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Abstract

This report gives an overview on existing surveys on the acceptance of CO_2 capture and storage and examines the existing literature on the acceptance of CO_2 capture an storage on a European and on a worldwide level. The applied methodologies as well as the findings on the acceptance in important literature sources are reviewed and compared. For the estimation of possible future acceptance of CO_2 capture and storage, possible comparisons to other energy technologies are analysed. Final conclusions are made drawn for the empirical research on CCS within the DYNAMIS project.

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1 OBJECTIVES

Work package 6.4 “Professional and public acceptance for carbon capture and storage activities” aims at identifying preconditions which have to be fulfilled in order to guarantee the broad public acceptance and the support of relevant stakeholders for carbon capture and storage. As a first step, the state of the art of existing findings on public acceptance was evaluated. Since 2000, a number of surveys were carried out in different countries focusing on the empirical investigation of general awareness of CCS issues in the public, attitudes and influencing factors on public opinion.

The evaluation of existing literature is seen as a background for own empirical investigations within the project and for recommendations of accompanying activities to the implementation of potential storage sites in selected areas, e. g. arguments, information campaigns, motivation of stakeholders as well as for the identification of critical areas, which could lead to barriers for the acceptance of CCS, e. g. the perception of technical risks, negative ecological impacts, etc.

The general assumption was that the broad public is not yet aware of the CCS issues. There are only few reports in mass media. They are more or less neutral towards CCS technologies and do not affect the public opinion so far. This is expected to change as soon as sites will be discussed or selected for the installation of a CO_2 storage and field experiments will be carried out. In the past the implementation of other large-scale technologies showed that broad opposition occurred first in regions concerned, e. g. nuclear disposal, large power stations, etc.

Another assumption was that people are not enough informed about the CCS technologies, so that they are not able to evaluate disadvantages and benefits. In this case attitudes are largely influenced by other factors, such as actors or communication sources and general feelings towards technology.

The scope of studies in this report will not be restricted to the European Union, because also findings from Australia, Japan, Canada or the US are interesting for further work. Currently further interesting studies are being published and will be evaluated. The report will be completed by the end of phase 1 of the project. Finally, also experiences from the introduction of other energy technologies will be included.

2 OVERVIEW OF EMPIRICAL STUDIES ON CCS ACCEPTANCE

Only in a few countries empirical studies on CCS acceptance were found. In Europe, studies are known from the Netherlands, Sweden and UK. Various methodological approaches were used, from discussions in small groups to written surveys with a large number of respondents. There are examples for studies based on perceptions of the broad public as well as on stakeholder or expert judgements. Table 2.1 shows an overview of studies.

Table 2.1: Surveys of public acceptance of CCS

Country	Type of survey	Sample	Date	Source
Australia	telephone interviews	900 respondents 35 key persons and citizens	2005	Ashworth et al. 2006
Canada	focus groups and internet-based national survey	1,972 respondents 2 group discussions	2004/05	Sharp et al. 2006
Japan	written questionnaire	267 + 423 students	2003, 2005	Tokushige et al. 2006, Itaoka et al. 2006
Japan	experiment	25 students	2003	Uno et al. 2004
Japan	written questionnaire group discussions	60 students 34 students or lay persons	2003	Uno et al. 2004
Netherlands	face-to-face explorative interviews	112 residents in areas with natural gas storage	2003	De Conninck/ Huijts 2004
Netherlands	(written) “information-choice questionnaire” “traditional” questionnaire	995 respondents 327 + 300 respondents	2004	De Best-Waldhober/ Daamen 2006
Netherlands	experiment	78 students from Leiden University		Terwel et al. 2006
Netherlands	interviews and workshop	stakeholders		Van Alphen et al. 2006
UK	face-to-face interviews	212 persons at Liverpool airport and 2 discussion groups	2002/03	Shakley et al. 2004
UK	group discussions	2 panels (10 students and 9 citizens)	2001	Gough et al. 2001
US	qualitative interviews and written questionnaire	18 + 126 respondents in Pittsburgh, area	2003	Palmgren et al. 2004
US	internet-based survey	1,236 respondents nation-wide	2006	Ansolabehere et al. 2006
EU	EU-wide survey: written questionnaire	results not yet available	2006	Flagstad et al. 2006
UK, US, Can, NZ, Australia	screening of print media	36 media analysed over 312 days	2006	Mander/Gough 2006
	International comparison			Reiner et al. 2006
Japan	written questionnaire	1,006 respondents (sample in Tokyo and Sapporo)	2003	Itaoka et al. 2004
UK	internet-based survey	1,056 respondents (national sample)	2003	Curry et al. 2005
US	internet-based survey	1,205 respondents	2003	Curry et al. 2004
Sweden	written questionnaire	742 respondents (sample)	2003	Johnsson 2006

