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## Accepted Manuscript

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### **Highlights**

- A survey provides insight into what the general UK public think about CCU.
- Awareness of CCU is low – only 9% of respondents knew what it was.
- The majority of people (51%) are in favour of CCU deployment.
- Current unfamiliarity and poor understanding of CCU may hinder future deployment.
- However, this also presents an opportunity the better to inform the public on CCU.

## Public awareness and acceptance of carbon capture and utilisation in the UK

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### Abstract

This paper presents the results of a UK survey of public opinion on carbon capture and utilisation (CCU). The survey of 1213 adults was carried out using a questionnaire developed as a part of this research. The aim was to establish the extent of people's awareness and acceptance of CCU and to elicit the importance they put on different sustainability issues relevant to CCU. The survey findings suggest that there is a very low level of public awareness of CCU – only 9% of the respondents expressed confidence in knowing what it was. The study indicates that, while the general public are willing and able to express preferences for sustainability issues relevant for CCU, a relatively high rate of 'don't know' responses indicates that respondents were unable to comprehend certain aspects. As public acceptance is vital for successful implementation of novel technologies, the current unfamiliarity and poor understanding of CCU among the general public may hinder its future deployment. However, low levels of awareness and understanding of CCU also mean that there is a considerable potential for public perception to be shaped by relevant stakeholders.

### 1. Introduction

Carbon capture and utilisation (CCU)<sup>1</sup> is a broad term which covers a range of technologies that capture and convert carbon dioxide (CO<sub>2</sub>) into viable commercial products, such as construction materials, chemicals and fuels. Together with carbon capture and storage (CCS), CCU has been receiving increasing attention in recent years, particularly in the context of climate change as these technologies are being perceived as promising options for greenhouse gas (GHG) emissions mitigation (Styring et al., 2011).

It is easy to see the appeal of CCU from a climate change perspective: by capturing CO<sub>2</sub> emitted by various industrial plants and using it to manufacture fuels, chemicals or materials, the CCU technologies not only have the potential to reduce CO<sub>2</sub> emissions but could also lower the costs of climate mitigation and shift some of the costs onto willing consumers who would readily pay for the resulting goods and services (IPCC, 2005; IEA, 2014). Moreover, CCU can also result in value-added products that create jobs and economic benefits and may offer other non-climate benefits, such as industrial waste stabilisation or gains in competitiveness (Styring et al., 2011; Mun and Cho, 2013; Stolaroff et al., 2005).

Although some are already in industrial use, most CCU technologies are still at a relatively immature stage of development (GCCSI, 2011; Fraga and Ng, 2015). As the CCU technologies move from the development to execution stages, their public recognition and acceptance will become increasingly important for their successful implementation (VCI and DECHEMA, 2009). An important consideration for any new technology is an understanding of the public's viewpoint since in many countries this can influence the direction of its future development and deployment. As it has been well documented, people not only need to be convinced of the advantages of a novel technology, but also have to accept the perceived

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<sup>1</sup> Carbon capture and utilisation (CCU) is also known as carbon dioxide utilisation (CDU) but for the purposes of this article it will be referred to as CCU.

impacts it may have on their everyday lives (see, for instance, Fischhoff et al., 1978; Gardner et al., 1982; Baird, 1986; Alhakami and Slovic, 1994).

However, little is known about public awareness and understanding of CCU (Jones et al., 2014; Jones et al. 2015). In an effort to fill this knowledge gap, this paper presents the results of a survey which aimed at establishing the extent of people's awareness and acceptance of carbon capture and utilisation in the UK.

The survey was conducted using a questionnaire developed by the authors as part of the project "A Comprehensive and Coordinated Approach to Carbon Capture and Utilisation (4CU)". One of the aims of 4CU is to develop a methodology for evaluating the sustainability of CCU, focusing on technologies for converting CO<sub>2</sub> to fuels. The evaluation takes into account environmental, economic and social aspects of CCU. The survey of public opinion on CCU presented in this paper constituted an integral part of the methodology development, providing the researchers with an insight into what stakeholders think about carbon capture and utilisation and informing its sustainability assessment. For more information on the 4CU project, visit [www.4CU.org.uk](http://www.4CU.org.uk).

## 2. Research method

A survey using an on-line questionnaire and a subsequent descriptive/inferential analysis were used to capture and explore the emerging opinions of CCU within a (non-expert) cross-section of the UK population ( $n=1213$ ). The specific objectives of the survey were twofold:

- to establish the extent of people's awareness and acceptance of CCU; and
- to elicit the importance the general public place on different sustainability issues relevant to CCU and to gauge the level of public understanding of these issues.

A survey by an on-line questionnaire was selected in this research because of the need to consult a reasonably large sample to ensure that the public's views are as representative of the UK population as possible. For this reason, and taking into account the time and resources available to the project, interviews or focus group discussions were considered unfeasible. It was also deemed impractical to have an open-ended questionnaire due to the complexity and assumed public's unfamiliarity of the subject, so the questions were designed to focus on specific aspects with the respondents being able to choose among multiple-choice answers.

