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Trust and Distrust in Carbon Capture and Utilization Industry as Relevant Factors for the Acceptance of Carbon-Based Products

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Climate change poses a key threat to today's societies and is caused by greenhouse gas emissions, mainly carbon dioxide emissions. Capture and Utilization of Carbon Dioxide (CCU) is a technological approach to reduce CO_2 emissions. Coincidentally, the approach also reduces the depletion of limited fossil resources by incorporating CO_2 as a raw material in the manufacture of products (e.g., plastics), thereby replacing fossil resources such as conventionally used oil. Even though some CCU products are nearing market maturity, systematic research on the acceptance of these products, especially regarding the (dis)trust in the companies that produce them, is still in its initial phase. Since a lack of trust could lead to a rejection of innovative products and technologies, the present study empirically investigates (dis)trust factors related to the acceptance of CCU plastic products. In a first step, interviews were carried out and analyzed to reveal relevant (dis)trust criteria for credibility of companies, desired information and marketing issues, and how CCU products are perceived. Afterwards, an online survey ($n = 127$) was conducted to identify and quantify important (dis)trust dimensions, and their connection to the acceptance of CCU products. The results showed that the participants had a slightly positive attitude toward CCU, and potential environmental, sustainability related, and economic benefits were acknowledged. In addition, potential barriers of CCU (sustainability risks, unknown risks, and health concerns) were rated rather neutrally and were thus not perceived as real barriers of CCU. When comparing companies to other institutions (e.g., research institutions, NGOs), the participants reported to trust companies least. Furthermore, four relevant trust (e.g., customer relationship) and distrust (e.g., bad customer orientation) dimensions were identified using CCU companies as an example of companies which manufacture innovative products. Finally, some first insights concerning the connection between the identified trust factors, CCU perception, credibility of the information sources, and the marketing of innovative products, are presented. The results enable deriving user-specific CCU product communication and information strategies.

Keywords: carbon dioxide capture and utilization (CCU), acceptance, perception, trust, user diversity, CO_2 derived products

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INTRODUCTION

Multiple technologies to reduce greenhouse gas emissions have been developed. The greenhouse gasses are mainly emitted during energy generation in power plants which use fossil fuels like coal and oil, by traffic and transportation, by agriculture, and by the construction industry [(Global Carbon Project (GCP), 2015)]. Innovative technological approaches aim to reduce Carbon Dioxide (CO_2) emissions by emitting no, or considerably less, CO_2 and by replacing the use of fossil resources (Adger et al., 2013), e.g., through energy generated by renewable resources (Twidell and Weir, 2015) or advancements in the field of electromobility (Held and Baumann, 2011). Despite these efforts, considerable amounts of CO_2 emissions are currently still being ejected - particularly by power plants.

Carbon Dioxide Capture and Utilization (CCU) is an option for the capture of CO_2 emissions from power plants, after which these are used as carbon feedstock for the manufacture of new products (e.g., fuels or plastics), thereby replacing conventionally used fossil resources such as oil and gas (Hunt et al., 2010; von der Assen and Bardow, 2014). In the field of CCU, the production of consumer plastic products (e.g., mattress foams) but also industrial products (e.g., fuels, insulation materials) is currently in the testing stage (MacDonald, 2015; Covestro, 2016). Next to technical, environmental, and economic perspectives on CCU, consumer acceptance is crucial for the market success or failure of novel (carbon-derived) products. In particular missing or misleading information, public misconceptions, and a low trust in actors and institutions can lead to the refusal and failure of innovative products (Siegrist, 2000; Wallquist et al., 2010). Referring to consumer products, it is therefore important to understand to which extent potential users accept CCU products and to which extent acceptance depends on trust and distrust in, and the credibility of, the technology, CCU-based products, and the respective industry. For CCU technologies, public acceptance and trust are of great importance. Previous studies revealed a connection between a negative public perception (often referred to as "mental or cognitive models") of CO_2 (e.g., van Heek et al., 2017a) and negative associations that are made with CO_2, which refer to CO_2 emissions, e.g., hazardous consequences for the planet (Widdicombe et al., 2013). So far, studies on the acceptance of CCU have focused on the public perception of CCU (Jones et al., 2014; Jones, 2015) using several dimensions as possible influencing factors. These studies include the perception of risk concerning CCU (Arning et al., 2017), acceptance of specific CCU products when taking the proportion of CO_2 in these products into consideration, saving of fossil resources, disposal conditions, and subjectively perceived health complaints (van Heek et al., 2017b). Nevertheless, the issue of trust in the CCU industry and the corresponding companies as factors for the acceptance of CCU products is under-researched so far.

To overcome this gap, the present study aimed to investigate the connection between trust in CCU companies and the acceptance of innovative CCU products by applying a two-step empirical approach. In a first step, relevant factors for trust and distrust in CCU industry as well as for the perception of CCU products were identified using an interview study. Subsequently, an online questionnaire was used to measure factors for trust, distrust, and CCU perception, to identify relevant trust and distrust dimensions, and to analyze the connection between trust in the CCU industry and the acceptance of CCU products. Additionally, the study investigated the influence of user factors on perceived trust and acceptance, because CCU products are everyday products and thus have a diverse public as potential users—not limited to technical experts—as potential consumers. The results of this study were used to derive communication and information recommendations for companies and manufacturers, whilst focusing on trust in, and the perception of, CCU products.

THE ACCEPTANCE OF CCU

This section presents the study's theoretical background. First, key aspects concerning the process steps of Carbon Dioxide Capture and Utilization (CCU) and the manufacturing of diverse product variations are described. Afterwards, the theoretical base for the acceptance of technology, acceptance research referring to sustainable technologies, and the current state of research on the acceptance of CCU, are covered. Finally, the research questions and the different aims of the present study are explained.

CCU—Carbon Dioxide Capture and Utilization

In recent years, the various options of CCU have increasingly been discussed and developed by industry, economy, and academia. After capturing CO_2—e.g., from power plants by pre-combustion, post-combustion, oxyfuel processes, or the recently discussed air capture—CO_2 can be transported using trucks, ships, or pipelines to the respective production sites (Markewitz et al., 2012). Once it arrived, there are several ways to utilize CO_2, such as physical utilization, chemical utilization, or the preparation of inorganic materials. Calcite and hydrotalcite are examples of inorganic materials, which can be prepared using CO_2 whereby the CO_2 is not, or only partially, fixed (Yong et al., 2002). Physical utilization is highly promising as CO_2 can be involved in a wide range of applications, it can, e.g., be used as refrigerant for fire extinguishers or cleaning processes (Markewitz et al., 2012) and for the carbonation of beverages (Duran et al., 2008). In comparison diverse types of chemical utilization revealed to be most efficient (Fan et al., 2015) as there are diverse options which allow the long-term, partially permanent, storage of CO_2, e.g., by producing urea, methanol (e.g., production of fuels), cyclic carbonates, and salicylic acid (e.g., Markewitz et al., 2012). Currently, a lot of these innovations are on the threshold of technological implementation, are currently being tested, or have already been implemented in pilot projects [e.g., foam mattresses (Covestro, 2016) or fuels (MacDonald, 2015)]. CCU is highly promising for the production of (poly)carbonates and fuels, since the demand and sales volume are high in these sectors. Consequently, there is also a high potential to exploit CO_2 as a renewable resource thereby replacing fossil resources (mostly oil) which are otherwise used (Markewitz et al., 2012). In the case of producing plastics, such

as (poly)carbonates, polyol, polypropylene, or polyurethane, CO_2 might serve as a basis for manufacturing by splitting the carbon block (C1) and could therefore be used for a variety of products, e.g., building materials or household articles (von der Assen and Bardow, 2014). An example in the field of synthetic fuels is the diesel-like synthetic oxymethylene ether (OME fuels) which can help to achieve climate targets by reducing NOx and soot emissions (Härtl et al., 2014; Feiling et al., 2016). Of course, a significant reduction of the global emission budget cannot be reached solely by applying CCU. However, studies on the life-cycle-assessment of CCU processes revealed that significant amounts of fossil resources (especially oil and gas), and also of CO_2 emissions during production, can be saved in comparison to conventional production (von der Assen and Bardow, 2014; von der Assen et al., 2014)

Acceptance of Sustainable Energy Technologies

Next to technological, environmental, and economic perspectives on technology and innovative product development, it is of great importance to analyze, whether and how future users accept novel products, and what the underlying positive and negative arguments for public perception and acceptance are (Shackley et al., 2005; van Heek et al., 2017a). Understanding the public perception and acceptance of novel products allows the development of user-specific recommendations, public information, and guidelines for the development process—even before end products reach the market (Cooper et al., 2004)

Within social science research on the acceptance of sustainable energy technologies, several terms and concepts regarding social and public acceptance and public perception are used interchangeably. In the present study, *(public) perception* regards the public's subjective understanding of technologies which can be assessed empirically using measurable indicators (e.g., the level of awareness of CCU, or people's knowledge on and attitudes toward the technology). *Acceptance* refers to an active (intention to use novel products) or passive (tolerance toward novel products) approval or adoption of technologies and corresponding products. In this case, public acceptance is to be understood as the approval of large-scale energy technology development or implementation, which is assumed to be present if there is no active opposition against it (e.g., protests; Schweizer-Ries, 2008).

Large scale technologies with multi-year development processes are often abstract, and not easily comprehended by the general public, as potential consequences of the technology are usually unknown and therefore often perceived as risky or hazardous (Zaunbrecher and Ziefle, 2016). Integrating knowledge about public acceptance in the development process as early as possible, is therefore essential to adapt the technological development (Kowalewski et al., 2013), and to shape information and communication strategies (Zaunbrecher and Ziefle, 2016). For potential consumers, CCU as well as CCU products represent a novel, unfamiliar technology, for which hands-on experience does not exist yet.