2.1 Europe

2.1.1 The Netherlands

The Energy Research Center of the Netherlands (De Conninck/ Huijts 2004) carried out an *inquiry on public perception of CCS in the region around Alkmaar* in the Northwest of the Netherlands, located above a gas storage field. In 2003, 112 inhabitants were interviewed personally, 84 % of them were aware of the gas storage, in particular as in the past this underground caused some small earthquakes. They received first some information about climate change, CCS technology, the possibility of storage in the region and potential risks. Finally they were informed about the view of industrial, governmental and environmental actors.

The study revealed that the respondents' information level was very low. It was assumed that their opinions mainly followed more the view of the most trusted institutions, the NGOs, than of other actors such as government or industry, but the results were ambiguous. In general the attitudes towards CCS were slightly positive, but more negative than positive associations with CCS were reported. Potential risks were higher rated than benefits for the society and even more for the respondents personally. Above all, a clear NIMBY feeling was found (Not In My Back Yard): the respondents were negative about CO_2 storage in their neighbourhood.

A study of the Center for Energy and Environmental Studies at the University of Leiden (De Best-Waldhober/Daamen 2006) applied a special method in order to receive useful answers in a situation of low information level of the respondents: an "*information-choice questionnaire*". The respondents (995) were asked to rate six different options of CCS with regard to their potential to reduce CO_2 emissions and to fulfil the national goals. They were informed about the background of these options and their role and on the consequences of these options. Their task was to rate each of these consequences on a scale between "big advantage" and "big disadvantage". On this basis each option could be determined as preferred or unacceptable. Between 12 and 24 % ranked the various options positively whereas only 4 to 6 % ranked them negatively.

For a comparison two smaller groups (327 and 300 respondents) received a "traditional" questionnaire covering evaluation of the global warming problem, CCS in general and the six CCS options in the same wording, but without any kind of information and without the description of consequences of the options. Most of the respondents stated that they have never heard of the specific technologies mentioned. After some minutes when they received a little bit of information (first group) or no information (second group, performing an unrelated task in the meantime) they were asked again to evaluate the options and it was observed that the opinions changed largely. The first group judged the options slightly more positive, the second group slightly more negative.

The authors conclude that uninformed respondents produce unstable, "pseudo" opinions and recommend the use of the information-choice questionnaire method. However it has to be stated that the options presented as well as the consequences to be evaluated were extremely complex for lay persons and that this method presupposes really "neutral" information and explanation. The authors plan to extend their studies and to cover also completely other energy options, e. g. renewables, nuclear energy, etc. in addition to CCS options.

At the University of Leiden an *experiment* was carried out with 78 students (Terwel et al. 2006). The participants were allocated to four groups where two conditions varied: the source of communication was either NGOs or industry and the issues communicated were either environ-

mental or economic arguments in favour of CCS. Finally they answered a questionnaire on their trust in the organisations, perceived honesty, competence, and concern for public interests. The hypothesis was that trust in organisations is higher after the provision of arguments that are congruent with the attributed motive than after the provision with incongruent arguments. The results pointed in this direction but were not significant. Perceived honesty accounted for different levels of trust. The authors assume that perceived competence is a further relevant factor. This was the starting point for another study (ter Moers et al. 2006). In an experiment 100 students from the Leiden University were allocated to four groups with the conditions low/high expertise and low/high trustworthiness of communicators. The results show that characteristics of communicators influence quality perception and acceptance of a message, but the influence is lower when communicator characteristics are incongruent. This implies that proponents – or opponents – of CCS should be perceived positively on multiple characteristics, e. g. competent and trustworthy, in order to be convincing.

The Department of Innovation Studies in the University of Utrecht carried out *interviews and a workshop with stakeholders* (van Alphen et al. 2006). Considering the fact that the information level of CCS is low in the public this approach was selected because it is argued that stakeholders are involved in the implementation of a technology, but also represent organisations which influence public opinion, e. g. via mass media. The persons surveyed were selected according to exactly these criteria. They belong to Government, Industry (associations), and environmental NGOs. The issues covered were twofold: firstly general attitudes regarding CCS and its role to combat climate change and secondly opinions on conditions which have to be fulfilled for broad implementation. In a further step stakeholders were invited to a workshop based on a computer system where participants can vote or present ideas simultaneously in order to encourage an open discussion. The advantage of this method was that stakeholders got in contact with each other and could outline a consensus.