The questionnaire was developed in several steps. First, through an iterative process of discussing, brainstorming and analysing various techno-economic, environmental and social issues with a number of experts from academy and industry, a list of sustainability issues deemed to be relevant for CCU was identified. This was then used to develop a pilot questionnaire, containing a set of questions designed to gauge the importance and relevance of the selected environmental, economic and social sustainability issues to CCU stakeholders. This pilot was tested on a small sample of expert stakeholders ( $n=16$ ), including representatives from industry and academia. The outputs from this expert consultation were then used to inform the development of the full questionnaire that was eventually used in the survey.

The questionnaire included 24 questions divided into three sections:

- Section 1 focused on people's understanding of the issues related to climate change. It consisted of ten questions designed to assess how informed the respondents felt about climate change, in particular about causes and consequences of climate change and the ways in which we can combat climate change.
- Section 2 asked nine questions about CCU with the aim to examine people's awareness and acceptance of CCU as a climate change mitigation technology.

- In Section 3, the participants were asked five questions about the sustainability issues related to CCU. They were presented with a list of techno-economic, environmental and social issues (which were previously identified by experts as possible considerations when assessing the sustainability of CCU) and asked to express their opinion for each of the listed issues.

The questionnaire also included a range of questions to determine the demographics of the sample. The full questionnaire can be found in Supplementary Information.

The survey was conducted on-line using the services of TNS, a research agency which has access to a large cross-section of UK population. A sample of  $n=1213$  adults aged 16+ and demographically representative of the UK population was surveyed in February 2015. Selected demographic characteristics of the sample are shown in Table 1.

Care was taken to ensure that other research in the TNS research omnibus at the same time was dissimilar from this research in an effort to minimise any potential for crossover influence on responses. The representativeness of the data was controlled through sample design, quotas and weighting adjustment. Data were weighted for the following characteristics: age, sex, region, social grade and tenure. The results included here are based on the weighted data.

The following sections summarise and discuss the main results of the survey, focusing on public awareness and acceptance issues. Note that the results regarding the sustainability issues (section 3 of the questionnaire) are subject of a forthcoming paper and are not discussed here.

### 3. Results

#### 3.1 Awareness of and attitudes towards CCU

One of the key findings of the survey was that the awareness of CCU is very low – only 9% of respondents expressed confidence in knowing what CCU was.

The respondents were asked if they had ever heard of CO<sub>2</sub> capture and utilisation and whether they knew what was meant by it (Q10, Section 1 in the questionnaire). As shown in Figure 2, whilst over a third of the respondents (36%) indicated that they had heard of CCU, only 9% said they had heard of it and knew what it was. Less than a third (27%) indicated that they had heard of it but did not really know what it was. The majority, almost two thirds (61%), had not heard of CCU.

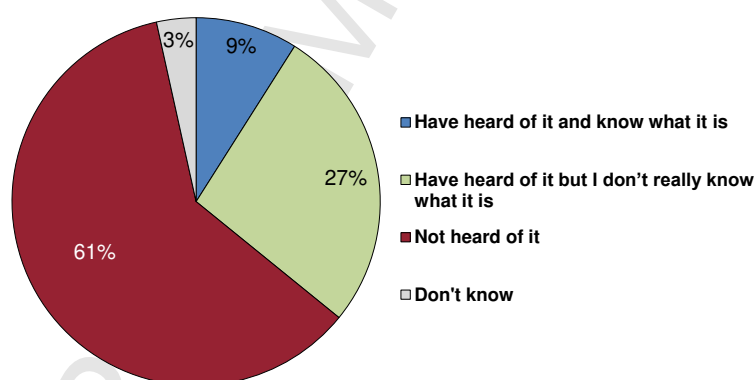
**Table 1 Summary of selected demographic characteristics of the sample (n=1213)**

Demographic characteristics		No. of respondents and percentage
SEX	Male	592 49%
	Female	621 51%
AGE	16-24	177 15%
	25-34	204 17%
	35-44	196 16%
	45-54	209

		17%
	55-64	169
		14%
	65+	259
		21%
WORK	Working	640
		53%
WORK	Not working	573
		47%
REGION <sup>a</sup>	North (Scotland/NE/Yorks/Humber)	399
		33%
	Midlands (East & West Midlands)	377
		31%
REGION <sup>a</sup>	South (South East/East of England/Greater London/Wales & West)	437
		36%
SOCIAL GRADE <sup>b</sup>	ABC1 (Middle Class)	652
		54%
	C2DE (Working Class)	561
		46%

<sup>a</sup> Excluding Northern Ireland.

<sup>b</sup> The social grade classification presented here follows the definitions of the National Readership Survey (NRS) for social grades which are a generic reference series for classifying and describing social classes (NRS, undated). The classifications are based on the occupation of the head of the household. The grades ABC1 equate to the middle class and C2DE equate to the working class. Note that only around 2% of the UK population is identified as the upper class and this group is not included in the classification scheme.



**Figure 1 Awareness of CCU (Base: n=1213).**

These findings on the level of awareness of CCU are very much compatible with the results of recent surveys on the public awareness of similar technologies, such as CCS. For instance, in a public attitudes survey conducted in the UK in March 2015, awareness of CCS polled at 38% (DECC, 2015).

