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The Dutch general public's opinion on CCS and energy transition: Development in awareness, knowledge, beliefs and opinions related to information and media coverage

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1 Executive Summary (public)

This report describes three studies on understanding the public view on CO_2 capture and storage (CCS) and energy innovations in the Netherlands. These studies are based on the premise that to understand the public's concerns and predict their future opinion, it is necessary to know how people arrive at their evaluations about CCS. Earlier research in CATO shows that what constitutes relevant information for people to develop their opinion is not straightforward or easily foreseen by CCS experts. The three new studies described in this report aimed to (1) enhance insight into currently held beliefs and awareness among the general public about CCS and CO_2; (2) study the interaction between balanced expert information and lay people beliefs; (3) investigate CCS in the media, people's media use and exposure to news about CCS. To meet aim (1), we interviewed 15 respondents to identify commonly held beliefs. Next, we investigated the prevalence of these beliefs by questionnaire among 401 respondents. To meet aim (2), we administered an information-choice questionnaire (ICQ) about CCS among 134 respondents and interviewed the respondents afterwards to allow for elicitation of remaining, unaddressed beliefs as well as responses to the expert information. To meet aim (3), we analyzed the 430 articles mentioning CCS in all major Dutch newspapers from mid 2009 to mid 2010 and investigated respondents media use and exposure to recent media events about CCS.

The results of these studies show several new and valuable insights in the public view on CCS with important implications for future policy and communication efforts. First of all, the knowledge and beliefs test made abundantly clear how much doubts and knowledge gaps there are amongst the general Dutch public regarding our energy system, CO_2, climate change and CCS. Only very few people understand how our current use of fossil fuels leads to CO_2 emissions which lead to climate change, even though almost all people state to know about global warming. Several misconceptions that were shared by a major percentage of people were revealed. Some of these also influenced the general attitude towards CCS, but attitude towards this technology was mainly related to perceived risks and benefits of CCS itself, as well as to more normative evaluations of the use of the technology. However, although knowledge of the characteristics of CO_2 and CO_2 storage did not have a strong direct relation with attitude towards CCS, knowledge was moderately to strongly related to the perceived consequences of CCS. Hence, it is likely that knowledge does indirectly influence the perception of CCS. It can be argued that the knowledge gaps found in this study are not influential to attitudes towards CCS alone. If the general population does not understand the problem our society faces when we do not mitigate CO_2 emissions, it will be extremely hard to get their approval of any kind of CO_2 mitigation option, be it large wind turbine parks or home renovations to improve energy efficiency.

An important finding from the comparison with earlier CATO research is that public awareness of CCS does seem to have increased during the last two years, without being accompanied by an increase in public knowledge about CCS or related topics. The medialog that was kept for this study between mid 2009 and mid 2010 showed that the discrepancy between trends in public awareness and knowledge is consistent with what is described in newspaper articles mentioning CCS. Only very few articles explain the rationale for CCS, hardly mentioning climate change or the fact that over 90% of our energy comes from fossil fuels. Most often mentioned are specific CCS project plans without explanation of the technology itself. This is again confirmed by the public awareness survey outcomes. Most people that had heard about CCS, also stated to know about specific project plans.

Important to keep in mind when interpreting these results is that causal relations cannot be proven given the design of these studies. Although we find that certain knowledge gaps and beliefs are related to attitude towards CCS, this does not imply that improving the knowledge levels will make people more negative or positive towards CCS. The results of the Information-Choice Questionnaire (ICQ) shows that people who are carefully informed about aspects and consequences of several energy technologies, with information coming from a diverse set of experts and translated to lay language, develop a more well-informed, stable and consistent opinion, but not necessarily a more positive or negative one. This is corroborated by the lack of difference between the results of the current ICQ and the similar ICQ that was administrated in 2007 . Both the current and the 2007 survey showed that after being well-informed about several mitigation options, people were not that enthusiastic about CCS, but not many people objected to it either. Although people were in general positive about the quality of the information from experts, the interviews done right after the ICQ showed that almost half of people are still in doubt regarding safety of CCS. None of the misconceptions that were commonly found in the knowledge and beliefs test were mentioned by people in the interviews after the ICQ though, showing the usefulness of this instrument, not just for research purposes, but for informing people as well.

In general, the outcomes of these studies suggest a major lack of public awareness and knowledge regarding options, rationale and consequences of CO_2 mitigation in the Netherlands. From a democratic point of view one could argue that people should at least be aware of the rationale for CO_2 mitigation and the possible options and consequences for both society and individuals. Given the current lack of awareness, improving this will require significant efforts on a national scale.

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Document Change Record

(this section shows the historical versions, with a short description of the updates)

Version	Nr of pages	Short description of change	Pages
See header	See header	First issue	See header

Table of Content

2 Applicable/Reference documents and Abbreviations

2.1 Applicable Documents

(Applicable Documents, including their version, are documents that are the "legal" basis to the work performed)

	Title	**Doc nr**	**Version**
AD-01a	Beschikking (Subsidieverlening CATO-2 programma verplichtingnummer 1-6843	ET/ED/9078040	2009.07.09
AD-01b	Wijzigingsaanvraag op subsidieverlening CATO-2 programma verplichtingennr. 1-6843	CCS/10066253	2010.05.11
AD-01c	Aanvraag uitstel CATO-2a verplichtingennr. 1-6843	ETM/10128722	2010.09.02
AD-01d	Toezegging CATO-2b	FES10036GXDU	2010.08.05
AD-01f	Besluit wijziging project CATO2b	FES1003AQ1FU	2010.09.21
AD-02a	Consortium Agreement	CATO-2-CA	2009.09.07
AD-02b	CATO-2 Consortium Agreement	CATO-2-CA	2010.09.09
~~AD-03a~~	~~Program Plan 2009~~	~~CATO2-WP0.A-D.03~~	~~2009.09.17~~
AD-03b	Program Plan 2010	CATO2-WP0.A-D.03	2010.09.30

3 Introduction

The Netherlands, just like most other countries, are faced with a changing energy system and many possibilities to handle different problems and opportunities. How the public views these issues can be of crucial influence on decisions made for future energy systems. But how involved is the public in fact in these matters? Earlier research in CATO, the Dutch program for CO_2 Capture and Storage (CCS) research, showed a major lack of awareness and knowledge of the public, not just regarding new energy technologies such as CCS, but also regarding current energy issues such as current use of fossil fuels and it's relation to climate change. At the same time, research in the same program offered a representative sample of the Dutch people information from experts that is multi-sourced, balanced and understandable. Not only were these people willing to take the effort to comprehend and evaluate this information and decide what they think are the best mitigation options for the Netherlands in coming decades, most of them were quite enthusiastic about contributing to society like this (de Best-Waldhober et al, 2009). This shows how a careful scientific method for providing people with the necessary information to reach an informed opinion and for helping them make use of this information to form opinions about different policy options can contribute. The method of the Information-Choice Questionnaire has several other advantages, such as contributing to stable, well-informed opinions on the topic at hand based on understandable, balanced and accurate information from many experts with diverse backgrounds and affiliations.

However, aforementioned earlier studies also show that although respondents base their opinion for a large part on the information from experts, part of their opinion remains unexplained and is therefore based on beliefs[1] or arguments that were not mentioned by experts. But both for the prediction of future opinion as well as for effective communication that fits the need of the public, it is essential to gain understanding what constitutes the base for the unexplained part of people's opinion. The current report therefore described three studies that go beyond earlier studies in gaining understanding of the public view on CCS and energy innovation in the Netherlands. These studies aimed to (1) enhance insight into currently held beliefs and awareness among the general public about CCS and CO_2; (2) study the interaction between balanced expert information and lay people beliefs; (3) investigate CCS in the media, the impact of people's media use and exposure to news about CCS. The studies were done within the 5th work package of the Dutch CATO-2 program in WP5.3 "Trends in public opinion". This research is an extension of research previously conducted on this topic within the framework of the first Dutch CATO program, where the general public's evaluation of and preference for several CO_2 emission reduction options, including two CCS options, was investigated using the method of the Informed Choice Questionnaire (ICQ).

3.1 Introduction public perception of CCS

For the general public Carbon Capture and Storage is a relatively new topic. In 2004 3.6% of a random sample of the general Dutch population stated to be aware of CCS technology and 20.2% stated to have heard of it. These figures increased somewhat to 46.7 and 10.4% respectively by 2008 (De Best-Waldhober et al, 2011). Reiner (2006) found similar results in a study comparing four different countries; the United States, the United Kingdom, Sweden and Japan. Between 22% of respondents in Japan and 4% in the U.S. confirm to have heard of CCS. Nevertheless, public acceptance of CCS has proven to be a crucial factor in the successful implementation of CCS as several demonstration projects have met with strong public opposition. The first Dutch CCS demonstration project of onshore CO_2 storage near the city of Barendrecht, the Netherlands, was cancelled due to the opposition of local politicians and public (Brunsting et al, 2011; Feenstra et al, 2010). The Dutch general public's awareness of CCS seems to have risen lately as recent research from the end of 2009 shows. 44.5% of 555 respondents drawn from the general Dutch population

[1] The authors are aware of the more stringent definition some scholars use for beliefs. Because of the explorative nature of this part of the study, however, we use the term in the broadest sense possible.

states to have heard of CCS, while 5.5% states to have heard quite a bit (Pietzner et al, 2011). This increasing self reported awareness does not necessarily mean respondents have extensive knowledge of CCS. In fact, the same study shows less than 3% of respondents correctly identify mitigation of global warming as the sole goal of CCS among a list of several environmental problems, including amongst others ozone depletion and acid rain. A longitudinal comparison by de Best-Waldhober and Daamen (2011) of public awareness and understanding between 2004 and 2008 also shows a lack of increase in understanding, combined with only a small increase in awareness late 2008. A similar finding was previously found in a survey conducted among 1972 respondents in Canada by Sharp et al. (2006). Although between 10% of respondents in Alberta and Saskatchewan and 15% of respondents in the rest of Canada said to have heard of CCS, only very few of the respondents were able to correctly identify the problem CCS[2] addresses. Awareness of CCS therefore does not directly imply knowledge of the technology. Thus far, however, no extensive and systematic research into the public's knowledge of CCS has been conducted in the Netherlands.

A modest awareness and potentially very low knowledge of the topic poses a challenge for opinion research. When asked about a topic they have not heard of many respondents will still be inclined to give their opinion. This was shown in a study conducted by Bishop et al. (1980) in which a substantial part of their respondents expressed views towards a non-existing act. Such uninformed opinions are very unstable and easily changed with any new information about the topic (De Best-Waldhober 2006; Bishop et al. 1991) and as such hold little value for understanding or predicting the public's evaluation of the topic. Additionally it would not form a solid basis for the development of communication about CCS. Researchers tackle this issue often by providing their respondents with information about CCS before asking them to evaluate it. Several studies have been conducted using this method, giving respondents information either through a questionnaire or by an expert or researcher in focus groups and interviews. Overall the outcomes of these studies confirm initial low levels of knowledge and shifts in opinion after respondents receive information (Curry et al. 2007; Miller et al. 2007; Itaoka et al 2009; Shackley et al. 2007). The direction of the opinion shift after information varies between the studies. In two studies using a questionnaire containing written information about CCS, Curry et al. (2004; 2007) found more respondents supported CCS when they had received information about it. In 2004, 6% of respondents without information supported the technology, while 16% of the respondents with information supported it. In 2007 the direction of this information effect remained the same although support slightly decreased compared to the 2004 study; 3% supported it without having information while 10% of respondents with information supported it. Itaoka et al. (2009) found the opposite effect. Respondents' support for CCS decreased after receiving information about CCS through neutral news articles and parts of the IPCC special report on CCS. This effect was stronger for respondents who did not have prior knowledge about CCS, which is in line with the research on pseudo opinions that shows that uninformed opinions are more easily changed (de Best-Waldhober et al, 2006). Upham et al. (2010) conducted six focus groups across Europe exploring the development of opinion about CCS through the course of the discussion and piecemeal information provision. A special DVD was developed for this purpose. Results of the research show respondents were fairly negative about the possible implementation of CCS, however, 80% of respondents agreed they needed more information about CCS to form an opinion. Both Itaoka et al. (2004; 2009) and Upham et al. (2011) found respondents' main focus was on the risks and safety of CO_2 storage. Pietzner et al. (2011) investigated the effect of positive versus negative information on opinion of lay people in 6 EU countries with at least 1000 respondents per country. They found more than half of respondents changed their initial opinion after receiving information. In The Netherlands, 64% of respondents changed their opinion. Additionally, respondents changed their opinion in the direction that was expected: those receiving positive information about CCS became more positive while those who received negative information became more negative. Overall these studies show an inconclusive effect of information on lay people's opinion about CCS, but they do show the importance and effect of the information provided when initial knowledge is low.

To avoid the issue of pseudo opinions, De Best-Waldhober et al. (2006) developed an Information Choice Questionnaire to measure informed opinions regarding six CCS options by providing a large

[2] Sharp et al use the abbreviation GDC (Geological disposal of CO2) in their survey, instead of CCS.

representative sample of the Dutch general public with valid and well-balanced information from experts. The method of the Information-Choice Questionnaire was used to inform respondents and aid them in their decision making process, so as to obtain more stable opinions and make a better prediction of future public opinion on CO_2-capture and storage technologies. Moreover, the ICQ method provided the possibility to analyze how the evaluation of certain aspects of energy options influenced the opinions of the options overall. Before respondents chose between policy options, they received information to make a more informed choice. First, the choice was explicitly framed as a decision problem (i.e. *"Which CCS options is the best to implement in the Netherlands by 2030 at the latest in order to reduce CO_2 emissions by 20% compare to the status quo?").* Respondents were furthermore informed about the background of the decision problem (e.g. they were told why these specific options were included in the decision problem). Second, respondents were provided with information about the consequences of the different policy options. The results of this ICQ suggested that, after processing relevant information, people are likely to agree with large scale implementation of each of the six CCS options. Respondents found all CCS options on average "adequate", seldom found these options unacceptable and did not choose one of the options over the others with a majority of respondents.

However, an important reservation of this study concerned the context of the choice problem that was presented to respondents. Because little was known about public perceptions of CCS, the choice problem restricted the choice of respondents for energy options to CCS technologies. This was useful to assess public perceptions of specific CCS technologies and their consequences. But although this restriction to CCS technologies gives us insight in to the evaluation of specific consequences, it does not show how the public evaluates CCS in comparison to other CO2 reduction options. From 2005 to 2007 therefore an ICQ was developed in which two CCS options were presented along with five other CO_2 emission reduction options, including: energy efficiency, energy efficiency and decreased materials use, wind energy, energy from biomass and nuclear energy. This way the choice more closely reflected a real life context in which CCS is a technology amongst a range of other CO_2 emission reduction options. When the CCS options are compared with other energy mitigation options, which is usually the case in real life, overall evaluations might change. The decision problem respondents were faced with in this version of the ICQ read as follows: "*How can the Dutch demand for energy be fulfilled in 2030 in such a way that emissions of carbon dioxide will be reduced by 50%?"*. Each of the seven presented options is set up to reduce 40 Mt CO_2 so respondents eventually had to choose three options to solve the problem of reducing CO_2 emissions by 50% which corresponds to 125 Mt CO_2. The results showed that people were on average moderately negative about the two CCS options. The CCS options were also the least often selected options for respondents' preferred energy mix. Upon completion of the choice task a majority of respondents indicated they thought the method to be clear and understandable and that it helped them to make a choice (79%). They also felt the information was impartial and a vast majority of 91% indicated to have enough information to make a choice between the options. The ICQ therefore proved to be an appropriate instrument to measure lay people's opinion about topics they are fairly unfamiliar with such as energy production in general and CCS in specific. A more elaborate discussion of the method of the ICQ and the development of the 2007 ICQ can be found in Appendix 1 to this report.

3.2 Introduction Knowledge and Beliefs Test

Even though respondents' overall evaluations of the emission reduction options, including the two CCS options, were largely based on the information they received about the consequences of these options, this information did not explain their overall evaluations entirely. To a certain extent, respondents base their opinion of the two CCS technologies on other factors than the information experts believed to be relevant. This raises the question which other information, perceived consequences, arguments, thoughts, or feelings, besides the information provided by experts in the ICQ, account for people's evaluation of CCS. Finding out what these remaining factors are will improve understanding and future predictions of public opinion of CCS. This can form a stronger basis for the development of communications which will then include factors respondents find relevant in addition to the ones provided by experts. Indeed, two studies found that lay people can have ideas and beliefs about CCS and related topics which are generally not addressed by experts and which sometimes are factually inaccurate (Palmgren 2004; Wallquist et al. 2009). Wallquist et al. (2009) conducted 16 in-depth interviews with lay people which revealed that people had concerns about the risks of CCS. This included fears that the pressure in the storage site would be too high and damage the storage site or that the CO_2 would rise to the surface and leak because it is a gas. Some compared it to nuclear waste storage and some would attribute negative properties to CO_2 such as "unhealthy and smelly", or that it could alter DNA of organisms. A more elaborate exploration of these lay people beliefs and their influence on opinion towards CCS therefore seems warranted. Understanding these beliefs and their prevalence in the population can help understand public opinion and steer development of high quality information in the direction that lay people find relevant to their opinion.

This study replicates the ICQ of 2007 using the same design and information which has been updated with help of Utrecht University and Ecofys to reflect the latest insights. Overall however the questionnaire is largely comparable to the version of 2007. To increase its predictive value in the future two additions to the study have been made. The ICQ was extended with an interview to retrieve any remaining thoughts respondents had after completing it, having processed all the expert information. A separate questionnaire was developed to retrieve uninformed beliefs lay people have about CCS which also included an assessment of their knowledge about CCS and related topics so knowledge gaps could be identified. The methodology of the complete study can be found in the method section of this report.

3.3 Medialog

If the question is what shapes people's opinion regarding CCS and other mitigation options, one can argue that the media might have an influence on public opinion development, or at least that what is in the media reflects what is in the public opinion. Kliest et al (2010) state that the increase in amount of articles about CCS in the media, compared to earlier studies also showing increase at that time (van Alphen, 2007), reflect the development of public opinion. However, as mentioned before, public awareness of CCS has increased only slightly and not until 2008, and understanding does not seem to increase at all. This raises the question in how far CCS in the media and public opinion regarding CCS interact. From May 1, 2009, until May 31, 2010, a log has been kept of how CCS is portrayed in the national media for this study. In this report the first results of the analysis of messages from the media log conducted within WP5.3 are presented, and results of our attempt to link insights from the media log to results from the ICQ and the Knowledge and Beliefs test.

Focus of this media analysis is the extent to which CCS is, or is not, related to other important knowledge concepts, as well as the extent to which the media reinforce particular misperceptions. Whereas the research design does not allow for drawing causal inferences between Knowledge Test results and the media log, it does allow investigation of the extent to which media content reflects lay people knowledge, omissions in knowledge, and misperceptions as measured in the knowledge test. To allow for this comparison, the focus of the analysis is on coding factual knowledge transmitted by the national media about CCS and related concepts, not on evaluative matters such as judgments about stakeholder integrity, stakeholder opinions about CCS, or stakeholder opinions about each other. In short, not the debate about CCS is investigated in this study, but the role of the media as a vehicle for knowledge transfer.

4 Method

Three instruments were developed to answer the first two research questions. To identify remaining beliefs resulting from processing expert information, we repeated the Information-Choice Questionnaire (ICQ) that had been administered in 2007 by De Best-Waldhober et al (2008) with updated expert information and extended with a face-to-face interview. To identify additional beliefs in response to the second research question, we developed a questionnaire about CCS and several related topics that did not contain information about CCS. Furthermore, a media log was kept from May 1, 2009, until May 31, 2010 of how CCS is portrayed in the national media. Below we describe these three instruments in detail.

4.1 Method of the extended Information-Choice Questionnaire

To explore the effect of expert information on laypeople's beliefs we used the method of the Information-Choice Questionnaire (ICQ). The ICQ has two goals. First, to provide respondents with the necessary information to reach an informed opinion. Second, to help respondents use this information to evaluate different policy options. The ICQ thus can be seen as a decision aid that guides respondents' information processing. Instead of asking respondents just to evaluate policy options, as often happens in conventional questionnaires, the ICQ asks respondents to evaluate these options as solutions to a policy problem and choose those options they prefer. The choice between policy options is explicitly framed as a decision problem. The policy goal has to be met, which means that rejecting all options is not possible. To enable respondents to make a decision they are provided with information regarding the background of the decision problem and information regarding the consequences of the different policy options. Next, they are requested to give a quantitative evaluation of each option and of each consequence (a rating on a scale with nineteen response categories ranging from -9 "a very big disadvantage" via 0 "irrelevant" to +9 "a very big advantage"). Quantifying their evaluations of the options and consequences helps respondents to process the information and evaluate each policy option and enables them to choose which policy options they prefer. For an extensive description of the ICQ we refer to Annex 1 of this report. In this study, we used an updated and extended version of the Information-Choice Questionnaire developed by De Best-Waldhober et al (2008). For this ICQ, several experts defined the following relevant and realistic policy problem: *"How can the Dutch demand for energy be fulfilled in 2030 in such a way that emissions of carbon dioxide will be reduced by 50%?"* Respondents were given information about 7 policy options and their consequences to solve this policy problem;

- Option 1 Improvement of energy efficiency
- Option 2 Improvement of energy efficiency plus decreased use of material and energy
- Option 3 Electricity from wind turbines at sea
- Option 4 Conversion of biomass to car fuel and electricity
- Option 5 Large plants where coal or gas is converted into electricity with CCS
- Option 6 Large plants where natural gas is converted into hydrogen with CCS
- Option 7 Electricity from nuclear plants.

Each of these options on its own reduces CO_2 emissions by 40 Mt, therefore the respondents should select three of these options to (almost) achieve the goal of reducing 125 Mt CO_2 to solve the policy problem. The information in this ICQ was compiled by and agreed upon by 22 experts from different organizational and professional backgrounds, including scientists from research institutes and universities, environmental NGO's and policy makers, and has been checked by another, similarly differentiated group of experts, after which it has been translated into lay language by psychologists. This translation was also checked by a different group of experts, and tested on two samples of lay people (135 people total) to ensure the information was still factual, balanced and comprehensible.

The final results of the 2007 ICQ, with a representative sample of the Dutch public containing 971 respondents, showed that respondents evaluated the quality of the information very positively, finding it mostly impartial, clear, not one-sided, and complete. A vast majority of the respondents felt the ICQ method helped them to make a choice between options. For further details on the development and the method of this ICQ we refer to Appendix 1 of this report.

For the present study, the expert information in the 2007 ICQ was reviewed again by Utrecht University and Ecofys and updated according to the latest insights and calculations. Most of these revisions, however, did not result in large changes in the lay language presented to the respondents. The following changes were made:

- In Energy Efficiency option 1 in the consequence for employment the expected amount of possible jobs created by this option in the European changed from 200.000 every 10 years changed to "hundreds of thousands extra jobs, especially in construction".
- In the same option consequences for transport the binding EU legislation changed from requiring passenger cars to drive 30 km/l in 2030 to requiring them to drive 18 km/l in 2035. Also respondents were informed the capacity of cars in 2005 was to drive 10 km/l, instead of 12.5 km/l in 2007.
- In Energy Efficiency option 2 in the consequence for transport the information was added that flights could become 8 to 40 euro more expensive if the CO_2 emissions would be taxed.
- In the wind energy option the number of necessary wind parks changed from 23 to 20.
- In the same option the number of wind turbines per wind park changed from 3500 to 1500 – 3000.
- The price information for this option changed. The extra costs for consumers changed from 10-20% to 10-15%, while the extra costs for industry changed from 40% to 25-30%.

Furthermore, the ICQ was extended to include questions about the respondent's awareness of media events related to CCS and media use as described in the next section about the Knowledge and Beliefs Test. Respondents also completed a measure of their interest in energy and climate change issues.

4.1.1 Post ICQ interview

Finally, to gain better understanding of how people react to the expert information given in the ICQ, face-to-face interviews were conducted after respondents completed the ICQ. The face-to-face interviews were conducted by an interviewer from the polling firm who was present at respondent's homes while they first individually completed the questionnaire. The interview protocol was very structured and included questions about:

- whether respondents had any thoughts on any of the options they had read about
- whether any of the options was difficult to answer
- whether they had any considerations about the two CCS options in specific which they could not express in the questionnaire
- whether they had any previous knowledge or thoughts not included in the information provided about these two options
- why they had or had not chosen the CCS options in their preferred package
- what they perceived to be the main difference between the option "Large plants where coal or gas is converted into electricity with CCS" and the option "Large plants where natural gas is converted into hydrogen with CCS".

After each of these questions respondents were also asked how this has influenced their evaluation of the option in question.

The final ICQ and the face-to-face interviews were administered to a random sample of the Dutch public (134 respondents) in May and June 2010.

4.2 Method of the Knowledge and Beliefs Test

The type of beliefs about CCS held by lay people, as well as the prevalence of these beliefs in the population, were measured by a questionnaire especially developed for this purpose.
This questionnaire did not only include questions about CCS, but also topics related to CCS technology; CO_2, electricity production and climate change. To include relevant beliefs commonly held by lay people, input for the questionnaire was generated on the basis of 15 in-depth interviews held with people with no professional involvement with CCS, climate or energy. Previous studies have shown 15 interviews are sufficient to elicit most commonly held beliefs as after this amount the emergence of new beliefs is negligible (Palmgren et al, 2004). We interviewed an approximately equal number of men and women with different educational levels, backgrounds, and professions. The mean age of this group was 49 and ranged from 19-59. The interviews were conducted using a very open protocol which allowed respondents to express their beliefs about these topics freely and only be prompted with general questions after a topic was exhausted. Examples of prompts are "Have you heard of climate change?" and then "how do you think it is caused" as well as "have you heard of carbon capture and storage?" and "How do you think this works?". Respondents did not receive any information, nor were they corrected in this part of the interview if they expressed factually erroneous beliefs. Only in the very end of the interview did they receive a short explanation about CCS and the greenhouse effect after which they were asked to compare CCS to the energy production options they had mentioned in the first part of the interview. The aim of this last part was intended to uncover any perceptions of CCS that were not expressed so far. Below a concise overview of the main results of these interviews is discussed.

4.2.1 Results of the in-depth interviews

Climate change

All respondents were well aware of the issue of climate change and most could easily name possible consequences of it. However, they were much less confident about their own knowledge of the causes of climate change. Most could state it has something to do with emissions, but often they were not sure which emissions exactly. Those who did know climate change was related to emissions of CO_2 often did not know what CO_2 did to affect the climate or they would not know exactly which human activities or used fuels were related to CO_2. The strongest association to CO_2 emissions were exhaust fumes from cars, energy production, spray cans, waste and one respondent mentioned leaking batteries. Most seemed to confuse climate change with other environmental problems such as depletion of the ozone layer, acid rain, and smog and air pollution. Many respondents also had doubts about whether climate change was occurring to the extent it was portrayed in public discourse and whether it was natural or caused by human activities.

CO_2

CO_2 proved to be a difficult topic for most respondents. All had heard of it and knew it was a gas which they often associated correctly with emissions and climate change. Many misperceptions and knowledge gaps existed however. Few respondents knew humans breathe out CO_2 and those who did sometimes differentiated between CO_2 expired by humans and more 'dirty' CO_2 from industrial emissions. A couple of respondents confused it with carbon monoxide. Often they believed CO_2 to be unhealthy, perceived it as a toxic (even though some were aware the toxicity depended on concentration) and sometimes even carcinogenic or hazardous to breath in or to come in skin contact with. In a few cases it was clear respondents ascribed such hazardous properties to CO_2 either because they associated it with carbon monoxide or through deductive reasoning, because "if CO_2 is so bad it can cause climate change, it must be dangerous for humans as well".

Energy production

Respondents were often well aware of the fact that CO_2 is emitted amongst other during energy production and many could also correctly indicate this was the case when fossil fuels are used. Some also believed nuclear energy emitted CO_2. Several respondents however were not completely certain about how electricity was produced or in which part of the process the CO_2 was emitted. For example one respondent believed the CO_2 was emitted during the transport of the electricity and the CO_2 was emitted through the cables. The most noticeable result was the fact respondents consistently overestimated the use of renewable energy and underestimated the use of fossil fuels. Several respondents places this ratio around 70% fossil fuel and 30% renewable sources, while not one respondent ascribed more than 85% to fossil fuels.

Carbon Capture and Storage

Only a few respondents had heard of CCS and those who did mentioned hearing about it from the project plans in Barendrecht. None of the respondents said to have a clear image of what the technology entailed. In the case of capture they were unsure where it would be captured from, some mentioned energy production sites, more often however they perceived it as filters on car exhaust pipes. Respondents also indicated finding it hard to imagine how a gas can be captured. In addition to preventing climate change many respondents also believed an aim of storage could be to subsequently use the CO_2 as an energy source. Some respondents did know it would be stored in depleted gas fields, but some of them however perceived the storage to be a "bubble of gas", lined with metal or concrete walls or that the CO_2 would be stored in tanks or barrels. As for possible consequences of CCS several respondents mentioned being afraid the CO_2 could catch on fire, explode, easily seep out of the storage because it is a gas or have negative long term effects on the health of those living near the storage. Images of Tsjernobyl came to mind several times, generally associating CO_2 storage to nuclear waste and general waste disposal. A few respondents believed implementing CCS in the Netherlands makes sense due to the existence of depleted gas fields.

4.2.2 Construction of the questionnaire

The beliefs mentioned by these respondents were included in the knowledge and beliefs questionnaire. A selection was made of beliefs most closely related to CCS technology and those most often mentioned by respondents. Additionally attention was paid to ensuring there was a balance between correct and incorrect answer options as well as a division of knowledge items which could be categorized as either correct or incorrect and items measuring perception or awareness. The questionnaire consisted of the following measures:

CO_2 knowledge:
- Awareness of CO_2
- Characteristics of CO_2

- Effects of CO_2
- Sources of CO_2

Attitude about CO_2
Knowledge of CCS:

- Awareness of CCS and project plans
- CCS capture points
- Aims of CCS

Perception of CCS storage
Understanding of term "porous rock"
Current electricity mix
Future electricity mix
Beliefs about climate change
Statements about possible consequences of CCS
Evaluative statements about CCS
Attitude about CCS
Awareness of media events related to CCS
Amount of time spent using several media sources
Newspapers respondent reads

4.2.3 Measures

CO_2 knowledge

Respondents' knowledge of CO_2 was measured using 32 items presenting either possible characteristics, effects or sources of CO_2. For example "CO_2 is flammable" was one of the possible characteristics of CO_2, "CO_2 influences the climate" was one of the effects and "CO_2 is released when spray cans with hair spray or deodorant are used" was one of the possible sources. The answers were measured on a 5-point scale ranging from 1: I am sure it is (or does) not, to 5: I am sure it is (or does). In this way the scale not only measures whether respondents think a statements is true or false, but also measures how sure they are of their answer. This scale was tested in several think out-loud interviews and respondents stated to correctly understand the meaning of the scale. The mid-point '3' meant the respondent was not sure of the answer or in other words 'I don't know'.