The core consensus of the stakeholders was positive towards CCS. They agreed on the view of climate change as a serious problem which has to be addressed by all measures: energy efficiency improvements, deployment of sustainable energy sources and also CCS. CCS is seen as a temporary way of fast and easy achieving large amounts of CO_2 reductions. They also emphasised that the climate problem is a global one and needs a global approach.

For environmental NGOs CCS is a necessary technology but not the first choice. Priority is laid on energy efficiency and renewable energies. The energy industry pointed out that CCS causes additional costs and lowers the overall efficiency of plants. In addition, it considered the technology not yet sufficiently developed to be used on large scale. The position of representatives from governmental institutions reflects the above mentioned core consensus of the whole group of respondents. They argued that they support the technology when it is safe, but want to leave the choice of implementation to the market.

The stakeholders widely agreed on the conditions for CCS implementation: above all safety, but also temporality for several decades only, simplicity, financial stimuli, cooperation between different sectors and acceptance by the broad public. Suggestions were made, such as initiation of pilot projects, regulations and standard setting for site selection, operation and monitoring, inclusion of CCS in the emission trading system, and effective communication to the public.

2.1.2 United Kingdom

In 2001, the Tyndall Centre of the Manchester School of Management asked a *small sample of lay persons* on CCS issues (Gough et al. 2001). The method of group discussion was chosen because it allows a discussion with mutual stimulation and a very detailed understanding of attitudes and underlying motives. One of the groups consisted of students of engineering, but not in the field of environmental sciences. The discussion in this group was much more lively and advanced, whereas the second group had difficulties with understanding of the issues, but no participant in both groups had previous knowledge on CCS.

The authors found limited opposition against CCS in both groups. Potential fear of risks was partially compensated by benefits for the climate. It was accepted as "bridging" technology. Objections were made with regard to safety of storage, costs, and absorption of resources required in order to develop alternatives. Nuclear waste disposal was used as analogue because of the long-term perspective, safety and monitoring aspects. With regard to potential storage solutions ocean disposal was completely rejected. Geological storage appeared safer with its "visible" physical barrier. For future communication strategies of CCS it is important to notice that the groups expressed a general scepticism towards the motives of energy industry. CCS activities will be more accepted if energy industry also demonstrates the support of renewable energies and energy efficiency. The participants were also convinced that mass media, which reflect the voices of proponents and opponents of CCS, will have a large influence on opinions.

Another Tyndall Centre study was based on 212 *face-to-face interviews with travellers at Liverpool Airport* in 2003, and continued group discussions in 2002–2003. Both surveys focused on associations with the unknown issue CCS, attitude change resulting from provided information, influence of socio-demographic variables and basic beliefs, and potential factors or measures to make CCS more or less acceptable for the public.

There were two discussion groups, one in Manchester and one in York. They varied in socio-demographic variables: a female group with administrative and secretarial occupations and a male group with managers and self-employed persons. Both groups participated in five sessions and received expert presentations within the sessions. The respondents in the airport survey were also briefly informed about impacts, costs, risks and perspectives of CCS.

The results can be summarised as follows. On first contact with the issues most people had a more negative or neutral view of CCS than a positive one or said that they don't know. After having received a small amount of information on the purpose of CCS the majority supported CCS as an important CO_2 mitigation option. Compared to renewable energy or energy efficiency support for CCS always was much smaller, but higher than for nuclear energy and increasing energy bills. Concerning socio-demographic variables the results did not show significant variations by gender, age or socio-economic status. As prerequisites of CCS acceptance were found: recognition of climate change as a serious problem and an understanding of the high amount of CO_2 to be reduced. The group discussions revealed that there was little knowledge about the contribution of various options to this objective. The general view was that all options for CO_2 reduction should be developed simultaneously. More certainty about the long-term risks of CCS and the use as "bridge" technology would help to increase acceptability by the public. Other factors would be: an appropriate regulation strategy involving all parties, Government, NGOs and industry, and a transparent and open decision-making process.