There were a few demographic sub-group differences in terms of whether people have heard of CCU (see Table 2). With regard to socio-demographic characteristics, chi-square tests revealed that there was a significant difference between female and male respondents regarding the level of awareness on CCU. The data indicate that men are more likely to know something about CCU: 74% of the respondents who said that they have heard about CCU and knew what it was were male, while only 26% were female. Interestingly, a similar type of survey on CCS found corresponding gender differences in the self-reported awareness (Special Eurobarometer, 2011). Unsurprisingly, the knowledge of CCU was also

related to education, as the higher-educated respondents were more likely to know about CCU (Table 3).

**Table 2 Awareness of CCU by gender and age**

	Total	Heard of and know what it is	Heard of but don't know what it is	Not heard of	Don't know
Respondents	1213	109	326	736	42
Male	592 49%	80 74%	195 60%	295 40%	22 53%
Female	621 51%	29 26%	132 40%	440 60%	20 47%
16-24	177 15%	21 20%	50 15%	89 12%	16 39%
25-34	204 17%	20 18%	48 15%	130 18%	6 14%
35-44	196 16%	19 17%	59 18%	107 15%	10 25%
45-54	209 17%	11 10%	55 17%	136 19%	6 15%
55-64	169 14%	15 13%	42 13%	111 15%	1 2%
65+	259 21%	23 21%	72 22%	162 22%	2 5%

**Table 3 Awareness of CCU by education**

	Total	CGCSE/ O-level/ CSE	Vocational qualification (NVQ1+2)	A level or equivalent (=NVQ3)/ BD or equivalent (=NVQ4)	Masters/PhD/ Other	No formal qualifications
Respondents	1213	374	153	557	112	90
Heard of and know what it is	109 9%	14 4%	9 6%	67 12%	23 21%	3 3%
Heard of but don't know what it is	326 27%	90 24%	49 32%	168 30%	35 31%	16 18%
Not heard of	736 61%	261 70%	91 59%	308 55%	53 47%	64 71%
Don't know	42 3%	9 2%	4 3%	14 2%	1 1%	6 7%

As mentioned in the previous section, the questionnaire included several questions designed to assess how informed the respondents felt about climate change, in particular about causes and consequences of climate change and the ways in which we can combat climate change (Section 1 of the questionnaire). One of the reasons for the inclusion of these questions was to test if and how the respondents' underlying views and beliefs about climate change were related to or influenced their perceptions of CCU.

The responses show a clear correlation between the respondents' interests in and knowledge of climate change issues and their awareness of CCU (see Table 4). The respondents with interests in and knowledge of climate change issues were more likely to have heard about CCU than those who did not have interests in or felt informed about climate change.

**Table 4 Awareness of climate change and the corresponding awareness of CCU**

	Total	Heard of and know what it is	Heard of but don't know what it is	Not heard of	Don't know
<b>Respondents</b>	1213	109	326	736	42
Very well informed	107 9%	36 33%	34 10%	31 4%	6 15%
Fairly well informed	591 49%	60 55%	200 61%	315 43%	15 36%
Not very well informed	404 33%	10 10%	80 25%	305 41%	9 22%
Not at all informed	77 6%	2 2%	7 2%	67 9%	- 1%
Don't know	35 3%	- -	6 2%	18 2%	11 26%
Net: Informed	697 57%	96 88%	233 71%	346 47%	21 51%
Net: Not informed	481 40%	13 12%	87 27%	372 51%	9 23%
Mean score	2.62	3.19	2.81	2.43	2.89
Standard deviation	0.74	0.689	0.637	0.72	0.754
Error variance	0	0.004	0.001	0.001	0.018

The respondents were also asked to state to what extent they agreed or disagreed with the statement "Climate change is important to me personally" on a scale from "Strongly disagree" to "Strongly agree" (Q1). Amongst the respondents who indicated that they knew what CCU was, 75% also stated that climate change issue was important to them personally, while only 11% of them did not regard climate change as personally important (Table 5).

**Table 5 Relations between the respondents' awareness of CCU and personal importance of climate change**

	Total	Heard of and know what it is	Heard of but don't know what it is	Not heard of	Don't know
<b>Respondents</b>	1213	109	326	736	42
Strongly agree	192 16%	39 36%	70 21%	81 11%	3 8%
Agree	450 37%	43 39%	142 43%	254 35%	11 27%
Neither agree nor disagree	384 32%	15 14%	76 23%	274 37%	20 47%
Disagree	116 10%	6 5%	23 7%	84 11%	3 7%

Strongly disagree	42 3%	7 6%	8 3%	26 4%	1 2%
No opinion	20 2%	- -	8 2%	11 2%	1 2%
Don't know	9 1%	- -	1 0.3%	5 1%	3 6%
Net: Agree	642 53%	81 75%	211 65%	335 46%	15 35%
Net: Disagree	158 13%	12 11%	31 9%	111 15%	4 10%
Mean score	3.54	3.93	3.76	3.39	3.34
Standard deviation	0.992	1.12	0.959	0.958	0.856
Error variance	0.001	0.012	0.003	0.001	0.019

