Environment, Development and Sustainability
https://doi.org/10.1007/s10668-023-03683-2

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How to shape communication for CO_2-derived insulation boards considering different accepter profiles

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Received: 31 March 2022 / Accepted: 23 July 2023

Abstract

Climate change is a constant global challenge. An approach to help mitigate climate change is carbon capture and utilization (CCU), in which captured CO_2 is reused as raw material for consumer products. Because innovations like CCU are unfamiliar to the general public, their communication is critical for a successful rollout. To date, sustainability innovation research has largely neglected the empirical study of communication. The present study contributes to studying the information and communication needs of laypeople based on perceptions and acceptance patterns for CCU by focusing on acceptance profiles for CCU-based insulation boards. In an empirical two-step approach, a qualitative interview prestudy was followed by a quantitative questionnaire measurement ($N=643$). Using k-means clustering, the respondents were divided into three acceptance groups: rejecters (15%), tentative accepters (51%), and strong accepters (34%). Analysis showed that regarding their demographics and personality traits, tentative accepters and rejecters were similar. All segments trusted science and health experts best, and only the rejecters distrusted some specific actors. Information on the product's risks and functional properties was most important for all acceptance groups. Based on the study's insights, both general and targeted managerial communication and policy guidelines were formulated.

Keywords Acceptance · Trust · Communication · Information · Carbon capture and utilization (CCU) · Insulation boards

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Published online: 16 September 2023

1 Introduction

Climate change is one of the biggest global challenges of the last decades, with severe consequences for the planet. A significant increase in the global temperature has been reported (NASA, 2020), and the effects of the changing climate are evident in many places around the world, including an increasing occurrence of floods, storms, forest dieback, loss of biodiversity, drought, and water scarcity (for an overview: Fu and Waltmann, 2022; Abass et al., 2022). Climate change severely threatens livelihood and life quality for humankind, flora and fauna. The greenhouse effect—which refers to the warming of Earth's surface and troposphere (Volk, 2010)—is a major driver behind climate change. If climate change is not tackled worldwide, global warming is expected to reach 1.5 °C between 2030 and 2052 (Allen et al., 2018 (IPPC), p. 4). As agreed on in the Paris Agreement, there is an urgent need to counteract the effect of the abundance of human-induced greenhouse gas emissions and work toward mitigating this problem (United Nations Climate Change, 2015; Allen et al., 2018 (IPCC)).

However, the success of actions toward a green energy policy and implementation of technical innovations not only requires a clear (inter)national commitment and strategy, but also needs to consider different components and factors along multiple dimensions. One example is the push for renewable technical innovations and the development of green market strategies (e.g., Kittner et al., 2017) that have to be balanced with policy efforts (Breetz et al., 2018) that support procedures with appropriate socioeconomic measures (Carley & Konisky, 2020; Knuth, 2018) as well as with tax incentives and financial support (e.g., Habeşoğlu et al., 2022, Qashou,et al., 2022). Finally, social justice, equity and acceptance factors are pivotal in order to integrate the public (Carley & Konisky, 2020; Simons et al., 2021a).

First and foremost, it is essential to decrease greenhouse gas emissions, like carbon dioxide (CO_2), by, e.g., increasing the energy efficiency of homes and switching to renewable energy (IPCC, 2018). However, such a large and drastic transition takes time. For energy-intensive industries, like the steel and cement industry, it is not yet possible to further reduce their emissions (Gartner, 2004; Benehal et al., 2013, Hasanbeigi, et al., 2012). Therefore, it is necessary to decrease greenhouse gas emissions, like carbon dioxide (CO_2), by, e.g., increasing the energy efficiency of homes and switching to renewable energy (Allen et al., 2018 (IPCC). Further, carbon capture technologies, like carbon capture and utilization (CCU), are often additionally included in mitigation policies (e.g., in the Netherlands International Energy Agency (IEA) 2020). When applying CCU, CO_2 is either captured from industrial point sources—e.g., fossil-fueled power plants (Cuéllar-Franca & Azapagic, 2015)—before it is emitted, or directly from the air (von der Assen et al., 2013). Through a series of steps, the CO_2 is further processed to eventually be used as raw material to produce other products, thereby partially replacing the conventionally used fossil resources (Pieri et al., 2018). There is a broad variety of possible uses for the captured CO_2, including the carbonation of beverages or the production of polyols (Mikulčić et al., 2019).

For CCU to be successful in mitigating climate change, the communication of this innovative technology and resulting products is a critical factor (Rogers, 2003). Even though individual predispositions (e.g., Im et al., 2003) and process characteristics of technology innovations (e.g., Driessen & Hillebrand, 2002; Schiedering et al. 2012) were identified as crucial for adoption by consumers, the empirical understanding of the communication requirements has been neglected so far. Only a small number of studies investigated the role of information and communication for the adoption of innovative products (Lee and Colarelli 2003, Zhang et al., 2021; Bruhn & Ahlers, 2017). Such studies usually target marketing or strategic communication (e.g., Herbes & Friege, 2017; Zukas, 2017).

However, the aim of communicating innovations should not be directed on convincing potential customers, but to enable informed decisions (Devine-Wright, 2012; Zaunbrecher & Ziefle, 2016; Kluge et al., 2021). This is only possible if the information needs, technology-related perceptions, acceptance patterns and communication requirements of the target group are carefully analyzed to be closely reflected in communication strategies (Offermann-van Heek et al., 2018; Simons et al., 2021a).

The present study focuses on laypeople's information and communication requirements based on their perceptions and acceptance patterns for one CCU product example: insulation boards consisting of polyurethane foam that is made with polyols produced by means of CCU.[1] The study thus contributes to the development of sustainable technology communication concepts, which are oriented toward the technology perceptions and needs of the target group and can help potential consumers to make an informed decision in the context of CO2-based products.

2 The acceptance and communication of sustainable innovations

A successful adoption of sustainable innovations requires the positive perception and acceptance of society and potential customers (Arning et al., 2018; Linzenich et al., 2021). Generally, acceptance can be defined as the (active or passive) approval of the innovation, including its development, implementation, and use (Dethloff, 2004). For renewable energy innovations the framework on *social acceptance* by Wüstenhagen et al. (2007) breaks down the construct of acceptance into three domains. Firstly, *socio-political* acceptance refers to the acceptance of the innovation itself and related policies by the public, key stakeholders, and policy makers. Secondly, *community or local* acceptance refers to the acceptance by those directly affected by the technology's infrastructure, e.g., because of its proximity to their home. Finally, *market* acceptance deals with the innovation's market adoption, including consumer acceptance. For CCU, the latter is particularly relevant for understanding the acceptance of CCU products.

Most previous studies on the acceptance of CCU (products) cover parts of socio-political and/or market acceptance (Wüstenhagen et al., 2007). These have found a generally positive perception and acceptance for both the technology (e.g., Arning et al., 2019) and specific products, e.g., CO_2-based fuel (Offermann-van Heek et al., 2020), mattresses (Arning et al., 2018) as well as for CO_2-derived insulation (Arning et al., 2021).

Focusing on the acceptance of CCU (products), especially perceived benefits were an important driver (e.g., Arning et al., 2019; Lutzke & Árvai, 2021), but value- and personality-related factors, like environmental awareness, also played a role in determining acceptance (Arning et al., 2018, 2021; Linzenich et al., 2021).

Several studies also revealed that the general public's level of awareness and knowledge of CCU is very low (e.g., Kluge et al., 2021; Perdan et al., 2017). Such low levels of knowledge about innovations can lead to increased risk perceptions and, accordingly, to the

[1] The acceptance of this product and the drivers behind the acceptance have previously been described in Simons et al. (2021b).

rejection of technologies (Slovic, 1987). More appropriate information and communication activities are therefore needed to bring the sustainable innovations to society's attention. However, simply providing (more detailed) technical information might not suffice to increase acceptance, and could even, as has been shown for CCS, have a contrary effect (Braun et al., 2018).

Whether the provided information fulfills its goals depends on the receivers' interpretation of it, which, in turn, depends on their individual characteristics (Brunsting et al., 2011). To design successful, and targeted, communication strategies, the differences between consumers—i.a., regarding their perception, socioeconomic background, values, and beliefs—should thus be considered.

Additionally, *trust* in the communicator is also vital for the success of communication (Slovic, 1993). In the context of the acceptance of sustainable energy technologies, trust is often defined as trust in the relevant actors/decision makers to act in favor of the public (Huijts et al., 2012). Trust is especially important when consumers do not have sufficient (technical) knowledge about the innovation (Linzenich et al., 2021; Offerman-van Heek et al. 2018). They then base their (risk) perception and acceptance on the information provided by experts and authorities (Siegrist & Cvetkovich, 2000). Because of the low public knowledge on CCU, trust might be particularly essential for its acceptance. Jones et al. (2017) found that skepticism of CCU products stemmed from a lack of trust in the industry promoting the technology. Additionally, Offermann-van Heek et al. (2018) uncovered a correlation between trust in the credibility of different information sources, and the perception of plastic CCU products. Finally, for the acceptance of CCS as a related technology the trust in relevant stakeholders has been found to be essential (e.g., L'Orange Seigo et al., 2014; Terwel et al., 2009; Williams et al., 2021). Laypeople trusted industry and government least and science and research institutions most (L'Orange Seigo et al., 2014; Williams et al., 2021). In the case of CCU the trust in the source of the communication influenced both the trust in CCU labels as source of information, as well as the intention to buy CCU products (Linzenich et al., 2019). Accordingly, when designing communication strategies for sustainable innovations, the source of the communication should also be chosen with care.

