondents read descriptions of climate change and either SAI (N=265) or BECCS (N=258) including the technology's risks and benefits. We assessed the perceptions of the respective technologies – whether respondents agreed with research and deployment and whether they thought the technology should never be used (see additional information for all questions and information texts in the online supplement[1]). At this stage, participants could also respond "don't know" instead of choosing a level of agreement. A control group of respondents only read the description of climate change (N=368). We recruited the respondents via a commercial online panel; they are representative for the German online population with respect to their age, gender, and state of residence. We measured additional variables, like level of education and whether they had heard about SAI, respectively BECCS, before. Respondents were on average 45 years old and 53 percent were female. 57 percent had at least a higher education entrance certificate *(Hochschulreife)*.

Survey 2

Survey 2 represents a stage where people have been introduced to SAI and the opinion of a stakeholder about it. We randomly presented a fictitious statement that either argued in favor or against research or deployment of SAI by a stakeholder from politics, science, or by a citizens' jury (see online supplement, appendix B). This should serve the purpose of providing a new quality of information, namely the opinion of a relevant actor. At this stage, *acceptance* was measured via the mean of the responses to twelve questions which asked about the agreement to statements like "SAI should be deployed to combat climate change". Participants were not offered the option "don't know", but we measured how *uncertain* they were about their responses to the acceptance questions via two items, "I don't know how to think about the possible deployment of SAI" and "I have no clear opinion on SAI". We assessed *acceptance* of SAI and the *uncertainty* about their responses on SAI twice: first, after reading a neutral information text about climate change and SAI risks and benefits, comparable to the information text in survey 1; second, after participants had read a stakeholder's statement on SAI. This particular design offers the opportunity to detect changes in acceptance and uncertainty caused by additional information from someone else whom participants do not know personally but with whose role in society they are familiar with. We also asked about other aspects, like *prior knowledge* of SAI and *affective reactions* towards climate change.

The sample included 399 respondents who were recruited via *Facebook* ads. The average age was 30 years. 66 percent of the respondents were female and the level of education was above the German average, with 86 percent stating that they had at least a higher education entrance certificate *(Hochschulreife)*. The resulting sample was therefore not representative for the German population and the results must be considered against this background. Nevertheless, people participating in this kind of online survey are probably more likely to resemble those that will actually participate in a future societal debate. Moreover, this non representative sample fits the requirements for inferential statistical testing, such as residual normal distribution and variance homogeneity. We used three different stakeholders as sources, and three different opinion statements but found no difference in respondents' uncertainty levels in an analysis of variance, neither for the sources ($F(2,396) = 0.602$, $p = .548$)[2] nor the statements ($F(2,396) = 0.028$, $p = .972$) and therefore pooled the data in the analysis.

Citizens' jury

The citizens' jury represents a situation where people have been thoroughly informed, have heard others' opinions about climate engineering and had the opportunity to formulate their own opinion and judgment in a group. It tries to reconcile the Habermasian discourse ethics with technology assessment (Grunwald 2010, Simonis 2013). There are different participatory methods called citizens' jury (Sommer 2015). The concept of our citizens' jury builds on Peter Dienel's (1978) so-called "Planungszelle". We pursued two different objectives: first, gaining insights in laypersons' perceptions of and reasoning about SAI and BECCS; second, empowering citizens to participate in public decision-making. Therefore, we understand the method as a tool of deliberative democracy (Ott 2014); it is not social science research in a narrow sense.