### 3.2 Opinions about the effectiveness of CCU in combating climate change

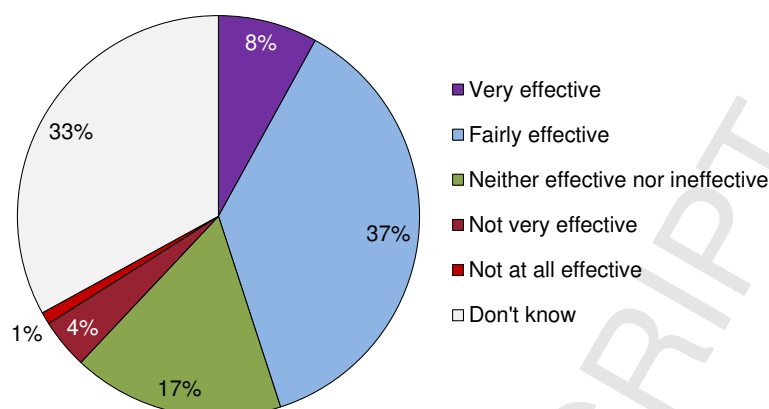
In Section 2 of the questionnaire, a brief definition of CCU was provided before the respondents were asked about their opinions about CCU. The following definition of the CCU technology was presented to the respondents:

*“Carbon capture and utilisation is a technology for capturing carbon dioxide emitted by various industrial plants (e.g. power plants) and using it to manufacture fuels, chemicals and materials.”*

The respondents were then asked several questions designed to gauge their opinions of CCU. Specifically, they were asked if they thought the CCU technology could be effective in combating climate change. The respondents were asked to give their response by using a five-point scale ranging from ‘very effective’ to ‘not at all effective’. As can be seen in Figure 2, more than four in ten people (45%) felt that CCU could be effective in combating climate change. More than a third (37%) felt the CCU technology could be ‘fairly effective’, while further 8% believed it could be ‘very effective’. Overall, a much higher proportion of the respondents thought that CCU could be effective in combating climate change (45%) than those who did not (5%). However, a third (33%) said that they ‘didn’t know’ whether CCU technology could be effective or not.

The respondents with prior awareness of CCU were more likely to think that CCU would be effective than those without prior awareness (68% vs. 35%).

There were some demographic sub-group differences in terms of how effective people thought that the CCU technology would be in reducing CO<sub>2</sub> emissions. Those with no formal qualifications were below average in terms of the proportion who thought that the CCU technology would be effective in combating climate change (Table 6). Younger respondents were more likely to see CCU as an effective climate change mitigation technology, in particular the 16-24 age group: 53 % of the youngest respondents thought CCU could be effective in combating climate change, while on average just over 40% of the participants from older age groups indicated the same (Table 7).



**Figure 2 Opinions about the effectiveness of CCU in combating climate change**  
(Q11: In your opinion, taking into account all you know about carbon capture and utilisation, do you think it could be effective or not in combating climate change? Base: n=1213)

**Table 6 Opinions about the effectiveness of CCU in combating climate change by education (Base: n=1213)**

	Total	CGCSE/ O-level/ CSE	Vocational qualification (NVQ1+2)	A level or equivalent (=NVQ3)/ BD or equivalent (=NVQ4)	Masters/PhD/ Other	No formal qualifications
<b>Respondents</b>	1213	374	153	557	112	90
Very effective	98 8%	30 8%	12 8%	38 7%	16 14%	5 5%
Fairly effective	446 37%	124 33%	58 38%	238 43%	46 41%	18 20%
Neither effective nor ineffective	212 17%	67 18%	32 21%	81 15%	11 10%	30 33%
Not very effective	54 4%	13 4%	4 3%	33 6%	7 6%	- -
Not at all effective	10 1%	- *	- -	3 1%	3 3%	3 3%
Don't know	394 33%	140 37%	47 31%	164 29%	28 25%	35 38%
Net: Effective	543 45%	154 41%	70 46%	276 50%	62 56%	23 25%
Net: Not effective	63 5%	14 4%	4 3%	36 6%	10 9%	3 3%
Mean score	3.69	3.72	3.74	3.7	3.78	3.39
Standard deviation	0.809	0.764	0.708	0.789	0.971	0.857
Error variance	0.001	0.002	0.005	0.002	0.011	0.013

**Table 7 Opinions about the effectiveness of CCU in combating climate change by age (Base: n=1213)**

Respondents	Total	16-24	25-34	35-44	45-54	55-64	65+
	1213	177	204	196	209	169	259
Very effective	98 8%	14 8%	20 10%	14 7%	18 9%	8 5%	24 9%
Fairly effective	446 37%	79 45%	67 33%	59 30%	68 33%	69 41%	103 40%
Neither effective nor ineffective	212 17%	20 11%	43 21%	40 21%	30 14%	37 22%	41 16%
Not very effective	54 4%	8 4%	6 3%	8 4%	12 6%	5 3%	15 6%
Not at all effective	10 1%	- -	1 *	- -	2 1%	3 2%	4 2%
Don't know	394 33%	55 31%	67 33%	75 38%	78 37%	47 28%	72 28%
Net: Effective	543 45%	94 53%	87 43%	72 37%	86 41%	77 46%	127 49%
Net: Not effective	63 5%	8 4%	6 3%	8 4%	14 7%	8 4%	19 7%
Mean score	3.69	3.83	3.73	3.64	3.67	3.62	3.68
Standard deviation	0.809	0.719	0.779	0.769	0.882	0.772	0.876
Error variance	0.001	0.004	0.004	0.005	0.006	0.005	0.004

### 3.3 Opinions about deployment of CCU in the UK

The respondents were asked about their preferences about possible use of CCU in the UK. They were asked to indicate on a five-point-scale (from 'totally in favour' to 'totally opposed') to what extent they would be in favour or opposed 'if production plants for carbon capture and utilisation were to be constructed in the UK' (Q12). The overall response is provided in Table 8. Just above a half (51% NET) were in favour of CCU while only 2% of the respondents indicated opposition to CCU. However, almost of a quarter of the respondents were indifferent (23% of 'neither in favour nor opposed' responses) and 17% 'didn't know'.