As mass communication plays a relevant role for public opinion, the Tyndall Centre completed the explorations mentioned by an *analysis of mass media*. Articles on CCS in print media were analysed in five English-speaking countries: UK, US, Canada, New Zealand and Australia (Mander/Gough 2006). The authors consider mass media such as newspapers and TV more important than other channels such as internet, informal networks or specialist press. One factor of influence is the position of articles, e. g. on the front page or in places of minor visibility, another way is the kind of presentation, wording, interpretation, embedding into stories, etc. ("amplification") in order to attract people's attention. The authors analysed the wording, the description of risks, and the information source of the journalists. Statements on CCS were compared to statements on other climate change mitigation technologies such as renewable energies or nuclear power. The review took place between autumn 2005 and spring 2006. Nation-wide print media, mainly daily newspapers and some weekly newspapers and magazins were analysed. It was a daily search for relevant key words, summary information on the articles found were recorded in a database.

Considerable differences were found between the countries involved. The highest attention was given to nuclear power except in the US where CCS was more often mentioned. In UK and Australia there was a very large number of articles on nuclear power, much larger than on other items (CCS, renewables, coal without CCS). In sum, 53 articles were collected in the UK, 30 in Australia, 16 in the US, 7 in Canada and only 2 in New Zealand. The large majority of articles presented a positive (42 %) or neutral (32 %) view on CCS. Articles with a mixed view (19 %) or a negative view (6 %) were a minority. Australia had the largest number of negative articles (23 %). The articles were strongly related to current events, such as the discussion about phasing out nuclear power, establishment of new power plants, impending electricity shortfalls or an announcement to build a hydrogen plant with CCS (California). Negative aspects most frequently raised were costs, safety and leakage issues, efficiency of the technology, doubts about the available storage capacity, and additional energy consumption for capture. Generally there was no polarised debate on CCS, but rather a neutral and informative reporting. A key message was that there is urgent need for a legislative framework for CCS implementation.

2.1.3 EU-wide research

The ongoing *EU project ACCSEPT* (Acceptance of CO_2 Capture, Storage, Economics, Policy and Technology) aims at assessing public acceptance of CCS in Europe and addressing gaps in socio-economic studies. A strong relation is assumed between social acceptance and regulations for CCS as well as risk management and public trust in actors in this field. The project started in 2006. A stakeholder workshop was already held and a written survey of social acceptance was carried out. Results are not yet available. The interview package included relatively detailed information on the background of the project, CO_2 reduction commitments, CCS concepts and processes, costs, financial support programmes, and legal issues. The target group are experts and stakeholders, the questionnaire was sent in national languages. Main issues were attitudes towards CCS, political, strategic, social and environmental arguments, the contribution of CCS to climate change mitigation, frame conditions, support measures, regulation issues, potential risks, and the role of public acceptance for CCS deployment.

2.2 Other countries

2.2.1 Australia

In Australia a broad *quantitative nation-wide survey* was carried out. In addition, in regional workshops in Queensland *in-depth discussions with stakeholders* were held (Ashworth et al. 2006). The methodology used for the workshops was a "participatory action research". The selected regions for recruiting the participants – one group with local decision-makers or other key actors and one with citizens – were located close to coal mines or power plants. They meet in two sessions; in the meantime they were provided with information and could seek for more information. The information was given by a multi-stakeholder advisory group with diverse, but overall balanced opinions on CCS.

Climate change was seen as a serious problem in the workshops and the need for governmental action was emphasized. As relevant measures were mainly suggested: improved energy efficiency, education and behavioural changes as well as activities of energy industry and manufacturers of energy-consuming goods. The participants were asked to identify issues on which they like to receive more information. The most important issue was CCS with 74 %, followed by climate change with 55 % and biomass with 50 %. Specific fields concerning CCS where participants felt a lack of knowledge were: transport, leakages from pipelines and storages, capture processes, risk of terrorism, worst cases, impact of hazards, types of storage and impacts of each type, threat for water systems, and safety of geological storages in case of an earthquake. As a result of the workshops the researchers observed a considerable change of priorities for technologies. Above all, biomass, CCS, and coal (without CCS) were more accepted than at the beginning. The preferences for solar energy, natural gas in a middle position and the strong opposition against nuclear power were stable. A detailed analysis showed that changes came from those who were first unsure about their preferences and strongly influenced by the information received, which was classified as accurate, balanced and credible.

The broad survey showed (cited by Coninck et al. 2006) that 70 % of the respondents were not able to explain what CCS means. Some others provided reasonable answers such as "storing gas underground" or "storing gas in barrels". 80 % were not aware of efforts made by the coal industry to reduce greenhouse gas emissions. The authors found also a lack of knowledge on other issues related to energy supply and climate change. The conclusion was that people will more likely accept new technologies the more accurate information they have.