To analyze the perception and acceptance of CCU, it is not appropriate to use traditional acceptance models [e.g., the technology acceptance model (TAM) (Davis, 1989) or derived models] as a theoretical basis, because these models mainly focus on existing technologies in the context of the usage of job-related information and communication technologies. Technology acceptance models referring to other large-scale technological areas (e.g., Siegrist, 2000; Huijts et al., 2012) provide a more suitable basis as they also integrate further factors such as trust, social norms, and the individual characteristics of the users and consumers. Siegrist (2000) found that trust in institutions influences the perception of benefits and barriers of a technology (here: gene technology), which is directly related to the acceptance of this technology. Huijts et al. (2012) presented a framework for the acceptance of technology thereby explaining the acceptance of sustainable energy technologies based on psychological theories. The model assumes that acceptance is influenced by individual factors, perceived costs, risks, and benefits, affective responses, (dis)trust, fairness of the implementation process, and personal and social norms. Similar to Siegrist (2000), Huijts et al. (2012) also integrated trust, defined as "trust in actors," in their acceptance framework, modeling direct influences from trust on positive and negative affects as well as perceived benefits, costs, and risks.

Of course, these two models predominantly referred to large-scale technologies, which is why they cannot be simply transferred to the context of CCU on the product-level. Additionally, a more detailed definition and concept of trust is necessary to analyze trust as a presumably acceptance-relevant factor. Nevertheless, both models give an idea of acceptance relevant criteria concerning innovative energy topics and deliver a basis for the present study as there has been hardly an acceptance study referring to the product level in the CCU context so far.

Focusing on innovative technologies, products, and their evaluations, future customers or users weight and balance perceived benefits as well as perceived barriers and risks (trade-offs). Particularly with regard to risk perception and risk communication (Slovic, 1993), credibility as well as trust of future users in companies, operators, or manufacturers are of major importance and address different concepts (Renn and Levine, 1991).

On the one hand, trust means the expectancy that messages or information are true and reliable and represents a prerequisite for the assignment of credibility to a source. More detailed research investigated different concepts with regard to trust in organizations, i.e., competence-based and integrity-based trust, and revealed influences on risk perception and technology acceptance (CCS) (Terwel et al., 2009).

Credibility—in turn—rests on "long-term evidence and commonly shared experience that a source is competent, fair, flexible to new demands, and consistent in its task performance and communication efforts" (Renn and Levine, 1991, p. 180). In line with this definition of credibility, there is also the often used term "confidence" which refers to "the belief, based on experience or evidence, that certain future events will occur as expected" by Siegrist (2010) as well as Earle (2010).

Hence, these definitions suggests a distinction between credibility in information sources and trust in actors, companies, or industry as a multi-dimensional construct. As trust in actors and credibility of information sources were known to be influencing factors for the acceptance of large-scale energy technologies (Siegrist, 2000; Wüstenhagen et al., 2007; Huijts et al., 2012), we assume that these factors are also crucial for the acceptance of CCU technologies and derived products. For the current study, we defined trust based on Renn and Levine (1991) and used also their definition of credibility (not confidence) as it seems to be most suitable for the investigation of the underlying research question (see RQ2).

Furthermore, it is of relevance—within trust-related research and in line with McKnight et al. (2004)—to distinguish between trust and distrust as separate concepts arguing that both are able to co-exist and differ with regard to their emotional structure and impact: "while trust concepts tend to be calm and collected, distrust concepts embody significant levels of fear and insecurity" (p. 39–40).

Summarizing, the presented concepts show that it is necessary and useful to differentiate between credibility (in information sources) as well as trust and distrust when the acceptance and perception of innovative technologies and products is investigated.

In particular with regard to a marketing point of view, trust, and credibility are of major importance in the context of innovative "green" product acceptance (Pickett-Baker and Ozaki, 2008). Previous research on innovative technologies, products, and their marketing shows that it is of great importance (a) to highlight benefits for the environment, (b) to highlight the innovative character of products, and—simultaneously—(c) to pay attention to inform people equitably about benefits as well as potential risks (de Vries et al., 2016). If this is not the case, there could be consequences like perceptions of manipulation or greenwashing which will impede building trust and decrease credibility of involved actors and companies. The marketing of CCU and low-carbon products as an example of innovative energy technologies will have to face exactly these challenges.

The Public Perception of CCU

During the last decades, numerous acceptance studies focusing on the predecessor technology of CCU—Carbon Dioxide Capture and Storage (CCS)—have been conducted worldwide. The results revealed that the acceptance of CCS greatly varied depending on the different countries. In particular the storage of CO_2 on diverse storage sites was considered to be critical, e.g., in the Netherlands (Huijts et al., 2007; van Alphen et al., 2007), Japan (Itaoka et al., 2005), China (Yang et al., 2016), Germany (Fischedick et al., 2009), USA (Krause et al., 2014), and also in a study focusing on a comparison of Japan, Sweden, UK, and USA (Reiner et al., 2006). In the case of CCS, several studies investigated misconceptions and pseudo-opinions, missing and misleading information, as well as insufficient trust in the actors and institutions (e.g., Yang et al., 2016), as relevant factors which could lead to rejection or even protests against large-scale technologies and the accompanying manufactured products (Wallquist et al., 2010; Terwel et al., 2011; de Vries et al., 2016). Simultaneously, diverse studies revealed a lack of knowledge and awareness with regard to CCS which could also be related with missing trust and rejecting attitudes (e.g., Shackley et al., 2005; Yang et al., 2016; van Heek et al., 2017a,b). The results suggest that these factors might also be crucial in the context of CCU acceptance and should therefore be investigated in detail.

It is a current topic of public discussion and has been argued critically, that CCU and CCS are cofounded in the public and the media, even though both technologies address different technological issues and take up different roles in the environmental policy debate (Bruhn et al., 2016). For this reason, the present study aimed to investigate CCU separated from CCS, and did therefore not mention the potential relationship to CCS storage processes and technical issues in the introduction and instruction parts.

Jones et al. (2017b) summarized the current state of the art and provided a research agenda referring to the social acceptance of carbon dioxide utilization presenting previous qualitative and quantitative approaches. Within these studies on the acceptance of CCU, perceived benefits and risks concerning the technology itself were identified—e.g., conceptual, technological, and societal issues (Jones et al., 2015). The results of Jones et al. (2014) showed—among others—that people differ in their preferences for CCU options (e.g., the production of cement was ranked best, while transport fuels were ranked least) and that people are skeptical over the worth of CCU (e.g., "only delay an inevitable release of CO_2," preventing societal change). Another study (van Heek et al., 2017a) investigated associations and acceptance of CO_2-derived plastic products revealing that people differ in their evaluation of product options (e.g., rejecting products which are close to the body). Further, research focused also on different dimensions of risk perception (Arning et al., 2017) differentiating between environmental risks, health risks (rated lowest), product feature and quality risks as (rated highest) well as sustainability risks. Current studies also concentrate on country-specific similarities and differences in the evaluation of CCU (Germany and UK, Jones et al., 2017a) and on people's awareness and evaluation of CCU whilst focusing on sustainability issues (Perdan et al., 2017).

In combination with the presented concepts and theories (section Acceptance of Sustainable Energy Technologies), it is therefore useful to conceptualize an explorative approach integrating perceived benefits and perceived barriers concerning CCU products, on the one hand, as well as trust, distrust, and credibility in information sources as potential acceptance-relevant factors, on the other hand.

This procedure is particularly necessary because (a) existing theoretical models for technology acceptance might not be able to assess the acceptance of the highly context-specific field of CCU technology acceptance (Arning et al., 2010) and (b) the field of trust in CCU industry and its relationship to the acceptance of CCU products is still underexplored.

Aim and Research Questions

Even though the number of studies which focused on the acceptance of CCU increased in the last few years, trust and distrust, specifically related to the CCU industry, have not been

investigated so far as factors for the acceptance of CCU and CCU products. Therefore, the aim of the present study's research was to identify relevant trust and distrust criteria as well as acceptance parameters referring to the CCU industry. In order to gain a deeper understanding, we first conducted a qualitative preceding study in which the main relevant trust-related arguments in favor of or against CCU products were identified. On the base of the outcomes, a quantitative questionnaire study was run afterwards. The questionnaire aimed to analyze and measure levels and dimensions of trust, distrust and credibility, and their relationship to the acceptance of CCU products. Beyond the main factors revealed in the preceding interview study, previous CCU acceptance research findings (e.g., Jones et al., 2015) were integrated to connect the findings to, and to extend, previous knowledge as well as to examine the relationship between (dis)trust, perceptions, and the acceptance of CCU products. Hence, the following research questions were investigated in our study:

1. How do potential users evaluate diverse potential benefits, potential barriers, and the acceptance of different CCU products? (*RQ1*)
2. How might the participants view different information sources as differently credible? *(RQ2)*
3. What information do potential users need about innovative (CCU) products and the corresponding manufacturing company and how should the marketing of CCU products be oriented? *(RQ3)*
4. Which factors and dimensions are relevant for trust and distrust in CCU companies? *(RQ4)*
5. How strong are potential connections between diverse dimensions of (dis)trust, credibility, and the perception of CCU products? (*RQ5*)

METHODOLOGY

The following section presents the study's empirical approach and its methodological and technical details. After describing the preceding qualitative study, the key results and conclusions for the quantitative study are described in detail. Afterwards, there is a focus on the concept and design of the quantitative study, followed by a characterization of the quantitative study's sample and an explanation of the applied statistical methods.

Empirical Approach

As the acceptance of specific CCU products, especially the impact of trust and distrust in companies as a factor for the acceptance of CO_2 derived products, has hardly been explored (see section The Public Perception of CCU), a preceding qualitative study was necessary to identify relevant perceived benefits and barriers, as well as trust and distrust criteria, in the context of CCU acceptance. Only after these factors have been determined, is it possible to reliably analyze the specific research questions and the relationships with the interacting acceptance. For that reason, we first used a qualitative interview study to reveal the most important factors concerning trust and CCU acceptance. Subsequently, we used an online questionnaire to quantify and weigh the previously identified acceptance- and trust-related factors. Within the next sections, a short summary of the interview study's key aspects and a detailed description of the quantitative online questionnaire's conceptualization, is given.

Qualitative Pre-study

This section provides a short overview focusing on the method, the characteristics of the interviewed participants, and the key results that served as a basis for the quantitative study's design.