Amongst the age groups, the 65+ group were the most in favour of the deployment of CCU: 60% of the respondents from this group indicated that they would be either 'totally' or 'fairly' in favour, while the 35-44 age group respondents were the least enthusiastic, with only 37% in favour of the deployment of CCU in the UK. Male respondents expressed a higher level of support for CCU than female respondents (56% vs 46%) although the level of opposition was similarly low for both genders: 3% and 2% respectively.

The responses also indicated that there was a correlation between the level of awareness and knowledge of CCU and support for its deployment, as the respondents who were knowledgeable about CCU were more in favour of its deployment in the UK than other sub-groups (see Table 8).

**Table 8 Correlation between the level of awareness and knowledge of CCU and support for its deployment (Base: n=1213)**

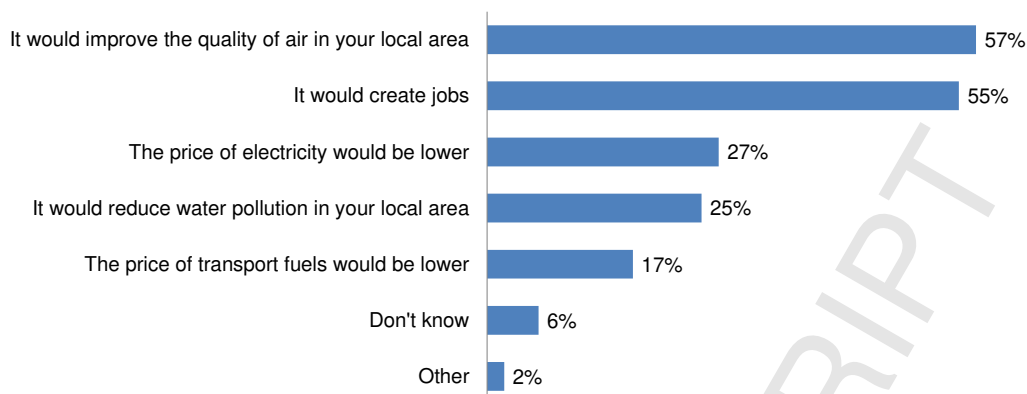
	Total	Heard of and know what it is	Heard of but don't know what it is	Not heard of	Don't know
<b>Respondents</b>	<b>1213</b>	<b>129</b>	<b>333</b>	<b>706</b>	<b>45</b>
Totally in favour	170 14%	34 31%	60 18%	72 10%	4 9%
Fairly in favour	444 37%	45 41%	146 45%	249 34%	4 10%
Neither in favour nor opposed	284 23%	19 18%	73 22%	178 24%	14 33%
Fairly opposed	23 2%	6 6%	4 1%	13 2%	1 2%
Totally opposed	5 0%	2 2%	1 0%	2 0%	- -
No opinion	80 7%	2 2%	14 4%	64 9%	- 1%
Don't know	206 17%	1 1%	29 9%	158 21%	19 45%
Net: In favour	614 51%	78 72%	207 63%	321 44%	8 19%
Net: Opposed	29 2%	8 8%	5 1%	15 2%	1 2%
Mean score	3.81	3.96	3.92	3.73	3.5
Standard deviation	0.779	0.962	0.74	0.743	0.833
Error variance	0.001	0.009	0.002	0.001	0.031

### 3.4 Perceived benefits from CCU technology

The respondents were asked about their perception of possible benefits from the CCU technology if it were used in their community (Q13). Overall, CCU was seen as a potentially beneficial technology. Just over a half of the respondents (51%) believed that they would benefit from CCU if 'a production plant for carbon capture and utilisation were located' in their community, while only 11% thought that they 'would not benefit'. However, a large proportion, nearly four in ten (39%), 'did not know' whether or not they would benefit if CCU technology were used in their community.