The citizens' jury took place on three weekends between January and March 2018. Participants were recruited via calls to randomly generated telephone numbers and participated voluntarily. Of the initial 25 participants, 17 attended all three weekends and co-signed the citizens' report. The seven women and ten men were

1 The supplement is available at *www.oekom.de/publikationen/zeitschriften/gaia/supplementary-material/c-157*.

2 Analyses of variance are used to analyze the differences among group means in a sample. F-values indicate the variability between group means, p-values indicate the significance of the results ($p < .05$ indicates a significant result on a five percent level).

on average 59 years old with an age range between 37 and 78 years. The citizens' jury approached the topic in three steps: in the first step, invited scientists from different disciplines provided information on climate engineering. Presentations spanned a broad variety of topics from climate change in general, SAI and BECCS – their implications, prospects, risks, and economic incentives –, to ethical arguments pro and contra both climate engineering technologies. In the second step, there were "question-and-answer" sessions; then participants discussed and reasoned about the technologies in small groups. In the third step, the participants wrote the so-called citizens' report (Bürgerforum Climate Engineering 2018) which is the main outcome of the citizens' jury. The content of the final citizens' report was approved by all participants. In general, participants of a citizens' jury address their report to relevant decision-makers. Since there is no current political debate about climate engineering in Germany, the citizens' report was sent to three prominent scientists active in the international climate change discourse or technology assessment: Armin Grunwald (Karlsruhe Institute of Technology), Ottmar Edenhofer, and Hans-Joachim Schellnhuber (both Potsdam Institute for Climate Impact Research).

The participants in the citizens' jury also assessed SAI and BECCS in a questionnaire that contained similar acceptance items as survey 1. We asked them twice: at the end of the first weekend, after the participants had been intensively informed about climate change and the technologies, and at the end of the third weekend, after deliberating and finishing the citizens' report. 17 participants filled out both surveys. We assess the differences between respondents with little knowledge about SAI or BECCS (i. e., survey 1) and citizens' jury participants who had intensively deliberated about the technologies.

Results

We have talked enough about climate change, haven't we?

Before discussing the participants' perceptions of BECCS and SAI in survey 1, we want to highlight an unexpected result concerning climate change perception. We were surprised about the self-reported lack of knowledge about climate change among participants in survey 1. In the group that had only read climate change information, 25 percent stated they had just learned a lot and seven percent made the additional effort to write down in the closing remarks that they had learned something new about climate change. The text, however, only contained widely discussed information from the IPCC's *Fifth Assessment Report* (IPCC 2014) about the expected impacts of a 2 °C warming. Our suspicion that these respondents might be climate-change deniers was not confirmed: they had already been convinced about anthropogenic climate change and had perceived it as a serious threat before reading the text. It seems there is not only the expected lack of knowledge about climate engineering, but also an unexpected lack of even basic knowledge about climate change despite the broad media coverage over the past years.

We also observed similar reactions in the citizens' jury: participants were deeply concerned and surprised by the scientists' presentations on climate change and its impacts. Their perception was that politicians and scientists were not communicating the issues adequately to the public. In the citizens' report, they call for increased efforts to inform society about climate change.

It seems there is not only the expected lack of knowledge about climate engineering, but also an unexpected lack of even basic knowledge about climate change despite the broad media coverage over the past years.

Forming an opinion is not an easy task

Turning to the respondents' perceptions of SAI and BECCS in survey 1, we found a lack of knowledge in the public, just as other studies have found before. Many had never heard of SAI (83 percent), respectively BECCS (71 percent), before. These shares were lower in the citizens' jury: 57 percent and 43 percent had never heard about SAI, respectively BECCS, before. How do respondents react to technologies and how do they form an opinion when they have only just been provided with basic information (survey 1) or basic information plus a stakeholder's statement (survey 2)?

Many respondents in survey 1 chose the option "don't know" instead of indicating a level of (dis-)agreement with deployment of the technologies. Asked whether they would accept the deployment of SAI or BECCS, 31 percent and 22 percent, respectively, responded that they "don't know". This is, however, not an indication of a general response pattern where respondent always choose "don't know": when asked about whether to agree with research, only 4.5 percent (SAI) respectively four percent (BECCS) chose "don't know". Choosing this option is independent of participants' level of education (SAI: $\chi^2(1) = 0.0001$, $p = .993$; BECCS: $\chi^2(1) = 0.1493$, $p = .699$).[3]

The answer "don't know" can be interpreted in different ways, for example, it could mean that participants did not want to make the cognitive effort to form an opinion or that they are actually uncertain and do not have an opinion (Krosnick et al. 2002). Uncertainty might be reduced with additional information and additional time to deliberate. Thus, we looked more closely at the aspect >

3 The chi^2 test examines whether two categorical variables are independently distributed ($p > .05$) or whether there is an association between the variables ($p \leq .05$).