In a part of the analysis a 3-point version of this scale was used. All incorrectly formulated items (for example: "CO_2 causes cancer") were recoded so that a higher score meant a more correct answer. Also then the lowest 3 answer categories were aggregated to form one group of incorrect and "I don't know" answers. This was done so as not to imply a respondent who gave an incorrect answer knows *less* than a respondent who stated they did not know the answer.

Overall CO_2 knowledge

This scale was made by aggregating all 31 items on the 3-point scale formed previously (except "CO_2 is poisonous" because of the difficulty of interpreting the meaning of this statement). This way a higher score meant a respondent had answered more items correctly with more certainty.

Awareness

Awareness of CO_2, CCS, CCS project plans in the Netherlands, the IPCC and project plans in Barendrecht were all measured using the question: "have you heard of…" with 3 answer categories "No", "A little bit" or "Yes".

Knowledge of CCS

Respondents' knowledge of suitable CCS capture points and the aims of CCS were measured by presenting respondents with a list of possible alternatives of which they could select as many as they believed to be correct. For subsequent analysis the knowledge of capture points was aggregated into one scale by giving respondent 1 point for every correct answer and subtracting 1 point for every incorrect answer. Because the list contained 5 correct answer options and 5 incorrect ones, a score of 5 meant a respondent had selected only correct items and a -5 that a respondent had selected only incorrect items. In the list of aims of CCS three out 10 answer options presented were correct: "mitigate climate change", "limit the increase of the greenhouse effect" and "Limit rise in temperatures". In subsequent analysis a 3-point scale was constructed. The first groups of respondents had selected solely incorrect aims of CCS, the second group had selected at least one of the correct options, but also at least one incorrect one, while in the third group there were respondents who had only selected at least one of the correct aims of CCS and no incorrect ones.

Perception of storage

Respondents' perceptions of possible CO_2 storage was measured using 7 items which described a possible storage with for example "The CO_2 will be stored in large barrels, tanks or containers" and "The CO_2 will be stored underground in the existing rock formations". For each description respondents could indicate how likely they perceived it to be the CO_2 would be stored in such a storage. This was done on a 7-point scale ranging from 1: very unlikely, to 7: very likely.

Perceived consequences of CCS

Respondents were presented with 12 statements about what could possibly be consequences of CCS, but not necessarily so. For each statement they were asked to indicate how likely the perceived the statement to be a consequence of CCS. Their answers were given on a 7-point scale ranging from 1: very unlikely, to 7: very likely.

Evaluation of CCS

Subsequently respondents were asked to state their agreement with 7 normative statements about CCS such as for example: "CO_2 storage is necessary to mitigate the rise in average temperature on earth" and "CO_2 storage carries too many risks for public health". Their answers were measured on a 7-point scale ranging from 1: strongly disagree to 7: strongly agree.

CO_2 and CCS Attitude

After the CO_2 knowledge items and after the CCS evaluative items respectively respondents were asked about their attitude towards CO_2 and CCS. Both were measured using 8 semantic scales with each presenting respondents with 2 opposing adjectives. Respondents were asked to indicate which adjective described their perception best on a 7-point scale. The closer their answer was to one of the scale ends the more the nearest adjective described their perception. For example one of the semantic scales had scale ends "positive – negative". Answer category 1 meant "positive" described their perception best, while answer category 7 meant "negative" described their perception best. For subsequent analysis all 8 scales were aggregated into one measure of CO_2 Attitude and CCS Attitude where a lower score signified a more negative attitude, while a higher score signified a more positive attitude.
Factor analysis of the 8 CCS scales revealed all the 8 items were indeed measuring the same construct and reliability analysis indicated the new CCS Attitude scale had a Cronbach's alpha of .927, which is very high. This justifies aggregating the eight scales into one measure of CCS Attitude.

CCS Broadcasts

In the end of the questionnaire respondents were asked about whether they had seen 2 television broadcast specials about CCS. The first one concerned an episode of Zembla from March 28th 2010 and of Netwerk from April 6th 2010. Respondents could state whether they had seen the whole show, a part of the show and whether they had not seen it or could not remember whether they had or had not.

Media consumption

At the very end of the questionnaire respondents were asked how much time they spend using four different media sources: newspapers, radio, television and internet. For each they were specifically asked how much time they use the media source for information about political and current affairs topics. In both cases answers were given in categories ranging from "not at all" to "more than 3 hours per day" with each category increasing in steps of 30 minutes per day. Additionally respondents were asked about the newspapers they read and how often they read each.

4.3 Method of the Medialog

4.3.1 Population of media messages

Aim of this research is to investigate a representative sample of all messages about CCS, which together reflect all opinions on CCS currently present in society. To achieve this goal we have opted to focus the analyses on messages in the national newspapers. Together, these newspapers reflect what we call the 'media landscape'. This means that all angles from which CCS is reported on, and the prominence of these angles, are reflected by newspaper articles. Events from the outside world, such as attention-getting television reporting on CCS, are also reported on in the national media. Thus by analyzing newspapers, a researcher obtains a complete impression of the ways in which a topic, in this case CCS, is written about, by whom, using which arguments, leading to what types of opinions.

That said, we did record large media events other than newspaper articles in the weeks before and during the surveying period. Furthermore, we have added questions to the surveys to measure the extent to which respondents have been exposed to these events, to be able to check if and how these events have influenced their opinion.

Social media (twitter, blogs, etc) have been excluded from this research as their different nature would also require an entirely different approach to the media analysis. Social media do not reflect the distribution of opinions in society the way national newspapers do. Rather, social media reflect special interests, and/or extreme positions of people willing and able to share their opinion with others. These opinions are not a reliable indication of general public perceptions and understanding of the technology which we want to obtain in WP5.3.

4.3.2 Research Sample

The research sample includes all national daily newspapers: AD, Het Financieele Dagblad, Nederlands Dagblad, NRC.next, NRC Handelsblad, Reformatorisch Dagblad, De Telegraaf, Trouw, DeVolkskrant, and the free newspapers Metro and Spits. The present sample also includes Parool, which is a newspaper for the Amsterdam region, and Agrarisch Dagblad, which is a specialist newspaper. Despite these titles being deviant in these respects from the other national newspapers, we have decided to retain them in the sample. Articles are retrieved from the database LexisNexis, www.lexisnexis.nl.

Data were collected using the following search string:
(CO2! OR kooldioxide! OR koolstofdioxide!) AND (afvang! OR opsla!)

This search string results from several rounds of data collection and pre-coding of parts of the material. We will not describe this process in detail, but we do think it is necessary to explain omission of the word 'transport' being the link between capture and storage. The initial search string contained the word transport!, but this yielded many irrelevant results. We have investigated if leaving out the word 'transport' in the search string would result in missing relevant articles about CCS. This was not the case.

For the present report we monitored from May 1, 2009, until the end of May, 2010, which is the end of the data collection period of the ICQ and knowledge test.

4.3.3 Defining and coding 'essential' Knowledge

To meet the aims of the media log and develop a codebook for capturing essential knowledge, a definition of this concept was needed. The definition of 'essential knowledge' of CCS in the meaning of 'being predictive of opinion' is a topic of ongoing research. To develop a solid working definition nonetheless, we approached this concept from three angles.

Firstly, we examined what constitutes complete, relevant, and correct information on CCS according to experts. To this end, we used three sources of expert information:

- The 'Argument map' of CCS (Kalshoven, 2010)
- IPCC report about most important barriers to CCS implementation (IPCC, 2005)
- Expert information and knowledge test from the ICQ conducted in 2007

Secondly, we examined what constitutes relevant knowledge from the point of view of respondents to the Knowledge and Beliefs Test (see section 5.2) and ICQ 2010 (see section 5.1). We have used the quantitative results from the Knowledge and Beliefs Test and the qualitative results from the ICQ 2010 (i.e. responses to the open-ended questions about each CCS option and responses to the concluding interviews) to enable ourselves not only to determine to what extent the 'blanks' in lay people's knowledge match 'blanks' in transferred knowledge by newspapers, but also to determine to what extent lay people may have knowledge and thoughts that are different from what experts deem relevant and the extent of coverage of these in newspapers.

Thirdly, we sampled several months of news coverage from the media log itself to see how CCS and related topics are in fact covered. On the one hand, to ensure we would not waste time attempting to code information that turned out absent in all articles. On the other hand, to ensure that we would not forget to code mention of a new piece of information introduced by newspaper articles but overlooked by experts and lay people. To facilitate consistent coding of the contents of articles, we adjusted the wording of the items in the codebook to the way in which newspapers in fact write about it and/or the way in which lay people in fact talked and wrote about it in the interviews and open-ended questions to the ICQ 2010.

Development and testing of the codebook took several iterations. In the end, the codebook was put online and tested using a sample month that is not part of the present results. Results were analyzed using Excel and SPSS. The next section describes the topics the codebook addressed.

4.3.4 Measures

Below we summarize the measures in the codebook relevant to the present report.

Basic Features of Articles

- Basic features of each article (e.g. date published, in which newspaper, number of words)
- Whether CCS is the main topic or a subtopic
- To which topics is CCS related (e.g. policy issues, economic issues, scientific issues)
- Coverage of events, stakeholders, and projects

Evaluative Questions

- How is CCS portrayed (positively, neutral, negative, or just mentioned)?
- Does he article contain signs of climate skepticism, e.g. that climate change is exaggerated?

Misconceptions

- Does the article contain information about CCS or related topics that is clearly incorrect?

Knowledge Questions

CO2:

  - What is it?
  - What effects does it have?
  - Where does it come from?
  - What do we use it for?

CCS:

- Capture mentioned? Explained?
- Transport mentioned? Explained?
- Storage mentioned? Explained?

Energy production and use:

- Why is energy produced, for whom?
- Why and how is electricity produced?
- Which source of energy accounts for which percentage in the energy mix?
- Is explained that a large percentage of our energy comes from fossil fuels?
- Does the article explain that fossil fuel use causes CO2 emissions?

Climate change:

- Is climate change discussed?
- Is temperature rise discussed?
- Is the greenhouse effect discussed?

Similar to the Knowledge test, we investigated to what extent the following events were described and linked in newspaper articles:

- Fossil fuels are still a dominant source for energy production
- More specifically, most of our electricity comes from fossil fuels
- Energy production (in particular electricity production) causes CO2 emissions.
- CO2 emissions contribute to climate change
- More specifically, CO2 emissions contribute to a rise in average global temperature.

5 Results

5.1 Results of the ICQ 2010

5.1.1 Sample

The Information Choice Questionnaire was administered to a sample of 135 respondents. Respondents completed the ICQ individually on the computer after which they were interviewed by an interviewer who was present while the respondent was filling in the survey as well.

Although the size of this sample is too small to be representative for the Dutch population, the random selection of respondents did lead to a diverse sample. 57% of respondents were male and 43% female. 37% of respondents fell in the age category 18-34, 32% in the category 35-54 and 31% was 55 years or older. 11% of respondents had a low level of education, approximately 57% had an intermediate level of education while 31% had a higher education level. All the provinces in the Netherlands were also represented in the sample with the distribution reflecting the order of province sizes in the Netherlands. An overview of the distribution of the Dutch population on these demographic variables is shown in Appendix 7.

A check of the responses revealed one respondents who did not seem to have completed the questionnaire seriously. Not only was the survey completed in an extremely short time span, also the evaluations of the consequences of the options including the overall evaluations were constantly the same. This one respondent was therefore excluded from further analysis which left a sample of 134 respondents.

Based on the sample size of the ICQ (n = 134) when interpreting the presented response percentages in this report one should reckon with an uncertainty margin of *maximally* plus or minus 8.5% (these margins apply with a 95% confidence level).

5.1.2 Evaluation and Choice in the ICQ 2010 compared to 2007

Ruling out scale or order effects

Scale effects
Two different scales were used to measure respondents' evaluations of global warming and the seven options. For each, respondents were asked their overall evaluation on a 7-point scale, ranging from "1 = very bad" to "7 = very good". They were also asked to give a grade ranging from one to ten. To test whether respondents give a similar evaluation on both scales we correlated the evaluations on both scales for all of the seven options and global warming. The correlations were high, ranging from .72 to .88, indicating that these measures were quite similar. This conclusion is supported by the results of the previous ICQ from 2007 which had a much larger sample. Therefore we will use only the evaluation on the 10-point scale as a measure of overall evaluation in the further analyses. The average overall evaluations on the 7-point scale can be found in Appendix 6.

Order effects
The 7 options were presented to respondents in six different orders to prevent evaluations of options to be influenced by the order in which they appear. The average overall evaluations of options based on order of presentation are shown in Appendix 6. Again, as in the previous ICQ the effects of order were small and very similar in order to the effects found in the 2007 study. The large sample of the previous ICQ, however, is much more suitable for this analysis and a better indicator of order effects,

because of the small sample of the current ICQ stronger effects are more easily obtained. These minor effects were furthermore averaged out as the overall evaluations that are further used in the analyses are an average of overall evaluations from the six different order versions. This minor effects of order therefore cannot be considered as a factor in the subsequent analyses.

Overall opinion options

In the following section the results of the current ICQ will be discussed in comparison to the results of the ICQ which was administered in 2007 (De Best-Waldhober et al, 2008) to paint a picture of the current state of affairs as well as the development of public opinion over the years. Some differences are possible to arise due to the difference in sample size. Because the ICQ in 2007 had 971 respondents effects are evened out more, while in the smaller sample of 2010 of 134 respondents every respondent already has a higher influence on the average and the overall picture. We will therefore pay attention mainly to some considerable differences between the results of 2007 and 2010, including overall evaluations of the seven options, evaluations of the consequences of the options, evaluations of global warming and trends in awareness.

Overall evaluations: Grades of the seven options

Respondents were asked to give each option a grade of 1 to 10, in concordance with the Dutch grading system. In the school system the higher the grade the better the result and the cutoff point between a failing and passing grade is 5.5. Grades 1 - 5.49 represent a failing grade and everything over 5.5 is a passing grade. A grade of up to 6 means one has done just well enough to pass but not more than that. 8 and over means one has done very well, with "10" being an excellent score. Respondents were asked to give the overall evaluation by grading each of the options at two points in the questionnaire. The first time was after they had evaluated all the consequences of an option. They first received an overview of how they had evaluated the consequences and their total disadvantage and advantage score for that option. The second opportunity to give an overall evaluation was after they had evaluated *all* the options. They received an overview of all the grades they had given and were presented with the opportunity to change their overall evaluations if their opinion had changed after they had viewed all the options and consequences. 19% of the respondents chose to do so for at least one option. In the following analysis this final grade given to each option is used.

Table 1 shows the mean grades of each of the options as well as the distribution of the grades and the standard deviation. Two of the seven options received a failing grade: "Electricity from nuclear plants" (5.4) and one of the CCS options "Large plants where coal or gas is converted into electricity with CCS" (5.0). This CCS option received the lowest grade of all the options, while "Large plants where natural gas is converted into hydrogen with CCS" got a barely passing grade of 5.9. This was the same grade the quite strict option "Improvement of energy efficiency and decreased use of material and energy" received, while the remaining three options, except nuclear, received rather positive average grades of around 7.5. While the second efficiency option and the hydrogen + CCS option have the same grade and a similar distribution of grades, nuclear and the first CCS option, which have similar overall grades, show a somewhat different distribution. The difference is mainly that nuclear receives more grades in the higher end of the scale (8-10) while the first CCS option receives more moderate grades (4-5 and 6-7).

Table 1: Overall evaluations of seven options in the ICQ: percentage for grades and means and standard deviations

Option	1 to 3	4 to 5	6 to 7	8 to 10	Mean grade	SD
Efficiency	0.7	3.7	41.1	53.7	7.48	1.26
Efficiency plus	7.4	29.3	47.8	15.6	5.90	1.58

Wind	3.6	1.4	38.8	50.8	7.47	1.49
Biomass	2.2	2.3	45.5	50.0	7.40	1.30
Powerplants + CCS	17.2	41.8	36.6	4.50	5.02	1.56
Hydrogen + CCS	6.7	30.5	48.6	13.4	5.90	1.54
Nuclear	17.2	32.9	35.1	14.9	5.38	2.03

The current pattern of evaluations quite closely reflects the results found in the ICQ of 2007. Table 2 shows a comparison of the mean grades in 2007 and 2010. The first CCS option is evaluated significantly more negatively in 2010 than it was in 2007, dropping from 5.34 to 5.02 ($F_{1,1103}$ = 5.151, p = .023) and it is the only option that is evaluated more negatively in the current measure compared to the previous one. The Hydrogen + CCS option was evaluated virtually the same with an average of 5.9. The biggest change in grade is found for the wind option which is evaluated significantly higher in 2010 (M = 7.47) than in 2007 (M = 7.15; $F_{1,1103}$ = 6.321, p = .012). The first efficiency option and the nuclear option were also evaluated slightly more positively in 2010 than in 2007, but this difference is not statistically significant.

Table 2: Comparison between mean overall evaluations of seven options in the 2007 ICQ and 2010 ICQ

Option	Mean grade 2007	Mean grade 2010
Efficiency	7.33	7.48
Efficiency plus	5.84	5.90
Wind*	7.15	7.47
Biomass	7.41	7.39
Powerplants + CCS*	5.34	5.02
Hydrogen + CCS	5.92	5.90
Nuclear	5.29	5.38

* significant change between 2007 and 2010

Relation between overall evaluation options

To test whether respondents tend to evaluate certain options alike we correlated the grades of the options to each other. The correlations varied from -.06 to .59. This range indicates respondents tend to evaluate some options quite alike and some very differently from each other. The two CCS options are evaluated fairly alike r = .59 and the first CCS option is also being evaluated somewhat similarly to the nuclear option r = .30. Correlations between the two CCS options and the options one to four are all low, being below .30. Other moderate correlations are found between the two efficiency options r = .49, the first efficiency option and wind energy .51 as well as the second efficiency option and wind, r = .37.

Seven options: choice and rejection

Besides evaluating the options respondents were also asked to choose three options they would like to take up in their preferred energy mix to solve the policy problem. Table 3 contains choice and rejection percentage for each option including these percentages from the ICQ 2007. Just like in 2007 most people choose the first efficiency option (88.1%) followed by wind (82.1%) and biomass (61.9). A combination of these three is also still the most popular combination of options and is chosen by 38.8% of the respondents. This is high considering the next most often chosen combination is chosen by 16.4% of respondents (combination of the two energy efficiency options and wind). The third most often chosen combination of options was that of efficiency, wind and nuclear. In 2007, nuclear did not occur in the top 3 of preferred combinations. Wind and nuclear were both chosen more often in 2010 than in 2007, while biomass and the two CCS options were chose less often. However these differences fail to reach statistical significance. The two CCS options were both chosen the least often of all the options and only by a few respondents (6% and 8.2% respectively).

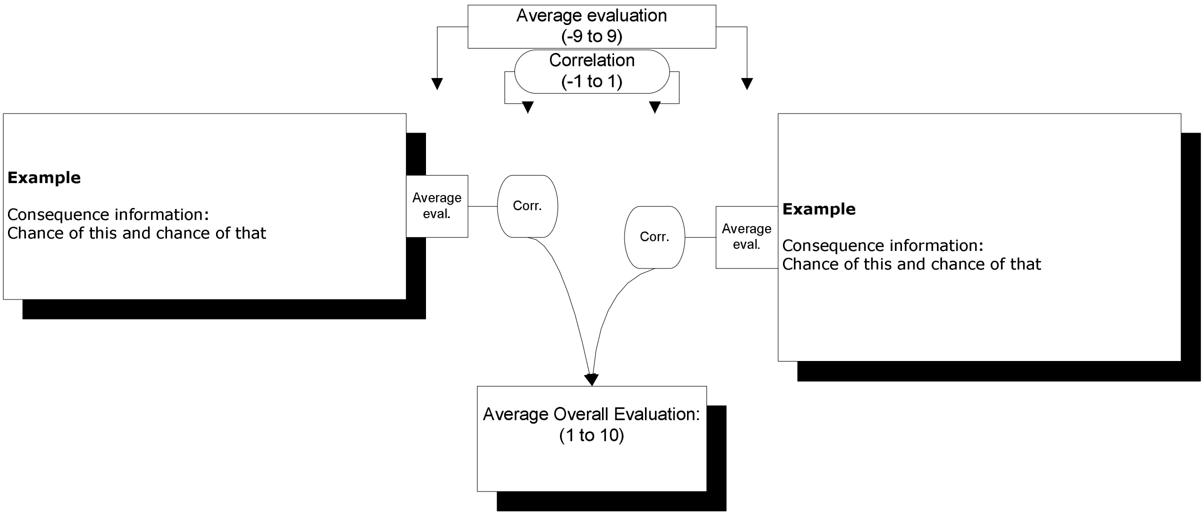
Table 3 Percentage of respondents choosing each option or rejecting it in 2010 compared to 2007

Option	Choice 2007 %	Choice 2010 %	Reject 2007 %	Reject 2010 %
Efficiency	90.2	88.1	0.4	1.5
Efficiency plus	24.0	24.6	5.9	8.2
Wind	75.4	82.1	1.9	1.5
Biomass	70.0	61.9	1.5	3.7
Powerplants + CCS	6.9	6.0	11.0	14.9
Hydrogen + CCS	10.6	8.2	6.8	5.2
Nuclear	22.9	29.1	20.0	19.4

Besides choosing their three favorite options, respondents could also indicate if there was any option they would consider to be unacceptable. The two options most often thought to be unacceptable by respondents are nuclear energy (19.4%) and the first CCS option (14.9%). The first efficiency option, wind energy and biomass were hardly ever thought to be unacceptable (ranging between 1.5% and 3.7%). The Hydrogen CCS option was considered to be unacceptable by less people than the first CCS option (6.8% compared to 14.9% respectively). There were no major differences with the results from 2007, even though the first CCS option is rejected by more people in 2010 than it was in 2007 (from 11.0% to 14.9%).

5.1.3 Evaluation of consequences in relation to overall evaluations

Before grading an option respondents were presented with the consequences of the option which they had to evaluate as well. First they would state whether they saw the consequence as a disadvantage, advantage or as not important. If they stated either disadvantage or advantage they could subsequently indicate how big a disadvantage or advantage it was to them on a nine point scale. To calculate the average evaluations of consequences of an option the evaluations were aggregated into one scale ranging from -9, signifying a large disadvantage through 0, meaning not important, to 9 signifying a large advantage. The following section shows for each option the relation of evaluations of its consequences to its overall grade. The outer right and outer left columns of each figure of an option contains the information regarding the consequences of a option. This information is an English translation of the Dutch information for lay people that respondents received. This Dutch information has been tested and improved vigorously, as described in section 4.1. The English translation of the lay information has not been tested or checked by experts again, but is simply a rather literal translation of the Dutch information for the purpose of this report. Right and left of the information columns, in the square box, the average evaluation of the specific consequence is given. Connected to this is the single correlation between the evaluation of the consequence and the overall evaluation of the option, given in the round box.



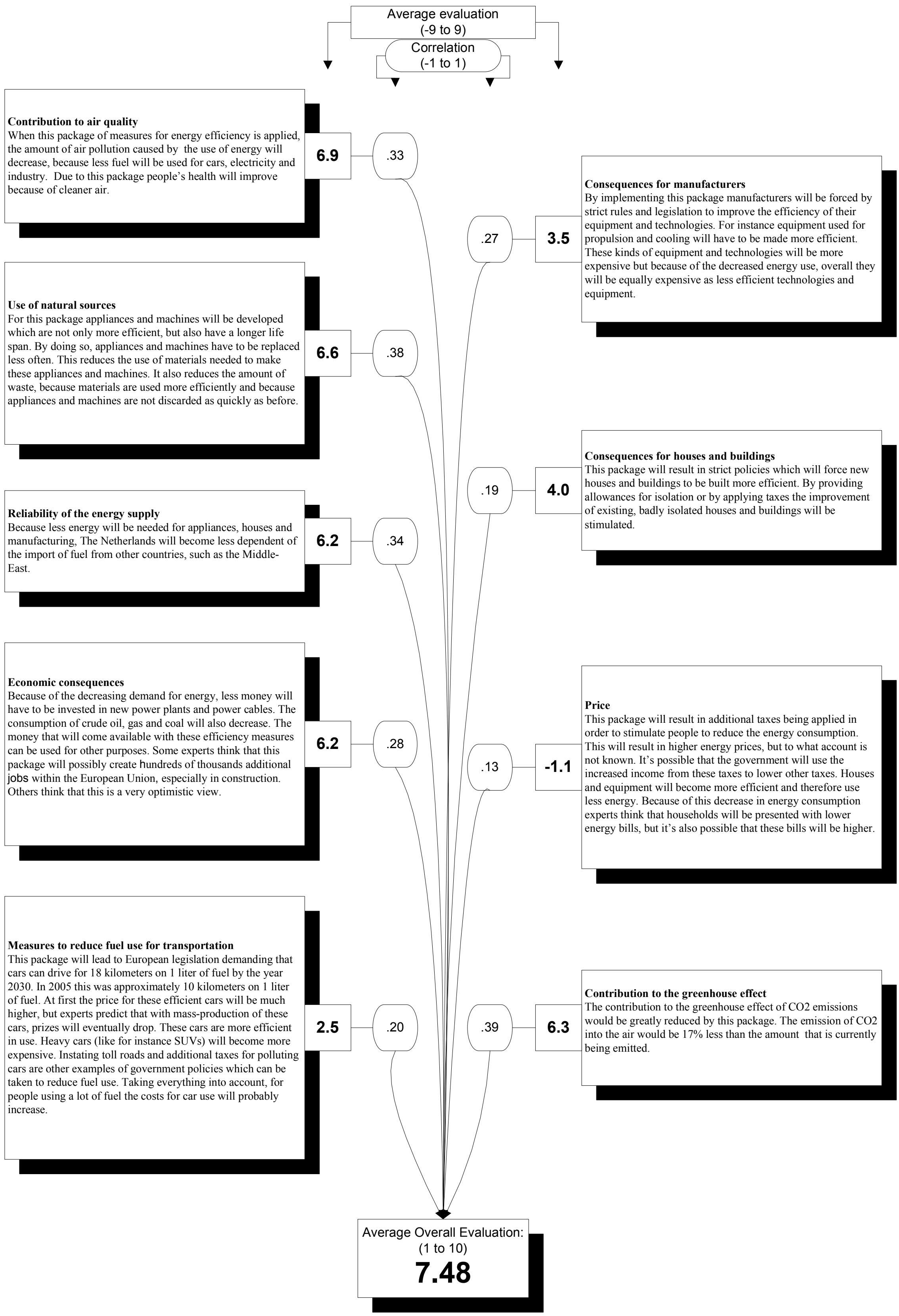
These correlations are all single correlations between evaluation of one consequence and the overall evaluation of the option it concerns. These correlations are an indication of the influence of each consequence on the overall evaluation of the option. These correlations give some insight in the relative influence of the different aspects or consequences. A correlation can vary between -1 and 1, with 0 meaning no relation between two variables. A correlation of 1 means a perfect linear relation between two variables, in the sense that the values of one variable are perfectly predictable from the value of the other variable. A correlation of -1 also means a perfect linear relation between two variables, however, a negative correlation means that as one variable increases, the other variable decreases, and vice versa. A positive correlation means that as one variable increases, the other variable also increases, and if one variable decreases, so does the other variable. As the correlation between the overall evaluation and the evaluation of a consequence rises, the consequence is likely to play a more important role in the determination of the overall evaluation.

In the middle column of the figures, the average overall evaluation of the option is given. The multiple correlation between the evaluations of the consequences of an option and the overall evaluation of that option is stated in the discussion of the figure. The multiple correlations represent how much the evaluations of the consequences of an option together are connected to the overall evaluation of an option. A multiple correlation can vary between 0 and 1. The squared multiple correlation (R^2) represents the proportion of variance that can be explained. In this case, the multiple correlation gives an indication of the degree to which the overall evaluation of an option can be explained or predicted from the evaluations of the consequences of that option. Multiple regression analyses were done to investigate this.

From consequence evaluations to overall evaluation: Option "Improvement of energy efficiency"

Just like for all the following options respondents were presented with general information about this option, with all the possible consequences which they all evaluated before finally grading the option on a scale from one to ten. The relation between the evaluations of all the consequences and the overall grade of this option, the multiple correlation, is moderate R = .45. This means that to a certain extent respondents base their overall evaluation of this option on information about the consequences, but not completely. A part of their overall evaluation is based on other considerations or factors than the information provided. The single correlations, shown in figure 1 between the consequences and the overall grade range from a low -1.1 to a moderate .39. The strongest relation exists between respondents evaluation of the consequence "much less contribution to the greenhouse effect" and their overall evaluation. The more positively people evaluate the fact that this option will contribute to reduction in CO_2 emissions, the more likely they are to give the option a higher overall grade. This consequence is on average evaluated as quite an advantage with an average evaluation of 6.3, and it seems to contribute to the high grade this option generally receives. The following three highest correlations between consequences and the overall grade are also with consequences that are rated rather positively; "Contribution to air quality", "Use of natural sources" and "Reliability of the energy supply". The fact that these positively evaluated consequences have the highest correlations with the grade explain to a certain degree this high grade. All other consequences are also evaluated positively, except for "price: lower or higher" which is evaluated as a slight disadvantage. Most of these other consequences, however, correlate only weakly to the overall grade, which means they hardly influence the respondents' overall opinion either in a negative or positive way.