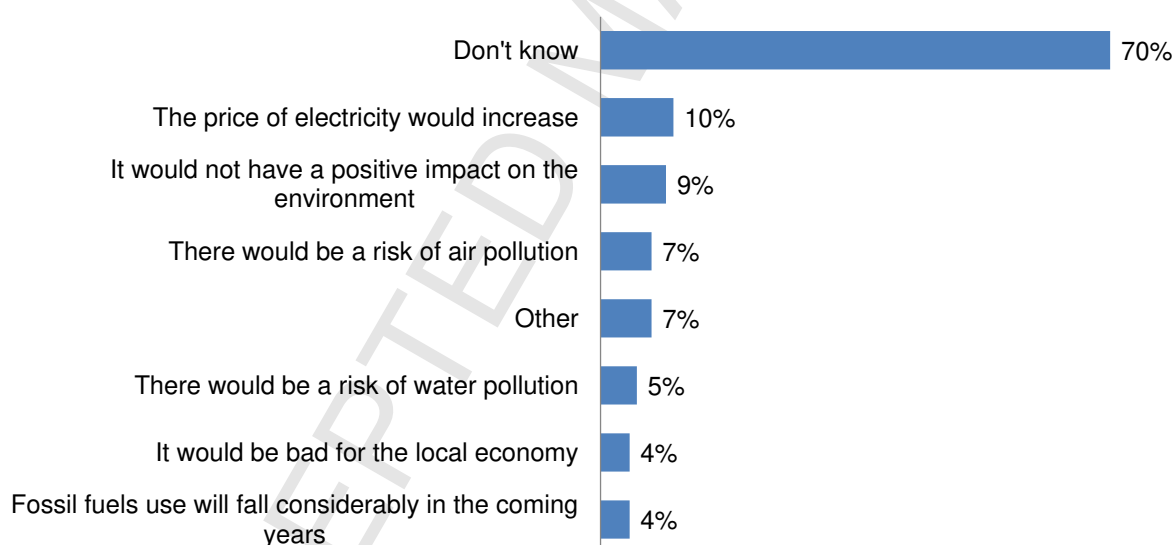
The respondents who had indicated that they thought they would benefit from CCU technology were asked about the reasons why. They had options to pick 'as many as applied' reasons from a pre-prepared list and/or to name other reasons they thought appropriate (Q14). Their responses are shown in Figure 3.

Two main reasons why people thought they would benefit from CCU technology (chosen from the pre-prepared list) were 'improvement in the local air quality' (57%) and 'job creation' (55%). Just above a quarter of the responses (27%) specified that CCU technology would result in lower electricity prices and a quarter (25%) indicated that 'it would reduce water pollution in the area'. 'Other' responses indicated that some respondents saw CCU as beneficial to them personally because of its potential to 'reduce atmospheric CO<sub>2</sub>' and 'help with climate change' and 'therefore benefits us all'.



**Figure 3 Summary of responses from respondents who said they would benefit from CCU (Q14. If you think you would benefit from a production plant for carbon capture and utilisation in your community, please tell us why you think so? Base: n=610)**

Those respondents who felt that they would not benefit from CCU technology if it were used in their community were asked why not. They also had had options to pick 'as many as applied' reasons from a pre-prepared list and/or to name other reasons they thought appropriate (Q15). As shown in Figure 4, seven in ten of the respondents who said they would not benefit from CCU responded with 'don't know' when asked for the reason why they thought they would not benefit. Other most frequent responses chosen by those who believed that they would not benefit from CCU were: 'it would lead to higher electricity prices' (10%) and 'it would not have a positive effect on the environment' (9%).



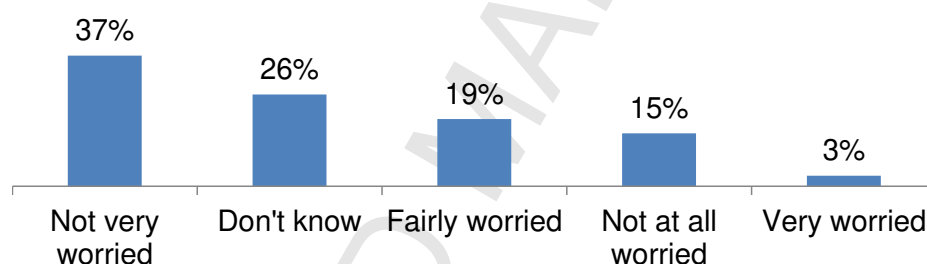
**Figure 4 Summary of responses from respondents who said they would not benefit from CCU (Q15. If you think you would not benefit from a production plant for carbon capture and utilisation in your community, please indicate why you think so? Base: n=131)**

Analysis of responses about perceived benefits from CCU shows that there was a higher percentage of positive responses among the respondents with a higher level of awareness of CCU: 72% of those who knew what CCU was believed that they would benefit from it. Those who thought that CCU technology would be effective also thought that they would benefit from the technology. Those who indicated that they were informed about climate change were also more likely to think that they would benefit from CCU.

In terms of sub-group demographics, there were notable differences between age groups. Younger respondents, in particular the 16-24 age group, were the most likely to anticipate benefits: 63% of the 16-24 age group perceived CCU as potentially beneficial to them personally. On the other hand, less than a half (47%) of the oldest group (65+) thought they would benefit from CCU. Younger respondents were also less likely to answer 'don't know' on this particular question.

### 3.5 Safety concerns

Novel, unfamiliar technologies usually raise safety concerns – CCS and hydraulic fracturing ('fracking') are just some of most recent examples where the general public have expressed their anxieties and worries about safety impacts of the new technologies (Shackley et al. 2007; Cooper et al., 2016). In order to gain insight into potential safety concerns about CCU, the respondents were asked to indicate whether they would be worried about possible location of a CCU plant within their community. They were asked to give their responses, using a four-point scale ranging from 'very worried' to 'not at all worried'. As indicated in Figure 5, more than a half of the respondents (52%) indicated that they would not be worried while 22% said they would be worried. However, around a quarter of the respondents (26%) said that they did not know whether they would be worried or not.