3 Research aims and empirical procedure

To develop a need- and target group-oriented communication for sustainable innovations such as CCU insulation boards, the product's perception and acceptance, as well as potential consumers' communicative requirements, need to be studied. The present study set out to do this for a CCU product example, i.e., thermal insulation boards consisting of polyurethane foam, which is made with polyols produced using CCU, hereafter referred to as *CCU insulation boards*.

Providing a concrete product example ensured that all respondents based their evaluation on the same CCU product. CCU insulation boards are an especially promising CCU product because of their relatively high technology readiness level and expected market launch in a few years' time (Covestro, n.d.). Additionally, on its own, thermally insulating buildings to increase energy efficiency is an important part of climate change mitigation strategies (IPCC, 2018). Combined with the remaining large number of badly insulated buildings and the frequent use of polyurethane-based materials for insulation, this underlines the current and future market demand for insulation materials like CCU insulation boards (Pavel & Blagoeva, 2018).

We considered aspects of the product's market and socio-political acceptance (Wüstenhagen et al., 2007) and defined the following research aims:

1. Identify **acceptance profiles** for CCU insulation boards and gain a better understanding of their demographics, personality traits, and attitudinal patterns.
2. Analyze **information and communication requirements** for the identified acceptance profiles regarding information needs, trusted actors, and information sources.
3. Formulate targeted **managerial recommendations for public communication** for CCU insulation boards based on the acceptance profiles' specific information and communication requirements.

We applied a two-step empirical procedure, by first conducting qualitative interviews with laypeople, technical and field experts to gain broad insights on the topic, and subsequently using these to run an online questionnaire study addressing the perception, acceptance, and communication of CCU insulation boards.

4 Method

4.1 Understanding acceptance argumentations and narratives

The interview study aimed to identify acceptance factors for CCU insulation boards, as well as the information requirements for the product's market rollout. We conducted semi-structured interviews with five technical experts who worked with/on CCU (insulation boards); three field experts with work-related familiarity with the insulation market; and 16 laypeople,[2] who were all house owners without work-related experience with CCU or the insulation market. A description of the sample can be found in Fig. 1.

A specific interview guideline was used in each target group to consider their familiarity with CCU and the insulation market. All interviewees volunteered to participate in the interviews and were not compensated for their efforts. Before starting, all interviewees were told they could stop the interview at any time, that they could freely express their thoughts, and that none of their answers would be wrong. If permission was granted, we recorded the interviews, and the participants were informed that the transcriptions would solely be used for research purposes.

The analysis of the interviews showed that the laypeople's knowledge on CCU was non-existent or very low, but that they were generally positive about the CCU technology and CCU insulation boards. Besides insights on the perceived benefits and barriers and important material properties, the interviews yielded important insights into the information and communication requirements for the product. Laypeople most frequently mentioned they wanted information directly related to the product, like its *price–performance ratio*, *functional properties*, and *health risks*. This would enable them to compare the material to other available insulation material.

[2] One interview was conducted with a couple, we thus spoke to 17 people in a total of 16 interviews.

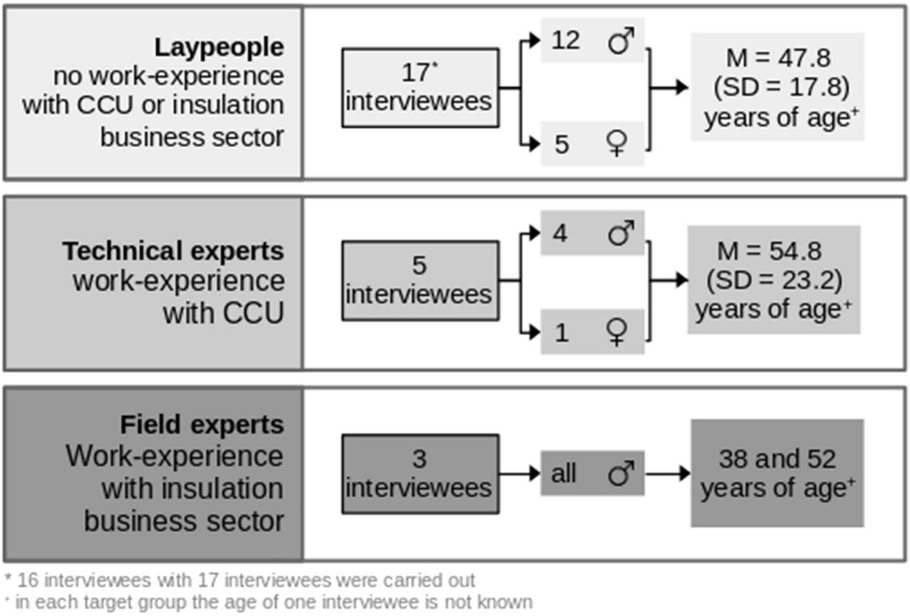

Fig. 1 Sample description of the sample used for the semi-structured interviews in the qualitative prestudy

> *The information on the requirements, being low flammability, no health– not health damaging. Then about [...] the aspect of sustainability. And of course costs and applicability.* (Male, age unknown, layperson).

In addition, *environmental benefits* were mentioned as important information to be communicated, i.e., by communicating *CO_2-savings*, the *CO_2-footprint*, or the product's *energy balance*. The latter referred to how much energy is used and saved during the product's lifetime. One layperson was also interested in how the product is *disposed*:

> *For insulation boards, the insulation value would be really important. Maybe the CO_2-savings that one has because of it. Yes, and whether it is somehow health damaging would also be important. And maybe how it can be disposed.* (Female, 29, layperson)

Furthermore, some laypeople specifically asked for information on the *advantages* and/or *disadvantages* of the product. And some required an *explanation on what CCU is and how it is used to produce CCU insulation boards*. Two technical experts also deemed such an explanation on the production process important.

> *Composition. Ratio of the composition for example. What materials are in it and what ensures that in this case the stored CO_2 does the same thing as other material. Does it really have something to do with efficiency. Does it insulate enough?* (Male, 52, layperson)

Regarding the product's composition, most laypeople, as well as all field experts and technical experts, felt like the use of CO_2 to produce CCU insulation boards should be communicated. However, this information was usually not important because it worried them, but because they felt like the use of CO_2 is the product's main benefit compared to conventional material:

> *That [CO_2 was used] would for me probably be one of the reasons to choose for that [material] between the alternatives.* (Female, 29, layperson)

Only two laypeople wanted the information to be able to familiarize themselves with the technology and discard any fears.

Finally, some laypeople mentioned they expected to find the information on *websites* they would encounter during their own research, and others said they thought the product should be communicated through *advertising*. Some also mentioned that they would acquire information through the conversation with the *insulation expert*. The importance of their advice for the eventual choice of an insulation material was recognized by the insulation experts themselves too.

4.2 The sample

The study aimed to collect a western European perspective on the product and resulted in a sample of 643 German and Dutch respondents. The final sample ($N=643$) consisted of 57% ($n=364$) male and 43% ($n=279$) female respondents. Their ages ranged between 18 and 87 years with an average of $M=55.8$ ($SD=14.5$). Moreover, 60% ($n=387$) completed a low level of education and 40% ($n=256$) a high one. Regarding the respondents' house ownership and experience with insulating, 29% ($n=185$) did not own a house when taking the survey, 37% ($n=239$) did own a house but had not insulated before, and 34% ($n=219$) owned a house and had insulated before. Finally, 51% ($n=331$) of the respondents were German and 49% ($n=312$) were Dutch.

4.3 The structure of the questionnaire

Based on the results of the qualitative prestudy and the literature on CCU acceptance, we designed an online questionnaire. Native speakers checked the Dutch and German versions for correctness and understandability. Additionally, CCU experts assessed the technical correctness of the questionnaire and communication experts its understandability and linguistic quality. Before running the study, the ethical board of the Faculty of Humanities at RWTH Aachen University approved the study's ethical acceptability.

We collected responses using a paid market research company. To ensure that the participating respondents fit our study's goal they answered screening questions: experience with house ownership, experience with insulation, nationality, and age. No respondents under the age of 18 participated. The screening was followed by an introduction on the study's topic. The participants were also reminded of their rights and informed on how the collected data would be handled (data privacy standards of the DSVGO (Schwartz, 2019).

The questionnaire consisted of six modules (Fig. 2):

1. *Demographic information* regarding age, gender, education, house ownership and experience with insulating materials.
2. *Personal factors* such as *self-efficacy* (Beierlein et al., 2014), *technical self-efficacy* (Beier, 1999), *environmental behavior* (European Commission, 2019), and *environmental concern* (Dunlap et al., 2000; Heath & Gifford, 2006) were measured using Likert scales.