Procedure

Semi-standardized interviews were chosen as a qualitative approach and an interview protocol was used to ensure that each interview included all relevant aspects[1].

The interviews started with several questions defining some demographic and attitudinal aspects to be able to classify and characterize the interview participants. Subsequent to demographic data (gender, age, education, profession), the participants evaluated their attitude toward technology in general, their environmental awareness, and their general trust [using six-point Likert scales ($max = 6$)].

After these initial questions, the interview started with a short introduction of CCU focusing on technical key characteristics (i.e., realistic savings of CO_2 emissions and fossil resource use compared to conventional production, von der Assen and Bardow, 2014) and examples of CCU products using a schematic fact sheet (Olfe-Kräutlein et al., 2014). More detailed information regarding the interview protocol can be found in Appendix A.

Then, the participants were asked to indicate which information about the manufacturing of products and about the corresponding manufacturing company they desire if they purchase new innovative products. Furthermore, the participants were asked to give reasons for why they would evaluate energy and chemistry companies as being trustworthy or even untrustworthy. In addition, the participants evaluated the CCU technology including perceived potential benefits and barriers. As a last aspect, the participants were asked to state any ideas and wishes concerning the way CCU products should be marketed.

Participants

Interviews were held in May 2016. Ten participants ($n = 10$) voluntarily participated (no incentives) in the interview study which, on average, lasted 30 min. As we specifically aimed for an investigation of laypeople's perception of trust and distrust in, and the credibility and acceptance of, CCU products in relation to CCU companies, all participants were laypeople without any connections to the energy or technology industry.

The participants were chosen by personal contact aiming for an equal distribution of women and men as well as different ages and different levels of education. Three participants were aged under 30 years and were students of different disciplines (e.g., applied geography, humanities). Four participants were middle-aged (30–40 years of age), had a middle level of education, and

[1]Detailed information about the interview protocol and all included aspects can be found in Appendix A. The interview protocol was translated as all interviews were conducted in German. Within section Procedure, only the most important key aspects are mentioned.

worked in a variety of professions (i.e., taxman, electric engineer, social worker, medical-technical radiology assistant). Further, three participants belonged to the older age group (above 50 years), had a comparatively lower level of education, and worked as nursing assistant, craftsman, or housekeeper.

Overall, six participants were female (4 were male) and their ages ranged between 21 and 60 years ($M = 36.7$; $SD = 13.9$). On average ($min = 1$; $max = 6$), the indications on the participants' individual attitudes toward technology ($M = 4.1$; $SD = 1.6$), their environmental awareness ($M = 3.9$; $SD = 0.7$), and their general attitude toward trust ($M = 4.1$; $SD = 0.9$) were rather positive as the average values were above the mean of the scale. None of the participants has already heard the term CCU prior to the interview study.

Results and Conclusions

In the following, the interview study's key results as well as the drawn conclusions for the design of the quantitative study are presented. The interviews were audiotaped and literally transcribed. Qualitative content analysis by Mayring (2010) was the theoretical foundation for the analysis of the interviews and three coders analyzed the material. The resulting category system can be retrieved from Appendix B focusing on information and trust-relevant aspects.

All aspects that were identified in the interview were integrated in the quantitative results part (see section Results). Referring to the desired information about the manufactured products and the corresponding manufacturing company, the information that was wanted most referred to the price-performance ratio, country of production, sustainability of production, and company's image.

> *"For me, the company's image and the way a company is presented to the public are decisive." (female, 21 years)*

Overall, the participants stated eight different aspects referring to information about the **manufactured products**. This ranged from details about the *production procedure*, *working conditions*, *product ingredients* and *product quality*, to information about the *sustainability of the production* process, *price-performance ratio*, potential *animal testing,* and *production country*.

> *"I would like to have some real and exact information about the sustainability of the production process..." (male, 32 years)*

When it comes to information about the **manufacturing company**, seven aspects were perceived as being important: a *company's image* as well as its *history* and *values*, but also the *employees*, *divisions of the company*, *environmental management,* and *potential partner companies*.

> *"I would like to know who is working for the company. If you know the people, then you get a picture of the company." (female, 32 years)*

The participants also explained seven aspects they considered to be the most relevant during the **marketing** of innovative products (e.g., *simplified representation of the technology*, *integrity, seal of approval*, *highlighting sustainability aspects,* a transparent *introduction of the company, sobriety* of marketing, and the *advertisement with the CCU technology*), which have been summarized by labeling them as *marketing issues*.

> *"... with a really clear seal of approval, which has been specially developed for it.... It should also be certified by the federal government or specific institutes." (male, 52 years)*

Overall, the participants mentioned 20 aspects of trust as factors that increase trust in relation to energy and chemistry companies (e.g., *good reputation of the company*, *transparency*, *fair working conditions*, *keeping promises*). A full list of the trust criteria can be seen in **Table 3**.

> *"It increases trust if the company keeps their promises referring the production process but also related to the products themselves." (female, 24 years)*

The participants also stated 13 aspects of distrust as factors that increase the distrust in companies (e.g., *conscious deception of customers, negative incidents, unfriendly staff, incompetent staff, missing safety standards, or unclear terminology*; a full list can be seen in **Table 4**).

> *"... and also if staff is unfriendly or reacts unfriendly on demands. This seems to me to be not very credible." (female, 56 years)*

Concerning the evaluation of the CCU technology, almost all participants perceived CCU positively as they acknowledged a potential contribution to environmental protection by reducing CO_2 emissions and usage of fossil resources. To conclude, the mentioned environmental, economic, and sustainability related benefits and possibilities of CCU were in line with the results of previous CCU acceptance research and were integrated in the subsequent quantitative study. The perceived barriers and risks, which were mentioned by the participants (e.g., health risks, sustainability risks), were also in line with previous research on the acceptance of CCU (Jones et al., 2015), and were thus also integrated in the quantitative study.

Quantitative Survey Study

An online survey was developed to measure and weight the previously identified relevant aspects concerning trust and distrust in energy and chemistry companies, acceptance, and perception of CCU products, as well as desired information and marketing issues regarding CCU products. This section describes the design of the survey, the sample, and the statistical methods that were applied to analyze the results.

Questionnaire Design

As mentioned in section Qualitative pre-study, the quantitative study's questionnaire items were based on the findings of the preceding qualitative interview study (full questionnaire can be seen in **Data Sheet 1**). After an introduction of the general topic (acceptance of CCU) and a short explanation of CCU as a technology which decreases CO_2 emissions (realistic proportions

were labeled; von der Assen and Bardow, 2014) and saves fossil resources, the first part of the questionnaire addressed the participants' demographic characteristics namely age, gender, postal code, educational level, and family status.

In the second part, the participants were asked to assess the following attitudinal variables each by using several items that were based on validated constructs and aiming for assessing the participants' subjectively perceived attitudes or characteristics: attitude toward technology (using four items, $\alpha = 0.90$; Beier, 1999; item example: "I really enjoy cracking a technical problem"), environmental awareness as well as conscious environmental behavior (using 12 items, $\alpha = 0.78$; Kuckartz et al., 2007; item example: "If we continue as before, we are heading for an environmental disaster"), general interpersonal trust (using nine items, $\alpha = 0.86$; McKnight et al., 2002; item example: "In general, people keep their promises") (McKnight et al., 2002), and trust in experts (using three items, $\alpha = 0.90$; (McKnight et al., 2002); item example: "Most experts are very competent in their field"). All these items were measured using six-point Likert scales ($min = 1$ = "I strongly disagree"; $max = 6$ = "I strongly agree").

Afterwards, basics of the CCU technology were described in more detail and different usage options were introduced. The introductory texts were developed in collaboration with technical experts, were checked for comprehensibility by experts and laypeople in several iteratively conducted pretests, and contained the most important information about the CCU technology process steps based on Olfe-Kräutlein et al. (2014). As examples of products, products with different levels of proximity toward people were chosen: using CO_2 for the carbonization of beverages, a CO_2-derived mattress as an example of plastic products, and CO_2 derived fuels. The introduction was deliberately kept condensed, but still informative and objective. The questionnaire's introduction of CCU and CCU products is depictured in **Figure 1**.

After the introduction, the participants evaluated potential *environmental benefits* (using five items, $\alpha = 0.86$; item example: "CCU is a solution to tackle climate change"), *economic benefits* (also using five items, $\alpha = 0.77$; item example: "CCU technology will create new jobs"), and *sustainability related benefits* (using three items, $\alpha = 0.70$; item example: "CCU gains time while trying to fight climate change"). Moreover, potential barriers were assessed by focusing on *health risks* (using four items, $\alpha = 0.74$; item example: "CO_2 is a pollutant and could pose a hazard to human health"), *unknown risks* (using five items, $\alpha = 0.78$; item example: "The CCU technology could pose unknown risks"), and *sustainability related risks* (using six items, $\alpha = 0.79$; item example: "CCU promotes the continued use of fossil fuels"). All benefit, barrier, and risk items, which showed a high sensitivity toward CCU acceptance, were taken from previous studies in this field (e.g., Jones et al., 2015).

Furthermore, the participants assessed the acceptance of CO_2 derived products in general (by using three items, $\alpha = 0.80$; item example: "I can generally imagine using CO_2 products"), but—differentiating between various usage options—also rated the acceptance of CO_2-utilization for the production of beverages (using two items, $\alpha = 0.88$), the manufacture of mattresses (using three items, $\alpha = 0.88$), and the production of fuels (also using three items, $\alpha = 0.85$).

To analyze the relevance of trust and distrust (see section The Public Perception of CCU), the participants rated trust factors (using 20 items, $\alpha = 0.91$) as well as distrust factors (using 13 items, $\alpha = 0.88$). All used trust and distrust factors are illustrated in **Tables 3**, **4** in section Identification of Relevant Dimensions for Trust and Distrust in CCU Companies (RQ4). Additionally, the credibility of different information sources (see **Figure 2**) was evaluated based on Siegrist's (2000) trust in institutions construct (see section Acceptance of Sustainable Energy Technologies; the term "credibility" was used to distinguish it from the CCU industry related trust and distrust factors).