2.2.2 Japan

In the framework of a field demonstration of CO_2 aquifer sequestration in 2003 an *experimental study* was conducted (Uno et al. 2004a). 25 students from a private girl's high school participated in six two-hour lessons on technologies "to save the earth". They were asked to collect more information on their own initiative and exchange opinions within the class. At the beginning they were already familiar with environmental issues, but not with CCS.

In the first place the participants suggested solutions such as introduce policies and regulations, improve education and raise consciousness or change individual life-style. However invited experts told how difficult it is to achieve sufficient results with these measures and introduced CCS among others. At the end of the experiment, with regard to CCS mainly affirmative descriptions of the technology were given, followed by a neutral position or minor reservations ("if it is not harmful", "if it is cheap and efficient", "if CO_2 can be reused"). Only two students

associated CCS with negative implications for the environment, high costs, unknown availability of storage sites or long-term aspects, but they also expected further technological development and solutions for these problems. The results underline the relevance of adequate information and of a forum to exchange information and opinions.

In the same region a *survey and group discussions* were carried out (Uno et al. 2004b). Most students had already learned about environmental issues, but their concern increased with the degree of gathering addition information. The awareness and knowledge of the lay persons were relatively low, especially on CCS. The trust of students in mass media information was relatively high whereas older people often were not able to judge whether the information is correct or even felt that media were dishonest. One reason was the use of many technical terms and a complex language. The participants had many open questions concerning CCS, the most important were linked to leakages, local effects, and reasons for the use of this technology. Most participants agreed with the further development of the technology and the experiment or found that it is too early to decide because of lack of knowledge. However the majority did not agree to the implementation of CCS in the neighbourhood (45 %) or agreed with reservation (17 %), only 7 % agreed. With regard to the implementation in an area distant from home the acceptance was slightly higher, but the highest percentage said that they were undecided (40 %). Additional information helped to deepen understanding and improved the acceptance but did not completely remove anxiety concerning CCS.

The authors concluded that the in-depth group discussions were an important element complementing the quantitative survey because the respondents are not yet familiar with CCS. The qualitative methods can also reveal the background of attitudes.

In 2003 in Tokyo and Sapporo a *broad survey* was carried out (Itaoka et al. 2004) with 1006 respondents. Two different questionnaires were developed: one with limited information on CCS and the other with extensive additional information. Compared to other CO_2 reduction technologies, CCS was relatively unknown. Main information sources were TV and newspapers. Four main factors were found which influence public views about CCS: opinions on risks and leakages, effectiveness of CCS, responsibility for CO_2 mitigation, and use of fossil fuel. 82 % of the respondents accepted CCS in general, at least under certain conditions, whereas 18 % reported fundamental opposition. Specific types of storage (offshore, onshore, lake, dilution) however received less agreement. The provision of extensive information could reduce fundamental opposition – depending on the type of information. For example, information on maintaining use of fossil fuels increased acceptance, but information on public awareness of responsibility for CO_2 mitigation had no influence. With regard to the types of storage only the acceptance of onshore geological storage was not changed by additional information.

In 2003 and 2005 *two surveys with students* (267 and 423 respondents) were made to analyse public acceptance of CO_2 geological storage (Tokushige et al. 2006). More than 60 % of the respondents had little knowledge about CCS, but 85 % said that they pay attention to global warming issues. The results showed that acceptance is strongly influenced by the perception of benefits. After having received information on benefits and on natural analogues, e. g. natural CO_2 accumulations, the perception of risks decreased and acceptance increased. In the second survey the respondents were provided with additional information on the field demonstration of CO_2 geological storage. This study also revealed four factors: risk perception, benefit perception, sense of environmental values, and trust. A path analysis showed (Itaoka et al. 2006) that the perception of effectiveness of CCS is most influential for public acceptance, it means that CCS is seen as a realistic option to reduce CO_2 and that the reduction potential is substantial. The

authors consider the dissemination of these arguments a key issue for the communication to the public.

2.2.3 United States and Canada

In 2003 two studies in Pittsburg were conducted in order to examine public acceptance of oceanic and geological CCS (Palmgren et al. 2004) based on a "*mental model method*". The first study used a semi-structured questionnaire, the second study was a closed-ended survey based on a written questionnaire, which aimed at testing the prevalence of beliefs identified in the first study. In both studies information was provided to the respondents. The first study consisted of 18 face-to-face interviews. The researchers found the sample sufficient in case of introduction of new concepts like CCS.