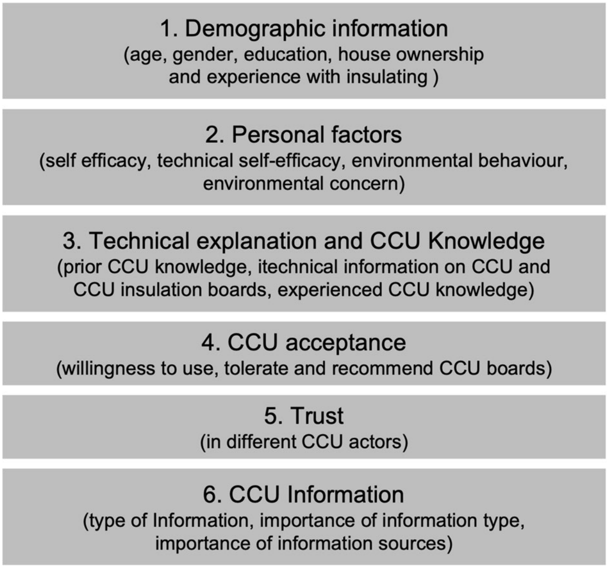

Fig. 2 Structure of the survey questionnaire

3. *CCU knowledge and CCU information*, where the respondents indicated how well informed they felt about CCU using a Likert scale (*prior CCU knowledge*). They then received a short technical explanation on CCU and CCU insulation boards (see Appendix A) and indicated how well informed about CCU they felt (*experienced CCU knowledge*).
4. *CCU acceptance* where respondents assessed their *acceptance* of the product using Likert scales that measured their willingness to use, tolerate, and recommend CCU insulation boards.
5. *Trust*, where the respondents used a Likert scale to indicate whether they would trust the following involved actors to regulate the minimization of environmental and health risks during the development of CCU insulation boards: *government*, *political parties*, *organizations without ties to the government*, *media*, *industry*, *science*, *health experts (e.g., doctors and biologists)*. As such, we connected trust to relevant risk perceptions for CCU.
6. *CCU information*, where the importance of different kinds of information on CCU insulation boards when choosing an insulation material was rated on Likert scales, as well as one for the importance of three different information sources: *websites* customers stumble upon during their own research, *advertisements* in the media, and the conversation with the *insulation expert*.

All included Likert scales used six answer options, ranging from 0 = *most negative answer* to 5 = *most positive answer*—the middle of the scales thus lay at 2.5—, and the items were randomized. It has to be noted that the study only covered CO_2 even though we were aware CCU also captures and reuses CO. This choice prevented the questionnaire from becoming too complex for the respondents with little knowledge on CCU. For similar reasons, the polyurethane foam used in CCU insulation boards was referred to as plastic.

4.3.1 Data (re)coding and construct building

Before analysis, the dataset was cleaned by removing incomplete cases, speeders, and cases with an unrealistic answering pattern. This resulted in a final dataset of $N = 643$ responses.

Subsequently, we computed constructs by taking the mean of the items in one construct. Based on Cronbach's alpha, all constructs were reliable with $\alpha > .7$ (See Appendix B subsection B.1). To group the nine information requirements we ran an exploratory factor analysis using minimum residual (OLS) extraction and oblimin rotation. As indicated by the Kaiser–Meyer–Olkin Measure (KMO), all items were adequate for the analysis with $KMO > .8$, and the sampling adequacy for the entire analysis was meritorious ($KMO = .89$) (Kaiser & Rice 1974, as cited in Field, 2018, p. 989–1060). We suppressed factor loadings < 0.6 and extracted two factors based on Kaiser's criterion (eigenvalue > 1). For these two factors, we computed a construct by taking the mean of the included items (See Appendix B subsection B.1). The first, *environment-related information* ($\alpha = .88$), consisted of 5 items referring to information on the environmental impact of CCU insulation boards. The second, *risks and functional properties* ($\alpha = .76$), consisted of three items referring to personally noticeable risks and functional properties of the product. One item did not load onto either factor. It was separately included in the analysis: *information on disadvantages*. Finally, we built a construct for *education* which differentiated between a *low* and *high* level of education (see Appendix B, subsection B.3).[3]

4.4 Clustering approach-revealing acceptance profiles

As descriptive statistics we reported the mean (M) and standard deviation (SD), or the frequency (n) and percentage. Unless otherwise noted, we set the level of statistical significance at $\alpha = .05$.

We used k-means clustering ($k = 3$) with 25 repetitions to find three clusters based on their level of acceptance: *low*, *medium*, and *high*. We then analyzed the differences between these three clusters. Depending on the data type, we either used one-way ANOVA with the Tukey test as post hoc test, or the Chi-squared test. For some evaluations, we also used paired samples t-tests to check whether the clusters' scores were significantly different from 2.5, the midpoint of the scale, and thus indicated a significant tendency toward the positive or negative. Finally, repeated measures ANOVAs were used to analyze the differences in the evaluation of the trust in the different actors, as well as the importance of the different information requirements, within each cluster. Paired samples t-tests with a Bonferroni correction were applied as post hoc test. As effect sizes we calculated Cohen's w for the Chi-square test, Cohen's d for the t-tests, and omega (ω) for the ANOVAs.[4]

[3] We used the International Standard Classification of Education (ISCED) (Eurostat Statistics Explained) and interpreted both the low and medium groups as low.

[4] Effect sizes are interpreted as 0.10 small, 0.30 medium, and 0.50 large for Cohen's w and omega ω; and 0.20 small, 0.50 medium, and 0.80 large for Cohen's d (Cohen 1988).

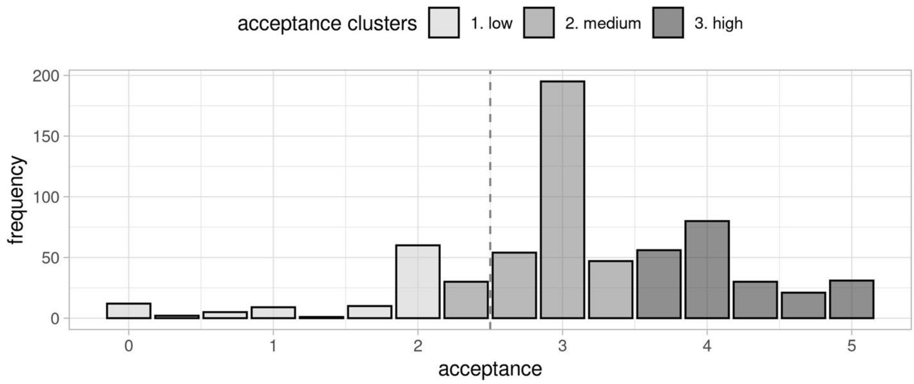

Fig. 3 Distribution of the three acceptance clusters

5 Results

We first describe the identified clusters and how they differ regarding their acceptance of CCU insulation boards, demographics, and personality traits (RQ1). We then outline the clusters' differences for their trust and communication and information requirements (RQ2). These insights are used to interpret the clusters and formulate managerial communication recommendations (RQ3).

5.1 Analysis of acceptance profiles

The three clusters significantly differed from each other ($F(2, 640) = 1337$, $p < .001$, $\omega = 0.90$; Tukey post hoc test: all combinations $p < .001$) regarding their acceptance of CCU insulation boards.

The *low* cluster was the smallest with $n = 99(15\%)$. With a mean score of $M = 1.53(SD = 0.72)$, it was the only cluster to score significantly lower than the midpoint of the scale, and thus tend toward a rejection of the product ($t = -13.5, p < .001, d = -1.36$). The answer distribution shows that the acceptance in the cluster ranged between 0 and 2, with most respondents scoring close to 2 (see Fig. 3). $51\%(n = 326)$ of the respondents belonged to the *medium* cluster. Although the average positive score of this cluster was tentative with a mean of $M = 2.93(SD = 0.27)$, it was still significantly deviating from the midpoint of the scale and thus tended toward a positive acceptance level ($t = 29.3, p < .001, d = 1.62$). Their answers ranged between 2.33 and 3.33 and the majority scored 3.00. The final $n = 218(34\%)$ belonged to the *high* cluster. On average, this cluster strongly accepted CCU insulation boards with a mean of $M = 4.17(SD = 0.45)$ that was significantly higher than the scale-midpoint 2.5 ($t = 54.8, p < .001, d = 3.71$). Their answers ranged between 3.67 and 5.00, with the majority close to 4.00 (see Fig. 3).