TABLE 1: Uncertainty about stratospheric aerosol injection (SAI) before and after reading a stakeholder's statement. Paired *t*-tests for changes of stated uncertainty in the acceptance groups. *Note:* Paired *t*-tests for differences in mean *uncertainty* between point of measurement 1 (T1) and point of measurement 2 (T2) in the acceptance groups; means *(M)*, standard deviations *(SD)*, degrees of freedom *(df)*, *t*-values *(t)* and significance tests *(p)* are reported; *p*-values are Bonferroni-corrected; $p < .001$ (significant on 0.1 percent level).

ACCEPTANCE GROUP	UNCERTAINTY *M*(T1)	*SD*(T1)	*M*(T2)	*SD*(T2)	*df*	*t*	*p*
low acceptance	20.36	21.13	17.25	18.66	57	1.15	.768
medium acceptance	50.22	24.14	39.84	25.57	243	8.55	< .001
high acceptance	31.78	24.49	29.3	26.86	96	1.09	.84

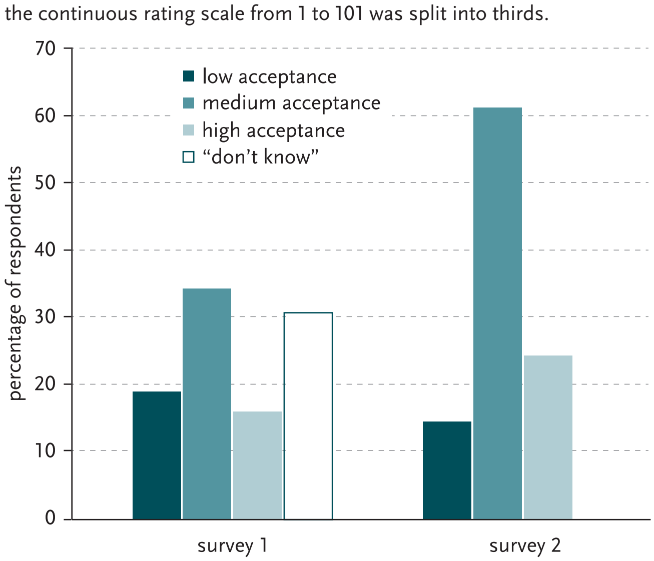
of *uncertainty* about what or how to think about SAI in survey 2 where participants did not have the option "don't know", but had to make a choice on a continuous rating scale from 1 to 101.

Uncertainty about how to rate acceptance

We compared the response distribution in the *acceptance* ratings between survey 1 and 2 before participants in survey 2 received the stakeholder's statement. For comparison, we divided numeric ratings into three categories each spanning one third of the scale. Figure 1 shows that without the option "don't know" the share of respondents in the medium acceptance category was substantially higher.

In survey 2, where we elicited *uncertainty* about the acceptance rating separately, we found that *uncertainty* differed between the three categories ($F(2,396) = 47.27$, $p = .001$). It was significantly higher in the medium acceptance category (*Mean (M)* = 50.22, *standard deviation (SD)* = 24.14) than in the low ($M = 31.70$, $SD = 24.49$, $p < .001$) and the high ($M = 20.36$, $SD = 21.13$, $p < .001$) *acceptance* category (Post-hoc Bonferroni-corrected *t*-tests; scale: 1 = maximum certainty, 101 = maximum uncertainty).