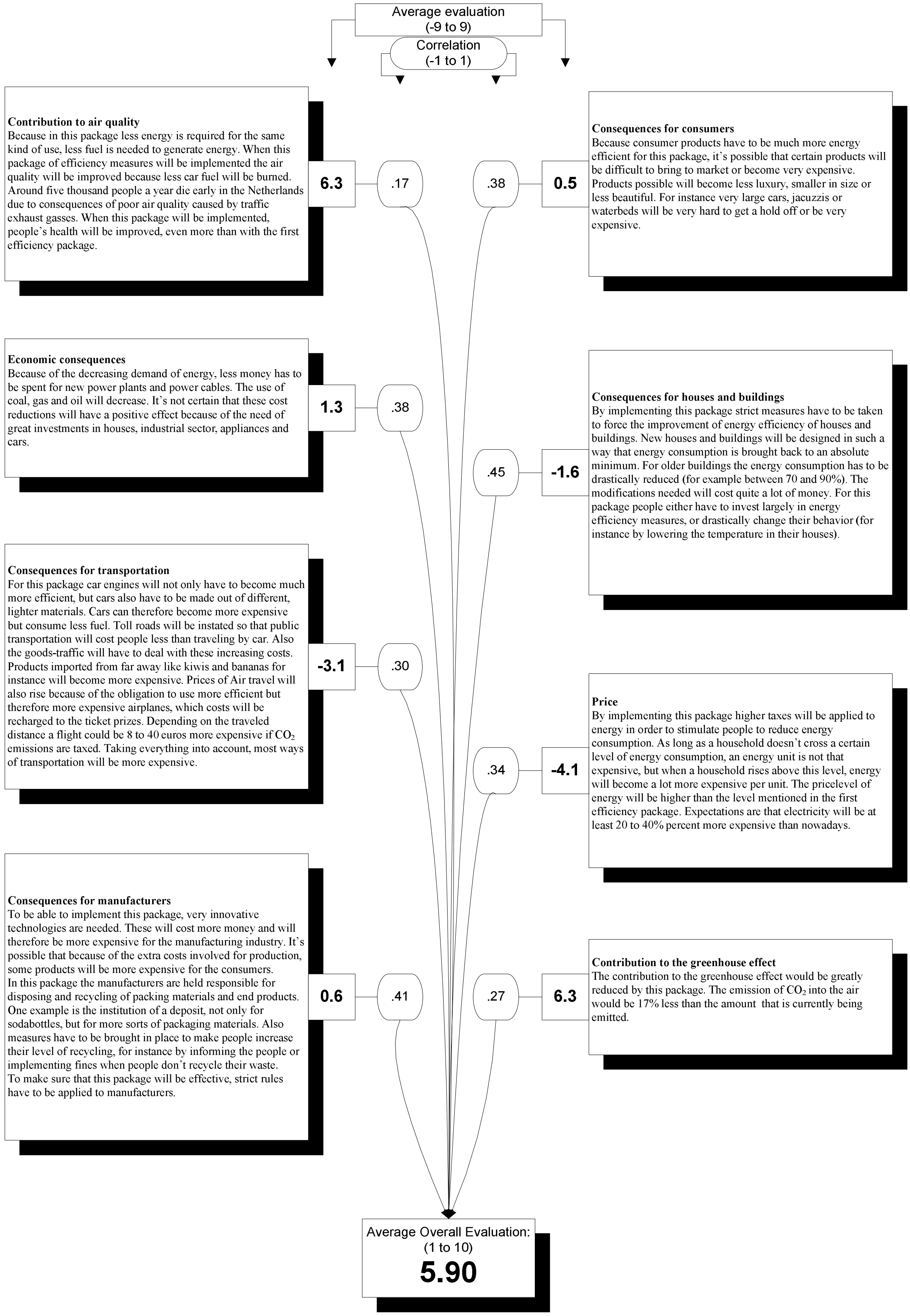
Figure 1: Improvement of energy efficiency



From consequence evaluations to overall evaluation: Option "Improvement of energy efficiency and decreased use of material and energy"

In this option as well, respondents received general information about the option followed by consequences they had to evaluate and were requested to grade the option on a scale of 1 to 10 after they had evaluated all the consequences. The multiple correlation between these consequences and the overall grade of this option is R = .60 which is moderately high. It is somewhat higher than the multiple correlation of the previous option which means in the case of this second efficiency option the information about the consequences has a bigger influence on how this option is graded. The single correlations between the consequences and the grade, shown in table 2, are still not very high, but higher than in the previous option. The strongest correlation is found between consequence "drastic regulations for energy use houses and buildings" and the overall grade. The fact that this consequences is evaluated slightly negatively with a -1.6 explains to a certain extent the fairly low grade this option received (5.9). In addition to this consequence several others that were evaluated negatively or as only slightly positive also have relatively high correlations to respondents' overall evaluation including "Economic consequences" which states this option might save money, but will also require large investments (M = 1.25), "consequences for manufacturers" which will have to comply to strict standards which might affect consumer good prices (M = .6) and the most negatively evaluated option "Implementation of higher taxes" (M = -4.0). These consequences correlate between .34 and .41 with the overall grade. The two very positively evaluated options "contribution to air quality" (M = 6.3) and "contribution to the greenhouse effect" (M = 6.3) both showed very weak correlations to the overall grade (.17 and .27 respectively), which means they hardly influence respondents' evaluation, what also contributes to understanding the very moderate grade this option received.

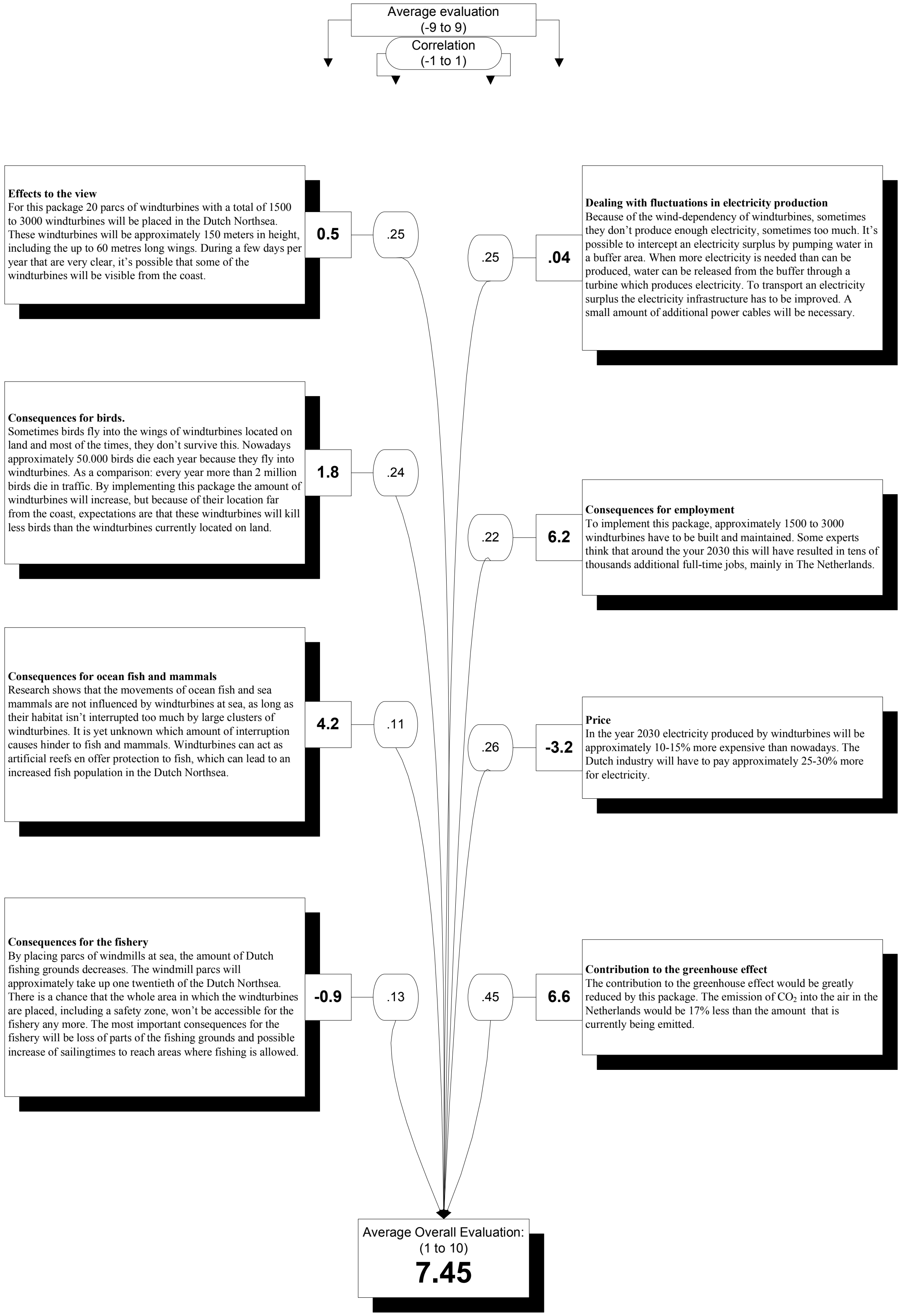
Figure 2: Improvement of energy efficiency and decreased use of material and energy



From consequence evaluations to overall evaluation: Option "Electricity from wind turbines at sea"

Again, respondents received general information about the option followed by consequences they had to evaluate and were finally requested to grade the option on a scale of 1 to 10 after they had evaluated all of its consequences. The multiple correlation between the consequences of this option and the overall evaluation is R = .55 which again is moderate, meaning the information about the consequences moderately influences respondents' overall evaluation, while some other arguments or factors, unaddressed by the information in the ICQ, play a role as well. The single correlations are shown in figure 3. One consequence in particular correlates with the overall evaluation more than the others: "less contribution to the greenhouse effect" (r = .45) and this consequence is evaluated as a strong advantage with a mean evaluation of 6.6. All the other single correlations are fairly weak ranging between .11 and .26. Respondents especially don't seem to take the consequences for fish and fishery into account, considering the very weak correlation between these consequences and the overall evaluation. As in the previous options respondents consider the costs to be quite a disadvantage; a consequence of wind turbines at sea would be an increase of 10 to 15% in electricity. They are more ambivalent about the consequences of the offshore turbines for the view from the coast or the intermittency of power generation associated with wind power. All these consequences however don't have a lot of influence on the overall evaluation. The quite positive overall grade seems to be explained mainly by the positive evaluation and strong correlation of the lowered contribution to the greenhouse effect of this option. The other consequences contribute a little bit to respondents' overall evaluation, but their positive view of this option is also influenced by other factors than the consequences described in the questionnaire.

Figure 3: Electricity from wind turbines at sea



From consequence evaluations to overall evaluation: Option "Conversion of biomass to car fuel and electricity"

Respondents received information about the option "Conversion of biomass to car fuel and electricity" after which they were presented by possible consequences of this option. They rated these consequences as explained before, after which they gave the option an overall grade. The multiple correlation between the consequences and the overall evaluation for this option is R = .55 as was the case in the previous option. This multiple correlation is moderate, again meaning respondents base a part of their overall evaluation on the information about these consequences but not all of it. They take arguments or factors not included in the information in this questionnaire into account. The single correlations of the consequences, shown in figure 4, are low to moderate, varying from -.03, meaning no relation at all to .43. The biggest influence on the overall evaluation is exerted by the consequences "electricity price will stay the same" and "it might have a positive effect on Netherlands' economy". Both of these consequences are evaluated as quite big advantages of the biomass option, which somewhat explains the overall positive grade the biomass option received. The consequences for land use for biomass production with certificate are evaluated as a big advantage and also correlate moderately with overall evaluation. However, the consequence for land use in the case of biomass production without certificate, which is evaluated as a big disadvantage, has no influence on respondents' overall evaluation. It might be that respondents who consider this consequence to be a disadvantage nevertheless do not believe this is likely to happen, so it does not influence their overall opinion.

Figure 4: Conversion of biomass to car fuel and electricity

Average evaluation (-9 to 9)
Correlation (-1 to 1)

Contribution to air quality — 6.2 — .26
Vehicles burning biofuel emit less toxic gasses and this leads to better air quality in cities compared to the current situation. In The Netherlands around 5000 people a year die early from the consequences of poor air quality caused by traffic exhaust gasses. When this package is realized on a large scale by the year 2030, air quality in The Netherlands will be greatly improved. This may improve the health of many people.

Use of land for biomass with certificate — 4.6 — .37
Land is needed to obtain biomass. To be able to obtain sufficient amounts of biomass for this package, land is needed in amounts which vary from half of the surface of The Netherlands to a surface larger than The Netherlands. Therefore most of the required biomass will have to be imported from regions such as Latin America, South and Eastern Africa, Eastern Europe/Russia and the vicinity of Australia. Biomass which is produced in a responsible manner (for instance by using grass or trees) will be certified (just like the certificates for hardwood). Responsibly produced biomass can result in an increase of income and employment and a decrease in poverty for the afore-mentioned regions. In addition the cultivation of these kind of crops can result in an improvement of the cultivating ground which in turn can result in a more lasting and during form of agriculture.

Use of land for biomass without certificate — -5.9 — -.03
Some experts think that The Netherlands will be able to import sufficient amounts of certified biomass needed for this package. Other experts think that this may become problematic, especially when other countries start importing large amounts of biomass too. Uncertified biomass isn't always produced in a responsible way which can have serious implications for the areas where the biomass is being produced. Worst case scenarios include exhaustion of water reserves, destruction of other cultivating grounds and/or forests and the banishment of small independent farmers.

Influence on food production — 1.6 — .22
When a large amount of countries start using biomass, there is a possibility that the need for cultivated land will be of such proportions that the amount of cultivated land available for food production will become too small. By improving agriculture in areas where the production is low, the same amount of food can be grown with a smaller amount of land so that more land will become available for the cultivation of biomass. Biomass can also be bred on grounds which are unusable for food growth. By cultivating biomass on these grounds, in some cases the breeding of biomass results in an improved quality of the cultivated land in such a way that it becomes possible to cultivate food on grounds which were not suitable before. The surpluses of forestry and agriculture which normally aren't used (such as leftover wood, saw-dust, straw) can be used as biomass.
Cultivation of biomass can lead to rivalry with the cultivation of food, but breeding biomass can also lead to improved management of cultivating grounds and stimulate an improved efficiency when it comes to cultivating food.

Reliability of the energy supply — 4.2 — .30
Experts place a great deal of importance on the reliability of the energy supply. This means that there should, at any given time, be enough energy available. The fuels needed for energy production partly have to be imported, but without being dependent of a small number of supplying countries (such as our current dependency of the Middle-East when it comes to crude oil). Biomass can be imported from lots of different countries on different continents. Some experts think that certified biomass can be imported from less countries. The change that the biomass needed for this package can't be imported in sufficient amounts is very small. Because biofuels replace crude oil the dependency towards the import of crude oil decreases. Therefore the reliability of the energy supply is reasonably good.

Expansion of seaports — 4.4 — .33
To be able to import and process the biomass necessary for this package larger seaports are required. Therefore the available seaports have to be expanded. The expansion of the seaports will result in additional employment. The increase in employment by this package will be larger than the decrease in employment resulting from a decreased use of coals and oil.

Necessity of new vehicles — 3.0 — .26
Most of the current cars are equipped to handle fuel which is partly biofuel (for these cars the biofuel is mixed with petrol or diesel). For this package approximately two thirds of all cars gradually have to be replaced by the year 2030 with cars that are equipped to handle pure biofuel. These cars have already been developed and are identical to the current cars apart from the fuel needed.

Economic consequences — 5.6 — .43
In this package biofuel replaces crude oil. Because biofuels, in time, will be less expensive than crude oil, less money will leave The Netherlands. This will have a positive result on the future trade balance of The Netherlands. This can have positive results on the Dutch economy.

Price — 5.7 — .41
The price of electricity produced from biomass is expected to be equal. The price of car fuel based on biofuel is expected to be a little lower. When the same level of taxes will be applied, in 2030 biofuel will be priced the same or possible 20% per litre lower than petrol currently is

Contribution to the greenhouse effect — 6.4 — .29
The contribution to the greenhouse effect of CO2 emissions would be greatly reduced by this package. The emission of CO2 into the air would be 17% less than the amount that is currently being emitted.

Average Overall Evaluation: (1 to 10)
7.39

From consequence evaluations to overall evaluation: Option "Large plants where coal or gas is converted into electricity with CCS"

As with the other options respondents were first presented with a description of the option after which they received information about the consequences which they evaluated as either disadvantages, advantages or as unimportant. After they had evaluated the consequences they gave an overall evaluation of this CCS option. The multiple correlation between the six consequences and the overall evaluation is R = .53, comparable to the options discussed earlier. This multiple correlation is moderate, which means the consequences explain a part, but not all of the overall evaluation. Other factors or arguments than the ones discussed in the questionnaire play a role in respondents' overall evaluation. This CCS option received the lowest grade of all options a 5.0 which is a failing grade in the Dutch system. The evaluations of the consequences and their relation to this overall grade give some insight into why and are shown in figure 5. All of the consequences were rated as a disadvantage except for the consequence "less contribution to the greenhouse effect", which is the same for all options. The single correlations range from fairly low to moderate, with the highest one being .40 for the consequence "safety of CO_2 storage" which is evaluated as a fairly big disadvantage. The second most related consequence is "safety of transport" which is also evaluated as a disadvantage and thus contributes to a more negative overall grade. The one positively evaluated consequence "less contribution to the greenhouse effect" is hardly related to the overall evaluation at all, meaning it has no positive (nor negative) influence on the overall grade. It is mainly the negatively evaluated consequences that have a moderate effect on the low grade this option received.

Figure 5: **Large plants where coal or gas is converted into electricity with capture and storage of CO_2**

From consequence evaluations to overall evaluation: Option "Large plants where gas is converted into hydrogen with CCS"

As with the other options respondents were first presented with a description of the option after which they received information about the consequences which they evaluated as explained earlier. After they had evaluated the consequences they gave an overall evaluation of this CCS option. The multiple correlation between the six consequences and the overall evaluation is R = .65 which is moderately high, meaning the consequences explain the overall evaluation fairly well, but still a part of respondents' evaluation is based on other arguments than the ones presented in this information. The single correlations between the consequences and the overall evaluation range from almost nonexistent, -.01, to moderate .43. Figure 6 shows all the correlations. The four consequences that have the strongest correlations to overall evaluation of the hydrogen and CCS option, "economic consequences: large investments" (.43) , "need for new vehicles" (.40) "need for new pipelines" (.40) and "safety of CO_2 storage" (.38) are all evaluated as disadvantages of this option. This means that they negatively influence respondents' overall evaluation. Just like in the previous CCS option, concerns about the safety of storage seem to play a big role in respondents' evaluation of this CCS option as well. Two consequences that were rated as moderate advantages "less noise" and "improvement in local air quality" do not have a large impact on the overall evaluation, especially the noise level reduction seems unimportant to respondents' choice of grade. The overall grade thus is mainly influenced by the consequences that respondents evaluated as negative and hardly by the consequences they graded as positive which to a certain extent explains the modest grade received by this option (5.9). The fact that respondents do perceive some advantages does make this grade slightly higher than the one given to the previous CCS option.

Figure 6: Conversion of natural gas into hydrogen in large plants with CO_2 capture and storage

Average evaluation (-9 to 9)

Correlation (-1 to 1)

New pipelines needed
The hydrogen would have to be transported to businesses and to hundreds of thousands of homes and buildings. This would necessitate a dense network of many underground pipelines. The realisation of this network will be massive and time-consuming, and will cause inconvenience due to excavations, including in residential areas.

-4.0 | .40

New vehicles needed
The implementation of this package necessitates the replacement of all cars by hydrogen fuelled cars. These cars could be more expensive in 2030 than a car that runs on gas, but it is expected that fuel cell cars will become less expensive over time.

-0.5 | .40

Contribution to air quality
Vehicles powered by hydrogen emit almost no poisonous substances, and improve the air quality in the cities greatly. In The Netherlands, approximately 5000 premature deaths are caused by poor air quality due to traffic exhaust. When this package is realized on a large scale in The Netherlands around 2030, thousands of lives will be saved annually in the Netherlands because of the cleaner air.

6.4 | -.01

Contribution to noise
Engines from cars and other vehicles that run on hydrogen, do not make any noise. The implementation of this package will lead to a decrease in the level of noise in cities and residential areas from 85 decibel to 70 or less decibel. (For example: 85 decibel is about the level of noise from a crowded intersection in the city, 70 decibel is about the level of noise from a calm intersection).

4.5 | .26

Safety of hydrogen plants
There has been a lot of experience gained in the last decades in the industry with the conversion of natural gas into hydrogen. The designs of these factories and the necessary safety precautions are standard. Experts do not always agree if hydrogen factories can be made as safe as current gas fired plants.

-1.8 | .39

Safety of use of hydrogen in daily life
Experts believe that transporting hydrogen through pipelines and using hydrogen in homes can be made as safe as the existing transport and use of natural gas. Costs for technical safety measures are, however, probably higher. Accidents caused by asphyxiation, fire or explosion will not occur more often than at present. Safety measures would make the use of hydrogen in fuel stations, buses and trucks just as safe as the current use of petrol.

1.2 | .22

Safety of CO_2 transport in pipelines
Too much CO_2 in the air is hazardous and can even be lethal. During the transportion of CO_2 in pipelines, the pipeline may spring a leak, causing the CO_2 to be emitting in the air. There is a small chance that a cloud of CO_2 which is dangerous for people, animals and plants will keep hanging in the air without dispersing. The chance of leakage is comparable to the chance of gas leakage in the current underground gas pipelines in the Netherlands. Approximately 2000 kilometres of pipelines will be needed for this package. For this amount of pipelines, it can be expected that accidents will occur about once every two years, but this will not always lead to the escape of CO_2. Expectations are that by placing good systems for monitoring the chance of leakage of CO_2 from pipelines will be very small.

-1.2 | .29

Safety underground CO_2 storage
Subsoil storage of CO_2 can cause minor earthquakes similar to those caused by natural gas mining. This might cause small ruptures in buildings in the area. Once CO_2 is stored in the underground storage space, it might leak away through poorly sealed wells, and tears and cracks in the sealing layer of the underground storage space. When an underground storage space keeps leaking for years, this will for the most part undo the emission reduction effect of this package. Although experts are not sure how much CO_2 would be released into the air, quantities are likely to be extremely small. In addition, there is a very small chance that the leaked CO_2 would accumulate in low lying closed spaces such as cellars. This would be hazardous and possibly lethal for humans, animals and plants occupying this type of space. There is a small chance that CO_2 leakage acidifies the surrounding groundwater. If this is used for drinking water, it will only be potable after it additional treatment. Expectations are that good monitoring will make the risk of CO_2 leakage from underground storage spaces very small.

-3.1 | .38

Reliability of energy supply
Experts place a great deal of importance on our being able to generate enough energy. Parts of the fuel necessary for this package must be imported from other countries. We do not wish to be dependant on the politics of only a few countries, such as the dependency on the Middle East for oil. In order to ensure high reliability it is possible to store reserves of gas for later use. It is also possible to produce hydrogen from other fuels than natural gas, such as coal or biomass.

2.9 | .17

Economic consequences
The Netherlands would have to invest a great deal of money in all of the changes necessary for the implementation of this package, including new installations and vehicles, and numerous CO_2 pipelines. It is unknown what the effect of these investments would have on the economy.

-2.9 | .43

Price
The costs of hydrogen for households will be approximately 25-35% higher than that of natural gas. Producing hydrogen is about twice as expensive as petrol. Because of this, the car fuel price will rise with about 20%. Electricity generated from hydrogen with this technology will cost the industry approximately twice as much as it does now. The fuel costs for road traffic will probably rise much less because hydrogen fuelled cars will be more efficient. It is expected that the costs for driving a hydrogen fuelled car in 2030 will be equal to the costs of driving a diesel car.

-1.3 | .28

Contribution to the greenhouse effect
The contribution to the greenhouse effect of CO_2 emissions in The Netherlands would be greatly reduced by this package. The emission of CO_2 would be 17% less than the amount that is currently being emitting.

5.9 | .28

Average Overall Evaluation: (1 to 10)
5.90

From consequence evaluations to overall evaluation: Option "Electricity from nuclear plants"

In this option as well, respondents received general information about the option followed by consequences they had to evaluate and were requested to grade the option on a scale of 1 to 10 after they had evaluated all the consequences. The multiple correlation between the consequences and the overall evaluation is R = .74, which is the highest of all options and generally moderate to high. This means the information about the consequences of this option explains the respondents' overall evaluation quite well, even though still not entirely. Respondents' still also take other factors or arguments into account not included in this information. The single correlations between the consequences and the overall evaluation of this option, shown in figure 7, are all moderate, meaning they are overall higher than the single correlations found in the other options. This could mean the information included here reflects people's arguments well, which could be the consequence of the maturity of the debate surrounding nuclear energy so the important arguments are well known. The consequence most strongly related to overall evaluation is the issue of nuclear waste. Respondents are clearly worried about this, because not only is it important for their overall opinion, they also rate it as the most negative consequence of all the consequences mentioned in this option. Other consequences with a moderate correlation to overall grade are "safety of nuclear power plants" and "protection of power plants against terrorist attacks", both evaluated as slight disadvantages. These consequences address the risks, but also state that safety standards are rather high. Distribution of the evaluations of these consequences shows some respondents evaluate it as a moderate advantage and some as a moderate disadvantage. This could mean some are reassured that the risks are well managed, while others might have doubts about this. In the average evaluation these responses cancel each other out to a certain extent. They do seem to exert moderate influence on the overall evaluation, which in this situation it means it can be both in a positive as in a negative way. Two consequences rated as moderate advantages of the nuclear option are "less contribution to greenhouse effect" and "energy security: more diversity of suppliers". These consequences however have a weaker influence on the overall evaluation. With the negatively evaluated consequences having more influence on overall evaluation this option in the end received a relatively low grade, which in the Dutch system is a failing grade.

Figure 7: Electricity from nuclear plants

Average evaluation (-9 to 9)
Correlation (-1 to 1)

Background radiation during normal operation
During normal operation of a nuclear power plant very small particles are released which produce very small amounts of radioactive radiation. The amount of radiation is even less than normally present in the area by nature. This amount of radiation will not cause any health problems on the short term. Some experts think that on the long term there will not be any risk of health problems due to this very small amount of radiation. Other experts think that we do not have enough knowledge to make predictions about this.

-2.3 | .48

Protection of power plants against terrorist attacks.
Some people are concerned about terrorist attacks on nuclear power plants with devastating results. The power plants mentioned in this package are very efficiently protected. Accidents with the reactor using bombs or airplane crashes on top or in the close vicinity of the power plant are very hard to accomplish. Sabotage by employees is not impossible, but difficult.

-1.4 | .49

Nuclear power plants en nuclear weapons
Spreading of nuclear weapons means that either countries currently not in possession of nuclear arms will be enabled to produce them or that nuclear weapons fall into the hands of terrorists. According to some experts, the spreading of nuclear arms will be more likely because of the development and use of nuclear power plants. Some experts think that when knowledge is being developed about nuclear technology for power production, this generates more knowledge about nuclear weapons as well. In addition to that, some expert think that the development of materials needed for the power plants leads to availability of materials used in the production of nuclear weapons. Other experts state that there is no connection between the development and deployment of nuclear power plants and the spreading of nuclear weapons.

-4.0 | .41

Nuclear waste
In the process of preparing uranium for the use in nuclear power plants, but especially when using uranium in the actual power plants, nuclear waste is produced. A portion of this nuclear waste will be very radioactive for thousands of years; it will produce a lot of radiation. In this package the nuclear waste will probably be stored in heavily secured barrels in deep underground storage facilities. Experts know that this method of storage is safe for the first couple of centuries and that there will be no leakages of any kind. Experts think that after this initial period the risk of leakage is very small, but they acknowledge the existence of uncertainties, because it's hard to predict what happens underneath the ground. Some experts think that as of 2030 it will be possible to treat nuclear waste in such a way that it will be strongly radioactive for a maximum period of 200 to 300 years. Other experts doubt whether this technology of nuclear waste treatment will be developed enough in 2030 to be able to use it at that time. Leakage of nuclear waste can produce health problems with plants, animals and people in cases where for instance the leakage occurs in the vicinity of the ground water. This may be prevented by making sure that the storage of the nuclear waste does not take place in the vicinity of ground water, but there's no way to be sure that in thousands of years the ground water will not get closer to the nuclear waste. Taking everything into account, experts predict that the risk of health problems for plants, animals and people caused by leakage of nuclear waste is very small.

-4.1 | .51

Reliability of the energy supply
Experts place a great deal of importance on the reliability of the energy supply. This means that there should, at any given time, be enough energy available. The fuels needed for energy production have to be imported, but without being dependent on a small number of supplying countries (such as our current dependency of the Middle-East when it comes to crude oil). Uranium can be imported from lots of different countries on different continents. Therefore the chance will be very small that the uranium needed for the nuclear plants cannot be imported. Besides that, building reserves of uranium is very easy because of the small amount of space uranium takes. Taking this into account, the overall reliability of energy coming from these plants will be good.

4.3 | .37

Price
Some experts expect that the price of electricity produced by nuclear power plants will be roughly the same as the current price of electricity produced by coalfired power plants. The price will increase when additional security measures have to be taken or when the nuclear waste from the plants has to be treated to reduce the period of radio-activity. Some experts estimate that due to these measures the price of electricity coming from nuclear power plants will be twenty percent higher. The costs involved in building a nuclear power plant are very high, but if and in what amount this has an effect on the price of electricity is unknown.

-3.5 | .44

Safety of nuclear power plants
The nuclear power plants mentioned in this package are build in such a way that human interference is unnecessary regarding checking the system for failures or resolving these failures. A protective dome wille be constructed around the nuclear power plant. Therefore these power plants are safer than the current nuclear power plants and much safer than for instance the former nuclear power plant in Tsjernobyl. The nuclear power plants mentioned in this package are just as safe as the current chemical industry in The Netherlands. The chance of a serious accident is very small. An example of a very serious accident with the power plant in this package is an accident with the reactor. People living within one and a half kilometer of the power plant have to be evacuated. An area with a radius of 20 by 40 kilometers around the power plant will be completely unusable for at least one year, but possibly a lot longer. The chance of an accident like this happening is less than once in two hundred thousand years. The chance of accidents with even more serious consequences is much less.

-0.9 | .49

Contribution to the greenhouse effect
The contribution to the greenhouse effect of CO_2 emissions would be greatly reduced by this package. The emission of CO_2 into the air would be 17 % less than the amount that is currently being emitted.