Finally, the participants' need for information concerning the manufacture of products (using eight items, $\alpha = 0.79$), corresponding manufacturing companies (using seven items, $\alpha = 0.88$), and desired marketing issues (using seven items, $\alpha = 0.88$), were evaluated based on the findings of the preceding interview study (all aspects can be found in **Table 2**).

The assessment of all these items (benefits, barriers, acceptance, information need, marketing, trust, distrust) was also based on six-point Likert scales (1 = "I totally disagree"; 6 = "I totally agree"). Values >3.5 indicated approval, while values <3.5 showed the rejection of a statement.

Sample

Data was collected by using an online questionnaire in Germany in summer 2016 and the completion of the questionnaire took, on average, 25 min.

One hundred and seventy-five participants took part in this first explorative study on trust in CCU industry. The participants were recruited by personal contact but also via mail and links on social networks aiming for an equal distribution of women and men as well as diverse sample in terms of age.

Since only complete and seriously filled out data sets could be used for further statistical analysis, $n = 127$ data sets were analyzed. The responses of 48 participants had to be excluded due to an unrealistic processing time, dubious answer behavior, and premature cancelation of the survey.

The participants' mean age was 35.9 years ($min = 19$; $max = 66$; $SD = 11.6$), 61.4% were female and 38.6% were male. The educational level was rather high with 45.7% of the participants holding a university degree. Furthermore, 26.0% completed an apprenticeship, 7.9% held a certificate of a higher (technical) college, 10.2% held a qualification for university entrance, 8.7% owned a secondary school certificate, and 1.6% reported to have a basic school qualification.

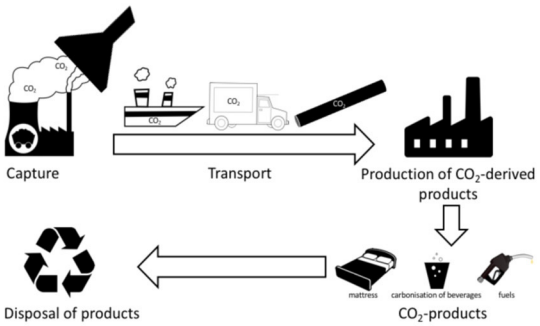
Regarding the participants' attitude toward technology, environmental awareness, and general trust, the respective item scores were combined to indexes and checked for reliability (see section Statistical methods). On average ($min = 1$; $max = 6$), technology expertise ($M = 4.4$; $SD = 1.1$) and environmental awareness ($M = 4.7$; $SD = 0.6$) were high when comparing them to the middle of the scale. In contrast, general (interpersonal) trust was rated comparatively neutral ($M = 3.7$; $SD = 0.7$).

Concerning previous experiences with CCU, only 18.9% of the sample indicated that they had already heard of the term "carbon

Introduction of Carbon Capture and Utilization (CCU)

CCU is a technology, where CO_2 emitted from carbon-intensive processes, for example by fossil fuel power generation, is used as a feedstock for the manufacture or other products.

The CCU process can be described as follows: After capturing CO_2 from large emitting sources it is transported by ship, truck, or via pipeline to a production facility and temporarily stored in storage tanks, before it is supplied as resource for further processing. There are diverse options of CO_2 utilization: chemical usage (e.g., polyols such as a mattress), biological usage (e.g., fuels), and direct use (e.g., carbonization of beverages). Finally, the products are used by customers and are disposed at the end of their life cycle.



The global need for CO_2 for the manufacture of CO_2-derived products is clearly lower than the worldwide annual amount of CO_2 emissions. Thus, CCU focuses not on the reduction of CO_2 emissions of power plants, but rather on savings of fossil resources (such as mineral oil and natural gas) for the manufacture of products. This way, CCU contributes to the conservation of limited fossil resources. Additionally, less new CO_2 emissions are released during the manufacture of CO_2-derived products compared to the manufacture of conventional products as the used CO_2 substitutes other emission-intensive source materials.

FIGURE 1 | Text and illustration of the introduction concerning the CCU technology and CCU products.

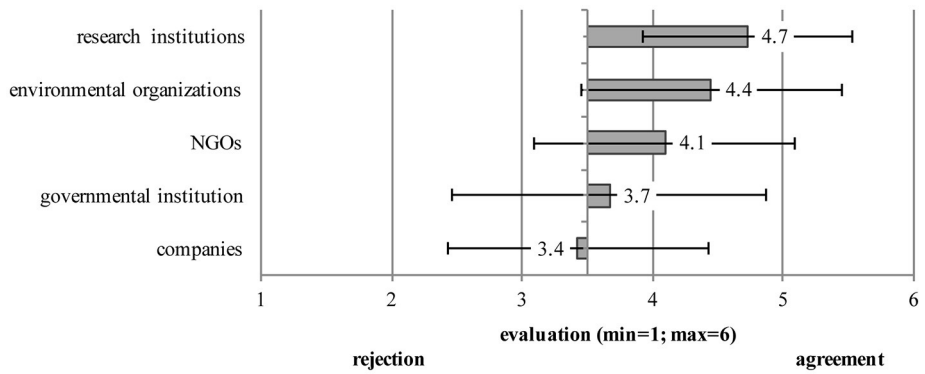


FIGURE 2 | Evaluation of the credibility of different information sources (whiskers indicate standard deviation).

capture & utilization." When asked for perceived knowledge on CCU, most participants (46.5%) indicated to feel "very badly" informed about CCU, while 24.4% felt "badly" and 19.7% "rather badly" informed. In contrast, only 7.1% reported to feel "rather well," 1.6% "well," and 0.8% "very well" informed about CCU.

Statistical Methods

To ensure measurement quality, item analyses were calculated prior to descriptive and inference statistical analyses. In line with methodological standards, a Cronbach's alpha > 0.7 indicated a satisfying internal consistency of the scales. The data was analyzed using bi-variate correlations of the technology- and user-related factors as well as a univariate analysis of the variance. Furthermore, Principal Component Analysis (PCA) was applied to identify the relevant dimensions of trust and distrust.

The descriptive results are reported by means (M) and standard deviations (SD), while correlation coefficients (r) and level of significance (p) are used to describe the bi-variate correlation analysis results. For describing the results of the univariate analysis of variance t-values (t) and the level of significance are reported (p).

RESULTS

First, descriptive results concerning the perception of the CCU technology and specific CO_2-derived products, as well as credibility of different information sources, are presented. In a second step, the participants' information needs regarding the CCU manufacturing process, CCU companies, and marketing of CCU products, are described. Moreover, the results of a Principal Component Analysis (PCA) are presented, thereby identifying relevant trust and distrust dimensions. To get first explorative insights in the relationship between the perception of CCU and (dis)trust, the results of correlation analyses are used to model the relationships.

Perception of CCU Technology and Products (RQ1)

During the completion of the online questionnaire, the participants were asked to assess several statements regarding the CCU technology in general to capture their opinion on the technology itself. **Table 1** illustrates the results of descriptive and, compared to the mid-point of the scale, inference statistical analyses. The means for the following statements were significantly higher than the mean of the scale indicating that the participants were positive about the following attributes of CCU: *CCU should only be considered as an alternative, next to other technologies, to combat climate change,* and *CCU signals a commitment to combat climate change*. Furthermore, the participants were also positive about the statement that *CCU should be accepted by the public* (again, the mean was significantly higher than the mid-point of the scale). In contrast, the participants were neutral about the statement *CCU is a "green" technology,* as its mean was not significantly different from the mid-point of the scale.

Addressing RQ1, the results in **Table 1** show that the participants were generally positive about *CCU products* (indicated by a significantly higher mean than the mid-point scale). Besides evaluation-related differences to the mid-point of the scale, *t*-tests were also calculated to investigate differences with regard to the perception of CCU products: among the given CCU product options, *CCU fuels* were perceived as the best option for the utilization of CO_2 ($M = 4.3$; $SD = 1.0$), while *CCU mattresses* [$t_{(1, 126)} = 6.826$, $p < 0.01$] and *CO_2 usage for the carbonization of beverages* [$t_{(1, 126)} = 4.171$; $p < 0.01$] were both evaluated significantly less positively in comparison to CCU fuels. *CCU mattresses* were the only product the participants were ambivalent about as the mean was not significantly different from the mid-point of the scale.

To obtain deeper insights into the acceptance motives and to answer RQ1, different dimensions of perceived benefits and barriers were also assessed by the participants (see **Table 1**). Concerning the perceived benefits, *environmental, sustainability related*, and *economic* benefits were evaluated on a similar level of significant agreement (as the means were significantly higher than the mid-point of the scale). In contrast, the participants were ambivalent about *sustainability related risks* and *unknown risks* as the means were not significantly different from the mid-point of the scale. The mean of *health concerns* was significantly lower than the mid-point of the scale indicating that the participants were negative about those type of risks (slight rejection).

Perception of Information Sources' Credibility (RQ2)

As a basis to analyze the connection between trust, distrust, and the perception of CCU, it was very important to know, how the credibility of companies as information sources is evaluated in the context of CCU as well as in comparison with other institutions. Therefore, the participants were also asked to assess the credibility of different information sources. As depicted in **Figure 2**, the participants indicated to trust *research institutions* ($M = 4.7$; $SD = 0.8$) and *environmental organizations* ($M = 4.5$; $SD = 1.0$) the most, indicated by agreements that were significantly higher than the mid-point of the scale. Moreover, *NGOs* ($M = 4.1$; $SD = 1.0$) were also considered to be trustworthy indicated by significantly higher means than the mid-point of the scale. In contrast, the participants were ambivalent about the credibility of *governmental institutions* ($M = 3.7$; $SD = 1.2$) and *companies* ($M = 3.4$; $SD = 1.0$) indicated by means that did not differ significantly from the mid-point of the scale.