FIGURE 1: Participants' *acceptance* of stratospheric aerosol injection (SAI) in survey 1 and 2 (after reading an information text on climate change and SAI). In survey 1, the original six response categories were combined into three: the two lowest, the two medium and the two highest; in survey 2, the continuous rating scale from 1 to 101 was split into thirds.



Is uncertainty reduced by learning about stakeholders' opinions?

In survey 2, respondents then proceeded to read the statement of a stakeholder. The *uncertainty* after reading the introductory information text was significantly decreased by reading the stakeholder statement ($M_1 = 41.39$, $SD_1 = 26.44$; $M_2 = 33.99$, $SD_2 = 26.27$; paired samples *t*-test: $t(398) = 7.24$, $p < .001$)[4]. In the medium acceptance group, we observed significantly lower *uncertainty* at the second point of measurement (table 1), but the stakeholder statement did not significantly change the *uncertainty* of participants in the low and high acceptance group.

Performing a one-way analysis of variance we found that *uncertainty* is related to knowledge about SAI that participants already had before they participated in the survey ($F(2,396) = 16.85$, $p < .001$; figure 2). Participants that stated they had "never" heard about SAI before, showed significantly higher *uncertainty* scores compared to participants that stated that they had heard at least "a little bit" ($p < .001$), who in turn had higher scores than participants who had heard "quite a lot" ($p = .026$) about it.

Perceptions of climate engineering based on careful deliberation

At the highest stage of knowledge and deliberation, the citizens' jury, participants discussed research and deployment of SAI in a very critical way. They rejected the use and accepted it only under very strong constraints on the scale of use and as a last resort, that is, in case of a "climate emergency". For them, rigorous mitigation was a sine qua non condition for deployment. Because they rejected SAI, they called for more research on methods to remove CO_2 from the atmosphere. However, they were very reluctant to accept BECCS. Their main concern was that large-scale energy-crop plantations would cause biodiversity loss and land-use conflicts would endanger food security. Similar to their argumentation about SAI, participants argued for strong constraints on BECCS: the cultivation of regional plants, regional supply chains, no fertilization, and CO_2 storage only underneath unsettled areas. Participants included alternatives to BECCS in the citizens' report that they perceived as more benign; for example BioChar (charcoal from biomass that can be used to increase soil carbon storage and enhance soil quality), which they did not evaluate critically, overestimating its removal potential (EASAC 2018).

4 Paired samples *t*-tests compare two means of the same individual/object.

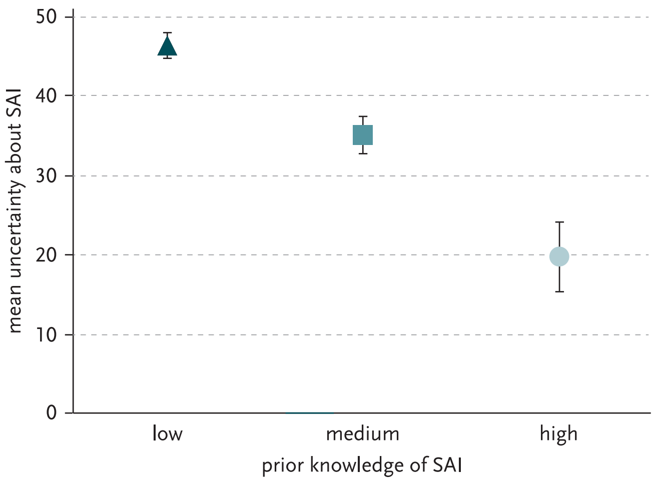


FIGURE 2: Differences in mean *uncertainty* by the level of *prior knowledge*, that is, whether and how much respondents had heard about stratospheric aerosol injection (SAI) before the survey: low, medium or high. The uncertainty scale ranged from 1 (maximum certainty) to 101 (maximum uncertainty). Error bars represent standard errors.