5.9 | .21

Average Overall Evaluation:
(1 to 10)
5.38

Comparison evaluations of consequences 2007 and 2010

A comparison between the evaluations of the consequences reveals very similar results. Most consequences are evaluated in the same way in 2010 as they were in 2007. Out of the 61 consequences only 5 have changed significantly between the measures. The "consequence for transport" of the efficiency option changed from an average evaluation of 1.2 to 2.5 ($F_{1,1103}$ = 7.024, p = .008). This still remains a fairly weak positive evaluation of this consequence. The consequence of electricity production from wind on energy price has changed from an evaluation of -4.0 to a less negative evaluation of -3.2 ($F_{1,1103}$ = 5.654, p = .018). The consequence of "effect on greenhouse effect" changed from 6.9 to 6.4 ($F_{1,1103}$ = 4.946, p = .026). The largest difference is found for the consequence "contribution to noise" of the Hydrogen + CCS option which has changed from an average evaluation of 5.8 to 4.5 ($F_{1,1103}$ = 20.393, $p < .001$). The fifth option to change is the consequence of nuclear electricity production on spread of nuclear weapons which changed from -4.7 to -4.0 ($F_{1,1103}$ = 4.061, p = .044). Overall there is a very high consistency between how consequences are evaluated on average. This is also true for the influence the evaluations of consequences have on the overall evaluations of the options. Despite the fact that not all of them are the same in 2010 as they were in 2007, the overall pattern of single correlations of consequence evaluation to overall evaluations remains very similar. Consequences that correlate most strongly with the options are still the ones correlating most strongly while the lowest correlating ones have also remained low in the 2010 survey.

5.1.4 Evaluations of global warming

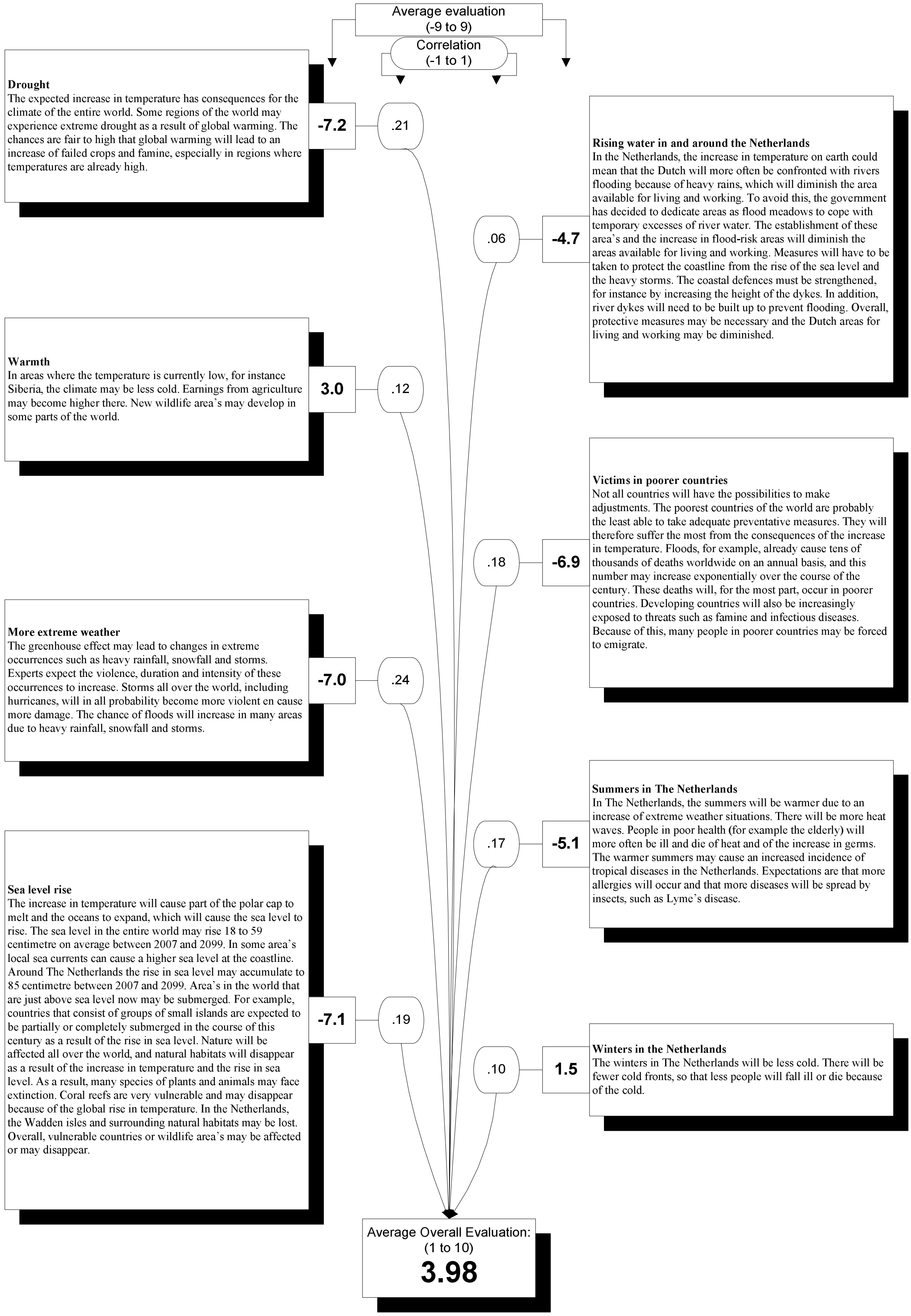
Evaluations of global warming consequences

In the beginning of the questionnaire respondents were introduced to global warming and the greenhouse effect as well as how this is affected by our current energy use. After this general introduction to the topic, in a similar way as with the seven energy options, respondents received information about eight possible consequences of the increase in the greenhouse effect. They evaluated each consequences as either a "disadvantage", "advantage" or "unimportant". Then, if they chose either "disadvantage" or "advantage" they rated how strong a disadvantage or advantage they believed it to be. In the end they were asked to give global warming a grade from 1 to 10 just as they later did for the energy options, with 1 being the lowest possible grade, meaning a negative evaluation and 10 the best possible grade, meaning a very positive evaluation. The results were analysed in the same way as the evaluations of the energy options and an explanation of this procedure is given in section 4.1. Figure 8 shows the average evaluations of consequences as well as their correlations to the overall evaluation.

Respondents considered the biggest advantages of a stronger greenhouse effects to be "more droughts", "extremer storms and rainfall", "sea level rise", and "poor countries affected most", just like in the ICQ administered in 2007. They are moderately negative about "rising water in and around the Netherlands" and "more heat waves". Two consequences they perceive as advantages are "warmer winters in the Netherlands" and "more warmth in cold areas". The multiple correlation between the evaluations of the consequences and overall evaluation of global warming is rather low R = .34. This means the information about the consequences hardly influences respondents' overall evaluation. The single correlations are also very low. The highest correlation is .24, which is fairly low and this is between the consequence about increased extreme weather events and overall evaluation. Mainly other issues, not included in this questionnaire, seem to influence respondents' perception of global warming.

The average grade respondents give global warming is 4.0, which is fairly low and a failing grade. This is almost the same as when the questionnaire was administered in 2007 when the average grade was 3.1. There is no statistical difference ($F_{1,1103} = .172$, $p = .678$) between these two grades, which means the overall evaluation has stayed the same between the two polls.

Figure 8: Consequences of the increase in temperature caused by the greenhouse effect



Climate Change beliefs

As in 2007 the questionnaire included additional questions about respondents' perceptions of global warming. These questions were presented after the ICQ measures and respondents did not receive any additional information on this topic. The results are shown in table 4. Respondents were asked about their belief that global warming is occurring, that it will occur more in the future, that it is a consequence of CO_2 emissions caused by humans and that the Netherlands should protect itself from the consequences. On all the questions a majority of respondents answered that they are convinced that this is indeed is so to a certain extent.

Table 4. Perceptions of global warming, percentages per part of the scale ranging from 1 "not at all" to 7 "very" Between brackets are the results of the 2007 survey.

	1-3	4	5-7
To what extent are you convinced that the climate on earth has become warmer on average in the past century?	15.6% (10.6)	15.6% (11.4)	68.9% (76.6)
To what extent are you convinced that the climate on earth will become even warmer on average in the coming century?	16.3% (7.9)	20.7% (8.8)	62.2% (81.8)
To what extent are you convinced that global warming is a consequence of CO2 emissions by mankind?	25.2% (14.8)	16.3% (13.5)	57.8% (70.2)
To what extent do you think it is necessary for the Netherlands to protect themselves against possible consequences of a warmer climate, such as floods, by for instance raising the dikes or strengthening the sea wall?	5.9% (3.2)	14.1% (8.1)	80.0% (87.6)
New in the 2010 survey:			
To what extent are you convinced that the climate on earth has changed in the past century?	17%	8.9%	73.4%
To what extent are you convinced that climate change is a consequence of CO2 emissions by mankind?	25.2%	13.3%	60.0%

A comparison between the 2007 data and the current data reveal a pattern of increased skepticism about global warming. On all four questions less people answer they are convinced of these statements in 2010 than in 2007. Both the answer option '4' meaning "unsure" and the end of the scale meaning "I'm not convinced" are chosen more often in 2010. An analysis of the difference between the means reveals that in all four questions the differences between the answers in 2007 and 2010 are statistically significant (All ANOVA analyses showed an F significant at the level of $p < .05$). Whereas in 2007 slightly over 75% of respondents was to a certain extent convinced the temperatures had gotten warmer on average, in 2010 this number fell to about 69%. The conviction that it would become even warmer fell more dramatically from 82% to 62.2%. The same is true for the conviction that global warming is a consequence of activities by mankind which fell from about 70% to about 58%. This rise in "climate skepticism" might be a consequence of several incidents concerning climate science which have taken place since the 2007 measure. The main one was the so called "Climategate" when in 2009 communications from the University of East Anglia's (UEA) Climatic Research Unit (CRU) became public and at first sight seemed to reveal 'conspiracies' of climate scientists to make climate change look more convincing than it was. Even though these allegations could not be substantiated they could have made a lasting impression on public discourse and perception (Leiserowitz et al, 2010). Even though a causal relation cannot be established, the rise in climate skepticism is likely to be connected to these events and change in discourse.

Relations between climate change beliefs

As in 2007 a vast majority is to a certain extent convinced the Netherlands should protect themselves against possible consequences of global warming (80%). This percentage is higher than the percentage of respondents convinced that global warming is actually happening. This could mean that some people gather on the side of precaution, believing measures should be taken even though they are not convinced global warming is happening. This is not to say there is no relation between these convictions at all. The more people are convinced the temperature on earth will become higher on average the more they think it is necessary for the Netherlands to take precautions r = .53.

The beliefs that the average temperature has risen, will continue to rise in the future and that global warming is caused by human activity are also related to each other. Respondents convinced temperatures have gotten warmer tend to be convinced it will get warmer in the future as well r = .65, this correlation being moderately high. Also, if people believe it will get warmer in the future they are also likely to believe global warming is caused by human actions r = .60.

In addition to the four questions posed in the 2007 questionnaire several others on the topic of climate change were added in the 2010 version. A distinction was made between "global warming" and "climate change" to test whether there are respondents who are convinced the climate is changing, but who are not necessarily convinced it is getting warmer. Indeed, more respondents are convinced the climate had changed in the past century than that the temperature has become higher on average (73.4% vs 68.9%). The correlation between the answers is .65, which means respondents tend to give similar answers to the two questions, but not identical. A comparison of the means reveals that the difference between the answers just fails to reach statistical significance ($t = 1.93$, $df = 133$, $p = .056$). The difference also exists between the questions "To what extent are you convinced that climate change is a consequence of CO2 emissions by mankind?" and the same question referring to global warming "To what extent are you convinced that global warming is a consequence of CO2 emissions by mankind?", but in this case the difference is smaller. More people are convinced the statement is true for climate change (60%) than for global warming (57.8%), however this difference is not significant and the correlation between the answers is very high, r = .86.

In addition, respondents were presented with two more statements about climate change and policy. One reflected an often heard argument with respect to international climate change mitigation cooperation. A majority of respondents agreed with the statement that reducing CO_2 emissions in the Netherlands makes no sense if other countries do not do the same (59.0% agreed with this). When asked about government spending towards CO_2 emission reduction less than a quarter of respondents (23.1%) believed spending should be increased even at the cost of other policies.

Table 5: Beliefs about climate change mitigation

Question:	Answer options		
	1-3	4	5-7
Reducing CO_2 emissions in the Netherlands makes no sense if other countries such as the United States and China do not reduce their CO_2 emissions.	29.9%	11.2%	59.0%
The Dutch government should spend more on the development of technologies that reduce CO_2 emissions, even if this reduces resources for other policies such as healthcare and education	47.8%	29.1%	23.1%

Willingness to take action regarding climate change

In the end of the questionnaire respondents were asked which type of action the respondent would be willing to participate in to express his or her opinion on climate change. The most often chosen actions were "sign a petition" (chosen by 63%) and "refrain from buying certain products" (66%). The other actions are not selected by more than 20% of the participants, including things like "donating to or becoming a member of an interest group" (21%), "wearing a sticker or badge" (18%), while only 10% of respondents state to be willing to participate in a public protest or other form of active participation (1%). These results show respondents are generally not very willing to actively get involved in public expression of their opinion on this topic.

Interest in Energy and Climate Change issues

In addition to these perceptions questions were added to measure respondents' interest in climate change and energy issues. For further analysis the interest in energy issues as measured by several items and interest in climate change issues measured by another set of items were aggregated in two separate scales "Interest Energy" and "Interest Climate Change". The internal consistency of the questions included in the "Interest Energy" scale was very high, with Cronbach's alpha being .90. The internal consistency between the "Interest Climate Change" items was even higher α = .93. A Cronbach's alpha can reach a maximum of 1 and it measures to what extent the different items are internally consistent and reliable and is an indication of the items measuring the same construct. On the Energy Interest scale respondents score an average of 5.0 and on Interest in Climate Change a 4.8 on a 7-point scale, indicating people are on average interested in these issues and slightly more interested in energy issues than in climate change issues. There is a moderately high correlation between the two scales themselves r = .66. This indicates respondents who are interested in energy issues are generally also interested in climate change issues, but not always. A within subjects t-test comparing these two scores reveals the difference is statistically significant ($t_{(133)} = 2.57$, $p = .011$), meaning respondents are on average significantly more interested in energy issues than climate change. Subsequently the two measures were related to the perceptions of climate change. First of all as could be expected interest in climate change has stronger correlations to perceptions of climate change than interest in energy. The highest correlation exists between respondents' interest in climate change and their perception that the earth's climate indeed has become warmer on average r = .50. The other correlations between interest in climate and perceptions of climate change range between .32 and .49. The lowest correlation is between interest in climate change and perception that global warming is caused by human activities (.32).

Relation between global warming perceptions and evaluation of the seven options

With the aim of CCS being climate change mitigation, previous studies have focused on unraveling the relation between people's convictions about global warming and their evaluations of CCS. Some have found indications of a slightly positive relation between lay people's understanding of the need to reduce CO_2 emissions and their perception of CCS (Shackley et al, 2005; Itaoka et al, 2006; Tokushige et al, 2007). In the 2007 study using the ICQ quantitative results found only very weak correlations between evaluations of the two CCS options and beliefs about global warming. The highest correlation found was .07, which is still very weak. The other options also showed weak correlations to convictions about global warming, with the strongest correlation of all being -.17 between the conviction that future climate will get warmer on average and the nuclear energy option. This analysis was repeated in the current study and again the results show mostly weak correlations between the energy options and convictions about global warming. Table 6 shows all the correlations. The correlations between evaluation of global warming and the seven energy options range between -.22 and .32. The only energy option that shows some significant correlations with convictions that global warming has occurred and will occur in the future is the wind energy option. The more respondents are convinced global warming has occurred the more positive they are likely to be about the wind energy option. The correlations between the CCS options and convictions about global warming occurring are low, ranging between -.09 and .13. Therefore again the results seem to imply there is hardly any relation between how respondents perceive global warming and how they evaluate CCS.

Table 6 Correlations between overall evaluations options and perceptions of global warming

	Evaluation global warming after info	Conviction passed warming	Conviction future warming	Conviction warming is manmade
Efficiency	-.22*	.06	.05	.15
Efficiency plus	-.09	.20	.09	.28**
Wind	-.19*	.27**	.22*	.20*
Biomass	.06	.03	.07	.01
Powerplants+ CCS	.32**	-.07	-.09	.07
Hydrogen + CCS	.17	-.02	.13	.08
Nuclear	.15	-.12	.04	.01

** p < 0.05, ** p < 0.01 The significance of the relationship does not imply strength.*

5.1.5 Self-reported awareness of options

In the beginning of the ICQ questionnaire respondents were asked whether they were aware of the two CCS options discussed further in the questionnaire. Subsequently, all respondents were additionally asked to rate both technologies on a scale from 1 to 10, in the same way they were asked to rate the technologies later in the questionnaire. The same questions were posed in the questionnaire of 2007. In 2010 most respondents state they have heard at least a little bit about the "large plants where coal or gas is converted into electricity with CCS" option. Only 11.2% state never to have heard of it. This is a considerable shift compared to the data from 2007 when just over half of respondents stated never to have heard of this CCS option. This is probably due to the publicity CCS has received in the Netherlands in 2009 and 2010 related to a planned project in the city of Barendrecht, involving CCS in combination with fossil fuel production. Even though still less than a quarter state to know 'quite a bit' about it, most people have heard about the existence of this technology. A much smaller shift has occurred within the other CCS option which includes hydrogen production. Here also more respondents state to have heard of this option compared to 2007, but still more than half state never to have heard of it. The switch has mainly between from respondents not hearing about it to knowing a little bit about it, as the percentage of respondents who claim to know quite a bit is still the same as in 2007. As a matter of fact no major news stories involving the combination of hydrogen production and CCS have been appearing in the Dutch media and no big shift was therefore to be expected.

Table 7: Percentages of respondents that state no, little knowledge or knowledge of the CCS options. Between brackets is data from 2007

Do you know of…	No, never heard of	A little bit	Yes, quite a bit
Powerplants + CCS	11.2% (51.2%)	65.7% (41.9%)	23.1% (6.9%)
Hydrogen + CCS	53.7% (67.7%)	41.0% (27.1%)	5.2% (5.2%)

Pseudo opinions

The results of 2007 already revealed respondents rarely refrain from giving their opinion, even if they state they had never heard of the option before. The same pattern can still be found in the 2010 data. Even though 15 respondents state they had never heard of Powerplants + CCS, all of them proceed to evaluate this option in the subsequent question. This is also the case with the Hydrogen + CCS option. Here 72 respondents state they had never heard of this option, while only 2 of them state they have "no opinion" when subsequently asked to rate the option.

5.1.6 Relation between uninformed and informed opinions of CCS

The evaluation of the two CCS options before respondents received information was compared to their overall evaluation after they had received all the information. For both of the options these correlations were quite low. The uninformed opinion of "Powerplants + CCS" correlated with the informed opinion with r = .26, and the uninformed opinion of "Hydrogen + CCS" correlates with the informed opinion of this option with r = .21. On average the two options are evaluated similarly with a 6.0 and 5.9 respectively. The average evaluation of the first CCS option however drops to 5.0 after respondents read the information. Even though the grade of the Hydrogen + CCS option remains the same on average, the low correlation indicates that individual respondents do change their opinions, some forming a more positive opinion after information while others form a more negative opinion. To explore to what extent respondents' evaluation of the options is based on information about the consequences as opposed to their opinion before information the multiple regression coefficient was calculated between evaluations of the consequences and the evaluation *before* information. In section 5.1.3 it is explained how the evaluations of the consequences as well as the multiple correlation coefficients are calculated. Subsequently these multiple correlation coefficients were compared to the previously calculated multiple correlation coefficients between the evaluations of the consequences and the overall evaluation *after* information (see section 5.1.3). This comparison reveals the extent to which the information about the consequences influences respondents' evaluation. If the influence of the information about consequences is higher on the evaluation after respondents have read this information than before they have read it this would mean the information is new to them. Indeed, analysis shows the information about the consequences has a larger effect on overall evaluation after respondents have read it than it has on the evaluation they give before reading it. For Hydrogen + CCS this difference is higher, which might be related to respondents low awareness of this option before the questionnaire, so information given here makes an even bigger impression on respondents' opinion.

Table 8: Multiple regression coefficients (R) of the effect of the evaluations of the consequences on overall evaluation before and after information

	Before	After
Powerplants + CCS	.32	.53
Hydrogen + CCS	.32	.65

5.1.7 Face-to-face interviews after the ICQ

After filling in the Information Choice Questionnaire respondents were interviewed face to face by an interviewer from a polling firm. The aim was to reveal any thoughts or questions that possibly remained that respondents were not able to convey through the evaluations they could give in the ICQ itself. The interviewer followed a structured protocol that addressed the following topics: any remaining questions about, thoughts or considerations about any of the seven options, whether there were any options respondents felt were difficult to evaluate, any specific thoughts about the two CCS options, any thoughts or considerations they had that weren't mentioned in the text, why respondents had or had not chosen one of the CCS options as their preferred option and finally what they perceived to be the major difference between the Powerplants + CCS option and Hydrogen + CCS option. After each of these questions respondents were also asked what the consequence was for their evaluation of the option. In addition to the interview respondents also had the opportunity to write down any comments about the option within the questionnaire in an open text field after they had finished evaluating an option. In the interview respondents frequently referred to this part of the questionnaire when they felt they had already given the answer there to the question the interviewer posed. Analysis revealed respondents did not mention topics in the text field of the questionnaire they would not also mention in the interview, sometimes however the answer in the text field would be more elaborate. Because of this, answers in the text field in the questionnaire were also included in the analysis of the answers in the post questionnaire interview.

Answers were categorized as either being about the ICQ itself or as thoughts about the CCS options based on the information in the ICQ. In most cases the number of respondents in the identified answer categories was fairly low and the analysis qualitative, the results are therefore presented in general terms to avoid giving the impression of quantitative certainty.

Statements about the ICQ

Three categories were identified in the statements about the ICQ questionnaire itself. Some respondents expressed doubts about the CCS information in the ICQ, some respondents mentioned things that were not discussed in the ICQ and others stated they missed certain information about the CCS options in the ICQ.

Not many people expressed doubts about information in the ICQ. The about dozen respondents who did have doubts about the information mainly asserted their doubts about the probabilities of risks described about CO_2 transport or storage in the ICQ. They either felt the information was too positive in judging the chance of problems arising or they felt the information failed to convince them the chances of anything happening would be small.

Even though most respondents said their pre-existing knowledge of CCS was very limited and they mainly based their opinion on information given in the ICQ, about a dozen did mention previously acquired knowledge they had not been given information about in the ICQ. Most of these respondents mentioned hearing about CCS in the media, mainly referring to project plans to store CCS under 'a neighbourhood'. These respondents felt the information given in the media about CCS was more negative than the information they received about CCS in the ICQ. They indicated that because of this they had given the CCS options a lower grade than they would have otherwise.

Questions that remained about the CCS options after the ICQ were diverse, ranging from questions about the consequences of the Netherlands' international economic position to questions about storage possibilities off-shore. Most of the questions, however, pertained to the safety of storage. Respondents felt the information about this was inconclusive or 'vague' and they wanted more information. When specifically asked whether they felt any of the options were difficult to evaluate, the dozen who selected one of the two CCS options indicated they felt it was difficult to answer because of the insecurities about the consequences of these options, mainly consequences relating to safety. They also mentioned the fact this was a new technology that they did not know a lot about. A few stated they would like to have information about the concrete projects going on in the Netherlands. Most of these respondents indicated this lack of knowledge made them more cautious in their evaluation, giving the option a lower grade.

Statements about CCS based on information in the ICQ

Most respondents mainly comment on contents of the information provided in the ICQ. The statements respondents made about the CCS options fall within a few categories: respondents comment either on the safety of the storage, the continuing use of fossil fuels or the finite nature of the solution.

Safety of storage is by far the most commented upon topic. Half of the 134 respondents mention they have concerns about the safety of storage. More than 40 respondents state they are unsure whether storage is safe enough. One respondent said "I like the idea, but absolutely not the storage", while another one stated "I did not choose this option because I really don't like it, because I think it's scary. I think it is scary to put things underground. What if something happens? Then half of the country is gone". Concerns about safety of storage or the perceived insufficient knowledge about CCS were also the main reasons respondents gave for not choosing one of the CCS options among their preferred three options. About 30 respondents state they feel there are too many uncertainties still existing about the consequences of CO_2 storage and the option has not been explored sufficiently to be implemented. Most of these respondents say they have chosen other options because of these concerns about safety. Several respondents also mention they have concerns about safety of pipelines or about the hassle associated with laying down a new pipeline infrastructure.

About a dozen of respondents mention the finiteness of this option to be a drawback, whether because of limited storage space or the finite amount of fossil fuels.

About a dozen respondents also mention the continuing use of fossil fuels as a drawback of the CCS options, whether because of continuing energy dependence or the negative effects on the environment. Respondents also expressed a general feeling that CCS was 'dirty' or 'polluting'.

Somewhat over a dozen respondents described their reaction to the CCS options in emotional terms, with descriptions such as "scary", "uncomfortable feeling" and "disquieting". Others seemed to have a quite principled stance expressing this with statements such as "I'm against this type of energy production anyway", "coal should not be allowed as a fuel anymore" and "I'm principally against storing CO_2 underground". These emotional responses and principled stances might be a part of the explanation why the evaluations of the consequences described in the ICQ do not fully explain the grades respondents given to these options in the end.

Respondents who had chosen one of the CCS options among their three preferred options were few. The ones who did indicated to have chosen it mainly because it seems effective to them in reducing CO_2 emissions and also some felt the information about the risks in the ICQ was reassuring them, as one respondent stated "I am more positive about it now, because of the safety as it is described, I am more reassured. Before I did not like this idea". The hydrogen option by some respondents is chose because they feel it is innovative and clean.

When asked explicitly what they perceived the major difference to be between option Powerplants + CCS and Hydrogen + CCS results of the interview seem to confirm the results found in the ICQ. The vast majority of respondents is more positive about the Hydrogen + CSC option and indeed the Hydrogen + CCS option received a 5.9 overall evaluation compared to the 5.0 respondents gave to Powerplants + CCS. More than 40 of these respondents indicated the main reason why they preferred the Hydrogen option is the fact that no coal is used and it feels 'cleaner'. So although safety remains a major concern for both options as indicated by the correlations between the evaluations of these consequences and their overall evaluations, the difference in the evaluations of the two options mainly lies in the use of coal by the Powerplants + CCS option, which is why it is evaluated more negatively.

5.2 Results Knowledge and Beliefs Test

5.2.1 Sample

The knowledge and beliefs test was administered in May and June of 2010. The sample consisted of 402 respondents of at least 18 years of age and was drawn randomly from the Dutch general population. One respondent was excluded from the analysis because he answered in the same way to all questions, including the same answer options on opposing attitude scales, and avoided any of the questions that required additional effort like open questions, indicating he might not have taken the questionnaire seriously. Omitting him left a sample of 401 respondents. Even though the sample is not large enough to be called representative of the Dutch population, the respondent's most common demographic variables (sex, education, age, province) closely reflect those of the general Dutch population. A comparison of our sample to the Dutch general population of 2008 (data from Central Bureau for Statistics) can be found in Appendix 7.

Based on the sample size of the ICQ ($n \approx 401$) when interpreting the presented response percentages in this report one should reckon with an uncertainty margin of *maximally* plus or minus 5% (these margins apply with a 95% confidence level).

5.2.2 Distribution of answers to knowledge and perception questions

Knowledge of CO_2 characteristics, effects and sources

The first part of the questionnaire tested people's awareness and knowledge about CO_2. Only 2 respondents indicated never to have heard of CO_2 and 13.5% said they had heard a little bit about it. Subsequently people were presented with 32 statements about the characteristics, effects and sources of CO_2. Of each statement they were asked to state whether they were 1 'certain that it is not true for CO_2' through 5 'certain this is true for CO_2'. The distribution of answers is displayed in Table 9.

The overall results show first of all large numbers of respondents who are unsure about the characteristics, effects and sources of CO_2. Of a large number of statements a third or more of the respondents did not know what the correct answer was. For example, 38% of the respondents are unsure about whether CO_2 causes cancer or not. Similarly 34% is unsure whether CO_2 is harmful if it comes in contact with skin and 32% is not sure whether CO_2 makes a livable climate on earth possible. The same uncertainty can be found about the sources of CO_2; 41% is unsure whether CO_2 leaks from batteries, 39% is unsure whether it is released during the production of natural gas and 29% about whether it is released during production of nuclear energy. People's limited understanding of sources that emit CO_2 might have consequences for their judgment on ways to reduce CO_2 emissions and their evaluation of different energy sources. For instance, almost half of the people do not realize energy production from natural gas emits CO_2, which might result in lower awareness that behavior that uses energy from natural gas contributes to climate change.

Moreover, in line with reasoning of aforementioned research on the stability of opinions, people who are unsure about such issues might easily be convinced with any new information, even if this information is not correct. This might cause unnecessary concern or otherwise poor judgment of the risk involved. For example, respondents who believe CO_2 is flammable or are unsure believe it is significantly more likely CO_2 storage will explode because the CO_2 catches on fire than respondents who are somewhat sure CO_2 is not flammable and those who are very sure it is not (M = 2.39, M = 3.23, M = 3.71 respectively; $F_{(2,398)} = 37.82$, $p < .001$).

Besides uncertainty the results also show respondents hold some erroneous beliefs about CO_2. About a quarter of respondents is somewhat to very convinced that: CO_2 is the same as carbon monoxide (27%), that people do not exhale CO_2 (25%) and that CO_2 emits hazardous radiation (23%). Respondents seem to confuse CO_2 with different environmental problems. Even though a vast majority is correctly convinced CO_2 influences the climate (83%), a large part is also convinced CO_2 causes acid rain (51%), smog (44%) and erodes the ozone layer (63%) and a lot of people are unsure about these statements (27%, 33% and 21% respectively). This corresponds to the qualitative findings from the interviews, which showed that people confuse these different environmental problems. For example most of the interviewed respondents believed the temperatures on earth are rising because the CO_2 erodes the ozone layer and lets more heat from the sun in or in other words, that CO_2 has the same effect on the ozone layer as do CFC's. This last finding is also supported by other quantitative data, which show that a majority of people believe CO_2 is released from spray cans (53%) or are unsure whether this is so (23%), which again is an indication that people confuse CO_2 with CFC's and its effects.