T-tests revealed that companies ($M = 3.4$; $SD = 1.0$) received the significantly lowest credibility evaluations compared to all other information sources, i.e., compared to governmental institutions [$t_{(1, 126)} = 2.386$; $p < 0.05$], NGOs [$t_{(1, 126)} = 6.015$; $p < 0.01$], environmental organizations [$t_{(1, 126)} = 8.958$; $p < 0.01$], and research institutions [$t_{(1, 126)} = 12.809$; $p < 0.01$].

Information Needs and Marketing (RQ3)

To understand which information concerning CCU products, the manufacturing companies, and CCU product marketing, the participants desire, for each construct seven (information on companies, marketing) and eight items were evaluated (information on CCU products). **Table 2** shows the results of descriptive and, compared to the mid-point of the scale, inference statistical analyses.

Regarding *CCU products* (see **Table 2**), significantly higher means than the mid-point of the scale indicated that the participants had a strong need for information on the *price performance ratio* and *product quality*. Likewise, the participants required information on the *product ingredients* as well as the *country of production*. The participants were ambivalent about information concerning the *sustainability of production* and *animal testing* as the means were not significantly different from the mid-point of the scale. Significantly lower means compared to the mid-point of the scales showed that information on *working conditions* and *production procedure* were not perceived as being relevant.

In respect to the need of information on CCU companies (see **Table 2**), the participants desired information on the *company's image* indicated by significantly higher means compared to the mid-point of the scale. The participants were ambivalent about information on the *company's values* and *environmental management* as the means were not significantly different from the mid-point of the scale, while the participants were significantly more negative about desiring information on the *company's divisions*, *history*, *employees*, and *partner companies*

TABLE 1 | Overview of the descriptive statistical results of all items concerning acceptance and perception of CCU.

Category	Items	*M*	*SD*	Difference from the scale mid-point [referring to: *t*(1, 126)]	
				t	*p*
General perception of CCU	CCU should only be considered as an alternative, next to other technologies, to combat climate change	4.6	1.0	12.068	<0.001
	CCU signals a commitment to combat climate change	4.3	0.9	10.609	<0.001
	CCU should be accepted by the public	4.1	0.9	7.494	<0.001
	CCU is a "green" technology	3.6	1.0	1.276	=0.204
Acceptance of CCU products	CCU products	4.2	0.8	10.560	<0.001
	CCU fuels	4.3	1.0	9.273	<0.001
	CCU mattresses	3.9	1.1	1.838	=0.068
	CCU for carbonization (beverages)	3.7	1.1	3.913	<0.001
Perceived Benefits & Barriers	Environmental benefits	4.3	0.8	10.283	<0.001
	Sustainability related benefits	4.2	0.7	10.387	<0.001
	Economic benefits	4.0	0.7	8.784	<0.001
	Sustainability related risks	3.6	0.7	−0.853	=0.395
	Unknown risks	3.4	0.7	1.858	=0.066
	Health concerns	3.1	0.8	−5.301	<0.001

indicated by significantly lower means than the mid-point of the scale.

As a final aspect concerning the need of information, the participants were asked how CCU products should be marketed (see **Table 2**: all aspects were rated significantly higher compared to the mid-point of the scale). The aspects *simplified representation of CCU technology*, *integrity*, and *highlighting sustainability* were evaluated highest and were thus desired to be emphasized during the marketing of CCU products. Other aspects such as a *seal of approval*, an *introduction to the company*, an *advertisement of the CCU technology*, and general *sobriety* were also rated as being important for the marketing of CCU products.

Identification of Relevant Dimensions for Trust and Distrust in CCU Companies (RQ4)

Based on the findings from the interview study, the participants evaluated 20 trust- and 13 distrust-related items (see **Tables 3**, **4**). All trust items were rated positively: *Min*: *introduction of staff* ($M = 4.0$; $SD = 1.0$); *Max*: o*bservance of safety standards* ($M = 5.2$; $SD = 0.9$). In the same way, all distrust-related items were rated positively: *Min*: *using terminology customers don't understand* ($M = 4.6$; $SD = 1.2$); *Max*: *conscious customer deception* ($M = 5.5$; $SD = 0.7$).

To figure out, of how many and which relevant dimensions trust and distrust consist, Principal Component Factor Analyses (PCA) were conducted. This was combined with item reliability analyses (Cronbachs's alpha) to test the internal homogeneity of each trust construct scale. The PCA was calculated for trust and distrust items separately as well as together in one analysis. The first "separate" calculation revealed 4 trust and 4 distrust dimensions, whereas the second alternative ("all in one") revealed 8 dimensions. Those 8 dimensions were actually the same as the 4 trust and 4 distrust dimensions from the first calculation. Based on McKnight et al. 2004 (see section Acceptance of Sustainable Energy Technologies), the trust and distrust dimensions are reported separately due to the assumption that the dimensions have different emotional structures and impacts.

Quality criteria for factor analyses proved that the data matrix was suitable (Bartlett's test of Sphericity $p < 0.001$) and the KMO measure was 0.896, which indicates high levels of sampling adequacy. Four items with factor loadings and reliability coefficients < 0.6 were excluded from further analyses (**Table 3**) (Hair, 2011), and this way the number of trust-related items was reduced from 20 items (evaluated in the questionnaire) to 16 trust-relevant items (**Table 3**).

The analysis revealed four relevant trust dimensions: the first trust dimension was called "customer relationship" and contained aspects which mainly addressed a direct contact with the company or the company's staff. The second trust dimension was the "company's transparency" also referred to as fair and safe working conditions. The third trust dimension, "moral values," focused on social commitment and the compliance with values, while the fourth factor dealt with the "company's reputation" and—next to a good reputation—it also regarded the recognized certifications of the company. All trust-related items were rated significantly higher than the mid-point of the scale (see **Table 3**).

The same analysis procedure was conducted for all distrust-relevant items, i.e., aspects that increase distrust in companies. **Table 4** shows the results for distrust in CCU companies revealing *four* relevant distrust dimensions. Here, the Bartlett's test of Sphericity ($p < 0.001$) again proved that the data matrix was suitable and the KMO measure was 0.831. *Two* items with

TABLE 2 | Overview of the descriptive statistical results of all items regarding information needs and marketing.

Category	Items	*M*	*SD*	Difference from the scale mid-point [referring to: *t*(1, 126)]	
				t	*p*
Information needs on CCU products	Price performance ratio	5.0	0.9	18.259	<0.001
	Product quality	4.9	0.8	20.136	<0.001
	Product ingredients	4.5	1.0	11.150	<0.001
	Country of production	4.5	1.0	4.541	<0.001
	Sustainability of production	3.6	1.2	0.857	=0.393
	Animal testing	3.5	1.5	0.153	=0.879
	Working conditions	3.2	1.3	−3.027	<0.001
	Production procedure	2.9	1.1	−6.358	<0.001
Information need on CCU company	Company's image	3.7	1.2	2.407	<0.05
	Company's values	3.5	1.2	−0.411	=0.682
	Environmental management	3.4	1.2	−0.897	=0.371
	Company's divisions	2.9	1.2	−5.377	<0.001
	Company's history	2.9	1.3	−5.717	<0.001
	Company's employees	2.8	1.1	−6.646	<0.001
	Partner companies	2.8	1.1	−7.077	<0.001
Marketing issues	Simplified representation of CCU technology	5.0	1.0	17.587	<0.001
	integrity	4.9	1.0	17.224	<0.001
	Highlighting sustainability	4.9	1.0	16.478	<0.001
	Seal of approval	4.7	1.1	11.822	<0.001
	Introduction to the company	4.6	1.1	10.750	<0.001
	Advertisement of the CCU technology	4.5	1.0	10.806	<0.001
	Sobriety	4.4	1.1	9.110	<0.001

factor loadings and reliability coefficients <0.6 were excluded from further analyses (Hair, 2011).

The *first* distrust dimension was called "customer deception" and—in addition to the conscious deception of customers—it also referred to the opacity of, and the contradiction of statements and actions made by the company. The *second* distrust factor, "bad customer orientation," dealt with the direct contact to the staff, which also included the presence of unfriendly or incompetent staff and the usage of terminology which customers cannot understand. As a third distrust dimension "bad working conditions" referred to bad or missing working and safety conditions, while the fourth dimension, "negative image," also included negative incidents concerning the company. All distrust-related items were rated significantly higher than the mid-point of the scale (see **Table 4**).

Relationships of (dis)trust, Credibility, and the Perception of CCU Products (RQ5)

To statistically analyze the relationship between the factors and addressing RQ5, bi-variate correlation analyses were conducted. While care should be taken not to assume causality, the results indicated that there were linear relationships.

First, significant relationships between the acceptance and the perception of benefits ($r = 0.444$; $p < 0.01$), barriers ($r = -0.329$; $p < 0.01$), credibility of information sources ($r = 0.376$; $p < 0.01$), and the way CCU products should be marketed ($r = 0.302$; $p < 0.01$), were revealed. As illustrated in **Table 5**, the results showed linear interrelations between the perception of benefits and credibility of information sources ($r = 0.501$; $p < 0.01$), between the credibility of information sources and marketing issues referring to CCU products ($r = 0.470$; $p < 0.01$), as well as between the perception of benefits and perception on how the CCU products should be marketed ($r = 0.696$; $p < 0.01$).

When integrating trust and distrust dimensions in the analysis, the results revealed significant linear relationships between the perception of benefits and the following trust dimensions: "company's reputation" ($r = 0.407$; $p < 0.01$), "moral values" ($r = 0.375$; $p < 0.01$), and "customer relationship" ($r = 0.198$; $p < 0.05$). The perception of barriers was significantly related to the distrust dimension "negative image" ($r = 0.258$; $p < 0.01$) and correlated negatively with the trust dimension "company's reputation" ($r = -0.233$; $p < 0.01$). Furthermore, the perception of credibility of information sources was significantly related to the trust dimensions "moral values" ($r = 0.362$; $p < 0.01$) and "company's reputation" ($r = 0.385$; $p < 0.01$), and it correlated negatively with the distrust dimension "negative image" ($r = -0.389$; $p < 0.01$).