Comparing acceptance between stages of deliberation

The survey results showed that participants of the citizens' jury were very reluctant to accept SAI as a strategy against climate change and they were more skeptical about it than about BECCS (figure 3; $p < .001$). In survey 1, overall agreement with "deploy never" and "deploy" between BECCS and SAI were also significantly different (each $p < .001$). Respondents were more critical about SAI compared to BECCS except for the acceptance of research, which was similar for the two technologies.

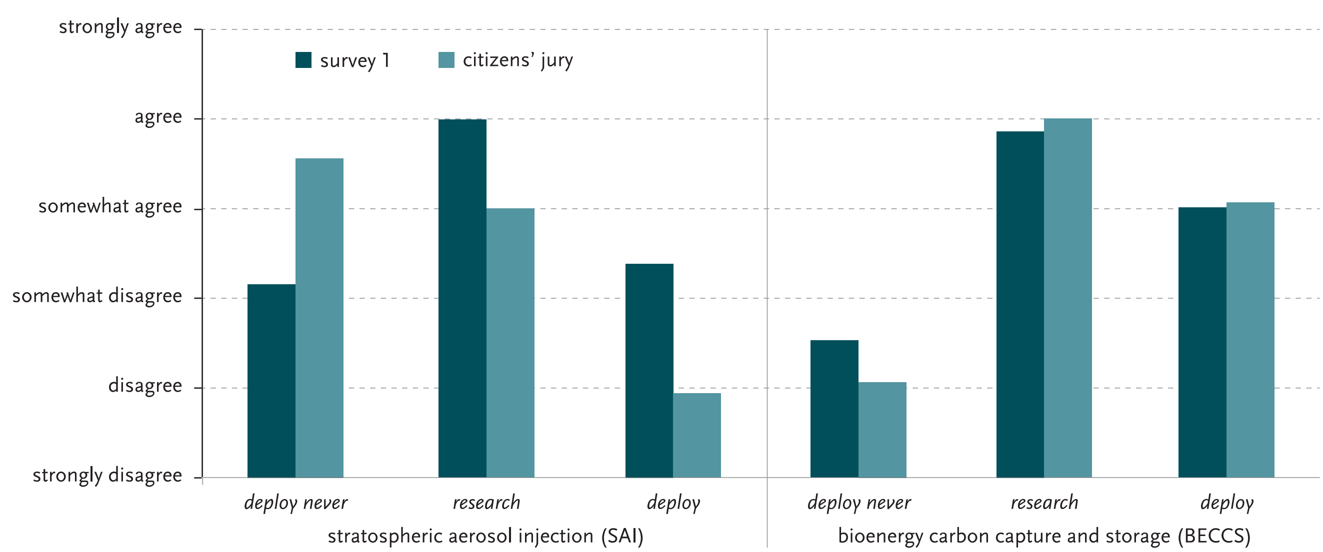
However, compared to citizens' jury participants, respondents in survey 1 were less opposed to researching or deploying SAI and less likely to reject it categorically ($p < .001$). For BECCS, the responses from survey 1 and the citizens' jury were not different for any of the three items. Thus, participating in the citizens' jury increased the skepticism toward SAI but not toward BECCS. Thus, with a spreading of knowledge about BECCS and SAI we do not expect major shifts in BECCS acceptance whereas SAI acceptance might decrease.

Participants of the citizens' jury split up in two groups to write the citizens' report – one group discussed and drafted the BECCS section ($N = 8$), the other the SAI section ($N = 9$). Before the participants self-selected into the groups, their acceptance ratings (measured at the end of the introductory weekend) were the same, except for a slightly lower rating for BECCS in the BECCS group compared to the SAI group. Some participants stated that they had chosen SAI because they perceived it as more problematic than BECCS.