Another noticeable result is that people have especially low awareness of the natural properties of CO_2. For example, 47% of respondents are either unsure about whether CO_2 is necessary for the growth of plants and trees (23%) or are convinced in fact it is not (24%) and as mentioned before only a minority of people (42%) state that CO_2 is necessary for a habitable climate on earth and only just over half state humans exhale CO_2 (52%).

Table 9: Knowledge of characteristics effects and sources of CO_2. Percentage of respondents to choose answer category

Characteristics of CO_2	I'm sure it is (does) not 1	2	3	4	I'm sure it is (does) 5
CO_2 is the same as carbon monoxide	43	12	18	14	13
You can smell CO_2	52	23	15	7	4
CO_2 is flammable	37	19	26	13	6
CO_2 is visible	77	17	5	1	1
CO_2 is a gas that can be found in nature	10	11	17	19	44
CO_2 is explosive	35	20	26	12	8
CO_2 turns to stone in time	35	22	38	4	2
CO_2 is a greenhouse gas	5	6	20	22	48
CO_2 emits hazardous radiation	41	22	23	8	6
CO_2 is toxic	19	10	18	20	33
CO_2 is in the air around us	3	4	14	24	57
Effects of CO_2					
CO_2 causes acid rain	10	12	27	29	22
CO_2 causes cancer	21	20	38	13	8
CO_2 influences the climate	1	2	14	32	51
CO_2 causes smog	11	13	33	24	20
CO_2 is necessary for the growth of plants and trees	12	12	23	16	36
CO_2 erodes the ozone layer	9	7	21	25	38
CO_2 is harmful if in contact with skin	33	23	34	7	3
CO_2 makes a livable climate on earth possible	11	16	32	19	23
Sources of CO_2					
CO_2 is released when you exhale	15	11	22	19	33
CO_2 is released when wood is burned	5	12	31	23	30
CO_2 is released when spray cans with hair spray or deodorant are used	15	12	23	23	26
CO_2 is released from the exhaust pipe when a car is driving	2	2	11	25	60
CO_2 is released when old batteries leak	23	19	41	9	8
CO_2 is released during waste disposal	4	6	31	34	26
CO_2 is released during the production of steel	4	9	48	20	18
CO_2 is released when plants and trees decompose	12	16	37	19	17
CO_2 is released during energy production from natural gas	4	6	39	25	27
CO_2 is released during energy production from coal	1	5	30	22	42
CO_2 is released during energy production from oil	1	4	37	25	32
CO_2 is released during energy production from wind	60	19	17	2	1
CO_2 is released during energy production from nuclear power	38	17	29	11	6

Knowledge of the current electricity mix and projection of the future electricity mix

Out of the 401 respondents 337 gave an indication of what our electricity mix was made up of, while the rest chose the 'I don't know' option. The results reveal a general underestimation of the use of fossil fuels, especially coal and natural gas, while the amount of renewable energy sources is overestimated. Respondents indicated coal accounts for 15% of our electricity mix on average and solar and wind account for 12% and 8% respectively. This while in 2008 the real figure for coal was 21% and wind and solar 4% and 0.03% respectively. This underestimation of the continuing use of fossil fuels and especially coal, might cause people to question the necessity for CCS, since this is a technology directly related to the emission of CO_2 from fossil fuels. The relation between the perceived electricity mix and attitude towards CCS is discussed later in this section.

In another question people were asked to estimate how large the share of fossil fuels will be in the electricity mix of 2050. This question was answered by all respondents, and on average people believe fossil fuels will account for 37% of our electricity mix in 2050. Almost half of the respondents believe fossil fuels will make up a third or less of this future electricity mix. Of course, only time will tell which respondents were right about this question.

Table 10: Respondents' average judgments of share of fuels in the The Netherlands' current electricity mix and actual share in 2008

Energy source	Mean	Actual 2008
Coal	15	20.8
Natural gas	31	59.8
Oil	14	0.2
Wind	12	3.6
Solar	8	0.03
Biomass	4	3.8
Hydro power	4	0.09
Nuclear	10	3.9
Geothermal	3	< 1.8*

Note: N = 337
Source Actual 2008: CBS Statline February 2011 www.cbs.nl
** represents the percentage of "other" fuel sources*

Perception of climate change

When asked whether they had heard of climate change, only 2% stated not to have heard of it, while 19% and 79% indicated to have heard a little bit and plenty about it respectively. Respondents were presented with four statements about the climate change issue and asked to state their level of agreement with them. The distribution of the answers can be seen in table 11. 65% of the respondents are to some extent convinced the climate on earth in becoming warmer on average and 53% are to some extent convinced this is a result of CO_2 emission by human actions. It is noticeable here that only 7% of the respondents are very convinced that man made CO_2 emissions are the cause of global warming. Almost half of the respondents (49%) are to some extent convinced global warming is being exaggerated and only 46% believes global warming can be stopped.

Table 11: Beliefs about climate change. Percentage of respondents choosing answer category

Statements about climate	Not at all convinced					Very convinced		
	1	2	3	4	5	6	7	No opinion
To what extent are you convinced the climate on earth will become warmer on average?	4	9	7	15	29	22	14	2
To what extent are you convinced global warming is a result of CO_2 emissions by human actions?	5	11	9	20	29	17	7	3

To what extent are you convinced global warming is being exaggerated	5	10	14	21	25	14	10	3
To what extent are you convinced global warming can be stopped?	5	13	16	19	24	16	6	2

Awareness and knowledge about CCS

When asked whether they had heard about carbon capture and storage 35% of the respondents indicated they had not, while 27% indicated they had heard a bit and 38% answered yes. To the question whether they had heard about plans to use CCS in the Netherlands 46% answered they had not, 23% said they had heard a bit about it and 32% answered yes. Out of the 151 respondents who have heard of CCS 95% also has heard about project plans in the Netherlands, answering 'yes' (77%) or 'a little bit' (18%), indicating most people possibly hear about CCS only when news about CCS projects reaches them. Despite the relatively high awareness levels of the respondents, their level of knowledge about CCS shows a more mixed picture.

Goals of CCS

Respondents could indicate which goals they thought CCS aimed to achieve and select as many goals as they wanted. 'Improvement of air quality' was chosen by the most respondents as a possible goal of CCS, with 67.3% of respondents selecting this answer category. 'Mitigation of climate change' was selected by 63.3%, and 57.4% of respondents thought CCS aimed to protect the ozone layer. Even though a large amount of respondents chose the correct answer category: 'mitigate climate change', only 8% of all respondents chose only one of the climate change related options ('limit rise in temperatures' and 'limit the increase of the greenhouse effect') without selecting any of the incorrect ones. This leads to believe despite a lot of people thinking it is plausible climate change is the reason for CCS, only a small amount of people know enough to know this is the only environmental problem CCS aims to contribute to.

Table 12: Respondents' perceptions of goals of CCS

Goal of CCS	percentage of respondents to select the category
Improve air quality	67
Mitigate climate change	63
Protect the ozone layer	57
Mitigate increasing greenhouse effect	57
Limit rise in temperatures	51
Prevent acid rain	36
To reduce pollution near factories	33
To use the CO_2 as an energy source in the future	26
To use the CO_2 as a raw material for products in the future	15
To warm the earth during the next ice age	4
Other	5

Capture points

In a similar way respondents were asked which capture points they believed were suitable for CCS. Most respondents selected one of the correct options, namely 'power plants' (59.6%), but they perceived intensive farming and filters on car exhaust pipes to be the second and third most plausible capture points, with 46.4% and 43.1% of respondents selecting these options respectively.

Table 13: Respondents' perception of suitable capture points

Capture point	% of respondents to select the category
Electricity plant	60

Oil refinery	56
Intensive farming	46
Cars with a filter on the exhaust pipe	43
Steel factory	41
Natural gas extraction	39
Ammonia factory	37
Paint factory	30
Nuclear power plant	23
Hydrogen power plant	18
None of the above	11

CO_2 storage

Respondents indicated their image of the CO_2 storage by evaluating how likely they believed it to be the CO_2 would be stored in each of the 7 presented options. Most respondents thought storage in underground rock formations to be somewhat to very likely (60%), a third of the respondents thought storage in underground bunkers to be somewhat to very likely, while only 19% believe storage under the seabed is likely. Storage in barrels or containers was believed to be very unlikely by the highest percentage of respondents (26%). The whole distribution of answers can be found in table 14.

Table 14: Respondents' perception of likeliness of several types of storage

Description of possible CO_2 storage	**% of respondents to choose answer category**						
	very unlikely				very likely		
	1	**2**	**3**	**4**	**5**	**6**	**7**
The CO_2 will be stored in large barrels, tanks or containers	26	15	10	23	14	8	5
The CO_2 will be stored underground in the existing rock formations	5	6	7	22	16	22	22
The CO_2 will be stored in underground bunkers with solid, impermeable walls	18	14	10	26	18	10	6
The CO_2 will be stored in empty salt mines	8	8	11	29	18	14	12
The CO_2 will be stored underground in caves and large cavities	14	15	12	28	16	11	5
The CO_2 will be stored under the sea bed	19	21	13	28	10	6	3
The CO_2 will be stored in old coal mines	15	15	14	29	18	7	4

Porous rock

A regularly heard term in CCS communication is the fact that the CO_2 will be stored in porous rock. To explore lay understanding of this term we presented respondents with three different alternatives of what describes this term best: a) it is the upper earth layer in contact with air that supplies the ground with oxygen, b) it is an earth layer underground with a lot of very tiny holes and c) it refers to fragile rock layers in the ground that crumble easily. Less than half of respondents chose the correct answer b), namely 40%. Almost a third (31%) of respondents believe it is a fragile rock layer that crumbles easily, while 15% stated not to know what it means. An ANOVA was performed to explore the effect of these three different understandings of the term on the perceived possibility of the CO_2 leaking from underground storage. Results reveal respondents who believe porous rock to be fragile easy crumbling rock formations find it significantly more likely the stored CO_2 will escape to the surface ($M = 4.2$ on 7-point scale, 7 = very likely) than those who chose the correct answer b) ($M = 3.8$; $F_{(2,338)} = 3.20$, $p = .042$). This shows a wrong understanding of such terms can have implications for how people perceive risks of CCS.

Perceived consequences of CCS

Respondents were presented with 12 statements presenting possible consequences of CCS as perceived by respondents in the qualitative interview. They were asked to evaluate for each presented statement how likely it is this would be a consequence of CCS. Again, respondents' answers are typified by a lot of insecurity. For most of the statements around a third of the respondents chose the middle category, indicating people are insecure about what to expect from CCS. The costs of CCS being charged to consumers was evaluated by most people to be somewhat likely to very likely (80%) with a large proportion of respondent believing this is *very* likely to happen. This is followed by the statement that CCS will give us time to develop renewable technologies (43%). On the other hand 37% of respondents believed it to be somewhat to very likely CCS would slow the development of renewable technologies. The correlation between these two statements is very low (-.05) which means there is no relation between respondents' beliefs about one statement or the other, or in other words some respondents might have opposing views on each of the two statements while others can believe both statements to be unlikely or likely consequences of CCS.

Statements about hazardous risks were believed to be likely by about a third of the respondents; 36% believe it is somewhat to very likely the CO_2 will leak to the surface and 33% believed this is possible during pile driving work for new homes. 37% believe CO_2 storage could become a target of terrorist attacks and 38% believe stored CO_2 could acidify ground water. There is uncertainty about the possibility of explosion of CCS, as about a third of respondents is unsure whether storage could explode due to it being under pressure or the CO_2 catching on fire. However, these were also statements the largest portion of respondents found unlikely, with for example almost 20% even believing it is *very* unlikely the storage would explode due to CO_2 catching on fire.

Table 15: Respondents' perception of likelihood of a statement being a consequence of CCS

Statement	**% of respondents selecting answer category**						
	very unlikely					very likely	
	1	**2**	**3**	**4**	**5**	**6**	**7**
CO_2 will acidify the ground water	7	11	11	36	26	6	4
CO_2 will leak from the storage to the surface	5	13	14	32	23	8	5
The stored CO_2 will leak to the surface during pile driving work	11	15	14	28	17	10	6
People will suffocate when CO_2 is released	13	16	17	29	14	8	4
A CO_2 storage can become a target of terrorist attacks	10	12	9	32	20	9	8
The CO_2 storage will explode because it is under pressure	13	18	16	37	10	5	3
The CO_2 storage will explode because the CO_2 catches fire	19	17	17	33	9	4	2
CO_2 storage will prevent ground subsidence	8	14	16	39	15	5	4
The costs of CO_2 storage will be charged to consumers	1	1	2	16	19	28	34
CO_2 storage will slow the development of renewable energy sources such as wind and solar energy	7	14	11	33	19	9	8
Implementing CO_2 will give us time to develop renewable energy sources such as wind and solar energy	4	6	10	38	26	11	6
Investing in Carbon capture and storage will give the Netherlands a technological advantage over other countries	6	6	10	41	25	9	5

Evaluative statements about CCS

In addition to possible consequences respondents were also presented with evaluative statements of CCS. The focus on safety of storage is even more visible here than in their perceptions of consequences. 56% of respondents believe the safety of CO_2 storage for the surroundings can never be guaranteed sufficiently and more than a third believes CCS carries too many risks for public health, while also more than a third is unsure about this. As for the need of CCS, only a minority of respondents believe CCS to be necessary to mitigate climate change, while 61% believe it is merely shifting the problem and 43% that companies will make a lot of money out of it. Noticeable is the fact that relatively a lot of respondents agreed with the statement that CCS was merely shifting the problem. At the same time, half of the respondents (49%) believe CCS is an obvious solution for the

Netherlands because of the existing depleted gas fields suitable for storing CO_2 even though most respondents agreed with this statement only moderately.

Table 16: Respondents' agreement with evaluative statements about CCS

Statement about CCS	**% of respondents selecting category**						
	strongly disagree				strongly agree		
	1	**2**	**3**	**4**	**5**	**6**	**7**
A CO_2 storage in the neighbourhood will cause hardly any inconvenience	7	13	16	35	17	9	3
The safety of CO_2 storage for the surroundings can never be sufficiently guaranteed	2	6	8	28	24	16	16
Putting CO_2 under the ground is shifting the problem	2	8	6	24	22	17	22
CO_2 storage carries too many risks for public health	3	9	12	38	20	10	9
CO_2 storage is an obvious solution for the Netherlands because of the existing depleted gas fields suitable for storing CO2	4	4	8	36	26	16	7
CO_2 storage will bring in a lot of money for companies that will employ it	3	3	7	44	21	13	9

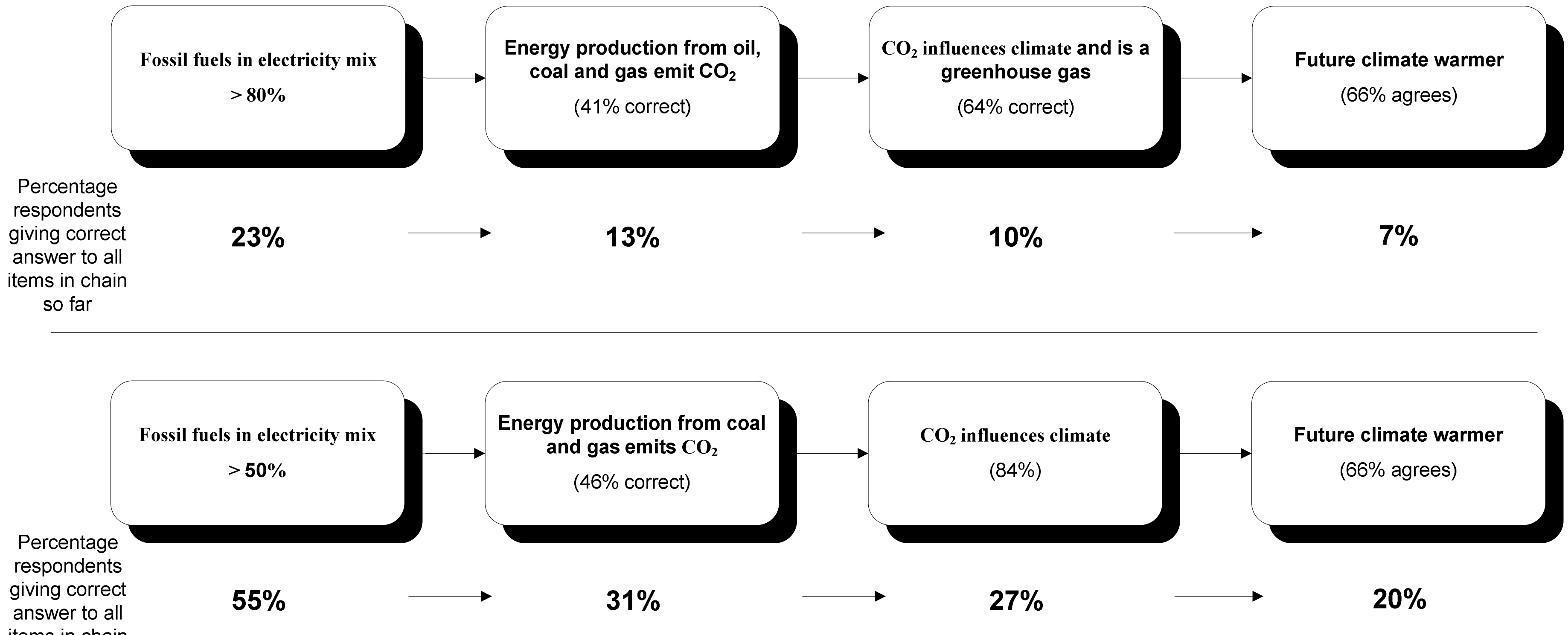
5.2.3 From electricity production to climate change

In the interviews prior to the survey it seemed some people did not understand fully how human behaviour leads to climate change. People could name some of the fuels that emit CO_2, but often not all, and they would for instance not know very well from which source their electricity, or even electricity in general is produced. On the other hand, with regard to communication about CCS projects it is often said that the local community will understand the need for CCS better if they can see it as a necessary method to mitigate climate change. This relation has been found in some previous research (Shackley et al, 2005; Itaoka et al, 2006; Tokushige et al, 2007). In the current study this is explored in section 5.3.5. Regardless of the strength or relation of this relation, it can be argued that knowledge of a couple of aspects of our current energy production is necessary to understand the need for CCS, whether it has an influence on evaluation of CCS or not. This includes knowledge about the fact that a large amount of our electricity is produced from fossil fuels, that fossil fuels release CO_2, that CO_2 is a greenhouse gas and affects the climate and that average world temperatures are rising because of it. In the survey several items measured this knowledge. A schematic of this sequence from fossil fuels to climate change and the corresponding items that measured each step can be seen in figure 9. The upper row of text boxes shows the item and the percentage of respondents correctly answering the particular question, while the row of percentages beneath shows how many percent of the total sample correctly answered all the questions in the reasoning chain so far. Even though the real correct answer to the question about the percentage of fossil fuels in the electricity mix would have been approximately 93%, an estimate of 80% or higher was counted as correct as this still indicates respondents' understanding that fossil fuels make up a vast amount of the energy mix. For the item measuring whether a respondent believes average temperatures will be higher in the future answer categories 5, 6 or 7 on the 7 point scale were counted as 'agree'. For the items about fossil fuel sources of CO_2 and CO_2's influence on climate answer categories 4 and 5 on the 5 point scale were counted as correct, 5 meaning 'I'm sure it does'. Figure 1 show the percentage of respondents that answered each item correctly and the percentage of respondents that answered all the previous items correctly.

The results reveal a steep decline in the amount of correct answers after each step. Only 27% of respondents indicated fossil fuels accounted for at least 80% of the electricity mix. Of these respondents roughly half also knew these fossil fuels emit CO_2, leaving 13% of the original sample. Only 10% of the total was left after questions were added about CO_2 being a greenhouse gas and influencing the climate. 7% of the total knew all this and agreed that average world temperature was rising.

A more lenient version of this rationale is shown in the bottom half of figure 9. Here an indication of the percentage of fossil fuels in the electricity mix was counted as correct if a respondent judged it to be at least 50%. Subsequently only items measuring knowledge that energy production from coal and natural gas were included, because oil does not make up a large part in the electricity mix. Subsequently only the knowledge that CO_2 influences the climate was included, thus excluding the item that CO_2 is a greenhouse gas. The same analysis was repeated with these items. Indeed more respondents give correct answers in this sequence. At the end of the causal chain 20% of respondents remain who have answered all the previous items correctly. The most incorrect answers are given in the second step, which reveals 46% of all respondents does not know whether energy production from both coal and gas emits CO_2. Almost half of all respondents believe fossil fuels make up 50% or less of our electricity mix or do not know the answer to this question. Thirdly 34% does not agree with the statement that average future temperatures will rise. Respondents generally do know that CO_2 influences the climate. Put together however still a vast majority of respondents cannot complete or does not fully agree with this chain of reasoning. Even if knowledge of the share of fossil fuels in the electricity mix is taken out of the analysis 28% of respondents are left over after the last three reasoning steps (energy production from coal and gas emits CO_2, CO_2 influences the climate and average temperatures are rising).

Figure 9: Respondents knowledge of causal chain of climate change



Note: Numbers within boxes represent percentage of respondents to answer the particular item correctly. Upper half of figure represents percentages using strict criteria, lower half percentages using more lenient scoring criteria

5.2.4 Knowledge and beliefs clusters

This questionnaire consists of several items measuring knowledge about CO_2, several others measuring perceived consequences of CCS, perceived storage etc. All these different items are not necessarily measuring just as many different kinds of knowledge as there are items. Often in such cases a pattern can be found showing what kind of knowledge a certain person has. In other words, if a person knows one thing about CO_2, it is likely he or she knows some other aspects of CO_2 as well which are similar in nature.

To reveal any patterns of beliefs or knowledge in this questionnaire a factor analysis was performed. In the first attempt all the items in the test were entered into the factor analysis. This, however, did not reveal an interpretable pattern. What this analysis mainly did was to separate the items depending on the scale they were measured on, so the 5 scale CO_2 items, from the 7 point evaluations of CCS etc. Therefore it seemed more informative to do three separate factor analyses for each of three groups of items: the 31 CO_2 items (the question about toxicity was not included here), the 7 items about the perceived storage of CO_2 and a third with the 19 items measuring perceived consequences of CCS and evaluative statements about CCS.

Factor analysis of the CO_2 items

For further analysis of the items measuring CO_2 knowledge the items were transformed in such a way that an answer on the higher end of the scale (answer points 4 and 5) also means the answer is correct. Subsequently the scale points one to three were accumulated into one scale point to avoid interpretation of the scale where a point 3 (unsure) would mean a person gave a 'more correct' answer than someone who answered point 1 or 2, which now means an incorrect answer. This way point 1 on this new 3-point scale meant the answer was either incorrect or unsure, point 2 meant a person gave the correct answer but was not entirely sure, and point 3 meant a person gave a correct answer and was sure about this.

A factor analysis of the 31 CO_2 items revealed 7 factors with an eigenvalue of 1 or higher. As a general rule of thumb only factors with at least an eigenvalue of 1 or higher are considered to be significant enough to interpret (Stevens, 2002). The first factor is always the construct that explains most of distribution of the answers, and this explanatory power decreases with each factor. The last two factors only have one item loading strongly on them ("CO_2 is visible" and "you can smell CO_2" respectively), which does not justify using them as factors (Stevens, 2002), therefore only the first 5 will be interpreted. Table 17 shows which items loaded on each of the 5 factors. This set of factors reveals a pattern that can be found among the CO_2 items.

On the first factor all the items that express the natural properties of CO_2 load strongly as well as two items expressing a very incorrect statement about CO_2; that it is the same as carbon monoxide and that it causes cancer. Keep in mind however these incorrect items were transformed so now they actually mean the opposite; 'CO_2 is *not* the same as carbon monoxide' and 'CO_2 does *not* cause cancer'. What this factor says is respondents who know CO_2 is a gas occurring in nature they also tend to know it is necessary for the growth of plants and trees and that people exhale it. At the same time these people are less likely to confuse it with carbon monoxide or to think it causes cancer. This factor is named "CO_2 Natural".

On the second factor only items about the sources of CO_2 load strongly, indicating this factor measures respondent's knowledge of where CO_2 is emitted. This factor is named "CO_2 Source".

The third factor has items loading on it that imply hazardous properties and effects of CO_2. As factor 3 reveals, there is a cluster of perceived hazardous properties and effects of CO_2 that people associate with each other such as hazardous radiation, the idea that CO_2 is hazardous in contact with skin, that it causes smog and deteriorates the ozone layer. Respondents who believe this to be true of CO_2 often believe the CO_2 is emitted from leaking batteries, nuclear energy and spray cans. This factor is named "CO_2 Hazardous".

The fourth factor has 3 items loading on it, all three expressing the properties of CO_2 related to the climate, including the fact that wind energy does not emit CO_2, implying respondents who know about the influence of CO_2 on climate generally also know wind energy in this case is a possible way to mitigate it.

Finally the fifth factor has two items loading on it; the items implying CO_2 is explosive and flammable, indicating respondents associate these two effects with each other.

Table 17: CO_2 knowledge factors and corresponding items[3]

CO_2 Natural Eigenvalue (EV) 8.9		**CO_2 Source** EV 3.2		**CO_2 Hazardous** EV 1.8	
Growth plants	.76	Source: steel production	.76	Source: batteries	.74
Habitable climate	.72	Source: energy from oil	.75	Source: spray cans	.67
Occurs naturally	.71	Source: waste disposal	.75	Source: nuclear	.61
Humans exhale	.70	Source: energy from coal	.71	Emits radiation	.55
Emitted from dead plants	.57	Source: energy from Natural gas	.62	Hazardous for skin contact	.54
In air around us	.54	Source: car exhaust	.59	Causes smog	.52
Not same as CO	.53	Source: burning wood	.52	Turns into stone	.49
Does not cause cancer	.52			Harms ozone layer	.48
				Causes acid rain	.45
CO_2 Climate EV 1.4		**CO_2 Explosive** EV 1.3			
Influences climate	.68	Is explosive	.84		
Is a greenhouse gas	.63	Is flammable	.50		
Not emitted from Wind energy	.53				

The numbers represent factor loadings after VARIMAX rotation

Factor analysis of CO_2 storage items

Another factor analysis was performed with the seven items measuring respondent's perception of what the CO_2 storage would look like. This analysis resulted in two factors: one with items loading on it expressing a natural storage site and the second expressing a man-made storage site such as barrels or bunkers. The item describing the storage as underground caves, included in this factor corresponds to an often found misconception among people that gas fields look like large gas cavities instead of porous rock. These factors are named Storage Natural and Storage Man-Made respectively.

[3] Items were previously recoded so that a higher score consistently meant a more correct answer on the 3-point scale. As a consequence for the originally incorrectly formulated items the meaning changed from for example: "CO_2 causes smog" to "CO_2 does not cause smog". However for the purpose of subsequent analysis with factors CO_2 Hazardous and CO_2 Explosive the original formulation will be used and the direction of the relations with other factors and measures will correspond to the original meaning and formulation of the items. In factor CO_2 Natural and CO_2 Climate the previously incorrectly formulated items remain in the new formulation so as to correspond to the correct formulation of the other items in those factors.

Table 18: CO_2 storage perception factors and corresponding items

Storage Natural EV: 2.4	Factor loading	Storage Man-Made EV: 1.5	Factor loading
Underground caves and cavities	.78	Large barrels, tanks or containers	.81
Empty salt mines	.75	Underground bunkers with thick impermeable walls	.77
Old coal mines	.69		
In underground rock formations	.67		
Under the seafloor	.51		

The numbers represent factor loadings after VARIMAX rotation

Factor analysis of consequences of and evaluative statements about CCS

The factor analysis of the 12 perceived consequences of CCS and 7 evaluative statements about CCS revealed 5 factors with an eigenvalue of more than one. Again however the last factor only had one item loading strongly on it (CO_2 storage will prevent ground subsidence), which is why it was not interpreted as a factor. The first factor clearly shows a pattern of perceived risks of CCS. Respondents who perceive an explosion due to CO_2 being flammable are more likely to believe it has too many risks for public health etc. This factor therefore is named CCS Risk.

The second factor mainly pertains to items measuring CO_2 behaviour underground and the possibility of leakage and is named CCS Leak.

The third factor reveals more economical and normative statements about CCS, such as the financial consequences for consumers and the perception that CCS is just moving the problem. This factor is named CCS Norm.

The last factor has all the items loading on it expressing the necessity for CCS and its benefits, and is named CCS Benefit. Together these four factors are referred to as CCS perception factors.