Table 5 also illustrates the correlation results focusing on the perception on how CCU products should be marketed. The perception of marketing issues significantly correlated with all trust dimensions: "customer relationship" ($r = 0.423$; $p < 0.01$), "company's transparency" ($r = 0.279$; $p < 0.01$) and "moral values" ($r = 0.483$; $p < 0.01$), while the dimension "company's reputation" showed, overall, the highest correlation ($r = 0.598$;

TABLE 3 | Results of **trust** items: PCA and descriptive statistical results (four items with factor loadings <0.6 were excluded and are marked in the table with an asterisk).

Item	Rotated factor loadings of questionnaire items	Trust 1 "Customer relationship"	Trust 2 "Company's transparency"	Trust 3 "Moral values"	Trust 4 "Company's reputation"	Descriptive results: M, (SD)	Difference from the scale mid-point [referring to: $t(1, 126)$]	
							t	*p*
1	Keeping promises	0.720				5.1 (0.8)	22.728	<0.001
2	Professional behavior	0.722				4.8 (0.9)	17.081	<0.001
3	Good complaint management	0.756				4.8 (0.8)	18.196	<0.001
4	Flexibility with unforeseen problems	0.640				4.9 (0.8)	20.461	<0.001
5	Availability to answer questions	0.709				4.9 (0.9)	16.728	<0.001
6	Friendly appearance of staff	0.750				4.7 (1.0)	13.622	<0.001
7	Honesty of staff	0.715				4.9 (0.8)	19.660	<0.001
8	Competency of staff	0.662				5.0 (0.8)	22.026	<0.001
9	Transparency		0.725			5.1 (0.8)	22.158	<0.001
10	Fair working conditions		0.620			4.9 (0.9)	17.059	<0.001
11	Complying of safety standards		0.728			5.2 (0.9)	22.045	<0.001
12	Introduction of staff			0.813		4.1 (1.1)	5.593	<0.001
13	Social commitment			0.828		4.4 (1.0)	9.826	<0.001
14	Compliance of values (company & own)			0.713		4.7 (1.0)	13.313	<0.001
15	Good reputation of company				0.701	4.7 (0.9)	16.173	<0.001
16	Recognized certifications of company				0.732	4.6 (0.8)	10.806	<0.001
17	Honesty of company statements*		0.583			5.1 (0.8)		
18	Product quality*	0.587				5.2 (0.7)		
19	Good price-performance ratio*	0.590				4.9 (0.9)		
20	Providing information*		0.577			5.0 (1.0)		

$p < 0.01$). Concerning the distrust dimensions, "bad customer orientation" ($r = 0.221$; $p < 0.05$), "customer deception" ($r = 0.328$; $p < 0.01$), and "negative image" ($r = 0.392$; $p < 0.01$) correlated also significantly with the perception on how CCU products should be marketed.

Overall, the results show that the trust and distrust dimensions were related with the acceptance of CCU products by correlating with the perception of benefits, barriers, the credibility of information sources, and the way of marketing CCU products.

DISCUSSION

This section discusses the study's main results, starting with the identified trust and distrust factors and the analyzed relationships. Furthermore, the results concerning the influence of user diversity are summarized and classified within the research area of CCU acceptance. Afterwards, recommendations for communication and information strategies, and an overview of limitations and future research suggestions, are given.

Modeling of Trust in CCU Companies

Whereas previous studies focused on trust in general, the current study took a closer look into the specific (dis)trust dimensions. Four dimensions, specifically trust and distrust in CCU companies and industry, were revealed covering different areas: personal contact with the company, (in)transparency of the information policy, public image of the company, working conditions, and moral values in general.

The results revealed that the perception of CCU products is directly connected to the acceptance of CCU products. On one hand, this is in line with previous findings on the perception of benefits and barriers (other technologies: Siegrist, 2000; Huijts et al., 2012; CCU: van Heek et al., 2017b). On the other hand, the results identified the perception on the credibility of information sources, and the perception on CCU product marketing, as (new) related and relevant parameters for the acceptance of CCU products. Moreover, our analyses revealed an indirect connection between CCU-industry-related trust and distrust dimensions and the acceptance of CCU products as there

TABLE 4 | Results of **distrust** items: PCA and descriptive statistical results (items with factor loadings <0.6 were excluded, marked in the table with an asterisk).

Item	Rotated factor loadings of questionnaire items	Distrust 1 "Customer deception"	Distrust 2 "Bad customer orientation"	Distrust 3 "Bad working conditions"	Distrust 4 "Negative image"	Descriptive results: *M*, (*SD*)	Difference from the scale mid-point [referring to: *t*(1, 126)]	
							t	*P*
1	Contradiction between company's statements and action	0.688				5.2 (0.7)	28.146	<0.001
2	Conscious deception of customers	0.801				5.5 (0.7)	33.565	<0.001
3	Opacity	0.663				5.0 (0.8)	15.812	<0.001
4	Decline in product quality	0.651				5.1 (0.7)	25.344	<0.001
5	Unfriendly staff		0.834			4.7 (1.1)	11.856	<0.001
6	Incompetent staff		0.752			5.0 (0.9)	19.577	<0.001
7	Using terminology customers don't understand		0.716			4.6 (1.2)	10.027	<0.001
8	Missing safety standards			0.814		5.1 (0.9)	18.746	<0.001
9	Miserable working conditions			0.808		4.8 (1.0)	14.566	<0.001
10	Negative image of company				.801	4.9 (1.0)	16.428	<0.001
11	Negative incidents regarding company				.851	4.8 (1.1)	13.622	<0.001
12	External detection of abuses*	0.553				5.3 (0.8)		
13	Greed for profit*			0.484		5.0 (1.1)		

is a direct correlation of trust and distrust with the perception of CCU (benefits, barriers, credibility, and—in particular—CCU product marketing). Siegrist (2000) already postulated this relationship in the context of gene technology. Terwel et al. (2009) adapted the Siegrist model 2000 in the context of CCS and showed that institutional trust influenced the perception of benefits and barriers which in turn impacted the acceptance of CCS. The presented study found the same effect in the context of CCU, thereby confirming the acceptance model by Huijts et al. (2012) in which trust is also connected with the perception of benefits and barriers in the context of renewable energy infrastructures. Therefore, the presented results confirm existing acceptance models (Siegrist, 2000; Huijts et al., 2012) and extend the validity of the model assumptions for the context of CCU.

In addition, the present research contributes to an understanding of trust in the field of CCU acceptance by modeling trust as the credibility of information sources and by identifying and relating diverse dimensions of trust and distrust, which are relevant for the acceptance: the contact to the CCU company (customer relationship, customer deception, bad customer orientation), a (lack of) information transparency, the company's reputation and image, underlying moral values, and working conditions. It is noteworthy that the company's reputation is the only trust dimension (among the ones that were studied in this research) that was not only significantly related with the credibility of information sources, but also with the perceived benefits and barriers. Apparently, it is of utmost importance for companies, in the context of renewable energy technologies, to provide a clear, trustful, and honest public image as users attach a high value to this.

Information Needs and Communication Strategies

The results showed that the participants indicated a higher need for information on the CCU products than on the corresponding manufacturing company. Hence, information on the respective products should be provided to the consumers and to interested buyers before, and during, the purchase. The results also revealed a need for detailed product information which focuses on the product price, the product's ingredients, and product's quality, while information on the production procedure is not required. The participants' feedback (e.g., in open comment fields) showed that information should be communicated transparently and honestly to future users.

In accordance with previous studies (e.g., van Heek et al., 2017a), the participants demand to be informed exactly on the CO_2 derived products, even though, from an expert's point of view, the products' base substance is not different from conventional ones. In contrast to the experts' suggestion not to provide information on the products (as they are not substantially different from conventional products), this study explicitly showed the importance of informing "lay people" and fulfilling their need to be informed about CCU products. As taken from the comments in the interviews, participants expect that responsible stakeholder transparently informing the consumer as

TABLE 5 | Results of correlation analysis: relationships between (dis)trust, credibility, and the perception of CCU products.

		CCU products				
		Marketing	**Credibility**	**Perceived benefits**	**Perceived barriers**	**Acceptance**
Trust	Customer relationship	0.423**		0.198*		
	Company's transparency	0.279**				
	Moral Values	0.483**	0.362**	0.375**		
	Company's reputation (Comp.)	0.598**	0.385**	0.407**	−0.233**	
Distrust	Customer deception	0.328**				
	Bad customer orientation	0.221*				
	Bad working conditions					
	Negative image	0.392**	−0.389**		0.258**	
CCU	Marketing	–	0.470**	0.696**		0.302**
	Credibility		–	0.501**		0.376**
	Perceived benefits			–		0.444**
	Perceived barriers				–	−0.329**
	Acceptance					–

*$p < 0.05$; **$p < 0.01$.

an inevitable precondition for building trust which—in turn—is an inevitable precondition for the acceptance of, and the willingness to adopt, CCU products. If companies choose to conceal this information—irrespective of the individual reasons for concealing information ("too complicated for laypeople," "too bothersome to provide information," "too risky to evoke public protest")—people may perceive this information strategy as not being transparent or opaque, or they may even feel deceived by the company selling the CCU products, which evokes a feeling of distrust.

Previous studies on mental models regarding CO_2 and CCU confirm these suggestions as the participants frequently mentioned irrational (from a technical point of view) but psychologically understandable concerns, such as toxicity and harmfulness ("CO_2 is toxic and harmful for human health") if they were asked for their associations to CO_2 (van Heek et al., 2017b). Research on risk communication in diverse areas has already shown that people need to get "good information" in order to be able to make sound choices and that the respective information has to be "carefully selected and clearly presented" (Morgan et al., 2002). Further, risk communication including specific information has to be designed and evaluated adequately in order (1) to avoid poorly structured or superfluous risk information that bore or frustrate recipients or lead to misconceptions and (2) to enable completing and correcting of existing mental models (Atman et al., 1994; Bostrom et al., 1994).

Therefore, if information is given to people in the context of CCU and CO_2 products, information and communication strategies also have to be developed carefully and should address the wishes and needs of future users of CCU products.