One of the results was that the respondents had a neutral view of CCS. Geological disposal was preferred to ocean disposal, after provision of information opposition against both options increased. A further question covered the willingness to pay if electricity companies would achieve a 50 % CO_2 reduction. Compared to other options such as various renewable energies, natural gas, energy efficiency and even nuclear power, CCS received the lowest acceptance. Additional information resulted only in a slight shift of rankings.

A similar methodological design was used in a Canadian study in 2004/2005 (Sharp et al. 2006). *Focus groups* were run in order to understand concerns and attitudes towards CCS, whereas a *representative Canadian survey* was used to test the findings. A strong majority of Canadians are aware of the climate change problem and need for action, but other national issues were more important. CCS is seen as a bridging technology while other long-term solutions can be developed. However risks were considered more important than benefits. The respondents were most concerned about unknown future impacts, contamination of ground water, leakages and harms to plants and animals. They clearly preferred renewable energy and energy efficiency and emphasised the need for a combined approach, but they preferred CCS to nuclear power and conventional oil, gas and coal power plants. Measures to improve the image of CCS could be: more information, involvement of the government (not only energy industry) and NGOs, strong regulations and monitoring. No clear determinants of acceptance or opposition could be identified except the perception of seriousness of the climate change problem.

In 2003 Curry et al. (2004) conducted a *survey in the US* with 1205 respondents. It was an internet-based public opinion survey on a broad range of energy and environmental issues, where CCS was one part of it. A large majority of respondents were not able to report correctly the objective of CCS (address global warming), about 70 % didn't know, 16 to 29 % thought that CCS can reduce toxic waste, acid rain, ozone depletion, water pollution or smog. Even persons who had already heard of CCS (4 %) were no more likely to answer correctly, but they did not say so frequently that they don't know. The authors conclude from the study that early successes or failures, which will lead to more public awareness, will have a large impact on public perception of CCS. With regard to general energy and environmental issues the study revealed that environment is not a pressing concern of the public, and among environmental issues global warming is not the most important one. Most respondents support investments in renewable energies, but when they received information of costs the acceptance decreased. Many were uncertain about what is causing global climate change and therefore how to address it.

In 2006 the *same survey design* was replicated with a different sample population, so that a direct comparison of answers was possible (Ansolabehere et al. 2006). National policies have

not changed between 2003 and 2006, but there was a public discussion on this issue. In the 2006 survey the majority of respondents recognised global warming as a problem and in a list of ten environmental problems global warming was for 30 % the most important issue compared to only 10 % in 2003. 28 % agreed that immediate action is necessary compared to 17 % in 2003. Also the willingness to pay for remedies was much higher than in 2003. However CCS was still widely unknown and there was only little increase in understanding of its role to reduce global warming. The technology preferences of climate change mitigation still were mainly renewable energies and improved energy efficiency, but more respondents considered CCS and nuclear power as possible technologies than in the 2003 survey.

In 2005 the US Department of Energy collected *public comments* on environmental impacts of its Carbon Sequestration Program. It organised eight meetings in various regions. CCS was presented as a permanent solution for CO_2 reduction, as a safe technology, which allows to continue the existing energy infrastructure. A description of the results was not yet found.

2.3 International comparison study

Reiner et al. (2006) conducted public opinion surveys in US, UK, Sweden and Japan. Topics were awareness of and preferences for various energy technologies, knowledge of the relationship between energy technologies and environmental impacts, views on research and development priorities, and judgements of political measures to combat global warming. The wording in the survey was as similar as possible in the countries involved.

The results verified former findings on a low to very low knowledge and understanding of CCS compared to other energy technologies (wind, nuclear, hydrogen, bioenergy, and energy efficiency, carbon sequestration – defined as planting trees). About 70 % in the UK and almost 80 % in the US were not able to judge the problem solving by CCS or carbon sequestration whereas in Sweden and Japan this holds true for only 20 to 30 %. The acceptance of solar energy, energy efficiency and wind energy was much higher in all countries than acceptance of nuclear energy and CCS. Bioenergy received a middle position. In case of CCS 40–50 % of respondents in the countries involved were not sure whether they would accept CCS or not, a much larger number than with all other technologies.