Table 19: CCS perception factors and corresponding items

CCS Risk EV: 5.4		CCS Leak EV: 2.3	
Storage explodes due to pressure	.81	CO_2 will leak from storage to surface	.81
Storage explodes because CO_2 catches fire	.78	Stored CO_2 can leak during pile driving work	.70
CO_2 storage mark for terrorist attacks	.77	CO_2 will acidify groundwater	.66
People will suffocate if CO_2 leaks	.62	CCS delays development of renewable energy	.46
Storage has too many risks for public health	.56		
CO_2 storage in neighbourhood would hardly cause any inconvenience	-.45		
CCS Norm EV: 1.7		**CCS Benefit** EV: 1.1	
Consumers will pay for costs of CCS	.72	Investing in CCS creates a technological advantage for The Netherlands	.73
Safety for surroundings of CO_2 storage will	.68	CCS gives more time to develop	.71

never be guaranteed		renewable energy technologies	
Storing CO_2 is just shifting the problem	.61	CCS is necessary to mitigate temperature rise	.69
Companies will make a lot of many with CCS	.52	CCS makes sense for The Netherlands because of suitable depleted gas fields	.50

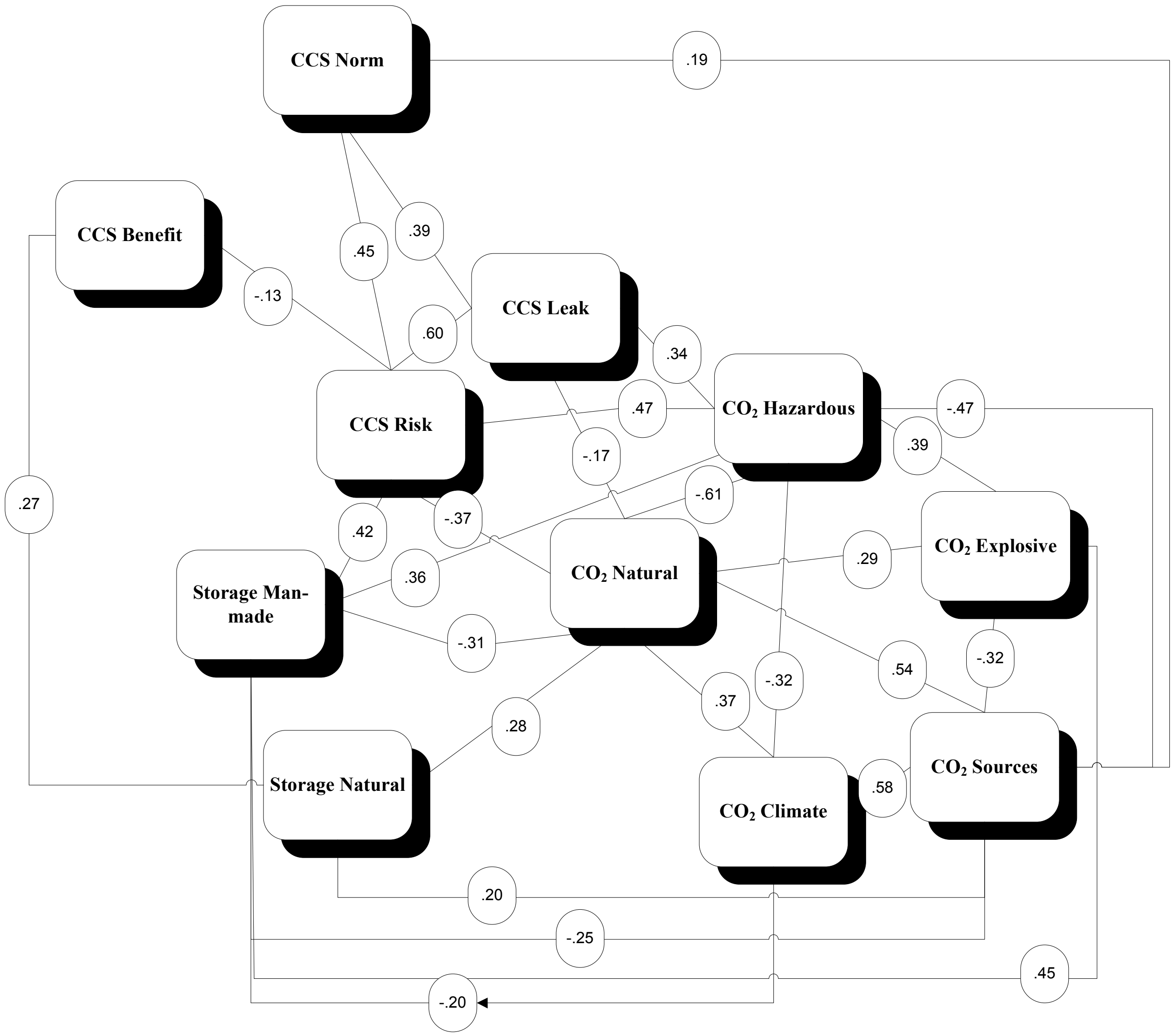
The numbers represent factor loadings after VARIMAX rotation

Relations amongst the factors

Knowing now how the different items within the specific topics relate to each other to form factors, subsequently all the factors themselves were correlated to each other to reveal general patterns of beliefs or knowledge in the questionnaire. Correlations between the factors are shown in figure 10.

Relations amongst the CCS perception factors
Looking first at the 4 CCS perception factors one can see three of the four factors correlate relatively strongly with each other: CCS Risk, CCS Leak and CCS Norm. Respondents who perceive CCS to pose high risks, such as a threat to public health or carry a chance of the storage exploding are also more likely to believe the stored CO_2 will leak (CCS Risk and CCS Leak r = .60) as well as believe CCS is not the right solution and that safety cannot be sufficiently guaranteed as measured by the CCS Norm factor which correlates moderately with CCS Risk as well (r = .45). It is interesting that these 3 factors reflecting negative perceptions of CCS all correlate weakly to the factor measuring perceived benefits of CCS. As one would expect the direction of the relation is negative, but the strength almost negligible. This implies that perceiving the risks of CCS to be high, doesn't necessarily mean one cannot at the same time believe CCS has benefits as well.

Figure 10: Single correlations amongst factors



Note: correlations amongst factors shown are significant at a level of $p < .01$

Relations between CCS factors and CO_2 factors
Relatively strong correlations are found between some CCS factors and CO_2 factors. More specifically, the CCS Risk factor correlates positively to the CO_2 Hazardous factor, r = .47. This correlation means respondents who perceive risks of CCS to be high also tend to ascribe to CO_2 such negative characteristics as emission of harmful radiation or that it is hazardous in skin contact. It seems a plausible thought that when people perceive CO_2 as a hazardous substance they judge the risks of CCS to be higher. A similar, though somewhat weaker, relation is found between CCS Leak and CO_2 Hazardous, r = .34. The CCS Norm factor, which also portrays a fairly negative view of CCS, doesn't relate to this CO_2 factor at all (r = .01), indicating perceptions of CO_2 mainly relate to concrete risks of CO_2 storage and chance of leakage, not more general normative evaluations.

Relations between CCS, CO_2 knowledge factors and storage perception factors
The perception of CCS as being high in risk does not only correlate highly with the perceived hazardousness of CO_2, but also with how people perceive the CCS storage to look like. Mainly, people who see CCS as risky and CO_2 as hazardous, also tend to believe the CO_2 will be stored in man-made structures such as bunkers and tankers, with CCS Risk correlating r = .42 with the factor CCS Man-made Storage and CO_2 Hazardous correlating r = .45 with it. This is possibly because some respondents perceive these structures to provide a safer buffer form the outside world, as was indicated by respondents in the qualitative interviews. Because people see the risks as high, they feel the CO_2 should be stored in an as safe as possible place and they don't believe a natural structure can contain a gas well enough.

Relations with CO_2 Natural factor
The factors CCS Risk, CCS Leak and CO_2 Hazardous, as well as the related perception of storage as being man-made, share in common that they all have an inverse relation to the perception of CO_2 having natural properties. They all correlate negatively to factor CO_2 Natural, with correlations ranging from -.31 to -.61. This means people who know about the natural properties of CO_2 are less likely to incorrectly believe CO_2 to emit radiation or cause acid rain while at the same time they judge the risks of CCS, like the CO_2 exploding or the consequences of leakage to be very severe, to be less likely. Respondents who score high on the CO_2 Natural factor also perceive it less likely that the CO_2 will be stored in man-made storage (r = -.31), while they are more likely to believe it will be stored in natural storage, even though this relation is quite weak. These results do not prove that knowledge of natural properties of CO_2 causes the risk perception to be lower, however.

In general it seems respondents who know a lot about CO_2 also have better knowledge of CCS. The CO_2 Natural factor correlates positively, though not very strongly to a correct knowledge of: the goals of CCS (r = .24), of the amount of fossil fuels used in the electricity mix being at least 80%, r = .26 and finally by also correlating positively with a correct answer to the question about what porous rock is (r = .23). The opposite is true for the CCS Risk factor, which correlates inversely with all these variables, indicating respondents who judge risks of CCS to be high, have slightly poorer knowledge of these aspects of CCS.

CCS and CO_2 knowledge pattern
These relations between the factors and knowledge of the topics shows a pattern where perceiving risks of CCS, including risk of leakage, to be higher coincides with lower knowledge of the natural properties of CO_2 and a higher prevalence of beliefs that CO_2 is a hazardous substance as well as the perception that it will be stored in sealed off man-made storage. Taken together with the results of the factor analysis this means there is a cluster of people who perceive the likeliness of most of the risks of CCS mentioned in the survey to be higher, just like

the hazardousness of CO_2, while at the same time having poorer knowledge of the natural properties of CO_2 as well as other aspects of CCS, such as storage and its goals. Inversely this means there is also a cluster of people who generally perceive the likeliness of hazardous consequences of CCS to be lower, who have a better knowledge of the natural properties of CO_2 and hold less beliefs about CO_2 being hazardous.

5.2.5 Relations to CCS Attitude

At the end of the survey all respondents evaluated CCS on eight 7-point semantic scales. They could indicated whether they perceived CCS to be: positive or negative, familiar or unfamiliar, good or bad, scary or not scary, clean or dirty, hazardous or harmless, safe or unsafe and useful or useless. For the analysis these eight scales were aggregated to form one measure of CCS Attitude, where 1 is an aggregation of all the negative scale ends and 7 is an aggregation of positive scale ends. Factor analysis revealed all the 8 items were indeed measuring the same construct and reliability analysis indicated the new CCS Attitude scale had a Cronbach's alpha of .927, which is very high. This justifies aggregating the eight scales into one measure of CCS Attitude.

Single correlations to CCS Attitude

In this part of the analysis respondents' perceptions and knowledge of CO_2, climate change and CCS were related to CCS Attitude to see how strongly these perceptions relate to their attitude towards CCS and whether certain perceptions had a more negative or positive relation to it. Figure 11 shows an overview of the single correlations between these variables and CCS Attitude. Of the single correlations, the strongest are between CCS attitude and the factors measuring perceived consequences and evaluation of CCS, with the factor CCS Risk correlating $r = -.64$ with CCS attitude and factor CCS Leak correlation $r = -.49$. Apparently the two strongest predictors of a person's attitude is their perception of the risks of CCS and the chance of the CO_2 leaking from storage. The more they perceive the risks to be likely the more negative they are about CCS. The inverse relation is found between the perceived benefits of CCS and CCS attitude ($r = .47$) meaning that the higher people perceive the benefits to be the more positive they are about CCS. Fairly low correlations are found with the other factors and variables. A somewhat interesting correlation still exists between the CO_2 factors 'CO_2 Natural' and 'CO_2 Hazardous' and CCS attitude, .26 and .29 respectively. The more hazardous respondents perceive CO_2 to be, the more negative they are about CCS, while the more natural respondents perceive CO_2 to be the more positive they are about CCS. These correlations are fairly low however. All the other single correlations are below .25.

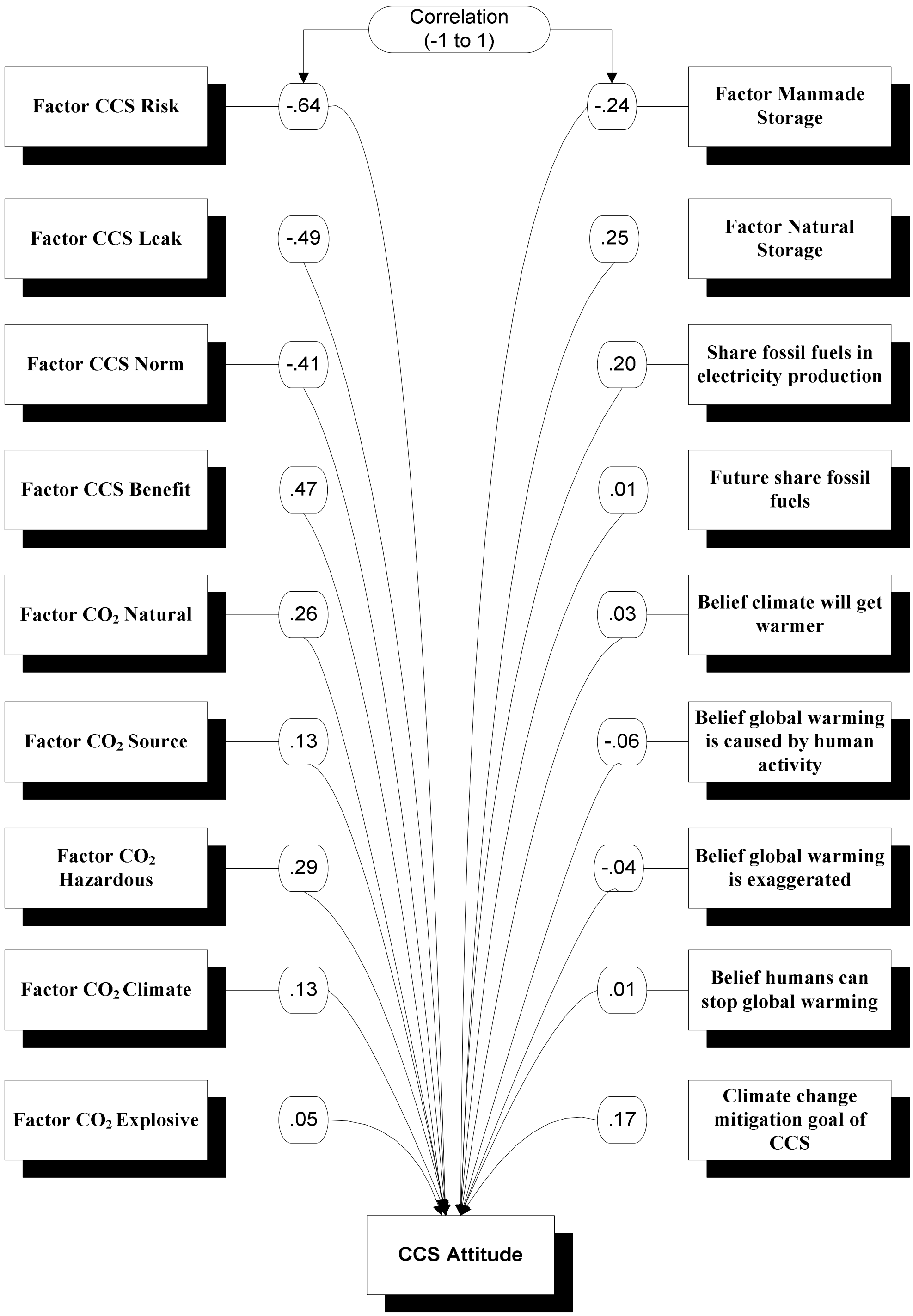
Climate change beliefs and CCS Attitude

Notable is the hardly existent correlation between beliefs about climate change and attitude about CCS. The correlations range between -.06 and .03. This indicates whether a respondent believes climate change is happening or not has hardly any connection to his or her perception of CCS. To explore this relation further we correlated the beliefs about climate change to the individual statement 'CCS is necessary to mitigate climate change'. The belief that climate change is a consequence of human behavior correlates moderately to this statement $r = .44$. In other words, people who believe in the anthropogenic causes of climate change are more likely to believe CCS is necessary to mitigate climate change. However, the statement 'CCS is necessary to mitigate climate change' correlates only weakly with CCS attitude (r = .22). A possible way to interpret this pattern is that even though to a certain extent respondents who believe in anthropogenic causes of climate change believe CCS is necessary, this does not make them more positive about CCS. This corresponds with the often heard perception of CCS as a 'necessary evil'. Even if people think CCS is necessary, does not mean they will *like* it more.

Perception electricity mix and CCS Attitude

The perceived share of fossil fuels in the electricity mix shows a weak correlation to CCS attitude, while the perceived share of fossil fuels in the future electricity mix shows hardly any correlation to it. Apparently uninformed opinions about CCS are unrelated to fossil fuel use, possibly because lay respondents are not aware of the role of fossil fuels in CCS. The amount of renewable energy, specifically the amount of solar and wind energy, in the current energy mix shows a slight negative correlation to CCS Attitude, with respondents being more negative about CCS the more renewable energy they believe is used, r = -.22. It might be respondents who are generally aware these sources do not emit CO_2 consider CCS to be redundant the more of these sources they believe is used. The data cannot establish this, however.

Figure 11: Single correlations with CCS Attitude



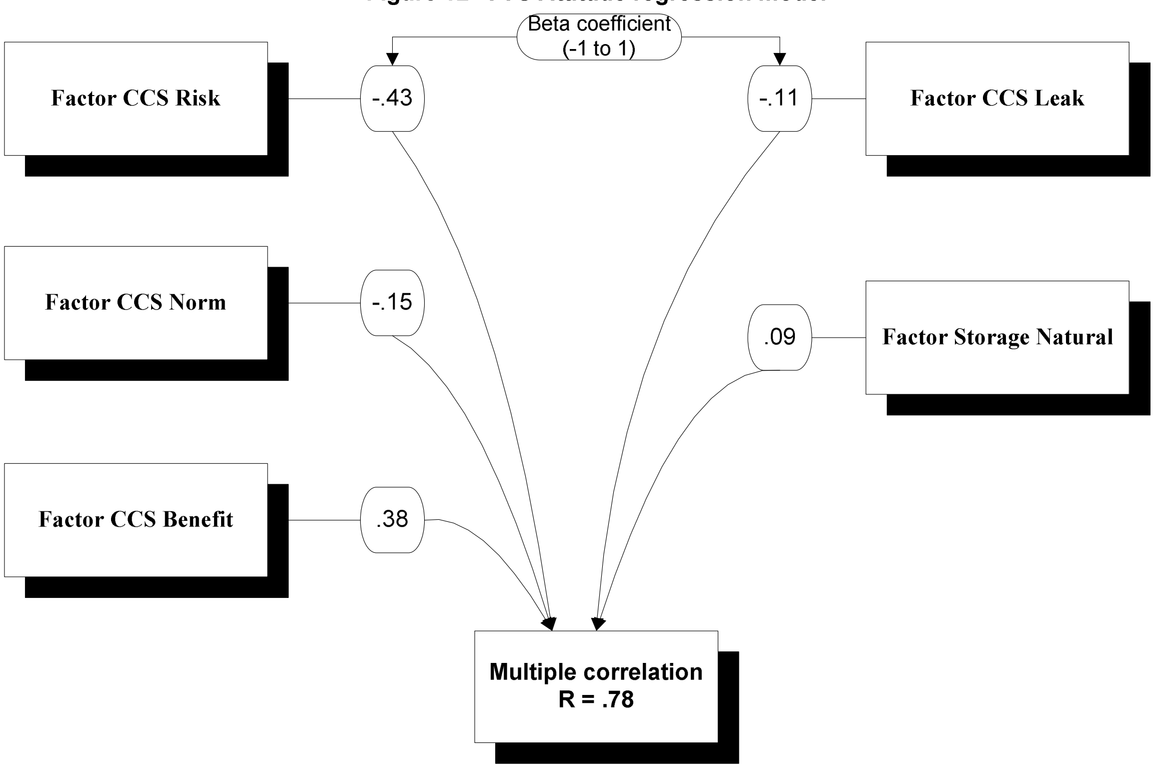
S Attitude model

To establish what most strongly influences CCS Attitude the multiple correlation was computed between all the factors discussed so far of CO_2, CCS and CCS storage perceptions, and climate change beliefs with CCS Attitude using a regression analysis. In addition the two variables measuring the perceived total of fossil fuels in the current electricity mix and fossil fuels in the 2050 electricity mix were added, as well as the variable that indicates whether a person had selected an incorrect goal of CCS or a correct one. The multiple correlation represents how these perceptions together are connected to respondent's CCS attitude or in this case to what extent the CCS Attitude can be explained from these perceptions.

The multiple correlation of this model is R = .77 while the squared multiple correlation is R^2 = .60. This means almost 60% of the variance in the answers of CCS attitude can be explained by respondents' perceptions of the items and factors included in this model. The remaining 40% are not explained by the perceptions and beliefs measured in this survey.

However, only five of the included measures have a significant influence on CSC Attitude, namely the four CCS perception factors (CCS Risk, CCS Leak, CCS Benefit and CCS Norm) and the factor Storage Natural. Indeed when only these factors are included in the regression on CCS Attitude the multiple correlation even increases to .78 and the R^2 to .61. Therefore the final model is includes only these five factors and is shown in figure 12.

Figure 12: CCS Attitude regression model



Note: all beta coefficients are significant at a level of *p* = .01

This model shows the measures of perceived consequences and evaluative statements about CCS have the most direct influence on respondents' CCS Attitude. In addition, knowledge about CO_2 being stored in natural storage sites also has a significant influence. Despite the fact that knowledge of CO_2, climate change, energy production and the aim of CCS do not exert a direct influence, their relation to the perceived consequences of CCS and evaluations still imply a role of knowledge of these issues in overall opinion of CCS, nevertheless it is an indirect one.

5.2.6 Demographic variables

To explore possible demographic differences in the perceptions and knowledge of CO_2 and CCS we tested for statistical significance in the differences based on gender, age, education level and political preference. For age we used a classification of 3 groups: 18-34, 35-54 and 55 and older. For education we distinguished three levels: low education (mainly vocational), middle education and high education (BA and MSc degrees). The analyses were performed with the following variables: Factors CCS Attitude, CCS Risk, CCS Leak, CCS Norm, CCS Benefit, CO_2 Natural, CO_2 Source, CO_2 Hazardous, CO_2 Climate, CO_2 Explosive, and belief in anthropogenic climate change. For none of these analyses an effect of political preference was found, except for the belief climate change is occurring for as respondents who vote for the green party (Groen Links) believe more in anthropogenic climate change than voters of the Socialist Party. On some of the variables interaction effects were found of some of the 4 included variables, but because the amount of respondents in these groups became too small in the case of interaction effects including the political preference measure, these interaction effects were not interpreted. Interpreting these with a low number of respondents would give very unreliable results. The significant differences between the groups will be discussed here. If a demographic variable is not mentioned, it means no significant difference between its groups has been found on the dependent variable in question. The number of respondents in all these analyses is lower than total, namely 398, because 3 respondents who did not state their education level were omitted from the sample for the purpose of these analyses.

Demographic differences on CCS Attitude

First, it is apparent differences in attitude towards CCS can be found across all three demographic variables. Men are significantly more positive about CCS (M = 4.05) than are women (M = 3.70; $F_{(1,398)}$ = 6.611, p = .011), people over the age of 55 are significantly more positive (M = 4.42) than the two younger groups (age 18-34 M = 3.78, age 35-54 M = 3.94; $F_{(2,398)}$ = 7.07, p = .001) and the highest educated group is more positive (M = 4.11) than the lowest educated group (M = 3.56; $F_{(2,398)}$ = 4.893, p = .008). These differences are significant, but still in absolute terms the most positive groups are only moderately positive about CCS having a mean score of just over the midpoint 4 and the more negative groups are only moderately negative about CCS having a mean score of just under the midpoint 4. There are no interaction effects between these three demographic variables on CCS Attitude. A possible explanation of why women and respondents with a lower education are more negative about CCS can be found in the rest of the results.

Demographic differences on perceptions of CCS

Women perceive the risks of CCS to be higher than men do, shown by their score on the factor CCS Risk (female M = 4.04, male M = 3.61; $F_{(1,398)}$ = 11.211, p = .001). The same holds for respondents with a low education level (low M = 4.07, high M = 3.61; $F_{(2,398)}$ = 6.767, p = .001).

The difference previously found between the age groups on their CCS attitude might to some extent be explained by their perception of likeliness of CO_2 leakage. It is the eldest group, which holds a relatively more positive attitude, that perceives this likelihood to be low, whereas the younger groups perceive it as being more likely to happen (age 18-34 M = 4.15, age 35-54 M = 4.0, 55 and older M = 3.72; $F_{(2,380)} = 11.211$, $p = .03$). No differences between any of the groups are found on perceived norms of CCS. On the perceived benefits of CCS there is a difference between the age groups, as the elderly perceive them to be higher (M = 4.51) than the two other groups (age 18-34 M = 4.25, age 35-54 M = 4.11; $F_{(2,380)} = 6.139$, $p = .002$). Again these results show significant differences which in absolute terms are not always very large. For example, despite the difference between the age groups on the perceived benefits of CCS, all three age groups perceive the benefits to be moderately high.

Demographic differences on knowledge of CO_2

Considering the inverse relation we found between CCS Risk and CO_2 Natural, it is not surprising that on the CO_2 Natural factor again differences can be found between the genders and between the education levels corresponding to those on the CCS Risk factor. Women are less aware of the natural properties of CO_2 (M = 1.74; on 3-point scale where 1 is either wrong answer or I don't know, 2 is somewhat sure of right answer and 3 is sure of right answer) than men are (M = 1.90; $F_{(1,398)} = 6.003$, $p = .015$), just as are respondents with low education (M = 1.54) compared to respondents with a high level of education (M = 2.1; $F_{(2,398)} = 23.964$, $p < .001$). Important to note is the difference between the genders, although significant, in both cases the absolute levels of knowledge are not very high. The difference between the high and low educated groups is considerably larger.

When it comes to the hazardous properties of CO_2 as measured by factor CO_2 Hazardous, it is women and low educated respondents who judge CO_2 to be more hazardous (female M = 1.51, low education M = 1.41) than do men (M = 1.67) or highly educated respondents (M = 1.76; gender $F_{(1,398)} = 8.65$, $p = .003$; education $F_{(2,398)} = 11.8839$, $p < .001$) Again, keep in mind this variable was recoded, so a higher score now means the person is more aware that CO_2 does *not* poses the mentioned hazardous characteristics. Differences can also be found on the other CO_2 factor variables.

Men have more correct answers on items included in the CO_2 Source factor (M = 2.0) than do women (M = 1.8; $F_{(1,398)} = 3.280$, $p = .003$. Respondents in the high education group have more correct answers on items included in the CO_2 Source factor (M = 2.0) as well as those in the CO2Climate factor (M = 2.4) than do respondents from the low level group (M = 1.7and M = 2.0) respectively; $F_{(1,398)} = 7.800$, $p <.001$ and $F_{(1,398)} = 10{,}020$, $p <.001$ respectively). Respondents from the oldest age category have a higher average score on the CO_2 Climate factor (M = 2.4) than do the youngest category respondents (M = 2.1; $F_{(1,398)} = 9.551$, $p <.001$).

Interesting to see is that these differences seem to fit with the knowledge and perception clusters as discussed in section 5.2.4. The cluster of people who are more negative about CCS, perceive the risks to be higher, see CO_2 as more hazardous and less natural and perceive storage of CCS as a manmade construction are more often women and low educated respondents, whereas men and highly educated respondents are slightly more positive about CCS, perceive the risks to be lower and are more knowledgeable about the natural properties of CO_2, while at the same time they perceive CO_2 as less hazardous and think natural storage is more likely. It has to be noted however the groups with higher levels of knowledge still show considerable knowledge gaps, as can be seen in the results discussed above, where on CO_2 knowledge hardly any of the groups reach a score of 2, let alone 3, which mainly points in the direction of a conclusion they know slightly more than the other groups, but still not a lot.

5.3 Comparison interview after the ICQ and perceptions from the Knowledge and Beliefs test

Another aim of this research was to study the interaction between balanced expert information and lay people beliefs. This was done by comparing thoughts respondents conveyed in the post ICQ interview with lay people beliefs expressed in the Knowledge and Beliefs test. In addition to the quantitative measures of knowledge and beliefs which were described in section 3.2 another item from the Knowledge and Beliefs Test, not previously discussed, is used for this comparison. Respondents in the Knowledge and Beliefs test were at one point asked through an open ended question if they had any idea why CCS should not be implemented. This was an open question to avoid influencing respondents. A direct comparison between the results of the Knowledge and Beliefs test and the post-ICQ interview is not possible. In the Knowledge and Beliefs test respondents were explicitly asked about correct and incorrect beliefs mentioned by respondents in interviews and even the open question about why CCS should not be implemented was more specific than the comparable question in the post ICQ interview why a respondent had not chosen one of the CCS options among their preferred option. Nevertheless some interesting general similarities and differences can be found. Because the results are not directly comparable and the analysis and results of the post ICQ interview are of a qualitative nature, the results of the comparison will be discussed in general terms.

The first and most clear similarity between the results of the two samples is respondents' focus on the issue of safety, both in the uninformed situation as well as after they had received information about this issue in the ICQ. As mentioned previously in discussion of the results from the post ICQ interviews half of respondents still expressed their concern about the safety of storage after having received information about this issue in the ICQ. Within the results of the Knowledge and Beliefs test it was also found the items measuring respondents' perception of risks of CCS storage and chances of leakage were the most predictive of their attitude about CCS. In the open question about why CCS should not be implemented safety of storage was also most often raised as a concern. Another similarity was the in both tests often mentioned perceptions that the technology and its consequences were still too unknown and not understood well enough. A slight difference seems to be the fact that several respondents in the Knowledge and Beliefs test mentions such risks as explosion, toxins underground and large quantities of CO_2 being released at once. In the interview after the ICQ only one respondent mentioned the belief that explosion could be a risk of CO_2 storage.

Several respondents in the Knowledge and Beliefs test also seem to have concerns not expressed by respondents in the post ICQ interview. A few mention they are worried plants will not have enough CO_2 anymore, that they wonder whether CCS is technically and financially feasible and there are also numerous questions about the capacity of storage space. Most of these issues are addressed in the information provided in the ICQ which could be the reason why these issues are raised less after respondents have read this information.

A noticeable difference is the fact that numerous respondents of the Knowledge and Beliefs test in the open question state they feel they do not know enough about CCS to give an answer to this question. This is expressed by hardly any of the respondents in the post ICQ interview. One issue seemed to arise in the post ICQ interview that was not mentioned in the Knowledge and Beliefs test; the issue of coal. The continuing use of fossil fuels in general and the use of coal in specific was often mentioned by respondents after the ICQ as being a big disadvantage of the Powerplant + CCS option. In the Knowledge and Beliefs test this did not seem to play a role. In the open question none of the respondents mentioned the use of coal or any fossil fuels. Additionally no relation was found between respondents' estimation of the amount of any of the fossil fuels used in the electricity mix and their attitude about CCS. It is possible uninformed respondents are not aware of the relation between CCS and the use of coal, whereas in the ICQ this issue is explicitly addressed.

5.4 Results Media use respondents ICQ and Knowledge and Beliefs Test

5.4.1 Awareness of CCS and current events

In both questionnaires respondents were presented with questions about their awareness of several media events relating to the topic at hand. In the end of both questionnaires they were asked whether they had ever heard of the Intergovernmental Panel on Climate Change and of the planned CCS project in the city of Barendrecht in the Netherlands. Those who indicated they had heard of these were asked to rate both on a 7-point scale ranging from 1 'very bad' to 7 'very good'. Respondents of the Knowledge and Beliefs test were also asked whether they had seen two recent broadcast specials about the CCS project in Barendrecht "Zembla" and "Netwerk".