Regarding demographics, the clusters only significantly differed for *gender* ($\chi(2, N = 643) = 7.85, p = .020, w = 0.11$). Whereas in the low (male: $n = 51, 52\%$=; female: $n = 48, 48\%$) and medium (male: $n = 173, 53\%$; female: $n = 47, 47\%$) clusters gender was almost equally distributed, the high cluster had a higher share of male ($n = 140, 64\%$)

Table 1 Descriptive statistics and results of ANOVA for **personality-related variables**. The included Tukey post hoc test shows which clusters significantly differed: medium and low (M/L), high and low (H/L), and/or high and medium (H/M)

	Acceptance clusters						ANOVA			Tukey post hoc		
	Low		Medium		High							
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*(2, 640)	*p*	*ω*	M/L	H/L	H/M
Self-efficacy	3.74	0.84	3.59	0.76	3.91	0.88	10.2	< .001	0.17			X
Technical self-efficacy	2.81	1.33	2.92	1.12	3.28	1.16	8.32	< .001	0.15		X	X
Environmental behavior	3.38	0.99	3.44	0.93	3.87	0.99	15.9	< .001	0.21		X	X
Environmental concern	3.49	0.77	3.50	0.78	3.74	0.83	6.45	.001	0.13		X	X

than female ($n = 78, 35\%$) respondents. All clusters had more respondents with a low level of *education* (low: $n = 67, 68\%$; medium: $n = 195, 60\%$; high: $n = 125, 57\%$) than with a high one (low: $n = 32, 32\%$; medium: $n = 131, 40\%$; high: $n = 125, 43\%$; $\chi(2, N = 643) = 3.07, p = .22, w = 0.069$). The clusters' *ages* were also similar, with $M = 56.4 (SD = 13.0)$ for the low cluster, $M = 55.9 (SD = 15.2)$ for the medium cluster, and $M = 55.3 (SD = 14.1)$ for the high cluster ($F(2, 640) = 0.21, p = .82, \omega = 0.050$). Finally, the clusters did not differ in their level of *experience with house ownership and insulation* ($\chi(2, N = 643) = 1.43, p = .84, w = 0.047$). In all clusters, similar amounts of respondents owned a house (low: $n = 30, 30\%$; medium: $n = 98, 30\%$; high: $n = 57, 26\%$), owned a house but did not have insulation experience (low: $n = 35, 35\%$; medium: $n = 122, 37\%$; high: $n = 82, 28\%$), and owned a house and had insulation experience (low: $n = 34, 34\%$; medium: $n = 106, 33\%$; high: $n = 79, 36\%$).

Looking at personality-related variables, Table 1 shows that the clusters significantly differed from each other for all personality-related variables.

The post hoc tests, however, indicated that the low and medium clusters did not differ for any of them. Additionally, the high cluster scored significantly higher than the medium cluster but not the low cluster for *self-efficacy*. For *technical self-efficacy*, *environmental behavior*, and *environmental concern*, the high cluster scored significantly higher than both others.

5.2 Trust, communication and information

To analyze the **trust in the evaluated actors** to regulate the health and environmental risks of CCU insulation boards, we considered the differences between the clusters' evaluations. The descriptive statistics for the clusters and the results of these tests can be found in Table 2 and Fig. 4.

For all actors, trust increased as the acceptance in the cluster increased. For the actors *science*, *organizations without ties to the government*, *government*, *industry*, and *political parties*, all three clusters significantly differed from each other. For the actors, health *experts* and *media* the low and medium clusters did not significantly differ, but the high cluster scored significantly higher than the others.

Next, we evaluated for each cluster whether there were significant differences in how they evaluated single actors. We found that for all three clusters such differences existed (low: $F(4.24, 518) = 29.5, p < .001, \omega = 0.29$; medium:

Table 2 Descriptive statistics and results of ANOVA test for the **trust in the actors** to regulate health and environmental risks of CCU insulation boards. The Tukey post hoc test is also included to show which clusters significantly differed: medium and low cluster (M/L), high and low cluster (H/L) and/or high and medium cluster (H/M)

	Acceptance clusters						ANOVA			Tukey Post hoc		
	Low		Medium		High							
	M	*SD*	*SD*	*SD*	*M*	*SD*	$F(2, 640)$	*p*	ω	M/L	H/L	H/M
Science	3.17	1.25	3.62	0.98	4.10	0.88	32.6	< .001	0.30	X	X	X
Health experts	3.33	1.24	3.56	0.99	3.89	1.12	16.2	< .001	0.17		X	X
Organizations without ties to the government	2.57	1.40	3.07	1.09	3.40	1.25	16.9	< .001	0.22	X	X	X
Government	2.46	1.62	3.05	1.22	3.57	1.24	26.4	< .001	0.27	X	X	X
Industry	2.27	1.50	2.92	1.24	3.53	1.26	34.6	< .001	0.31	X	X	X
Media	2.24	1.39	2.57	1.16	2.89	1.37	9.75	< .001	0.16		X	X
Political parties	2.15	1.50	2.65	1.25	3.07	1.45	16.2	< .001	0.21	X	X	X

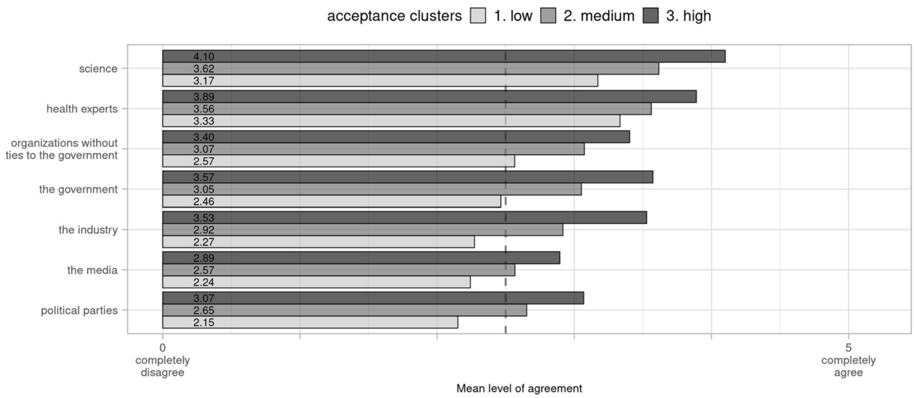

Fig. 4 Mean evaluation of **trust in the actors** to regulate health and environmental risks of CCU insulation boards for the three acceptance clusters. The standard deviations can be seen in Table 2

$F(4.69, 1525) = 83.1, p < .001, \omega = 0.31$; high: $F(5.02, 1090) = 46.7, p < .001, \omega = 0.30$). The results of the multiple paired sample t-tests can be found in Appendix C (subsection C.1).

In all three clusters, the *government*, *organizations without ties to the government*, and *industry* were evaluated similarly and received scores in between the scores of the other actors. In the low and medium cluster, *science* and *health experts* were evaluated similarly as well and were trusted significantly more than all others. In the high cluster, *science* received a significantly higher score than all other actors, followed by *health experts*, which scored significantly higher than the remaining actors. In the high and medium cluster *political parties* and *media* were evaluated similarly, thereby receiving a significantly lower score than all others. However, for the low cluster, both similarly trusted actors received similar scores as other actors as well. *Industry* was evaluated

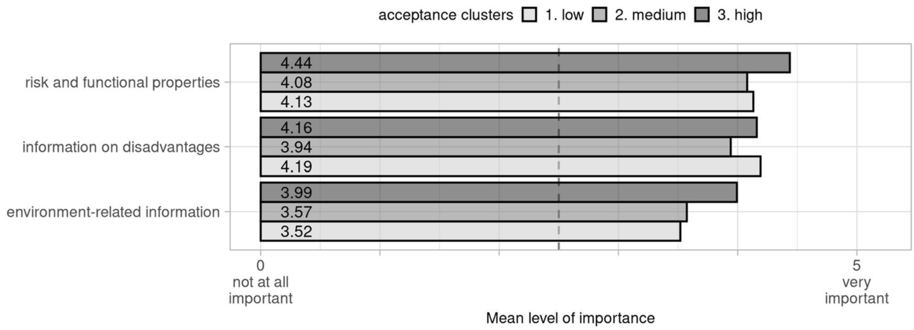

Fig. 5 Mean level of importance of **information types** for CCU insulation boards for the three acceptance clusters. The standard deviations can be retrieved from the text

similarly by both of them and *organizations without ties to the government* and *government* received similar scores as the *media*.

Although all clusters had a low *prior knowledge on CCU*, their mean scores did significantly differ ($F(2, 640) = 8.31, p < .001, \omega = 0.15$). The high cluster ($M = 0.92, SD = 1.41$) scored significantly higher than the low ($M = 0.45, SD = 1.01$) and medium ($M = 0.54, SD = 1.06$) clusters, which scored similarly. For the *experienced knowledge on CCU* after the explanation, all clusters significantly differed from each other ($F(2, 640) = 54.2, p < .001, \omega = 0.38$; Tukey post hoc all $p < .001$). Again, the high cluster scored the highest ($M = 3.85, SD = 0.89$), followed by the medium ($M = 3.14, SD = 0.99$), and the low cluster ($M = 2.72, SD = 1.22$).

Looking at the **type of information** the clusters required we also found differences (see Fig. 5).

The high cluster ($M = 3.99, SD = 0.83$) required significantly more *environment-related information* on CCU insulation boards than the low ($M = 3.52, SD = 1.07$) and medium cluster ($M = 3.57, SD = 0.80$; $F(2, 640) = 18.5p < .001, \omega = 0.23$) which scored similarly. This was also the case for information on the *risks and functional properties* of the product (low: $M = 4.13, SD = 0.90$; medium: $M = 4.08, SD = 0.70$; high: $M = 4.44, SD = 0.57$; $F(2, 640) = 17.9, p < .001, \omega = 0.22$). For information on the product's *disadvantages*, the high cluster ($M = 4.16, SD = 0.95$) scored significantly higher than the medium ($M = 3.94, SD = 0.95$), but not than the low cluster ($M = 4.19, SD = 0.87$; $F(2, 640) = 4.80, p = .008, \omega = 0.11$).