**Figure 5 Summary of responses about perceived safety of CCU** (Q16 If a production plant for carbon capture and utilisation were to be located within your community, do you think that you would be...? Base: n=1213)

The respondents who said they were worried about the location of CCU facilities close to their homes were asked why they would be worried about them (Q17). Several responses were listed and multiple answers were possible. Main concerns among the 'worried' respondents were possible negative effects on the environment and health, and 'the risk of leaks while the site is in operation'. More than 40% indicated that 'possible negative effects on the environment and health' were reasons why they would worry about local CCU facilities. A similar number (43%) cited 'the risk of leaks while the site was in operation' as a concern. Nearly four in ten (38%) mentioned that 'transport of CO<sub>2</sub> to the site may not be safe'. In addition, 36% were concerned about 'a possible drop in local property prices' and 16% worried about 'the risk of terrorist attack' (see Figure 6).

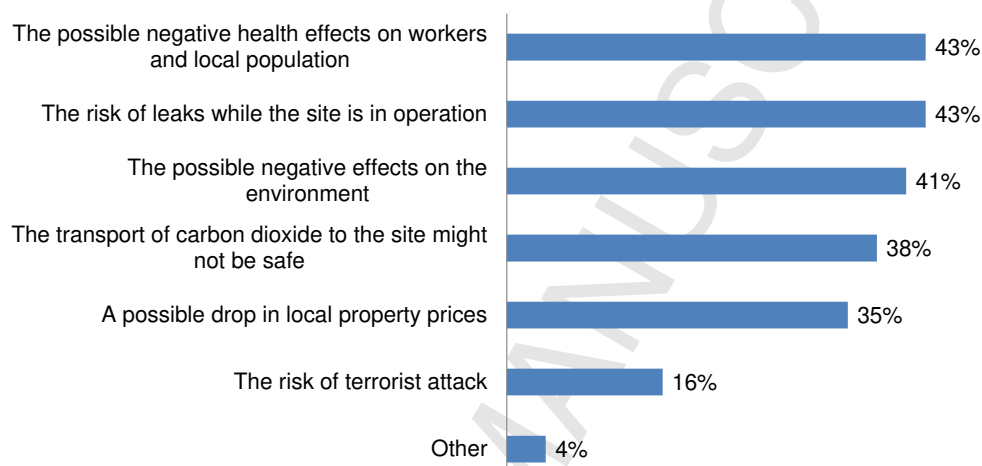
Four percent of the respondents added other reasons for concerns. Examples of these other concerns mentioned, albeit not necessarily safety ones, included:

- *'As long as we are investing in ways to keep using fossil fuels, there will be little investment in renewables.'*
- *'Cop out from real renewables.'*
- *'Yet another 'green' waste of money.'*

- *'Increased traffic.'*

Older respondents (65+) were the least likely to be worried about the location of CCU facilities in their community, with 64% saying they would not be worried. Men were also less likely to be worried than women: 59% of male respondents indicated that they would not be worried compared to 45% of female respondents. This is in line with a well-documented tendency of males to be less concerned with risk than women, often referred to as 'the white male effect' (Flynn et al., 1994).

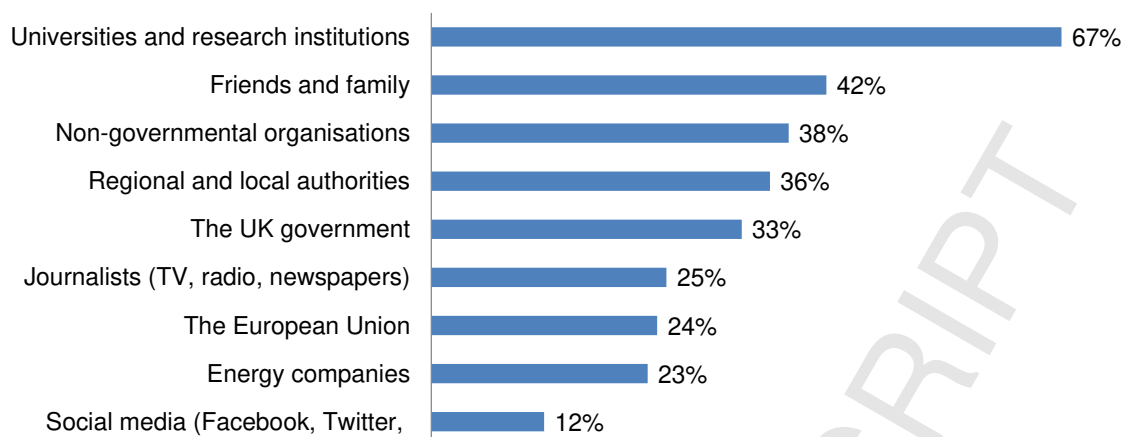
Interestingly, the respondents who indicated that they were familiar with CCU were more likely to express safety concerns: more than a third (38%) of those who claimed they knew what CCU was indicated that they would be worried about the deployment of CCU in their community compared to only 20% of those who said that they'd never heard of CCU.