Awareness IPCC

Of the 134 respondents that filled in the ICQ, 35 (26%) reported having heard "a little bit" about the IPCC and only 6 (4.5%) claimed to really know about it. These 41 respondents evaluated the IPCC with a 5 on the 7-point scale, which is fairly positive. Very similar results are found among the 401 respondents of the Knowledge and Beliefs test where 24.3% of respondent state to have hear either a little bit or plenty about the IPCC. The respondents who have heard of the IPCC rate the organization with a 5 on a 7-point scale, just like in the ICQ, which indicates a moderately positive evaluation. Even though the IPCC has received some media attention lately in the sample of newspaper articles on CCS analyzed for the purpose of this study (see section XX) IPCC was discussed in only a few of them.

Broadcasts about CCS

Very little respondents report to have seen either the "Zembla" or "Netwerk" broadcasts about CCS. Only 1.2% states to have seen the full Zembla broadcast and another 3% claims to have seen a part of it. The results are similar for the Netwerk broadcast which 1% states to have seen entirely and 4.7% states to have seen a part of. The group of respondents who have seen these broadcasts are too small to warrant any further analysis with it.

Awareness project plans in Barendrecht

More respondents have heard of the project plans in Barendrecht. A quarter of the ICQ sample reported not to have heard of these plans, while 40% claimed to have heard a little bit and 36% claimed to know plenty about it. 76% of the 119 respondents who before information state they have heard about the Powerplants + CCS option in the end of the questionnaire also state they have heard of the project plans in Barendrecht, which might indicate most of respondents' only contact with CCS is information about concrete project plans in the media. This pattern is supported by results of the Knowledge and Beliefs test. Of the 259 respondents who state they have heard at least a little bit about CO_2 capture and storage 87% also has heard of CCS project plans in the Netherlands. In fact 76% of the respondent who have heard of CCS have also heard about project plans in Barendrecht, which again might mean this is the main context within which people receive information about CCS. Indeed, results of the media analysis show that in the headlines of the articles we analysed from May 2009 – May 2010, the words 'Barendrecht', 'CO2', and 'Opslag' occurred far more frequently than any other term (see section 4.6).

Awareness project plans Barendrecht and CCS Attitude

To explore the relation between awareness of the project plans in Barendrecht and evaluations of CCS within the results of the Knowledge and Beliefs test we compared respondents' scores on the CCS Attitude scale based on their awareness of the project in Barendrecht. The results from the ANOVA show respondents who state they have heard of project plans in Barendrecht are significantly more positive about CCS (M = 4.3 on the 7-point scale) than respondents who say they have not heard of it (M = 3.7) or only a little bit (M = 3.8; $F_{(2,398)}$= 10.8, $p < .001$). This is not to say that respondents who have heard of plans in Barendrecht are more positive of CCS *because* of this. Causes can be many. For instance in the results of the Knowledge and Beliefs Test there are somewhat more men and respondents with higher education in the sample that has heard of these plans, and as was described earlier these groups are generally more positive about CCS. In the results of the ICQ no effect of this awareness of plans in Barendrecht on evaluation of the Powerplant + CCS option can be found.

Awareness CCS and CCS knowledge

To see whether respondents of the Knowledge and Beliefs test who stated they had heard of CCS before the questionnaire knew more about CCS than respondents who had not heard of CCS, we compared these groups' scores on correct goals of CCS, correct capture points and correct storage of the CO_2. Indeed, respondents who had heard of CCS before were significantly more likely to know the goal of CCS than those who had not heard of it beforehand (Measured on a 3-point scale where a higher score signified a more correct answer; Aware: M=1, unaware: M = .6; $F_{(2,398)}$= 21.1, $p < .001$). Those who had heard of CCS were able to select more correct capture points of CCS and select less wrong ones (M=.78 on a scale of -5 to 5 where -5 means only wrong capture points selected and 5 means only right capture points selected) than respondents who had heard either 'a little bit' (M = .23) or not at all about CCS (M=-.18; $F_{(2,398)}$= 18.06, $p < .001$). Those who had heard of CCS were also more likely to correctly believe the CO_2 would be stored in existing underground rock formations (M=5.8 on a 7-point scale where a higher score is more correct answer) compared to those who hadn't heard of it (M=4.1, $F_{(2,398)}$= 38.54, $p < .001$). As pointed out before, this difference, although significant, does not say anything about the causal relationship between awareness of CCS and knowledge about CCS. It is however plausible to believe respondents' who have heard about CCS have also received more information about the details of it. Alternatively among respondents who had heard about CCS are more respondents with a higher education who might be making more educated guesses about the specifics of CCS technology.

5.4.2 Media consumption and CCS

General media use

In the end of both questionnaires respondents were asked how many hours a day they watch television, listen to the radio, read newspapers and use the internet. For each of these four information channels they were also asked how much of the time they use it for information about politics and current events. Answers were given on a scale ranging from 1 'no time' to 7 'more than 3 hours per day' with intervals of 30 minutes. They received the same question about using these media particularly for news and current events. In general, respondents spend most time watching television, followed by listening to radio and browsing the internet. Relatively little time is spend reading newspapers. To catch up with news and current affairs, respondents again spend most time watching television but the newspaper is the second most often used medium, followed by radio and the internet.

Media use and awareness of CCS in Knowledge and Beliefs Test

The effects of respondents' media consumption on awareness of CCS were explored in both sets of results. All the correlations reported below are significant at a level of at least p = .01. Correlations that are not significant at this level are not reported. A lot of these correlations could be considered quite low (ranging around .2 or even lower). However, considering the very indirect effect media use has both on knowledge and opinions of the public, these significant results are still relevant to report, especially as compared to other correlations that are found they do convey a general pattern.

Whether respondents of the Knowledge and Beliefs test had heard of CCS is correlated to the amount of time they spend reading newspapers in general (r = .21) and slightly stronger to the amount of time they spend reading about political and current affairs topics (r = .27) as well as the amount of such topics they watch on television (r = .20). The other media sources, such as radio, internet and general watching of television showed lower relations to awareness of CCS.

A very similar pattern is found between media consumption and the project plans in Barendrecht, where the highest relationship exists between awareness of these project plans and the amount of time respondents spend watching political and current affairs programs on television as well as reading about political and current affairs topics in the newspapers (for both r = .20). Awareness of climate change did not reveal any considerable relationship to media consumption which might be due to the very high awareness of respondents of climate change overall. Nevertheless, a significant correlation is found between awareness of climate change and again the reading of political and current affairs topics in newspapers (.15).

Media use and awareness CCS and current events

Within the ICQ the relationship was explored between respondents' media consumption and pre existing awareness of the two CCS options as well as the project plans in Barendrecht and the IPCC. Here most correlations are very weak, hardly reaching .1. The only significant correlation is found between the amount of time spent watching political and current affairs programs on television (r = .30) and awareness of project plans in Barendrecht and between these project plans and the amount of time spent reading about such topics in newspapers (r = .24). Beliefs about climate change were only weakly correlated to media consumption, the correlation not exceeding .19. In the ICQ respondents are specifically asked whether they have ever heard of "Large plants where coal or gas is converted into electricity with capture and storage of CO_2". The fact that respondents' reported awareness of this option hardly correlates to their media consumption while their reported awareness of project plans in Barendrecht does, might imply that information about the Barendrecht project in the media does not necessarily cover the technological aspects of CCS. Respondents might have a general notion that 'something' is happening in Barendrecht, while not being fully aware of what this is about or which technology it entails. As is also revealed by the media analysis of news reports about CCS, the project plans in the city of Barendrecht are often discussed in terms other than the technology.

Media use and knowledge and perceptions of CCS and CO_2

The correlations were also explored within the Knowledge and Beliefs Test between media consumption and knowledge of CO_2, goals of CCS, storage of CCS as well as beliefs about possible consequences of CCS. Even though the highest correlations were always between the amount of time spent reading political and current affairs topics in newspapers and the mentioned variables, none of these correlations was higher than .2 which is quite weak in general, but still noticeable considering the generally indirect and diffuse effect of media consumption on knowledge. The results reveal a pattern where time spent reading newspapers shows higher relationships with all these variables compared to the other media sources.

Media use and knowledge CO_2
Overall knowledge of CO_2 had a correlation of .18 with the amount of time spent reading about political and current affairs topics in newspapers and a correlation of .17 in general. In comparison, none of the other correlations between media channels and knowledge of CO_2 achieved significance or exceed a strength of -.1 to .1.

Correlations with the five CO_2 factors reveal the details of this relationship. The more respondents indicate to read about current affairs topics and politics in newspapers the more likely they are know about the natural properties of CO_2 (.13), and the less likely they are to perceive CO_2 as hazardous (-.18). Amount of time spent reading newspapers in general also correlates significantly with the factor CO_2 Hazardous -.15 as well as with factor CO_2 Climate .15 and negatively with factor CO_2 explosive .13. None of the other media channels correlate significantly to any of the CO_2 factors. This pattern shows the more respondents read about current affairs topics in newspapers the more they are likely to know about CO_2. A cause cannot be established however. Other factors, such as education level might play a role in this relationship. As can be seen in the following paragraph “education and media use” higher educated respondents indicate to read more about current events issues in newspapers.

Media use and knowledge and perception of CCS
No significant correlations were found between media consumption and knowledge of the correct goals of CCS. As for perceptions of storage space the highest correlations were found between the amount of time spent reading newspapers in general and political and current affairs topics in newspapers in specific and the perception that the CO_2 would be stored in existing underground rock formations (r = .19 and .15 respectively). Time spent reading newspapers was significantly, but negatively correlated to the perception that it would be stored in tanks or barrels (-.16) or in underground bunkers -.13. Internet use on the other hand was positively correlated to the perception that the CO_2 would be stored in underground bunkers .14. Reading newspapers therefore was found to be correlated slightly positively with correct answer options and negatively with incorrect ones, while internet use was correlated to an incorrect perception.

Looking at the correlations between media use and perceptions of consequences of CCS again the only significant correlations are found between the amount of time spent reading political and current affairs topics in newspapers and internet use and perceived consequences of CCS. Here also these correlations are fairly low. The more respondents indicate to read about political and current affairs topics in newspapers the slightly less likely they are to believe the stored CO_2 will leak from storage during pile driving work (-.15) that it will become a mark for terrorist attacks (-.1) or that it will acidify ground water (r = -.13) The more time respondents spend reading newspapers in general as well as current affairs issues and politics in particular the less likely they are to agree that CCS has too many risks for public health (r = -.1 and -.13) and the slightly more likely they are to agree CCS is a viable option for the Netherlands considering the availability of empty gas fields. Internet use on the other hand is correlated positively to the belief that CCS carries too many risks for public health (r = .12), to the perception that CO_2 will leak from storage during pile driving work (.15), that it will become a target of terrorist attacks (.11) and that it will explode due to pressure (.12). There is a slight tendency that the more one uses the internet the more one is also likely to agree to the statement that using CCS is just shifting the problem. Additionally internet use is also slightly correlated to the perception that implementing

CCS will slow the development of renewable technologies (.15). None of the other perceptions of consequences had a significant correlation with media use.

Education and media use

Within the Knowledge and Beliefs Test ANOVA's were conducted to test whether there was a difference between the education levels in the average amount of time they use the different media sources. Significant differences emerge with respect to television and newspapers. On average, respondents with higher education levels spend less time watching television (M = 4.8) than do the two groups with a low (M = 5.9) and middle level of education (M = 5.5; $F_{(2,395)}$ = 35.473, p < .001). On the other hand the middle (M = 2.7) and higher education group (M = 2.9) indicate to spend more time reading newspapers than the low education group (M = 2.4; $F_{(2,395)}$ = 6,034, p = .003). The high education group states to spend more time reading political and current affairs issues in newspapers (M = 2.5) than does the low education group (M = 2.0; $F_{(2,395)}$ =7,969, p < .001). The fact that newspapers are more often read by people with a higher education could be a part of the explanation why newspapers are found to correlate with measures of knowledge.

5.5 Results Medialog

At present, the analyses have been conducted on the data from May 1, 2009, until May 31, 2010. This includes the period in which the public opinion surveys (ICQ and test of knowledge and attitudes) were conducted and thus encompasses messages and events that may have influenced survey responses.

5.5.1 Descriptives

The search resulted in 430 relevant articles, which is on average 33 articles per month. On average these articles contain 494 words, which is the equivalent of about three quarters of an A4-sized page of text. 20% of the articles contain at least one illustration or photo. 323 of the articles (75%) are news or background items, and 53 of the articles (12%) are expert opinions or columns. The remainder of the articles are letters from readers, interviews, book reviews, or announcements of radio and television broadcasts on CCS. The large majority of the articles are focused on events in the Netherlands (354 articles or 82%), a much smaller group of articles has a worldwide scope (n=39 or 9%) or European scope (n=24 or 5.6%). The remainder of the articles is about specific countries or regions within or outside Europe.

Figure 13 shows the number of articles by newspaper, ordered clockwise from lowest to highest number of articles. This chart shows that the free newspapers Spits and Metro give least attention to CCS, together with het Parool which is focused on the Amsterdam region and Agrarisch Dagblad which is a special interest newspaper. NRC.Next often takes over messages from the mother newspaper NRC Handelsblad. The highest number of articles is found in the Financieele Dagblad, followed by Trouw and Reformatorisch Dagblad.

Figure 13. Number of articles by newspaper

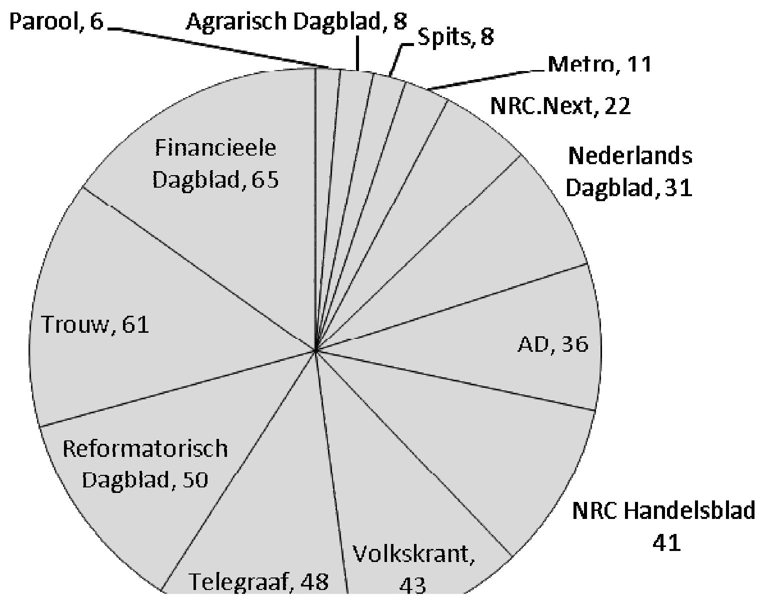


Figure 14 shows the total number of newspapers printed (which is called 'impressions') for all titles in 2009 (CEBUCO, 2009). The five paid newspapers in the Netherlands with the highest number of impressions and thus the largest audiences are De Telegraaf, Algemeen Dagblad, De Volkskrant, NRC Handelsblad, and Trouw. The order of the newspapers in this chart from left to right is the same as the clockwise order of titles in Figure 13, which shows at a glance that there is a weak relation between the size of the newspaper and the number of articles it contains about CCS. The three titles that most often report on CCS have relatively few impressions, meaning that a relatively small group of newspaper readers is exposed to a relatively high number of CCs messages.

Figure 14: Impressions by Newspaper

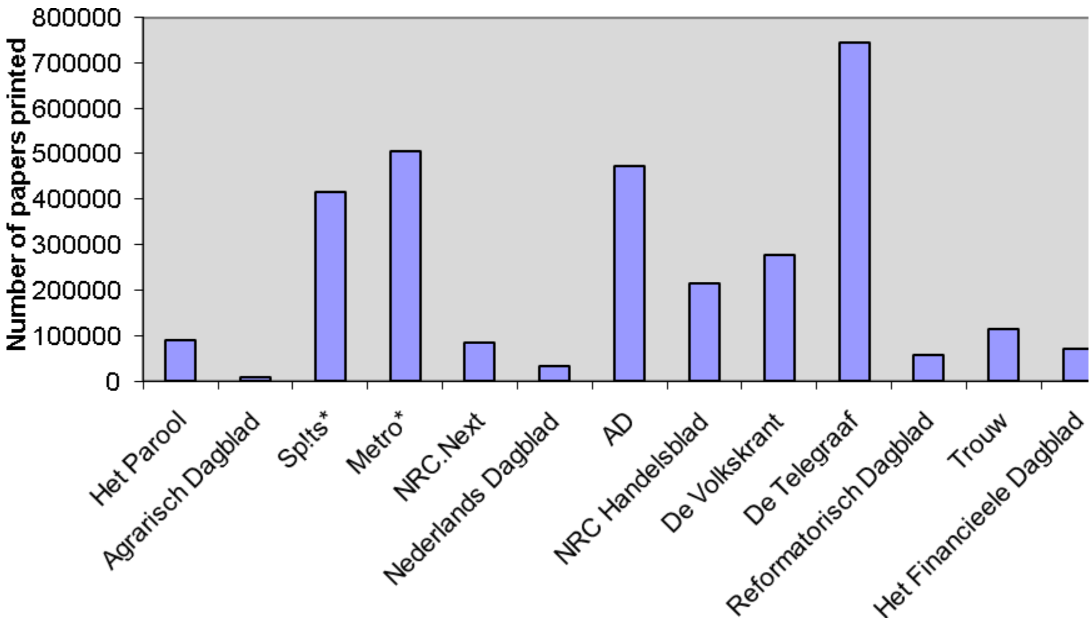
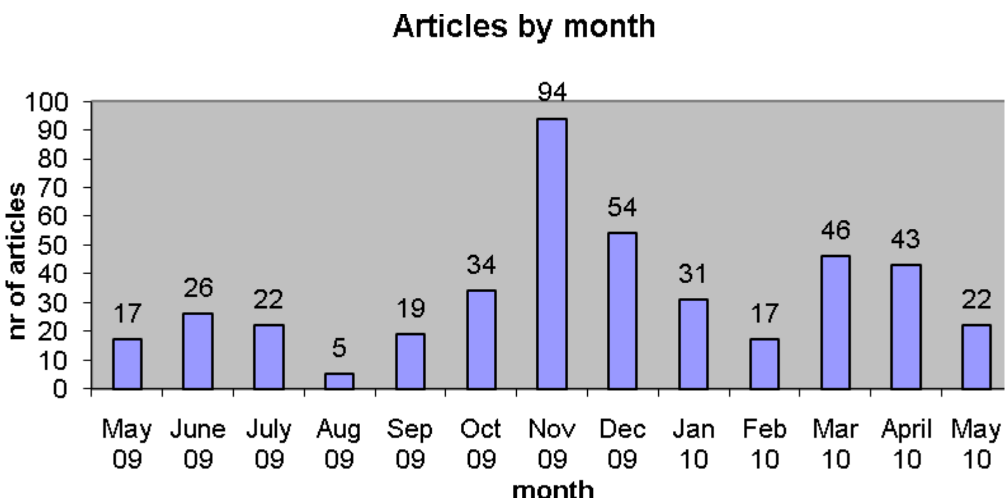


Figure 15 shows the number of articles by month. As his graph shows, the number of articles peaked in November 2009. When looking at the exact dates, we found that the peak days were November 19 and November 20. The related event is the announcement of the decision of the Dutch government to grant permission to the Barendrecht CCS project. After these dates, however, the attention to CCS quickly levels off to the same height as before the announcement of the governmental decision. Attention increases again in March 2010, after the fall of the government and the announcement that the CCS project in Barendrecht will be subject to a new law ('Crisis- en Herstelwet'). This law had already been announced early in 2009. In March, however, it was apparent that the law had been approved, would take effect on April 1st, 2010, and would apply to the Barendrecht project. The so-called 'crisis law' enables the government to bypass certain environmental and construction rules and procedures, thus speeding up projects thought necessary to boost the national economy. Application of the law to Barendrecht is said to disable the municipality of Barendrecht to protest against the plan. However, the media also report that because the government has fallen in February 2010, the final decision about Barendrecht will be in the hands of a new government after the elections in June 2010. The announcement of the 'crisis law' and the postponement of a final decision, against the background of preparations for new elections in June, are followed by a period of discussion about the Barendrecht project and about CCS in general between, amongst others, experts, politicians, and project developers by the end of March 2010 and throughout April 2010. Two television items on CCS, discussed previously, are broadcasted by the Dutch news shows Zembla (28-03-2010) and Netwerk (06-04-2010). In these shows, as well as in several newspaper articles, the suggestion is raised that scientists do not at all agree about, for example, the risks of CO_2 storage, and that scientists who are critical towards CCS are silenced. This gives rise to several debates in the second chamber which are extensively covered by the newspapers. April 2010 ends with a series of essays and interviews by several experts and stakeholder representatives. Topics are, amongst others: the activities and strategic choices of Shell; the safety of CCS; the importance of CCS for climate mitigation; and the costs of CCS. Then finally May 2010 is a quiet month, the only event being the announcement of the local authorities in Barendrecht of a 'principal decision' to say no to the project, which would be reinforced in June 2010.

Figure 15. Number of articles by month



5.5.2 Topics covered

In 136 of the total body of 430 articles, the words *CO_2* and *Opslag* (storage) both occur in the title (32%). The word *CO_2* occurs in title of 185 articles (43%). *Barendrecht*, the most well-known CCS project at the moment, is mentioned in 98 of the titles (23%). The word cloud in figure 16 based on the 50 most occurring words in the headlines clearly visualizes the prominence of the words Barendrecht, CO_2-opslag, CO_2, and opslag. The IPCC, which we know from the knowledge test has low awareness among lay people, had made the headlines in this sample only once and is mentioned in the body of 13 articles (3%). Thus, the discussion about IPCC's climate report is not often related to discussions about CCS.

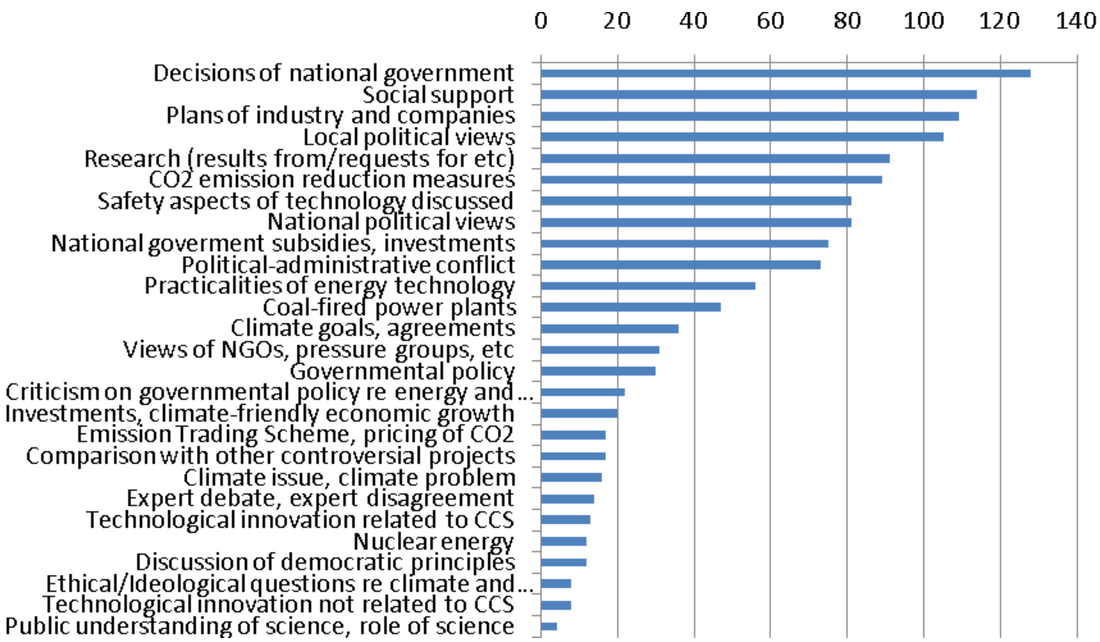
Figure 16. Word cloud based on 50 most frequent words in article headlines (n=430).

In 241 articles (56%), CCS is the main topic. 189 articles (44%) have another main topic such as criticism on national governmental policy (n = 30 or 7%), announcement of plans of industry and companies (n = 21 or 5%), or views of political parties (n = 18 or 4%).

Figure 17 shows the frequencies with which CCS is related to particular subtopics. As this figure shows, CCS is most often discussed in relation to decisions of the national government (30%), public acceptance (26.5%), plans of industry and companies (25%), and views of local political parties (24%). Views of NGOs are a much less frequent topic (7%), as is climate change as a problem to which CCS is one of the possible solutions (less than 4%).

In all, it appears that CCS is mainly discussed from an economic and political perspective and to a much lesser extent in the context of climate change and CO2 mitigation.

Figure 17: Main topics related to CCS and number of articles in which the topic is mentioned.



5.5.3 Stakeholders, Locations, and Events

Of all articles, 421 (97.9%) mention at least one actor or stakeholder. An overview of stakeholders and frequency of occurrence is mentioned in figure 18. As this figure shows, the Dutch government and the industry are the most frequently mentioned stakeholders, followed by local authorities, the local public, and national political parties. In 287 articles (66.7%), at least one location is mentioned. An overview of locations and frequency of occurrence is mentioned in figure 19. As this figure shows, Barendrecht is mentioned most often by far. Only 4 articles (0.9%) contain one or more references to previous accidents involving CO_2, such as lake Nyos in Cameroon or Möndchengladbach in Germany.

Figure 18: Stakeholders by number of articles

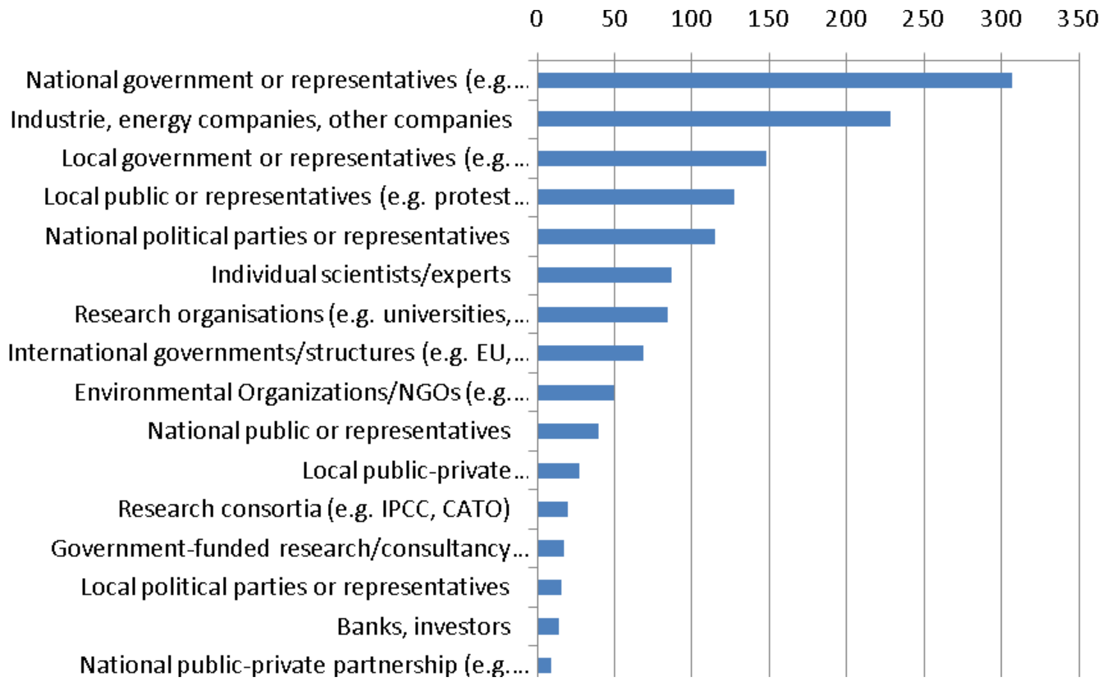
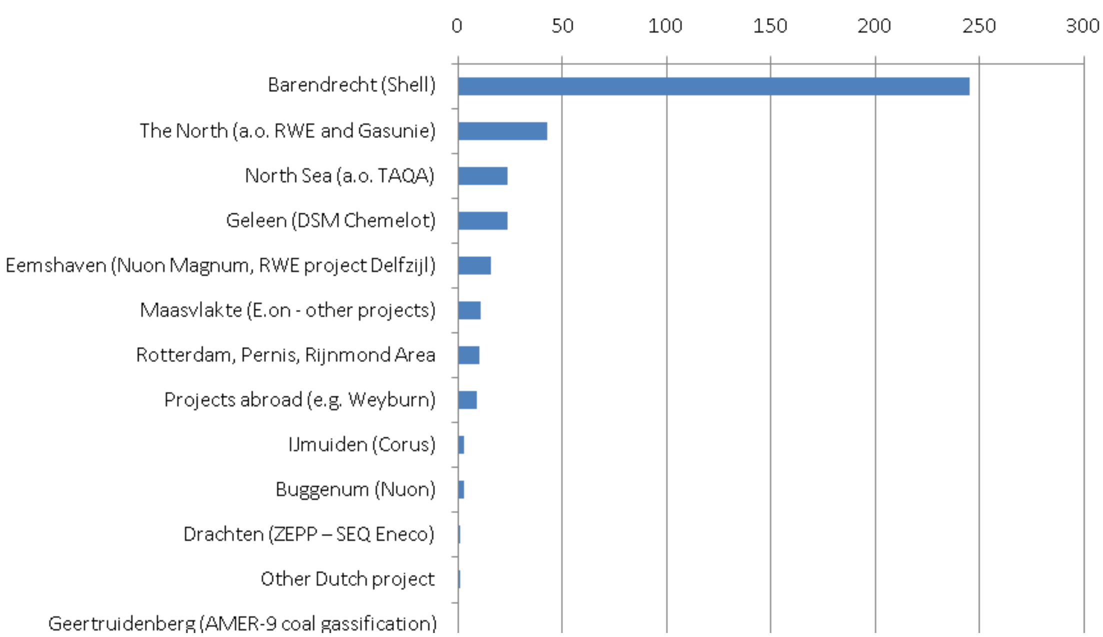


Figure 19: Locations by number of articles



5.5.4 Argumentation and Evaluation of CCS

Positive associations, such as 'environmental solution' or 'clean coal', were found in 43 articles (10%). Negative associations, such as 'no real solution', 'controversial project', or 'dumping' were found in 122 articles (28%). We like to note that this number includes instances of conflict (e.g. 'a slap in the face','Shell's powerful lobby') mentioned by opponents to CCS in Barendrecht, which we also coded as negative associations. These associations arguably pertain to the process of project development rather than to the technology per se. However, perceptions of the process are likely to transfer to perceptions of the technology.