We also evaluated the **importance of different information sources** for which the three acceptance clusters differed as well (see Fig. 6). For *websites* the high cluster ($M = 3.87, SD = 0.95$) scored significantly higher than both other clusters (low: $M = 3.26, SD = 1.22$; medium: $M = 3.45, SD = 0.89$; $F(2, 640) = 17.54, p < .001, \omega = 0.22$). For *advertisements in the media* all cluster significantly differed ($F(2, 640) = 17.09, p < .001, \omega = 0.22$; Tukey post hoc all $p < .05$). The high cluster scored the highest ($M = 2.73, SD = 1.52$), followed by the medium ($M = 2.24, SD = 1.17$), and low cluster ($M = 1.86, SD = 1.33$). This was also the case for the consultations of *insulation experts* for which all clusters significantly differed ($F(2, 640) = 32.0, p < .001, \omega = 0.30$; Tukey post hoc all $p < .01$) and the importance increased with increasing acceptance (low: $M = 3.33, SD = 1.31$; medium: $M = 3.67, SD = 0.96$; high: $M = 4.19, SD = 0.79$).

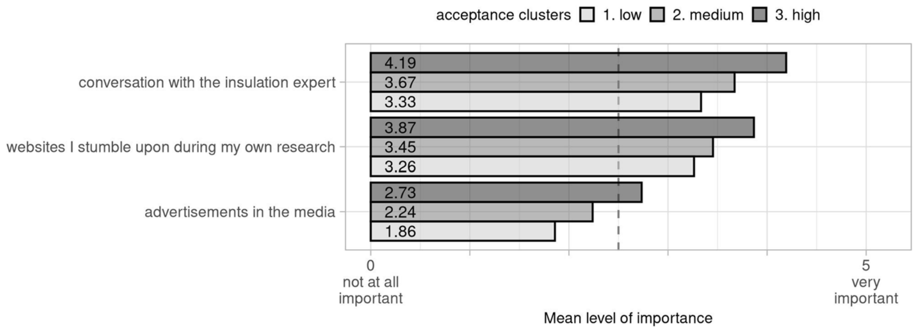

Fig. 6 Mean level of importance of **information source** for information on CCU insulation boards for the three acceptance clusters. The standard deviations can be retrieved from the text

Finally, we evaluated for each cluster whether their indication of the importance of the different kinds of information, as well as the information sources, differed. In all clusters, there were significant differences for the types of information (low: $F(2, 196) = 28.9, p < .001, \omega = 0.30$; medium: $F(1.85, 600) = 65.6, p < .001, \omega = 0.25$; high: $F(1.77, 384) = 25.8, p < .001, \omega = 0.22$) and the information sources (low: $F(2, 196) = 60.9, p < .001, \omega = 0.46$; medium: $F(1.84, 597) = 274, p < .001, \omega = 0.52$; high: $F(1.56, 340) = 142, p < .001, \omega = 0.48$). The results of the subsequent pairwise paired t-tests can be found in Appendix B (subsection B.2 and subsection B.3).

The low cluster evaluated *information on disadvantages* and *risks and functional properties* similarly. These two types of information were significantly more important than *environment-related information*. The cluster also evaluated the information sources *insulation experts* and *websites* similarly and as more important than *advertisements* in the media. The medium cluster significantly differed for all three types of information and information sources. Information on the *risks and functional properties* was most important, followed by information on the *disadvantages*, and finally *environment-related information*. The *insulation expert* was the most important source, followed by *websites*, and finally *advertisements*. For the high acceptance cluster, *environment-related information* and *information on disadvantages* were similarly important, less so than information on the *risks and functional properties*. The importance of the information sources all significantly differed from each other, with the *insulation expert* being most important, and *advertisements* least.

6 Discussion

For the successful rollout of the CCU technology, and thus possibly yield the environmental benefits, it is important to consider the acceptance of these products alongside the acceptance of the technology itself. It should be recognized that the possible consumers of these products differ and that knowledge on these differences is necessary to formulate targeted communication strategies.

The present study contributed to studying the social acceptance of CCU by considering aspects of the market and socio-political acceptance (Wüstenhagen et al., 2007) of

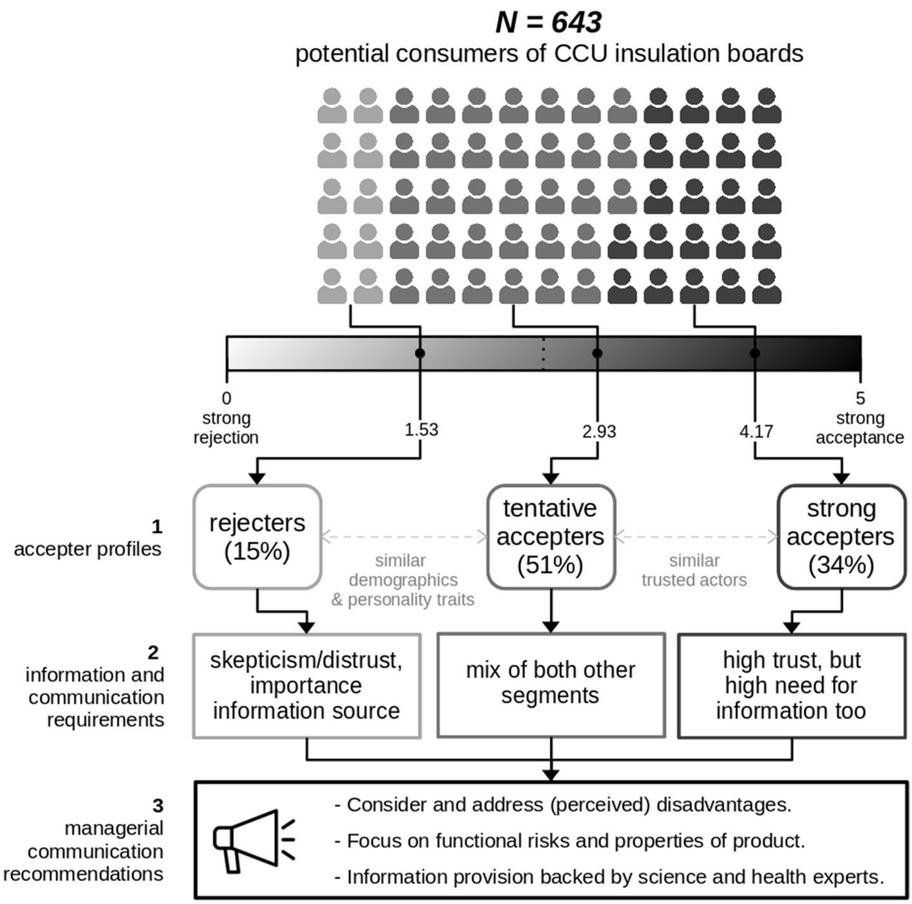

Fig. 7 Overview of the results of the present study based on the formulated research aims

one such product—CCU insulation boards—, thereby seeking to understand the differences between different types of accepters—i.e., possible consumers with a low, medium, and high acceptance of the product—to formulate targeted communication guidelines for CCU insulation boards. We pursued a mixed-methods procedure by conducting interviews to uncover initial evaluations and information requirements and using these insights to develop a questionnaire. We also considered the trust in relevant actors for the acceptance and communication of the product. Using k-means clustering three groups were identified for which we derived specific communication guidelines. An overview hereof can be found in Fig. 7).

6.1 Classification of users

We based the segmentation of consumers on their acceptance of CCU insulation boards. The cluster with *low* acceptance consisted of ***rejecters***. All respondents in this cluster scored lower than the midpoint of the scale. It must be noted that whereas their mean acceptance was quite low, only few strongly rejected the product (score around 1.00) and most scored (close to) 2.00, which is still a rejection, but not a very strong one. The *medium* cluster consisted of some tentative rejecters, but most of them tended toward an acceptance of the product. However, because most of the scores were around 3.00, this acceptance was not strong yet either. The medium cluster was therefore classified as **tentative accepters**. Finally, most respondents in the high cluster showed a strong acceptance (scores around 4.00) and were classified as **strong *accepters***.

Based on this classification and the cluster sizes, we saw that most respondents were *tentative accepters*. This is in line with previous findings in which mean acceptance scores were positive, but not particularly high—e.g., for CO_2-based insulation boards (Arning et al., 2021), CO_2-based fuel (Offermann-van Heek et al., 2020), and the CCU technology itself (Arning et al., 2019). Among the remaining respondents were some *rejecters*, but a substantial part of them were *strong accepters*. When comparing our segmentation with the acceptance profiles for CO_2-based mattresses by Arning et al. (2018), we see both similarities and discrepancies. Interestingly, their group sizes are similar to ours, with their *cautious* segment being the largest by far, followed by their *approvers*, and finally their *rejecters*. However, when purely looking at the acceptance of the product in these groups—as indicated by the willingness to use and buy the mattresses—we see that compared to the acceptance in our three segments for CCU insulation boards, the acceptance for CO_2-based mattresses was somewhat lower. Their *cautious* segment even slightly rejected the product, whereas our *tentative accepters* tended toward an acceptance of the insulation boards. These differences could underline that CCU insulation boards are evaluated more positively, e.g., because of the greater distance between the product and the body of the homeowners (van Heek et al., 2017). Additionally, it illustrates that consumer segments for one CCU product are not necessarily directly transferable to another.