The participants also indicated to need a CCU product marketing that depicts the CCU technology in a simplified way and highlights the environmental and sustainability related benefits, but also the potential disadvantages. The openness when communicating benefits as well as potential disadvantages, is seen as an unmistakable indication of the companies' honesty and thus a sign of esteem toward the users. Out of the interviewees' perspective, users must be able to make the choice to adopt or not to adopt a technical product on the basis of all information on the product, the production process, and the manufacturer—in contrast to the product being coaxed and forced on by companies or politicians which market products for their own benefits (making money, winning elections). In this line of argumentation, a seal of approval—ideally provided by independent institutions—was requested by the participants, which could promote the communication of environmental benefits (especially savings of emissions and fossil resources). Future studies should investigate whether the fact that products use such a seal is even more important for specific groups of people, as our participants' feedback (in survey and interviews) suggests that people with a low inclination to need trust sources also differ regarding their previous trust experiences. For people who experienced distrust concerning innovative products, trust and distrust might generally be more important and—since "first impressions count"—the distrust experience shapes their behavior concerning the acceptance or rejection of innovative products (Dwyer et al., 1987; Cho, 2006).

A specific issue in developing effective communication strategies is the adequate handling of laypeople that do not have much technical knowledge, but rather rely their acceptance or trust decisions on affective beliefs and perceptions toward the reliability of public information and communication (Rowe and Wright, 2001; Achterberg et al., 2010). Schmidt and Donsbach (2016) reported that experts and laypeople do have different thematic priorities regarding information needs, which makes it essential to address those knowledge gaps of laypeople in order

to steer an effective communication (Brunsting et al., 2013). Therefore, novel forms of public information strategies need to be developed: (a) laypeople should not be overloaded by generic information about technical facts (which they might not be interested in and which do not fill their knowledge gaps), and (b) the public should be integrated in policy decisions to learn in which way, about what, and also when in the product development process people need to be informed. In addition, public communication should be as transparent as possible and include both, an open-mined exchange of benefits and drawbacks as well as potential risks of a technology. By this, laypeople are empowered to correctly evaluate the trade-off between benefits and concerns (Brunsting et al., 2013). In this context, work done by Ashworth et al. (2009) and Pisarski and Ashworth (2013) is of impact. They argue that changes in opinion toward renewable energy technology can happen if community audiences are included in open and critical discussions (e.g., in form of round tables) which, in turn, increases laypeople's interest in engaging in energy-related topics and allow to form attitudes and opinions on a richer and more trusted information basis.

Using these recommendations might help to increase public knowledge about CCU and CCU products, increase consumers' trust in the technology and producers, and reduce the probability of forming misconceptions related to CO_2 derived products.

Limitations and Future Research

The present study was useful as a first study in the field of (dis)trust in CCU industry and its relationship to the acceptance of CCU products. Our approach gained insights into relevant trust and distrust criteria, and revealed an indirect relationship of trust and distrust with CCU product acceptance by a directly connection of trust and distrust to the perception of benefits, barriers, credibility, and desired marketing issues. However, there are still some methodological and content-related limitations which should be considered in future studies.

Sample Size

For the adopted approach, a sample size of more than 100 people is sufficient in a methodological and statistical sense. As most respondents were laypeople, the findings are valid for the "normal" population. Still, it is useful to broaden the sample size and aiming for a census representing sample to measure the view of an entire population on the topic. From a statistical point of view, a larger sample size would allow to extend correlation analyses—which only reveal relations between the trust components—by path analyses. Using, e.g., hierarchical regression analysis, we could reveal stronger connections and combined relationships of the constructs in the model. This could not be accomplished in the current sample—due to the limited size and the inhomogeneity of user characteristics (e.g., regarding education level).

The Role of Knowledge and CCU Technology Expertise

With regard to the knowledge types, an interesting finding had been reported by Brunsting et al. (2013) who showed in the context of CCS that the perceived—subjective—knowledge is a better predictor for acceptance in contrast to the factual domain knowledge. For the CCU context, the relation between subjective and objective knowledge and their impact on CCU acceptance is not yet known. Future studies will therefore concentrate on the role of domain-specific knowledge on both acceptance and trust as a potential moderating factors of acceptance.

In this context, the role of the perceived knowledge regarding CCU could also be pursued in a more detailed way. In our sample, the level of knowledge about the CCU technology was very low. In accordance with numerous studies in the context of acceptance of CCS and, also CCU, the low level of real as well as perceived knowledge is a very common phenomenon (Curry et al., 2005; Shackley et al., 2005; Jones et al., 2015).

Importantly, these results should not be taken to suggest that the acceptance (or rejection) of CCU—like other technologies—can be solely explained by a knowledge deficit (Nisbet and Scheufele, 2009). The underlying motives for and causes of people's acceptance or rejection of technologies are a much more complex connection between the perception of benefits and barriers, trust, and knowledge.

Until now, previous studies results revealed no significant relationships between perceived knowledge and trust in CCU industry.

Thus, while a low level of knowledge could contribute to the formation of misconceptions and pseudo-opinions (De Best-Waldhober and Daamen, 2006; Wallquist et al., 2010; de Vries et al., 2016); one should not assume that these misconceptions or pseudo-opinions can be overcome (and acceptance guaranteed) by the simple provision of information.

Similarly, in terms of building trust, research consistently shows that trust is a complex phenomenon, depending on individual characteristics as well as on company related factors. Thus, the development of trust cannot simply be prescribed in a top-down manner by giving isolated (technical) CCU information to people. Trust is not generated by knowledge and information alone. It is also a matter of the reliability and perceived honesty with which users credit the source, information, and authority.

In future studies, it is necessary to explore the relationship between knowledge, trust, and acceptance of CCU, including investigations into whether attempts to improve knowledge should be combined with hands-on experience with CCU products in order to foster public acceptance.

User Diversity

In addition to the understanding of trust in CCU products in terms of companies' characteristics or the openness of information policies, it is an important issue that individual factors of consumers also shape the adoption willingness of CCU products, and, as a consequence acceptance. Previous studies in the context of novel infrastructure technology acceptance revealed that demographic factors such as age, gender, and education level (Siegrist, 2000; Liu et al., 2013; Sardianou and Genoudi, 2013; Bertsch et al., 2016; Lee et al., 2017) but also individual factors like environmental awareness (Hartmann and Apaolaza-Ibáñez, 2012), risk perceptions (Zoellner et al., 2008), personal trust (Huijts et al., 2012), the confidence when handling

technology and the level of domain knowledge (van Heek et al., 2017b) do considerably impact the acceptance of novel infrastructure technologies. Within future research activities, it is therefore of major importance to investigate whether and to which extent user diversity (demographic as well as individual attitudinal variables) influences the evaluation of trust and distrust criteria as well as their relationships with CCU product acceptance. Since we assume that interpersonal trust is a user-specific factor of major relevance in this context (see section Information Needs and Communication Strategies), we aim for replicating the study differentiating between different facets of trust. As the present study was a first study in the field and included only single elements of trust, we like to integrate other trust facets [e.g., (dis)trust in diverse authorities] in future studies to gain a broader understanding of personal and technology-specific trust criteria.

Methodology, Thematic Framing, and Instruction

Of course, the present study was a scenario-based approach enabling only to investigate expressed preferences which might differ from actual behavior (Ajzen and Fishbein, 1977, 1980) (not) to use or purchase CO_2-derived products. Future studies will have to investigate similarities and differences between expressed and revealed preferences. Additionally, it is currently not known if the trust and distrust factors might not contribute equally to a positive or negative perception of CCU and CCU products. Relative importance, weightings as well as positive or negative contributions of those factors referring to CCU and CCU product perception should be investigated in a conjoint study in the future.

As previous studies showed that the thematic framing (introduction of the CCU technology) shapes the evaluation and acceptance of CCU (and CCU products) (Jones et al., 2017a), one should naturally consider that instruction biases cannot be fully excluded. In order to minimize these effects, we developed the instructions very carefully and used only instruction material which had been checked for reliability and correctness by technical (CCU) experts. This way, we provided only technically accurate (e.g., realistic proportions of savings of CO_2 emission and fossil resource use compared to conventional production processes) and but still comprehensible information (e.g., proportions of CO_2 and fossil resources savings; von der Assen and Bardow, 2014). Still, however, future studies should investigate in more detail to which extent varying instructions and information shape the participants' evaluation. This would be also insightful to understand how and in which way public information material should be tailored.

An additional factor, that is indirectly related to thematic framing and instruction, refers to the costs of innovative technologies and products as influencing factor for acceptance. At a later stage—when CO_2-derived products are available for end consumers—costs will have to be investigated focusing on specific price levels, that future users are willing or are not willing to pay for innovative low-carbon products. The feedback of our participants showed that low-carbon products do not have to be inevitably cheaper than conventional products: if the product quality and functionality is high, the participants stated to be even willing to pay higher prices. Thus, future users will have to investigate costs as influencing factor for the acceptance of innovative products based on realistic price levels.

Cultural Influences

Finally, our findings only refer to one specific country, Germany. On the base of the findings here, we cannot estimate in how far the findings also hold for other cultures and countries, likewise. The question of trust in institutions and in companies is presumably culture-specific. Cultural effects regard not only a country's openness to eco innovations (Domenech and Bahn-Walkowiak, in press), the national wealth and the cultural dynamics (Srite and Karahanna, 2006; Tang and Koveos, 2008), the (social) risk perception and uncertainty avoidance (Tansey and O'riordan, 1999), but also prevailing policy efforts in educating societies for sustainable behaviors and values (Inglehart and Baker, 2000). Therefore, we would like to replicate the study in countries that differ regarding the mentioned factors to enable direct comparisons of the relationship between trust in companies and industry and the acceptance of CCU products depending on different countries and cultures.

CONCLUSION

As a first study in the specific field of (dis)trust in CCU industry and acceptance of CCU products, the results gained insights into relevant trust and distrust criteria regarding direct contact to the company (customer relationship, customer deception, bad customer orientation), (lack of) transparency, company's reputation and image, moral values, and working conditions. Moreover, the study showed that (dis)trust is indirectly connected with the acceptance of CCU products by direct relationships between the (dis)trust dimensions and the perception of benefits, barriers, credibility of information sources, and the perception how CCU products should be marketed. In addition, the study revealed the information needs of future users and their desire to be fairly informed on the potential benefits as well as the potential barriers of CO_2 derived products.