In addition, the influence of information was tested by separating two groups in the UK and US surveys of which one group received additional information, e. g. that renewable energy is more expensive than other energy sources or that nuclear energy does not produce CO_2. The results were different in the US and UK: the support for renewable energies decreased slightly in the UK and by half in the US. The acceptance of CCS increased considerably: in the US from 6 to 16 % (“would definitively use”) and in the UK even from 1 to 10 %.

3 EXPERIENCES FROM OTHER TECHNOLOGICAL FIELDS

One of the objectives of WP 6.4 is to learn from experiences with the acceptance of other technologies in order to prevent avoidable opposition against CCS which could be based on comparison to these technologies. Public acceptance is strongly influenced by risk perception and can be partially "irrational" without taking into account the actual or scientifically well-founded risk. This phenomenon can also been interpreted as difference between scientific and "social" rationality. The perception of risks is embedded in social and psychological contexts (Slovic 2000). Another fact is that there is often no consensus on the amount of risks associated to technologies which are controversially discussed among different groups of experts or stakeholders. As far as there is relatively little public awareness of a technology, experts' supporting and opposing arguments concerning risks can have a strong influence on forming public attitudes.

Technological field for a possible comparison could be natural gas storage, hydrogen, nuclear and wind energy. Mainly the nuclear discussion but also wind energy shows a high influence of environmental groups on public opinions.

3.1 Natural gas storage

The storage of natural gas is a technology which in principle can also be affected by leakages or accidents. The difference is that the objective of the storage is to use the gas later and not to provide a final disposal. The acceptance of natural gas storages is relatively high; there is no strong tendency towards opposition which would lead to a complete abandonment of a storage site, but only to delays in installation. Natural gas storage is not an issue of general awareness in the public. If there are objections, they occur only on a restricted regional level. A review in Germany showed that in the case of three projects some opposition occurred in the past. In two of these cases – one was a tourist area – finally the storage was established with some delay and operated without trouble, whereas in the third case – in an inhabited region in Berlin – an explosion happened, which set off vehement opposition, but it was no long-term serious obstacle for the further use of the site. Coninck et al. (2006) mentioned other analogues for acceptance of CCS, e. g. liquid petroleum gas storage and the Underground Injection Control Program in the US because of similarities in the regulatory framework.

3.2 Hydrogen

In the past, hydrogen was used as an industrial gas, but a future hydrogen economy includes a much broader application, also on the level of private individuals. Sometimes the issue of public acceptance is discussed, but there is a relatively week analogy. In case of CCS storage sites inhabitants of the respective region are effective by potential risks not having direct benefits from the technology. However in case of hydrogen individuals are using an advanced technology, a clean and possibly relatively cheap fuel – arguments promoting strongly the acceptance of this energy source. According to a study of Flynn et al. (2006) the analysis of risk perception in the case of hydrogen energy shows that there still is little awareness of this issue in the public. As far as hydrogen-based energy technologies exist more or less in the form of prototypes or in laboratories and include a complex technological system they are subject to various, often contradictory, conjectures. Even experts have difficulties to assess benefits and risks due to limited knowledge of safety aspects and effects on health and environment. Evidence on public acceptance still is rare, but all available studies show a positive assessment of hydrogen-powered transportation (Altmann et al. 2004). However many people are undecided and need more information – the same situation as in the case of CCS.

3.3 Nuclear energy

There is a wide consensus between experts that risks caused by nuclear energy use are not comparable to those potentially caused by CCS. Basically CO_2 capture does not have a hazard potential like a nuclear plant. However sometimes in press reports the question occurs whether opposition from environmental groups or the broad public can emerge referring to a comparison of CO_2 storages to nuclear waste disposals, mainly due to the long-term aspect of storage and its risk potential as a burden for many future generations. In the public's opinions nuclear energy is perceived as a system including generation, transport and storage sites – unlike in the case of CCS where the discussion concentrates on storage Therefore it is worthwhile to reflect the development of acceptance of and opposition against nuclear power.

Nuclear energy use was always a highly controversial issue since the 1950ies. On the one hand, large benefits were communicated with respect to the unlimited availability of cheap energy as a precondition for economic growth. Lay persons felt more a threat because of the association to nuclear weapons. NGOs communicated warnings against use of nuclear energy because of risks and long-term impact. Severe opposition occurred against selected sites for power plants and storage facilities. Finally at the moment nuclear power is the least accepted energy technology in Europe compared with others (Table 3.1).