To identify differences between the clusters, we looked at demographics and personality traits. Compared to the other groups, the *strong accepters* were more often male, had a higher (technical) self-efficacy, and indicated to behave more environmentally and be more environmentally concerned. However, the *rejecters* and *tentative accepters* did not significantly differ for any demographics or personality traits. The included demographics and personality traits do thus not help to explain the acceptance differences for these groups. We assume that other personality- and perception-related factors that have found to affect acceptance but were not included in this study could help to differentiate between these groups—e.g., perceived health and sustainability concerns (e.g., Arning et al., 2021), benefit perception (e.g., Arning et al., 2019; Huijts et al., 2012), and climate knowledge (Lutzke and Árvai 2021). Nevertheless, the rejecters' low experienced knowledge on CCU after the explanation, as well as distrust in some of the relevant actors for CCU insulation boards, helps to explain their rejection compared to the other groups (e.g., Huijts et al., 2012).

The mentioned trust in relevant actors refers to the respondents' trust that they will ensure the minimization of the environmental and health risks of CCU insulation boards. As such, we directly coupled the trust in relevant actors to previously identified risks/barriers for CCU (products) (e.g., van Heek et al., 2017). Our results confirm that acceptance increases when there is more trust in the relevant actors (e.g., Huijts et al., 2012; Slovic, 1993). This relationship, although indirectly through risk perception, has also been found for CCS (L'Orange Seigo et al., 2014). For CCU, no directly comparable results exist yet. Although trust has been found to increase acceptance or willingness to buy the CCU products when studied as trust in a CCU label (e.g., Linzenich et al., 2019) or trust in the credibility of information sources (Offermann-van Heek et al., 2018), general trust in the relevant actors has not been focused on.

By comparing the trust of the different actors within each group, we saw that descriptively speaking, the *tentative accepters* and *strong accepters* tended toward trust for all actors rather than distrust. Although the *strong accepters* trusted more strongly, the way in which different actors were trusted compared to each other was very similar for these two groups. Both trusted *science* and *health experts* most, and *media* and *political parties* least. Contrarily, the *rejecters* showed more distrust. Even though they also somewhat trusted *science* and *health experts*, they did so less than the other clusters. Additionally, they tended toward a distrust not only for *media* and *political parties*, but also for *industry* and the *government*. For CCS, *researchers* have also been found to be among the best trusted stakeholders, and *industry* and *government* to be trusted badly (e.g., L'Orange Seigo et al., 2014). As such, we see it as a good starting condition for CCU that the low trust for these latter two actors only tends toward an actual distrust for the *rejecters*.

Overall, the respondents felt badly informed about CCU before receiving the explanation, which is in line with findings from previous studies (e.g., Jones et al., 2017; Linzenich et al, 2021; Lutzke & Árvai, 2021). After the explanation the respondents felt better informed but not all did so to the same extent. The higher the acceptance in the cluster, the more informed they felt. Altogether, CCU still seems to be a technology few laypeople are aware of and whether the information they receive succeeds in giving them a sense of being informed affects their acceptance of CCU products. This finding shows that there is no one-fits-all communication approach and highlights the importance of the careful design of targeted communication strategies that fit the needs of the receivers (e.g., Brunsting et al., 2011).

6.2 Different information and communication requirements

The findings of the present study allowed us to formulate some general communication guidelines which should be minded irrespective of the already present level of acceptance, as well as some specific guidelines for the different acceptance groups.

6.2.1 General communication guidelines

We first need to stress the necessity of honest and transparent information and communication, ideally early on in the development process (e.g., Kluge et al., 2021). This requirement has frequently been stressed in previous studies (e.g., Jones et al., 2017; Linzenich et al., 2021) and is depicted in our respondents' indicated importance of information on the disadvantages of CCU insulation boards. To ensure that provided information is trusted and succeeds in fostering acceptance, and in the end adoption, it does not suffice to only cover the benefits of a product. Instead, its disadvantages, in comparison to other materials, need to be included too. Additionally, possibly wrongfully perceived barriers, like the risk of leaking CO_2 (e.g., van Heek et al., 2017), need to be identified and clarified.

Secondly, the importance of information on the functional properties and risks of CCU insulation boards should be noted (e.g., Offermann-van Heek et al., 2018). Even though the applied CCU technique and environmental benefits could be important for specific consumers, the first thing on their mind when choosing an insulation material will likely be how well the material performs compared to other materials. This information should be extensively available and should not be overshadowed by other CCU-related content.

Moreover, the information source should always be carefully considered when designing communication strategies. This refers to the used medium as well as the entity issuing the information. The latter is especially important since the public's knowledge and awareness on CCU are low. The receivers' trust in the entity providing the information is therefore essential for the interpretation of provided information on CCU (e.g., Siegrist & Cvetkovich, 2000). In turn, their interpretation could decide whether laypeople trust the provided information and thus influence their intention to buy the product (e.g., Atkinson & Rosenthal, 2014). We found that most respondents did not trust the media. However, when promoting CCU (products) it is unavoidable to use media. To increase the trustworthiness of this information we therefore suggest that the material is designed as a general information provision rather than a direct advertisement, since—at least for CCU insulation boards—advertisements are not seen as important information sources. Additionally, the material should use traceable trusted sources, like endorsements from science and health experts.

Finally, for CCU insulation boards, the role of the insulation expert should not be underestimated. Their advice was (among) the most important source(s) of information in all acceptance groups. It is thus necessary to get these actors, who are presumably laypeople regarding CCU, on board with CCU insulation boards.

6.2.2 Consumer-group specific communication guidelines

Below we formulated specific information and communication needs for the identified acceptance profiles.

The *strong accepters* illustrate that a general trust in the relevant actors for the production and promotion of CCU insulation boards, as well as an already present strong acceptance, does not mean no further information is required. In fact, to them, all types of information were highly important. Because of their already strong acceptance of the product, we assume that this high information need stems from a general interest in being well informed when choosing an insulation material. We believe that their relatively high (technical) self-efficacy and strong trust in science show that the strong accepters are confident of their own ability to research CCU insulation boards and understand the available information. Although the conversation with the insulation expert could be an important starting point for them, this does likely not suffice and they will research the product themselves too. It is therefore important that a broad range of (detailed) information is available online. Their environmentally concerned nature, and wish to behave environmentally aware, thereby underlines the need for information on the environmental (dis)advantages.

For the ***rejecters*** the provided explanation did not suffice, since their experienced knowledge after the explanation, descriptively speaking, barely tended toward feeling informed. Because of their relatively high self-efficacy and the simple wording of the explanation this might not have been the result of them simply not understanding the explanation. Instead, we expect that the provided information was not extensive and/or trustworthy enough. To counteract the remaining skepticism and distrust it is important for the rejecters to also include information on the disadvantages when discussing the functional properties and risks of CCU insulation boards. Environmental arguments are likely less important for this group and might not be decisive in the end. Just like for the *strong acceptors*, we believe they will not blindly trust on the conversation with the insulation expert and therefore require the extensive availability of online information. However, because of a general distrust of most relevant actors for CCU insulation boards the source of this information needs to be chosen with care. It could be troublesome that the *rejecters* do not trust the industry, since CCU (products) are inevitably connected to this actor. However, communication strategies should not try to (re)build this trust since this would take a long time (Slovic, 1993). Instead, information stemming from the industries that produce CCU insulation boards should be combined with endorsements of science and health experts. The credibility of the information would then benefit from the trust in the latter two actors (Brunsting et al., 2011).

Finally, based on the present findings, it is hard to formulate communication guidelines for the ***tentative accepters*** since we found similarities with the rejecters and strong accepters, but not much to set them apart from these two extremes. However, because of their tentative acceptance and large group size, this is the group for which it might be most important to design good communication strategies to provide them with a reliable base for their decision making. We assume they are undecided and somewhat insecure about innovations in general, and insulation boards in particular. They do not only need more and/or other information to be won over, failing to provide the right kind of information could easily flip their unstable attitude toward a rejection. At this point, we must conclude that, besides the general communication guidelines, we cannot formulate targeted guidelines for the tentative accepters. Nevertheless, the general guidelines will be a good start. We might also get a better idea of what specific communication they require once CCU products, like CCU insulation boards, become available on the market. A less theoretical and more hands-on experience with the product could alter their tentative nature (e.g., Rogers, 2003; Zaunbrecher et al., 2021).

6.3 Limitations and future research

The present study resulted in initial communication recommendations for CCU insulation boards, while recognizing the importance of group differences, as well as trust in the relevant actors. However, there are some limitations that need to be addressed by future research.