**Figure 6 Summary of responses from 'worried' respondents** (Q17. If your answer to Q16 was "Very worried" or "Fairly worried", please tell us why you would be worried? Base: n=291)

### 3.6 Sources of information about CCU

Public acceptance of a new technology often depends on information disseminated by media and professionally involved actors such as national governments, local authorities, NGOs, and industrial stakeholders (Huijts, 2007). With this in mind, the questionnaire included a question which asked respondents to indicate how much they would trust various organisations in terms of providing information about CCU (Q18). They were presented with a list of institutions and asked to indicate on a five-point scale (from 'totally trust' to 'totally distrust') their level of trust in each of prospective information providers. The results in Figure 7 suggest that universities and research institutions are the most trusted sources of information about CCU while energy companies and social media are the least trusted. These two sources of information were trusted to a greater extent by those who were knowledgeable about CCU than those in other sub-groups, while there were no significant differences in the level of trust/distrust in energy companies amongst the sub-groups.



**Figure 7 Trust in information sources about CCU: Net trust** (Q18. Please indicate how much you would trust information about carbon capture and utilisation if you heard it from... Base: n=1213)

#### 4. Discussion

As mentioned earlier in the paper, more than 60% of the respondents indicated that they had never heard of CCU before participating in the survey, while 27% said that they had heard of it but did not know much about it. Measuring a level of awareness using questions such as 'Have you ever heard of...' relies on self-reporting which is indeed sensitive to the bias that respondents might indicate that they have heard of a particular subject in order to appear knowledgeable or to give an answer they think is expected from them. Bearing in mind the likely presence of the bias against admitting ignorance and the fact that, generally speaking, polls tend to overstate recognition, the low response rates for self-reported awareness of CCU appear even more striking. In addition, a relatively high rate of 'don't know' responses and the respondents' comments suggest further that for the large majority of the general public in the UK CCU is still very much an unfamiliar technology.

The survey results show that, despite the reported low levels of familiarity and awareness, the perceptions regarding the deployment of CCU and its potential role in climate change mitigation, as revealed by mean values and standard deviations, are largely positive. It should be noted that the perceptions of CCU described in this paper, are indeed initial perceptions as they were reported by respondents with little or no information about carbon capture and utilisation.

Initial perceptions of an unfamiliar technology, precisely because they are reported by people who have little or no knowledge about the technology, can be expected to be strongly influenced by new information. At appropriate points in our survey the respondents were provided with some information to help them answer the questions. For instance, while evaluating the initial perceptions regarding CCU, the respondents were given a very brief description of what CCU entails. Brief descriptions of relevant sustainability issues were also embedded in the questions about their importance to the respondents. However, the information provided was limited in scope and aimed mainly at facilitating meaningful responses rather than educating or extensively informing the respondents about CCU.

Taking into account the very low level of self-reported awareness of CCU, and, as mentioned above, limited information on CCU provided in the questionnaire, public views expressed in our survey could be classified as largely uninformed opinions. Previous research on public perceptions of unfamiliar technologies, for example a number of quantitative surveys on public acceptance of CCS, has indicated that uninformed respondents are nevertheless willing to express their opinion when asked to do so in a survey (De Best-Waldhober et al., 2009). Our study confirms that trend – the respondents in

our survey were able and willing to express their opinions on a range of issues regarding CCU despite the self-reported low levels of familiarity with the technology.

As such opinions are formed in the moment of answering the questionnaire they are habitually referred to as “pseudo-opinions” (Bishop et al., 1980). It has been argued that these uninformed opinions are weak and unstable, and as such regarded as unsuitable for predicting future public support or opposition to a technology (Jones et al., 2014; Malone et al., 2010).

However, while acknowledging limitations of the insight based on initial, uninformed public perceptions, one could argue that it is, nevertheless, desirable to know about public perceptions of a technology such as CCU as early as possible - exactly because only few people have developed strong attitudes. As previous research on public perceptions of similarly unfamiliar technologies has indicated, opinions change with increasing exposure to information (Shackley et al., 2005; Upham and Roberts, 2011). Hence, it is reasonable to expect that future communications about CCU will heavily influence initial perceptions people hold. The current low levels of awareness and understanding of CCU mean that there is considerable potential for public perception to be shaped by relevant actors. Gaining an early insight into public, albeit uninformed, opinions may therefore prove to be a valuable tool for a future communication strategy enabling it to have a stronger impact on the development of public attitudes towards CCU.

## 5. Conclusions

The results of our survey illustrate that, overall, the general public in the UK is not yet familiar with CCU. The results also indicate that there is a relatively high level of initial acceptance, and, in principle, a very low level of opposition to CCU, albeit built on very limited knowledge and a low base of awareness.

To the best of our knowledge, our study was the first survey on carbon capture and utilisation in the UK that consulted a large and nationally representative sample. However, whilst the survey allowed for a wide public participation, it did not guarantee that those taking part were fully engaged and/or understood all the technical and scientific aspects embedded in the questionnaire. We fully acknowledge these limitations but nevertheless believe that the results of the survey provide a valuable preliminary insight into the current level of awareness and acceptance of CCU in the UK.

We consider this survey as only the first step towards a better understanding and integration of the public's views into the sustainability assessment of CCU. The second step relates to integrating the results from consultations, such as the survey discussed in this paper, into the assessment process itself. In reality, to gain a fully involved and representative view from the public regarding CCU, much more than a single questionnaire would be required. Other means, such as facilitated focus groups and research interviews should be pursued in an effort to gain a deeper understanding of what people think about CCU, whether they regard it as a sustainable technology and, perhaps more importantly, whether they want to see it commonly deployed in the UK.

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