Future studies should further focus on the directions of relationship between (dis)trust and acceptance as product acceptance requires trust in the manufacturing company and the consumer's acceptance is prerequisite for the success of innovative technologies. The derived communication and information strategies could support manufacturers and their product marketing in addressing future consumers' wishes and needs.

ETHICS STATEMENT

We did not seek ethical approval from the ethics committee, as our study falls in the category where no such approval is necessary in Germany. This category spans all non-invasive, non-clinical research on human subjects, where subjects are transparently informed about the purpose, aim, and risks of the studies and when these risks are reasonably low. Prior to starting the procedure, they were informed that it is of

high importance to understand free opinions and attitudes on sustainable energy supply from the citizens' perspective and that we were very happy if they would share their opinions with us. Still, however we stressed that they are free in taking part or not and their participation was completely voluntary. The participants were not reimbursed for taking part in the study. Further, we ensured a high standard privacy protection and let the participants know that none of their answers can be referred to them as persons. Demographic data were also submitted voluntarily and all participants were informed that on request their personal data would be deleted from our encrypted hard drives. After these careful explanations participants reported to feel well informed about the purpose and the aim of the study and their freedom to quit participation at any time. Regarding the privacy policy explanations, the participants reported to understand that high standards were applied and deliberately accepted participation. Participant privacy is a key value that our university has committed itself to uphold. From the comments in the open question fields at the end of the survey, we learnt that those participants were interested in the topic and were keen to look at the results, which we assured them to receive.

AUTHOR CONTRIBUTIONS

All authors had an active part in preparing this manuscript, the underlying research, and the conceptualization of the empirical study (JO, AL, KA, and MZ). The first author is main responsible for the present article (JO). The conceptualization phase was accomplished by all authors, with the first author (JO) and the last author (MZ) having a specific role. Both authors had the closest contact with the technology engineers (controlling for the technical accuracy), the funding institution, and the university departments which were involved. The item development and the logic of the empirical procedure in line with the statistical analyses was done with the major support of AL and KA. The discussion and future research section was done by all authors in close cooperation.

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SUPPLEMENTARY MATERIAL

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

APPENDIX

Appendix A

Interview Protocol (Including Pre-questionnaire Questions):

General information: Interview study is conducted within the research of the Chair for Communication Science and the Human-Computer Interaction Center of RWTH Aachen University. The interviews will probably take between 30 and 45 min. Interviews will be audio-recorded. (Declaration of consent)

1. *Demographic data*
   a. Age
   b. Gender
   c. Highest educational level
   d. (Current) occupation
2. *Self-assessment of attitudinal variables*
   a. Attitude toward technology:
      - "I am generally interested in technology."
        - Answering options: "I strongly agree"/ "I agree"/ "I rather agree" / "I rather disagree" / "I disagree" / "I strongly disagree"

   b. Environmental awareness:
      - "I would describe myself as environmentally conscious."
        - Answering options: "I strongly agree"/ "I agree"/ "I rather agree" / "I rather disagree" / "I disagree" / "I strongly disagree"

   c. Attitude toward trust:
      - "I would describe myself as a person who trusts others."
        - Answering options: "I strongly agree"/ "I agree"/ "I rather agree" / "I rather disagree" / "I disagree" / "I strongly disagree"

3. *Information about companies and products*
   a. Do you inform yourself about production or the company when buying a new/innovative product?
   b. What is important to you? What are you paying attention to?
   c. Which aspects constitute a trustworthy company from your perspective?
      - Do you pay attention to special aspects of companies? (e.g., sustainability, "green image", . . .)
      - Whose statements about companies do you give faith?

   d. Which aspects do undermine trust in companies?
      - What has to happen to turn a credible company in a unreliable company?

4. *Current awareness about CCU:*
   a. Do you have already heard the term "carbon dioxide capture and utilization"? If yes, what do you know about it?

Introduction of CCU and potential CCU products (using the mentioned information material (Olfe-Kräutlein et al., 2014).

- Key aspects:
  - Demographic change; diverse technologies developed in order to reduce CO_2 emissions and use of fossil resources; CCU as one option to contribute to reduce emissions and resource use
  - CCU has not the potential to reach measurable reductions within the global emissions budget; however, reductions of almost 20% CO_2 emissions and fossil resource use could be reached compared to the production of conventional products (source: von der Assen and Bardow, 2014).
  - Diverse sources of CO_2, different types of utilization, different product options (mattresses, parts of shoes, furniture, isolation material)

5. *CCU Technology: Perceived benefits and chances*
   a. Do you perceived benefits or chances related to the CCU technology? Which benefits do you see?
      - . . . for the environment?

- … for you individually?
- … for the society?
- … for the economy?

b. Do you have any other relevant aspects in mind?

6. *CCU Technology: Perceived barriers and risks*

a. Do you perceive risks related to the CCU technology? Which potential barriers or risks do you see?

- … related to the production?
- … related to the technical realiozation?
- … related to the environment?
- … related to human health?

b. Do you have any other perceived barriers or concerns in mind?

7. *CCU products: We have already talked about different possibilities and options of CCU products.*

a. Could you generally imagine to use CCU products?
b. What are positive aspects you think about?
c. What are negative aspects? Do you have concerns?
d. Under which conditions would you use a CCU product?
f. Do you perceive product-related differences? If yes, which differences and why?

8. *Chemistry and energy companies:* initially, we already talked about trustworthy companies. Referring to CCU, especially energy and chemistry companies are of importance.

a. What role does the company play for buying and also using of CCU products?
b. How should a company operate to classify it as trustworthy?
c. Do you generally trust in energy and chemistry companies?
d Are you able to reason your trust or distrust?
f. What has to happen to turn a credible energy or chemistry company in a unreliable company?
e. How should CCU products be marketed to make the companies trustworthy?

9. *Conclusion:*

a. How do you generally think about the CCU technology?
b At which point do you desire more information?

Appendix B

TABLE 1B | Category System of the Qualitative Analysis Focusing on Information- and Trust-Relevant Aspects of CCU.

Root category	Sub-category	Sub-sub-category	Exemplary statement
Communication and marketing	Information about products	Production procedure	"For me, it is really important and also interesting to know how innovative products are manufactured." (m, 32)
		Working conditions	"I would like to know how the working conditions for the employees look like..." (w, 56)
		Product ingredients	"I inform myself about possibly critical ingredients of products..." (w,32)
		Product quality	"I would like to have information about the quality of a product and its production." (m, 28)
		Sustainability of production price-performance-ratio	"I would like to have some real and exact information about the sustainability of the production process..." (m, 32) "For products especially, the price-performance ratio has to be right: It may cost a little more, but then it must also be reasonable." (w, 60)
		Animal testing	"I would like to know whether a company conducts animal experiments, as I do not buy the product then." (w, 32)
		Production country	"I like to check where a product comes from and where it is produced because I want to know if the quality is right." (w, 56)
	Information need on CCU company	Company's image	"For me, the company's image and the way a company is presented to the public are decisive." (w, 21)
		Environmental management	"I would be interested in information on the environmental management of the company including real facts." (m, 28)
		Company's employees	"I would like to know who is working for the company. If you know the people, then you get a picture of the company." (w, 32)
		…	
	Marketing issues	Simplified representation of CCU technology	"It should be explained and illustrated simply so that everyone can understand it." (w,30)
		Integrity	"The marketing of the CCU products should be seriously and professionally, and not an exaggerated advertisement." (w,60)
		Sustainability	"... so, I would definitely give the public an understanding of the environmental aspect of CCU and CCU products." (m, 52)
		Seal of approval	"... with a really clear seal of approval, which has been specially developed for it. ... It should also be certified by the federal government or specific institutes." (m, 52)
		Introduction to the company	"The company should be presented e.g. on television to gain insights behind the scenes..." (w, 24)
		Advertisement of the CCU technology	"In the first instance, the CCU technology itself should be promoted." (w, 32)
		sobriety	"Very simple. This is important. Not much around - simply the product. I think companies often try to deflect from products by focusing packaging, design, and so on..." (w,56)
Trust	Trust-building factors	Keeping promises	"It increases trust if the company keeps their promises referring the production process but also related to the products themselves." (w, 24)
		Professional behavior	"Of course, professional behavior and integrity supports trust." (w, 30)
		Good complaint management	"You should be taken seriously if you have any complaints..." (m, 52)
		Transparency	"... if the company is very explicit and clear about what it does and everything is transparent." (w, 56)
		Fair working conditions	"For me, it is important that the employees are treated reasonably and fairly." (m, 28)
		Complying of safety standards	"To know if safety standards are complied and are checked regularly supports trust and credibility." (w, 56)
		Good reputation of company	"... of course, well-known names are crucial: then I have more confidence than with unfamiliar names or imitated (cheap) products or so..." (m, 52)

(Continued)

TABLE 1B | Continued

Root category	Sub-category	Sub-sub-category	Exemplary statement
		Recognized certifications of company	" ... It should be certified by recognized institutions that the products are manufactured correctly..." (m, 28)
		Product quality	"If the products' quality simply keeps what the company promised." (m, 52)
		…	
	Distrust-factors	Contradiction between company's statements and action	"... e.g., if a product is suddenly completely different than it was before." (w, 56)
		Opacity	"... e.g., if it is simply not visible and comprehensible, how the processes are running." (w, 60)
		Unfriendly staff	"... and also if staff is unfriendly or reacts unfriendly on demands. This seems to me to be not very credible." (w, 56)
		Using terminology customers don't understand	"A very technical and not easy to understand language does not support credibility." (w, 60)
		Miserable working conditions	"Distrust results also from bad working conditions for employees or if they are mistreated." (m, 24)
		negative incidents regarding company	"A scandal, that is first tried to be concealed but then is busted, leads to absolute distrust and incredibility." (m, 32)
		…	
…	…	…	