Firstly, we grouped the respondents based on their level of acceptance of CCU insulation boards. Although we analyzed their demographics and personality traits, this only gave us a fairly good idea of who the *strong accepters* are compared to the other acceptance groups. However, in practice, communication cannot be targeted on acceptance since we will not know upfront whether, and to what extent, someone accepts a product. Instead, a more detailed profiling of the different groups regarding their demographics and personality traits is necessary. Additionally, this will help to formulate targeted communication guidelines for the *tentative accepters*. We also recognize that using a different clustering technique might yield different results.

Secondly, the respondents received pre-determined types of information and information sources to consider. We cannot ensure that in a real-life situation they would look for these types of information on their own. As a result, we cannot exclude that they overestimated their perceived importance of these types of information (sources). We suggest that future, more extensive, qualitative studies aim to identify which other information requirements for CCU insulation boards exist. Additionally, insights on the importance of different types of information and product characteristics in a more real-life choice scenario would be valuable for the design of the communication for CCU and CCU products.

Thirdly, the present study only covered parts of the social acceptance of CCU insulation boards. Other acceptance aspects, like the community acceptance of CCU, need to be ensured before CCU insulation boards will make it to the market (Wüstenhagen et al., 2007). Additionally, future studies need to address the acceptance of CCU insulation boards by insulation experts as a part of the market acceptance of the product. Their acceptance is vital because if they do not adopt the product, and provide transparent and reliable information, it will not reach their customers. Insulation experts require their own targeted communication strategies.

Moreover, the findings are only applicable to CCU insulation boards. Some of the communication guidelines might apply to other products as well, like the need for honest and transparent communication and the provision of information on the product's functional properties (e.g., Offermann-van Heek et al., 2018). However, insulation material is an expensive product that, most consumers, will not buy more than a few times. The decision process when choosing an insulation material could therefore differ from the process applied when choosing a product that is less expensive and more frequently bought. The trust in the relevant actors might also be weighed differently for different types of products. For that reason, future studies should uncover which communication guidelines are universally applicable for CCU products. Additionally, more specific insights on the information requirements and trust for other types of products and their cognitive-affective acceptance evaluations (e.g., Cox et al., 2021; Slovic, 1993) need to be gathered. In addition, we should also strive to understand the complexity of sustainable (eco-)innovations (Cillo et al., 2019; Munodawaf et al., 2019). Beyond the novel technologies, the importance of policy support measures, and consumer acceptance, the environmental managerial perspectives in companies are not sufficiently considered, even though they are an important part of a sustainable society (Munodawaf et al., 2019). Companies that pursue an energy efficient strategy and invest profits in, e.g., energy efficiency, climate protection, environmental protection, or public welfare measures, as part of their corporate strategy are an essential building block of a sustainable economy with secure jobs and a healthy environment. In order to also achieve a holistic understanding of eco-innovations and their requirements at the company level, a broad perspective and interdisciplinary approach is required. In particular, the impact of political framework conditions, the embedding of sustainability in corporate decision making, the role of communicative narratives about sustainability and psychological influential factors at the level of decision makers in companies must be considered.

7 Conclusions

If CCU is ever going to help mitigate climate change, CCU products need to be accepted and adopted by consumers. Whether this is successful could stand or fall with how the products are communicated. The present study therefore investigated acceptance and communication requirements of potential consumers of CCU products and derived recommendations for a communication concept for insulation boards as CCU product based on acceptance, information and communication needs and requirements. Based on our findings, we therefore strongly advise managerial decision makers to follow consumer-profile specific communication strategies rather than assuming that the (environmental) benefit of CCU approaches is simply accepted and uncritically followed by these future consumers.

We identified three acceptance groups regarding the acceptance of CCU insulation boards: rejecters (15%), tentative accepters (51%), and strong accepters (34%). Overall, the strong accepters are quite different from the other two groups which are very similar to each other. However, considering the respondents trust in the relevant actors to minimize the product's health and environmental risks, the rejecters stood out for showing more distrust than the other groups, which scored similarly. Finally, the groups' information and communication needs were also considered, and we found both similarities and discrepancies between the groups (see Sect. 6.2). The identified acceptance groups, as well as their unique profiles, underline the need to consider the differences between possible consumers. Effective communication should consider the appropriate strategies, both regarding the provided information and the entities issuing said information. Only when differences between consumers are acknowledged can individual hurdles be resolved, thereby increasing the likelihood of the successful adoption of CCU and CCU products which could bring about a positive impact on the environment. The present study thus contributes to the communication of sustainable technological innovations, which not only focus on the transmission of technological facts, but above all on the individual acceptance and communication requirements.

Appendix

A. English translation of explanation on CCU (insulation boards)

See Fig. 8.

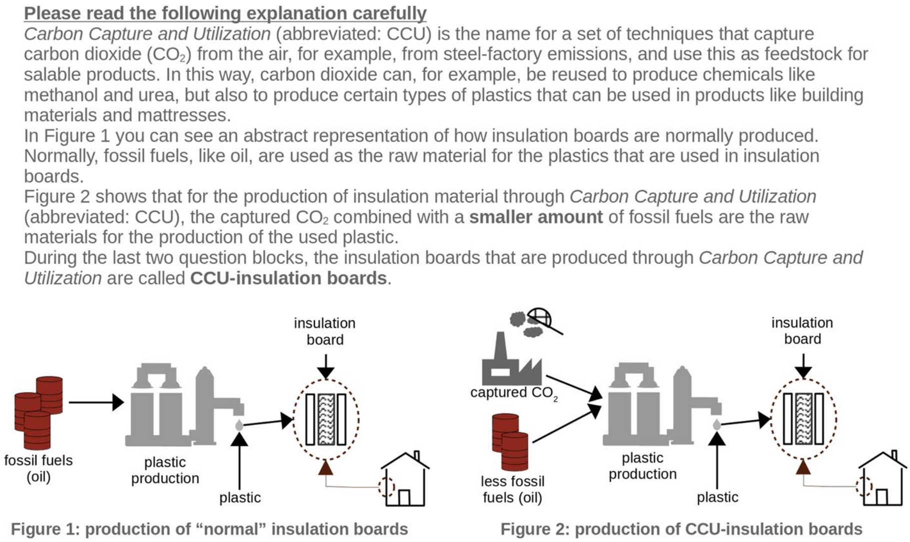

Fig. 8 An English translation of the explanation on CCU (insulation boards) provided in the questionnaire

B. Constructs building

B.1. Personality traits constructs

The complete sample's ($N = 643$) descriptive statistics for the items of the constructs for the personality traits included in the present study. The table also includes the constructs' reliability scores (Cronbach's alpha).

#	Items	*M*	*SD*
	Self-efficacy ($\alpha = .92$)	3.72	0.83
1	To solve difficult situations, I can rely on my own abilities	3.76	0.86
2	I am able to solve most problems on my own	3.79	0.85
3	I can usually even solve challenging and complex tasks well	3.63	0.96
	Technical self-efficacy ($\alpha = .88$)	3.02	1.18
4	I am able to solve most technical problems I am confronted with on my own	2.88	1.31
5	I really enjoy cracking a technical problem	2.89	1.39
6	Because I was able to handle technical problems well so far, I have an optimistic view on future technical problems	3.07	1.31
7	^{R}I feel helpless toward technical problems so I rather stay away from them	3.26	1.47
	environmental behavior ($\alpha = .86$)	3.57	0.98
12	I try to avoid waste caused by unnecessary packaging (plastic bags, to-go cups, etc.)	3.78	1.08
13	I purposefully buy products that cause as little harm as possible to the environment both during their production and use	3.28	1.21
14	When buying building material, I pay attention that it does not contain harmful substances	3.39	1.31
15	I cut down my energy consumption (for example by turning down the air conditioning or heating, not leaving		
	Appliances on stand-by, buying energy efficient appliances, etc.)	3.85	1.07
	environmental concern ($\alpha = .76$)	3.58	0.80
16	When humans interfere with nature it often produces serious consequences	3.63	1.09
17	Humans are severely abusing the environment	3.89	1.03
18	Despite our special abilities, humans are still subject to the laws of nature	3.89	0.95
19	The balance of nature is very delicate and easily upset	3.81	1.04
20	^{R}The so-called ecological crisis facing humankind has been greatly exaggerated	3.33	1.45
21	^{R}I do not believe that a single person can make a difference regarding the fight against climate change and other ecological problems	2.94	1.47
	acceptance ($\alpha = .94$)	3.13	0.98
22	I would live in a home that is insulated with CCU insulation boards	3.23	1.06
23	I would consider CCU insulation boards	3.15	1.06
24	I would recommend the use of CCU insulation boards	3.02	1.05

R Indicates that the item was recoded.