After deliberating and writing the citizens' report, two differences become apparent between the groups: first, the BECCS group shifted toward an even more critical assessment of SAI. They were mostly against research on SAI, while in the SAI group all were in favor of research. Members in both groups strongly opposed using SAI, but SAI group members were more reluctant to rule it out categorically. Second, this shift did not occur for BECCS. The SAI group continued to hold more favorable views on BECCS deployment. While the BECCS group was less in favor of researching it, the SAI group displayed higher ratings for research on BECCS compared to before the deliberation.

We have two (not mutually exclusive) explanations for these observations: first, as the participants self-selected into the groups, the members might have been different with respect to unobserved individual characteristics that influence the openness to engage with potentially threatening futures. Second, we observed group dynamics that led to a search for alternative removal methods oth- >

FIGURE 3: Mean responses for stratospheric aerosol injection (SAI) and bioenergy carbon capture and storage (BECCS) acceptance from survey 1 (N varies between 182 and 248) and the citizens' jury survey. *Deploy never:* "[SAI/BECCS] should never be used, no matter how bad the impacts of climate change are"; *research:* "The feasibility of using [SAI/BECCS] against climate change should be researched"; *deploy:* "[SAI/BECCS] should be used to fight against climate change".



er than BECCS in the BECCS group, while the SAI group focused on their technology and emphasized the importance of mitigation and CO_2 removal as alternatives in general (including BECCS).

Discussion: connecting discourses – we need to talk

Public acceptance is often perceived as one of the main limiting factors to research and deployment for CO_2 removal (Fuss et al. 2014) and for solar radiation management (Burns et al. 2016). It is, however, unclear what the public actually thinks because hardly anyone has heard about the methods. Representative surveys can give insights but remain limited in their external validity because respondents have to form an opinion in a very short time based on very little information. At the same time negative emission technologies, like BECCS, are an integral part for reaching the 1.5 °C goal in modelling studies and their feasibility also has implications for emission reduction targets.

Contrary to the common concern that the efforts to reduce emissions might slacken once climate engineering is discussed (Lin 2013, Morrow 2014), we observed a shift in the attention towards mitigation and technologies that were perceived as more benign. All participants in the citizens' jury voiced an increased awareness about climate change and a higher willingness to mitigate greenhouse gases, that is, an inverse moral hazard. In addition, the members of the SAI group pushed for CO_2 removal methods, as they perceived them as the lesser evil compared to SAI. Members of the BECCS group were looking for what they thought of as more benign alternatives to BECCS. Thus, we observe not just – like other studies before (Merk et al. 2016) – an inverse moral hazard between SAI and mitigation but also between SAI and BECCS. Future research should explore whether these trade-offs also occur in more representative settings.

The groups we observed are more self-selected at every step: 1. a representative online survey, 2. the sample was recruited via *Facebook,* and 3. a small group of highly motivated members of a citizens' jury that was by no means representative for the general population. But also in the real world those who are knowledgeable about a topic and engage with it do it voluntarily. Others might not care enough about a specific topic or might not have the capacity to get heavily involved. The opinions of the citizens' jury might in this sense be a good indicator for the opinions of actively engaged citizens who care about climate change. In our case, they showed strong interest in learning more about SAI, BECCS and other CO_2 removal methods. From their reactions as well as the survey responses, we conclude that climate change researchers and policy-makers should not overestimate the knowledge about climate change in the public, despite the high levels of concern reported in surveys.

Societal stakeholders, like politicians and NGOs, should not shy away from talking about CO_2 removal proposals, otherwise public perception will remain an indistinct bogey that inhibits societal discourse, until the expert discourse might have silently bet on using the methods for too long. If the silence continues, the worst-case scenario is that opposition outweighs support which would mean that the assumed remaining emission budgets for 1.5 °C were too high because societies' acceptance of CO_2 removal was overestimated. However, if we keep missing emission targets, the political pressure to explore SAI might increase with a high potential for conflict between supporters and opponents because at all stages we observed high levels of rejection among laypersons. Thus, a societal debate that connects to the expert discourse is needed in the short term.

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