Table 3.1: Acceptance of energy sources in EU-25

Are you in favour or opposed to the use of these different sources of energy in your country?	**In favour**
• Solar energy	80 %
• Wind energy	71 %
• Hydroelectric energy	65 %
• Ocean energy (tidal. wave, marine current)	60 %
• Biomass (wood, plants, biogas)	55 %
• Gas	42 %
• Oil	27 %
• Coal	26 %
• Nuclear energy	20 %

Source: EU Commission 2006

The broad public however is not enough informed about technical details, and the attitudes pro or contra nuclear energy are more of a general nature. Usually psychologically motivated objections of the public are very resistant to change. The Eurobarometer surveys also reveal that the acceptance of nuclear energy varies with emerging events and changing values in the society. Thus the public opinion was influenced by a shift from technology-orientation and belief in economic progress to environmental concerns, by the nuclear accidents of Harrisburg and Tschernobyl., strongly rising energy prices, etc. Perceived risks also vary with general attitudes. A higher acceptance of nuclear energy can result from the current climate change discussion.

Conclusions can be derived as follows: It is important to avoid highly emotional debates on CCS at the time being when the broad public is not yet informed on this technology. A neutral view should be offered and arguments should keep to the facts. Main communicators should be scientists, environmental groups and consumer organisations because they are in the public's confidence (EU Commission 2006) and able to provide trusted information.

3.4 Wind energy

Wind energy usually is a highly accepted energy technology for experts and the broad public. The Eurobarometer and other surveys show that the public strongly favours wind energy and the use of renewable energies in general (European Commission 2007). Opposition is almost non-existent (3 %). Despite this fact, some locations for wind plants are discussed controversially. Main arguments against wind plants are the perception of a negative optical effect on the environment, noise and potential damages to birds. This affects emotional issues, for example the view of landscape and recreation, but also economic aspects, e. g. tourism. From that point of view the CCS technology is not comparable to wind energy because a clean coal plant does not look much different to a conventional one. However the issue of risk of accidents with a plant – which is of minor importance for onshore plants – may emerge substantially in the case of offshore plants, e. g. shipping accidents (Byzio et al. 2005). Similar to nuclear accidents the threat is less caused by the frequency of events than by the amount of damage.

Another important conclusion from the perception of wind energy is the dilemma of NGOs with environmental background with regard to the judgement of this type of energy generation: on the one hand the desirability of wind as a renewable energy, which is in the line of their core concern, i. e. climate protection and sustainability, and on the other hand conflicts emerging from negative effects such as threats for the fauna. This can result in a strong confrontation course.

4 CONCLUSIONS FOR EMPIRICAL RESEARCH ON SOCIAL ACCEPTANCE IN THE DYNAMIS PROJECT

There are not many empirical studies of social acceptance of CCS, and they were made in only very few countries. Generally authors emphasise the important role of public perceptions for the implementation of the technology. Social acceptance includes acceptance by the broad public as well as by stakeholders.

Existing studies of lay people's perception showed the low level of knowledge and understanding of CCS issues and of the relation to the climate change problem. Within a choice of alternative technologies renewable energies and improved energy efficiency are always strongly preferred to CCS. From a methodological point of view most studies recognised that there is need for providing information to the respondents in order to assure that statements to this issue make sense at all. The reactions found in the sense of change of attitudes are controversial and need further research. It can be assumed that some answers still are "artificial". In sum, relevant categories for CCS acceptance can be classified as follows (Table 4.2):

Table 4.2: Relevant categories for CCS acceptance

Category	Comments (or Specification or Criteria or???)
Information	general awareness knowledge sources of information
Communication	communication channels type of communication (personal, mass media, campaigns, etc.) transparency content of news reporting (balanced, trustworthy, informative, etc.)
Interest	in policy, public affairs, technology, environment, etc.
Trust	in sources of information in decision-makers in experts in industry
Perceived benefits	climate change mitigation secure energy supply
Perceived risks	risks for health or environment because of hazards, leakages, transport burden for future generations unspecific dread
Costs	cheap energy supply social costs of CCS
General attitudes	values and beliefs: towards technology, environment, social aspects, economic issues influence of socio-demographic background
Legal framework	regulations on storage site selection participation in decision-making operation, monitoring responsibility, liability

In the DYNAMIS project the researchers concentrate first on the stakeholders, e. g. experts, because they are considered to be influencing agents for public opinion. Relevant issues were compiled from the aspects in Table 4.1 and for the elaboration of questions available questionnaires of the studies reviewed were helpful. Later in the second phase of the project another approach will be used to explore "realistic" attitudes: surveys of the broad public in areas where CCS issues will be discussed when storage sites are planned.

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