B.2 Factor analysis information requirements

The complete sample's ($N = 643$) descriptive statistics of the items included in the factor analysis for the information requirements. The table also includes the computed constructs, their reliability score (Cronbach's alpha), and the factor loadings for the items in each factor (.6). The question for these items was as follows: **To choose an insulation material, how important would the following information on CCU insulation boards be to you?**

#	Items	Factor loading	*M*	*SD*
	Environment-related information ($\alpha = 0.88$)		3.71	0.88
1	The benefits for the environment	0.81	3.85	1.07
2	The energy balance: whether the product/material saves more energy during its lifetime than it requires for its production/disposal	0.64	3.82	1.01
3	The CO_2-footprint during the lifecycle of the product/material (from production to disposal)	0.92	3.61	1.10
4	Understandable explanation of the production process and product	0.69	3.60	1.10
5	information about the removal and disposal of the product	0.71	3.65	1.05
	Risks and functional properties ($\alpha = 0.76$)		4.21	0.72
6	The functional properties (like insulation value, lifespan, and fire safety)	0.87	4.23	0.85
7	The price-performance ratio	0.65	4.05	0.91
8	Information on the possible health risks	0.61	4.33	0.85
	Information on disadvantages		4.05	0.94
9	The disadvantages	–	4.05	0.94

B.3. Education categories

Grouping of answer options for the German and Dutch questions on education in a high and low category based on the International Standard Classification of Education (ISCED) (Eurostat Statistics Explained). Because the Dutch question did not differentiate between different levels of secondary education, both the ISCED low and medium category were seen as low.

German respondents ($n = 331$)

Low		High	
	freq		*freq*
Kein Schulabschluss	1	Meister	15
Haupt-/Volksschulabschluss	11	Hochschulabschluss*	91
Realschulabschluss	41	Promotion	5
Abitur/Fachabitur	47		
Berufsausbildung	120		

Dutch respondents ($n = 312$)

Low		High	
	freq		*freq*
Geen opleiding/basis Onderwijs	0	Hogere Beroepsopleiding	93
Middelbaar onderwijs	75	Universitaire Opleiding	46
Beroepsopleiding	92	Doctoraat	6
Anders: Havo	1		

C. Pairwise paired samples t-tests

C.1. Trust in actors

Low cluster (n = 99, df = 98).

Group 1	Group 2	Statistic	*p*	p_{adj}	Significance
Organizations without ties to the government	Government	0.73	*0.47*	1.00	ns
Organizations without ties to the government	Health experts	– 6.27	< *0.001*	< *0.001*	***
Organizations without ties to the government	Political parties	3.45	< *0.001*	*0.018*	*
Organizations without ties to the government	Science	– 4.98	< *0.001*	< *0.001*	***
Organizations without ties to the government	Industry	2.05	*0.043*	*0.91*	ns
Organizations without ties to the government	Media	2.77	*0.007*	*0.14*	ns
Government	Health experts	-6.19	< 0.001	< 0.001	***
Government	Political parties	3.76	< 0.001	0.006	**
Government	Science	– 5.43	< *0.001*	< *0.001*	***
Government	Industry	1.79	*0.076*	1.00	ns
Government	Media	1.90	*0.061*	1.00	ns
Health experts	Political parties	8.43	< *0.001*	< *0.001*	***
Health experts	Science	2.03	0.45	*0.94*	ns
Health experts	Industry	7.51	< *0.001*	< *0.001*	***
Health experts	Media	8.39	< *0.001*	< *0.001*	***
Political parties	Science	– 8.00	< *0.001*	< *0.001*	***
Political parties	Industry	– 1.08	*0.28*	1.00	ns
Political parties	Media	– 0.89	*0.38*	1.00	ns
Science	Industry	7.41	< *0.001*	< *0.001*	***
Science	Media	7.18	< *0.001*	< *0.001*	***
Industry	Media	0.26	0.79	1.00	ns

Medium cluster (n = 326, df = 325).

Group 1	Group 2	Statistic	*p*	p_{adj}	Significance
Organizations without ties to the government	Government	0.36	*0.72*	1.00	ns
Organizations without ties to the government	Health experts	– 8.42	< *0.001*	< *0.001*	***
Organizations without ties to The government	Political parties	– 4.98	< *0.001*	< *0.001*	***
organizations without ties to the government	Science	– 9.43	< *0.001*	< *0.001*	***
Organizations without ties to the government	Industry	2.20	*0.003*	*0.60*	ns
Organizations without ties to the government	Media	7.91	< *0.001*	< *0.001*	***
Government	Health experts	– 8.15	< *0.001*	< *0.001*	***
Government	Political parties	8.63	< *0.001*	< *0.001*	***
Government	Science	– 9.12	< *0.001*	< *0.001*	***
Government	Industry	2.33	*0.020*	*0.42*	ns
Government	Media	7.44	< *0.001*	< *0.001*	***
Health experts	Political parties	-1.33	0.19	1.00	ns
Health experts	Industry	9.47	< *0.001*	< *0.001*	***
Health experts	Media	14.3	< *0.001*	< *0.001*	***

Group 1	Group 2	Statistic	*p*	p_{adj}	Significance
Political parties	Science	– 14.1	< 0.001	< 0.001	***
political parties	Industry	– 4.44	< 0.001	< 0.001	***
Political parties	Media	1.31	0.19	1.00	ns
Science	Industry	12.0	< 0.001	< 0.001	***
Science	Media	15.1	< 0.001	< 0.001	***
Industry	Media	4.73	< 0.001	< 0.001	***

High cluster (n = 218, df = 217)

Group 1	Group 2	Statistic	*p*	p_{adj}	Significance
Organizations without ties to the government	Government	3.55	0.056	1.00	ns
Organizations without ties to the government	Health experts	– 5.57	< 0.001	< 0.001	***
Organizations without ties to the government	Political parties	3.90	< 0.001	0.003	**
Organizations without ties to the government	Science	– 7.93	< 0.001	< 0.001	***
Organizations without ties to the government	Industry	– 1.17	0.24	1.00	ns
Organizations without ties to the government	Media	5.90	< 0.001	< 0.001	***
Government	Health experts	– 3.55	< 0.001	0.010	*
Government	Political parties	6.85	< 0.001	< 0.001	***
Government	Science	– 6.41	< 0.001	< 0.001	***
Government	Industry	0.50	0.62	1.00	ns
Government	Media	7.54	< 0.001	< 0.001	***
Health experts	Political parties	8.73	< 0.001	< 0.001	***
Health experts	Science	– 3.28	0.001	0.026	*
Health experts	Industry	3.93	< 0.001	0.002	**
Health experts	Media	11.6	< 0.001	< 0.001	***
Political parties	Science	– 11.0	< 0.001	< 0.001	***
Political parties	Industry	-4.66	< 0.001	< 0.001	***
Political parties	Media	2.08	0.039	0.82	ns
Science	Industry	7.66	< 0.001	< 0.001	***
Science	Media	13.3	< 0.001	< 0.001	***
Industry	Media	7.11	< 0.001	< 0.001	***

C.2. Information requirements

Low cluster (n = 99, df = 98)

Group 1	Group 2	Statistic	*p*	p_{adj}	Significance
Environment-related information	Information on disadvantages	– 6.26	< 0.001	< 0.001	***
Environment-related information	Risks and functional properties	– 6.30	< 0.001	< 0.001	***
Information on disadvantages	Risks and functional properties	0.69	0.49	1.00	ns
Medium cluster (n = 326, df = 325)					

Group 1	Group 2	Statistic	p	p_{adj}	Significance
Environment-related information	Information on disadvantages	– 7.13	< 0.001	< 0.001	***
Environment-related information	Risks and functional properties	– 12.4	< 0.001	< 0.001	***
Information on disadvantages	Risks and functional properties	– 3.13	0.002	0.006	**
High cluster (n = 218, df = 217)					
Environment-related information	Information on disadvantages	– 2.30	0.023	0.068	ns
Environment-related information	Risks and functional properties	– 8.08	< 0.001	< 0.001	***
Information on disadvantages	Risks and functional properties	– 4.76	< 0.001	< 0.001	***

C.3. Information sources

Low cluster (n = 99, df = 98).

Group 1	Group 2	Statistic	p	p_{adj}	Significance
Advertisements in media	Websites during own research	– 8.71	< 0.001	< 0.001	***
Advertisements in media	Conversation with insulation expert	– 10.1	< 0.001	< 0.001	***
Websites during own research	Conversation with insulation expert	– 0.49	0.62	1.00	ns
Medium cluster (n = 326, df = 325)					
Advertisements in media	Websites during own research	– 18.5	< 0.001	< 0.001	***
Advertisements in media	Conversation with insulation expert	– 19.3	< 0.001	< 0.001	***
Websites during own research	Conversation with insulation expert	– 3.81	< 0.001	< 0.001	***
High cluster (n = 218, df = 217)					
Advertisements in media	Websites during own research	– 13.0	< 0.001	< 0.001	***
Advertisements in media	Conversation with insulation expert	– 13.1	< 0.001	< 0.001	***
Websites during own research	Conversation with insulation expert	– 4.65	< 0.001	< 0.001	***

Acknowledgements This project has received funding from the European Union's Horizon 2020 research and innovation programme [No 768919]. The funding source was further not involved in conducting the study.

Funding Open Access funding enabled and organized by Projekt DEAL. This project has received funding from the European Union's Horizon 2020 research and innovation programme [No 768919]. The funding source was further not involved in conducting the study.

Data availability The datasets generated and analyzed during the current study are not publicly available due to the formulation of the consent given to us by the respondents. They were assured that our research team would be the only party using the data and that this would only serve scientific purposes.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Information of contained The information contained in this document has been prepared solely for the purpose of providing information about the Carbon4PUR project. The document reflects only the Carbon4PUR consortium's view and the EC is not responsible for any use that may be made of the information it contains.

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