The overall evaluation of CCS in the article was derived from the presence of arguments, the number and type of arguments, the presence of positive or negative associations, choice of words in title and body of the article, and tone of voice. In 23.7% of the articles, CCS is only mentioned. In 15.1% of the articles CCS is evaluated positively, in 31.6% of the cases neutral, and in 29.5% of the cases negatively. We analyzed whether the number of positive, neutral, or negative articles differed by newspaper. The 4 titles with the smallest number of articles were not included in the analyses since results could otherwise not be interpreted. No significant differences between newspapers were found.

5.5.5 Newspapers as a source of misperceptions

In 9 articles information was encountered of which the correctness can be questioned or which could induce misunderstanding by the way it was written down. For example, it was mentioned that CO_2 would be transported through an existing pipeline whereas transport would take place through a new pipeline within an existing corridor of pipelines. However, few instances of bare nonsense were found. Expressions that may possibly give rise to misperceptions (it is a topic for further research if they indeed do) were found in 51 articles. The most often occurring expressions were:

- 'CO_2 storage in the soil' (sounds as if storage is just below the surface)
- '(back) into the sea' (sounds like CO_2 is pumped directly into the sea)
- 'helps to counter the greenhouse effect' (instead of merely mitigating it). This phrase suggests that the greenhouse effect in itself is a bad thing. However, this phrase was only encountered a handful of times. In all, the greenhouse effect was only mentioned in 8 articles (see below). It appears that the term is too complicated to mention and explain in a newspaper article, and better be avoided.

5.5.6 CCS in context

We also investigated in what way and to what extent CCS is linked to other climate and energy issues such as climate change, energy production, energy use (in particular electricity), and $_{CO2}$ emission reduction measures.

CO_2

In 189 of the articles (44%), some explanation is given about CO_2. In 163 articles (38%), at least one feature of CO_2 is mentioned (e.g. 'same as carbon dioxide', or 'greenhouse gas'). In 112 articles (26%), at least one source of CO_2 is mentioned (e.g. 'coal-fired power plant'). In 34 articles (8%), at least one effect of CO_2 is mentioned (e.g. 'affects the climate'). In only 5 articles (just over 1%), it is explained that CO_2 can be used in other industries (e.g. growth of vegetables or fire extinguishing).

We investigated whether the amount of knowledge transferred differed by newspaper, again leaving out the 4 titles that contain the least CCS articles. No significant differences were found between newspapers in the number of articles that contain at least one bit of knowledge about either CO_2 features, effects, sources, or appliances. Next, we investigated whether the number of knowledge items mentioned differed by newspaper. But again no significant differences were found.

Looking at the type of knowledge transferred about features of CO_2, 86 articles (20%) mention that CO_2 is the same as carbon dioxide. 100 articles (over 23%) mention that CCS is a greenhouse gas. No attention is given to CO_2 being a part of the air around us (only one article mentions this), and little attention is given to the fact that we breathe CO_2 in and out ourselves (3 mentions), that CO_2 is neither explosive (4 mentions) nor flammable (3 mentions), that CO_2 is odourless (2 mentions) and colorless (3 mentions), and that CO_2 is not the same as carbon monoxide. No significant differences between newspapers were found.

Looking at the type of knowledge transferred about effects of CO_2, 12 articles (less than 3%) mention that CO_2 affects the climate and/or contributes to the rise in temperature. Hardly any article explains that CO_2 contributes to the greenhouse effect (3 mentions), contributes to the growth of plants (3 mentions). Not a single article explains that CO_2 is actually needed to enable life on earth. Regarding misperceptions, claims that CO_2 would cause environmental pollution are almost non-existent (3 mentions). No claims are made that CO_2 would cause air pollution, damages the ozone layer, causes acid rain, or causes cancer. Numbers are too low for analyzing differences between newspapers.

Looking at the type of knowledge transferred about sources of CO_2, 12 articles (2.8%) report that CO_2 is released at power plants and 10 articles (2.3%) mention that CO_2 is released at electricity production facilities. 9 articles (2.1%) explain that CO_2 is released when burning fossil fuels. Specifying fossil fuels, 14 articles (3.3%) mention that CO_2 is released when burning coal, 9 articles (2.1%) mention gas as a CO_2 source, 8 articles (1.9%) mention oil, and only one article (0.2%) mentions biomass. Specifying the purpose of burning fossil fuels, 32 articles (7.4%) mention CO_2 is released from coal-fired power plants and 11 of those 32 articles (2.6%) also mention gas-fired power plants as a source of CO_2 emission. No mention is made of biomass-fired power plants, and only 3 articles (0.7%) mention hydrogen production as a source of CO_2. In 47 articles (10.9%), a source of CO_2 is mentioned but the type is not specified (e.g. 'Nuon's Magnum plant). Deforestation as source of CO_2 emission is only mentioned in 3 articles (0.7%). Intensive cattle farming is not mentioned as a source of CO2. It is not mentioned that people and animals breathe out CO_2. Just one article mentions the built environment as a source of CO_2, and 2 articles mention transport. 10 articles (2.3%) mention 'the industry' as a source of CO_2, and 3 articles mention 'heavy industry' (0.7%). Specifying industry, 4 articles mention oil refineries, 7 articles mention steel production, 3 articles mention ammonia production, 1 article mentions the production of fertilizers, and 2 articles to the production of cement. Production of paint is not mentioned as a source of CO_2 emissions, nor is waste processing. Numbers are too low for analyzing differences between newspapers.

Looking at the type of knowledge transferred about appliances of CO_2, 2 articles mention that CO_2 is used to grow vegetables, 3 articles mention it is used in the production of beer and soft drinks, and 1 article mentions it can be used as fire extinguisher. Numbers are too low for analyzing differences between newspapers.

Carbon Capture, Transport, and Storage

165 articles (38%) mention either the capture, transport, or storage part of the CCS chain. Storage of CO2 is mentioned in 150 articles (34.9%). Capture of CO_2 is mentioned in 59 articles (13.7%). Transport of CO_2 is mentioned in 29 articles 9 (6.7%). Articles discussing the entire chain are rare, with only 17 articles (4.0%) discussing the entire chain.

Of the 59 articles mentioning capture, 51 (11.9%) also mention at least one source from which CO_2 is captured. Furthermore, 14 articles (3.3%) describe the process of capturing in detail. No significant differences between newspapers were found.

Of the 29 articles mentioning transport, 23 (5.3%) also mention at least one method of transport (pipeline, ship, or truck). 11 articles (3.6%) mention further details of transportation. Numbers are too low for analyzing differences between newspapers.

Of the 150 articles mentioning storage, 120 articles (27.9%) mention at least one method of storage (empty oil or gas fields, deep carbon layers, or saline acquifers). By far the most frequently mentioned method of storage is in an empty gas field (111 articles or 25.8%). Further details about storage are found in 31 articles (7.2%). Further specifying the location of potential storage sites, 88 articles (20.5%) mention an onshore site, 11 articles (2.6%) mention an offshore site, and 36 articles (8.4%) mention both. The depth of storage is discussed in 18 articles (4.2%) and the duration of storage is discussed in 5 articles (1.2%).

Analysis of differences between newspapers (leaving out the four titles with the smallest number of articles), shows that the type of CO2 storage is mentioned in significantly more articles in Reformatorisch Dagblad (48%) than in NRC.Next (14%), $F(8,388) = 2.26$, $p = .02$. CO_2 storage in general is mentioned in more articles in Reformatorisch Dagblad (54%) than in NRC.Next (18%) but the difference just ceases to be significant, $F(8,388) = 1.77$, $p = .08$. The specific type 'empty gas field' is mentioned in more articles in Reformatorisch Dagblad (44%) than in NRC.Next (14%), but this also just ceases to be significant, $F(8,388) = 1.90$, $p = .06$.

It must be noted, however, that Reformatorisch Dagblad and NRC.Next both have a relatively low number of impressions and thus a low impact on overall public opinion. We therefore repeated the above analyses with only the five largest newspapers. No significant differences between those newspapers were found.

Energy production and use

Only 51 (11.9%) of the 430 articles analyzed provide some knowledge about energy production methods, users of energy, demand for energy, electricity production, use of fossil fuels, and the relation between use of fossil fuels and CO_2 emissions.

Of these 51 articles, 31 (7.2%) relate the use of fossil energy to CO_2 emissions. 21 (4.9%) address the question why we produce energy, e.g. to heat our houses. 23 articles (5.3%) mention one or more methods for electricity production, and 8 of these articles (1.9%) also mention something about the share of the method in total electricity production. 15 articles (3.5%) mention a growing demand for energy. 11 articles (2.6%) discuss the continued need for fossil fuels in the near future, and 10 articles (2.3%) mention that we will run out of fossil fuels sooner or later. Numbers are too small for analyzing differences between newspapers.

Climate change

The issue of climate change is mentioned in 84 articles (19.5%). Climate change is mentioned in 58 articles (13.5%). Of these articles, 15 articles (3.5%) mention one or more effects of climate change. In 14 articles (3.3%), climate change is related to the use of fossil fuels.

The issue of temperature rise is mentioned in 44 articles (10.2%). Of these articles, 11 (2.6%) mention effects of temperature rise and 12 articles (2.8%) mention that temperature rise is related to the use of fossil fuels. The target to keep temperature rise at or below 2 degrees celcius is mentioned in 16 articles (3.7%).

The greenhouse effect is mentioned in 9 articles (2.1%), but only 2 of these articles (0.5%) explain what this term means.

Climate skepticism is found in 8 articles (1.9%), all of which propose that the climate is not changing as fast as scientists claim or that its effects will not be as averse. Additionally, 1 article states that the influence of men in curbing climate change is overrated and another article mentions that there is nothing men can do to prevent climate change.

Significant differences between newspapers were found between NRC and NRC.Next on the one hand, in each of which 36% of the articles contain some information about climate change, and Algemeen Dagblad on the other hand, in which only 6% of the articles contain some information about climate change, $F(8,388) = 3.05$, $p = .00$.

When repeating the analysis with just the five largest Dutch newspapers, we found that in both the NRC (36%) and Trouw (31%) significantly more articles contain some information about climate change than articles in the Algemeen Dagblad (6%), $F(8,388) = 3.20$, $p = .02$.

Measures for emissions reduction and energy production

82 of the articles (19%) contain some information about the mix of measures or technologies we will need for energy production and/or emissions reduction. Specific targets for these measures, e.g. the percentage of energy from renewable energy sources by 2020, are mentioned in 44 of the articles (10.2%). A target for CO_2 emission reduction is mentioned in 49 of the articles (11.4%). In 32 articles (7.4%), it is stated or implied that CCS is a necessary measure whereas in 15 articles (3.5%) it is stated that we do not need or should not use CCS. The remainder of the articles is not explicit about whether or not CCS is necessary.

5.5.7 Comparison between media results and Knowledge and Beliefs Test

To investigate which relations (if any) exist between media use and other characteristics of the public such as general interest in climate/energy issues, knowledge, attitudes, and particular beliefs, questions about media use have been included in these surveys. Results have been reported in section 5.4. Below we will relate results of the Knowledge and Beliefs Test to results of the media log as reported above. No distinction will be made amongst specific newspapers because both the sample of the Knowledge and Beliefs Test and the sample of newspaper articles from the medialog are too low to make useful comparisons. Overall patterns found amongst knowledge and awareness of respondents and results from the medialog will be discussed.

One of the most noticeable results of the medialog is the fact that most of the time CCS is discussed in relation to a specific project and even more specifically in relation to the project in Barendrecht. Indeed as discussed previously, many respondents of the Knowledge and Beliefs Test who state to have heard about CCS also report to have heard of specific project plans in The Netherlands and of the project in Barendrecht. This supports the notion that possibly most respondents hear about CCS only through information that reaches them about specific project plans. One may think that reading news about CCS in relation to Barendrecht may negatively influence public opinion on CCS. However, we found the opposite to be true. People who have heard about Barendrecht are actually more positive about CCS than people who have not heard of it. We would like to repeat however that causes for this can be many. Besides the fact that such articles might attract people with a specific interest in technology, it may also be an effect of the 'mere exposure effect' (Zajonc, 1968) which means respondents become more positive about an issue just by encountering it often. The current results however cannot distinguish between the possible causes of this attitude difference.

When it comes to knowledge and misperceptions found in the Knowledge and Beliefs Test, two points in relation to the medialog can be made. First of all, the most often conveyed knowledge about CO_2 and CCS in the media is also what is generally best known already by respondents. About CO_2, newspaper articles most often say it influences the climate, which in the test is stated correctly by 84% of the respondents. In articles usually at least one source of CO_2 is mentioned. A majority of respondents does associate at least one of the fossil fuels with CO_2 emissions, however they often do not know accurately about all of the fuels whether they emit CO_2 or not.

Regarding CCS most respondents believe the CO_2 will be stored in underground rock formations and the fact that the CO_2 would be stored in depleted gas fields is also often mentioned in newspaper articles. A lot of people however also believe the CO_2 will be stored in underground cavities or caves and do not know the correct meaning of the term "porous rock". This might indicate that although specific geological formations where CO_2 could be stored are mentioned, they are not explained in newspapers. The current results do not provide evidence of this, however.

Climate change mitigation as an aim of CCS is not mentioned very often in newspapers, even though most respondents do believe this to be a plausible goal of CCS. Nevertheless, as mentioned previously, respondents also select a lot of other environmental problems as possible aims of CCS. Even though none of the newspaper articles convey any erroneous information about the aim of CCS being ozone layer depletion, air pollution or acid rain, CCS is often said to do something for "the environment". This term is often used instead of "climate change" or "global warming". Possibly people then confuse different environmental problems with the climate change problem.

Secondly, even though newspapers do not convey any misperceptions found amongst lay people in the Knowledge and Beliefs Test they also do not inform people about these issues. For example very little attention is given to the fact that CO_2 is *not* flammable or explosive. On the other hand information about knowledge gaps lay people have about the natural properties of CO_2 is also not given often, such as the fact that CO_2 is in the air around us or that we breathe some in and more out ourselves. Results of the Knowledge and Beliefs Test show that a large part of respondents did not know and ascribe to all parts of the causal chain from fossil fuel use in electricity production to the occurrence of global warming. The analysis of newspaper articles showed that most of the time when any of these steps was mentioned it only pertained to a part of the causal chain. The article would either mention the influence of CO_2 on the climate or the link between energy production and CO_2 emissions, but never the complete picture.

6 Summary and Conclusions

6.1 Research Summary

The Netherlands, just like most other countries, are faced with a changing energy system and many possibilities to handle different problems and opportunities. How the public views these issues can be of crucial influence on decisions made for future energy systems. But how involved is the public in fact in these matters? Earlier research in CATO, the Dutch program for CCS research, showed a major lack of awareness and knowledge of the public, not just regarding new energy technologies such as CCS, but also regarding current energy issues such as current use of fossil fuels and it's relation to climate change. At the same time, research in the same program offered a representative sample of the Dutch people information from experts that is multi-sourced, balanced and understandable. Not only were these people willing to take the effort to comprehend and evaluate this information and decide what they think are the best mitigation options for the Netherlands in coming decades, most of them were quite enthusiastic about contributing to society like this (de Best-Waldhober et al, 2009). This shows how a careful scientific method for providing people with the necessary information to reach an informed opinion and for helping them make use of this information to form opinions about different policy options can contribute. The method of the Information-Choice Questionnaire has several other advantages, such as contributing to stable, well-informed opinions on the topic at hand based on understandable, balanced and accurate information from many experts with diverse backgrounds and affiliations.

However, aforementioned earlier studies also show that although respondents base their opinion for a large part on the information from experts, part of their opinion remains unexplained and is therefore based on beliefs or arguments that were not mentioned by experts. But both for the prediction of future opinion as well as for effective communication that fits the need of the public, it is essential to gain understanding what constitutes the base for the unexplained part of people's opinion. The current report therefore described three studies that go beyond earlier studies in gaining understanding of the public view on CCS and energy innovation in the Netherlands. These studies aimed to (1) enhance insight into currently held beliefs and awareness among the general public about CCS and CO_2; (2) study the interaction between balanced expert information and lay people beliefs; (3) investigate the impact of media use and exposure to news about CCS. To meet aim (1), we interviewed 15 respondents to identify commonly held beliefs. Next, we investigated the prevalence of these beliefs by questionnaire among 401 respondents. To meet aim (2), we administered an information-choice questionnaire (ICQ) about CCS among 134 respondents and interviewed the respondents afterwards to allow for elicitation of remaining, unaddressed beliefs as well as responses to the expert information. To meet aim (3), we analyzed the 430 articles mentioning CCS in all major Dutch newspapers in the year prior to the first to studies, and investigated respondents media use and exposure to recent media events about CCS.

6.2 Public Knowledge

The questionnaire aimed at testing beliefs, knowledge and awareness first of all showed large numbers of respondents who are unsure about the characteristics, effects and sources of CO_2. Of a large number of statements a third or more of the respondents did not know what the correct answer was. For example, 38% of the respondents are unsure about whether CO_2 causes cancer or not. The characteristics of CO_2 that have a substantial percentage of people in doubt are whether CO_2 is flammable, is explosive, turns to stone, or emits radiation. A smaller percentage of people is convinced that it is, just as a another part of respondents is convinced it is not. A substantial percentage of people is also in doubt about the effects of CO_2, doubting about CO_2 causing acid rain, cancer, or smog, whether it is harmful in contact with skin, or doubting if it makes the earth habitable. Here too, a small percentage is erroneously convinced of several harmful effects of CO_2 that have no scientific basis. Furthermore, there is much doubt about the sources of CO_2. Around a third, sometimes up to half of people do not know whether CO_2 is released when wood is burned, when old batteries leak, when steel is produced, when plants and trees decompose, when electricity is produced using natural gas, or coal, or oil, or using nuclear power. Most striking though is that there is quite a bit of confusion among the Dutch public as to our current energy use and its' relation to climate change. Although a majority of people state to have some idea of global warming and understand that CO_2 emissions influence climate, much less people can give a reasonable estimate of how much fossil fuel is used in the Netherlands, or can answer correctly that the use of gas, oil or coal for electricity production produces CO_2. Even when the analyses are not that restrictive and answers that are near correct are counted as correct, still less than twenty percent of people understand all four steps. This has major implications, not just for the possible use of CCS in the Netherlands, but for other technologies or options as well. If the vast majority of Dutch people do not understand why or how CO_2 emissions should be reduced, it is unlikely that they will support any action towards this goal or even take action themselves. It also implies that many people do not understand the major benefit of several mitigation options, which makes it harder to justify any disadvantages. The authors of this report therefore strongly advocate the development of national effort to close this knowledge gap as much as possible in the Netherlands.

A pattern was found amongst people's knowledge of the different topics as well as their perceptions of CCS. Overall, people who are more positive about CCS tend to perceive CCS as posing less risks and provide more benefits. This is accompanied by a better knowledge of the goals of CCS; that the aim of CCS is to mitigate climate change. They have higher overall knowledge of CO_2 including better knowledge of the natural properties of CO_2 as well as that CO_2 does not have hazardous properties such as harmful radiation or the potential of causing cancer. On the other hand people who are more negative about CCS show the opposite pattern. They believe it is less likely CO_2 will be stored in natural storage sites, compared to the previous group they believe it is more likely it will be stored in man-made storage such as barrels or containers and they are less aware of the aim of CCS. They have less knowledge of the natural properties of CO_2 and perceive CO_2 to be more hazardous.

The reader should be reminded of two important facts here though. One is that although the more positive group about CCS has more knowledge, their overall evaluation of CCS is only slightly favourable towards CCS in absolute terms. This is in line with conclusions from our earlier work, that being more informed leads to more informed and more consistent opinions on CCS, but not necessarily to more positive or negative opinions. Second, with the design of the study, we can analyze relations between factors, but not causality. It is possible that a more positive attitude towards new technology is what causes more knowledge, not the other way around. Furthermore, demographic differences were found on most of these issues, both with regards to gender as well as education levels. However, especially with regards to gender, despite some of the differences being statistically significant in real terms they are too low to warrant special targeting in information campaigns of any of these groups. As previously noted, when it comes to actual knowledge of CO_2, energy production, climate change and CCS the levels are low overall and a more general approach is advised.

6.3 Trends in public opinion 2007 - 2010

Several comparisons with earlier studies in this area are possible. Both the Information-Choice Questionnaire and the belief questionnaire contained measures that were identical or very similar to measures taken before. The Information-Choice Questionnaire used was for the large part identical to the ICQ that was used in 2007. Although the information from experts in the questionnaire was reviewed again by several experts to make sure that no part of the information was outdated, only minor changes had to be made and hence the measures in 2007 and 2010 were highly similar. A comparison of the results of 2007 with the results of the current study shows that the evaluations of the options, choices and rejections of options are all close to identical. Again, after respondents had processed all information regarding the consequences of an option, they were asked to grade the option on a scale of 1 to 10. In the Dutch school system, grades are on a scale of 1 to 10, with 1 meaning the lowest possible score and 10 meaning the highest possible score. A "6" (i.e. 5.510 is considered a just acceptable score ("adequate"). This means in the Dutch grading system you did just good enough to pass but not any better. 5 or lower means you have failed the test. The two CCS options, " Large plants where coal or gas are converted into electricity with CCS" and " Large plants where gas is converted into hydrogen with CCS", were evaluated somewhat negatively by most respondents. The first CCS option was graded clearly below 6 on average (2010: 5.02, 2007: 5.34), the second CCS option was graded just below 6 on average (2010: 5.90, 2007: 5.92). Apparently, as in 2007, many respondents in the 2010 sample are not that enthusiastic regarding the two CCS options.

In comparison, respondents evaluated most of the other options in the questionnaire rather positively. The first efficiency option was evaluated (2010: 7.48, 2007: 7.33) on average, the wind energy option was evaluated (2010: 7.47, 2007: 7.15) on average on the biomass options was evaluated (2010:7.40, 2007: 7.41) on average. Respondents were also less positive about the second efficiency option and the nuclear energy option, which on average were evaluated (2010: 5.90, 2007:5.84) and (2010:5.38, 2007: 5.29) respectively. Nuclear energy was also the option the respondent were most divided about again in 2010, as a substantial percentage of respondents evaluated this option very negatively and only a slightly less substantial percentage evaluated this option very positively.

The results from the comparison between these two measures show the robustness of the method for gaining high quality opinions that are representative for the Dutch population, as the comparison shows no significant differences between the two measurements on any of the main variables. The lack of difference also means that although the 2010 sample used in the current study is too small to be representative, the similarity of the results combined with the fact that the 2007 study was representative for the Dutch population indicate that the answers of the 2010 sample are also representative for the Dutch population. Furthermore, it shows that informed opinions have hardly changed in the past three years in the Netherlands. Only the wind option was evaluated significantly higher on average, but this still concerned a mere difference of three tenths of a point on a ten point scale. The CCS option with coal and gas was evaluated significantly lower on average, but this also concerned only three tenths of a point.

6.4 Trends in public awareness 2007 - 2010

When we compared awareness of CCS technology with earlier measures, significant differences do emerge. Earlier work comparing samples from 2004 to 2008 (de Best-Waldhober and Daamen, 2011) showed a first rise of general awareness of the technology around 2009, with the percentage of people that claim to know a bit about CCS or specific CCS technologies rising from around 25% to around 30%. Respondents were asked at the beginning of the ICQ (before any information was given) about their awareness of two specific CCS technologies, with the questions being phrased exactly the same as in the 2007 ICQ sample. Especially the percentage of people that answers they know a bit about these technologies rises significantly, with percentages going up from 42% for the CCS option using coal and gas to 66%, and percentages for the CCS option with hydrogen going up from 27% to 41%. For the first CCS option mentioned, the percentage of people answering they know quite a bit also goes up significantly from 7% to 23%. Although the sample of the ICQ in 2010 is small, these differences are substantial enough to conclude that public awareness of CCS in the Netherlands is rising significantly.

This is shown by the results from the knowledge test as well, where respondents were asked about their awareness of CCS in general (i.e. no specific technology). Compared to a sample in 2009 receiving a similar, though not identical, question, the percentages of the sample that state to know a little bit decreases, but the percentage that states to know quite a bit increases substantially from 10% to 38%. Remarkably, of the people who state in 2010 that they have heard quite a bit about CCS in general, 95% also confirms to have heard of specific plans for the deployment of CCS in the Netherlands. This seems to indicate that most people do not hear of CCS until they hear of specific plans. Given that knowledge levels around energy and climate seem to remain low among the majority of people, an important conclusion from these results is that most people have no idea or opinion about CCS, its advantages, disadvantages or necessity, until they are faced with actual project plans.

Regarding the public's awareness of necessity of CCS, one might argue that a belief in man-made climate change could be a necessary prerequisite for supporting the use of CCS technology. However, as in previous studies, we found hardly any relation between the attitude towards climate change and the attitude towards CCS. To some extent, the belief that climate change is a consequence of human behaviour relates to the belief that CCS is necessary to mitigate climate change. In turn, however, this belief has little impact on CCS attitude. Our interpretation of this pattern is that even though respondents who believe in anthropogenic climate change to a certain extent also believe CCS is necessary, this does not make them more positive about CCS. This corresponds with the often heard perception of CCS as a 'necessary evil'. Even if people think CCS is necessary, does not mean they will be more positive about it.

Although the relation between beliefs about climate change or global warming was no different than in earlier measures, we did find substantial changes in the percentages of people who hold these beliefs. The 2010 measures show that substantially smaller percentages of people are convinced that the average temperature on earth will rise. Percentages of people who are somewhat to very convinced about this have dropped from 82% in 2007 to 63% in 2010. The percentages of people who are convinced that global warming is caused by mankind have also dropped severely from 70% in 2007 to 55% in 2010.

An obvious conclusion seems that this rise in "climate scepticism" is a consequence of several incidents concerning climate science that have taken place between the 2007 and the present measures. The main one was the so called "Climategate" when in 2009 communications from the University of East Anglia's (UEA) Climatic Research Unit (CRU) became public and at first sight seemed to reveal 'conspiracies' of climate scientists to make climate change look more convincing than it was. Even though these allegations could not be substantiated they could have made a lasting impression on public discourse and perception. Furthermore, in 2009 several mistakes were found in IPCC reports, making media question the integrity of this institution. Studies in other countries also show severe drops in percentages of people convinced of manmade climate change and can time these shifts in public opinion within the three months of "Climategate" (Leiserowitz et al, 2010)

However, our research does not indicate a causal relationship between these events and increases in public "climate skepticism". The strongest argument for the lack of causal relationship is that only a handful of our total of 535 respondents report they have heard of the IPCC. The co-occurrence of shifts in public opinion and "Climategate" in other countries cannot be regarded sufficient evidence for causal relationship either.

6.5 Relation between opinion and media exposure

The lack of public awareness of the IPCC leaves one wondering how top of mind such events are and how this relates to the occurrence in the media. The media log we kept from mid 2009 until mid 2010 was restricted to articles mentioning CCS or part of the CCS chain at least once. Therefore, bear in mind that we can only relate trends in public opinion about global warming and other topics to media exposure to the extent that these topics were covered in relation to CCS.

That said, it was striking that of the 430 articles analyzed, only 3% mentioned the IPCC. Apparently, although the IPCC in general received extensive coverage, the events involving IPCC have rarely been linked to the topic of CCS. Even more striking, however, is that CCS is hardly linked to global warming with less than 4% of articles mentioning global warming as a problem (and CCS as a possible solution). Instead, most articles frame CCS as an economic, policy, or political issue. In general, attention for CCS in newspapers was short-lived. Although the project in Barendrecht received extensive coverage at times an important decision about the project was made, attention to this project and to CCS in general levelled off just as quickly as it arose.

Regarding knowledge transfer about topics related to CCS, we found that in 38% of the articles at least one feature of CO2 is mentioned. The most often mentioned features are 'same as carbon dioxide', and 'greenhouse gas' whereas other features are mentioned much less frequently. The issue of climate change or temperature rise is mentioned in 19.5% of the articles, the mix of measures or technologies we will need for energy production and/or emissions reduction is addressed in 19% of the articles, and only 11% of the articles provide some knowledge about energy production and use. In only very few articles information is provided that explains the necessity of CCS or the reason for employing the technology. Moreover, almost none of the articles explains the whole chain from using fossil fuels to climate change and all steps in between.

A notable finding was that the three newspapers that most often report on CCS have a relatively small audience, which indicates that a relatively small group of newspaper readers is exposed to a relatively high number of CCS messages. In general, however, we did not find significant differences between newspapers in amount and type of knowledge transferred. This is in line with results from the Knowledge test which showed that only the total amount of time spend on reading newspapers is related to knowledge level, not the reading of specific titles. It must be noted, though, that for some newspapers the number of readers as well as the number of articles analyzed were too small to test for statistically significant differences. Replication with higher numbers of respondents and continuation of the media log to increase the body of articles will enable more substantial conclusions in the near future.

Nevertheless, intensity of newspaper reading is related to levels of public knowledge whereas the intensity of watching television, listening to radio, or browsing the internet is not. We may therefore conclude that newspaper content is a better indicator of public knowledge than the content of other news media, making newspaper analysis a suitable tool for monitoring developments in public knowledge. Here we do want to make a distinction between national and local public. Our results show for instance that a very minor percentage of people had seen the television broadcasts of Netwerk and Zembla about CO_2 storage in Barendrecht, too small even to analyze any differences between people who had and who had not seen these broadcasts. However, research in Barendrecht by Terwel et al (2010) shows not only that over half of the people in their representative sample had seen these broadcasts, but a majority stated that these broadcasts had significantly influenced their opinion on CO_2 storage in Barendrecht.

In sum, our analyses do not yield evidence that national newspapers reinforce or create particular misperceptions as found in the knowledge test. However, they also do little to correct misperceptions or fill the 'blanks' in people's knowledge. That said, we do not state that this should be a primary task of newspapers. News media and information media are two very different things. However, it is one of the tasks of journalists to take into account their readers' level of comprehension of the issue they write about. Since our research has shown that people have little knowledge, even the highly educated regular readers of newspapers, it could be argued that news articles on CCS may need to be enriched with a bit more context information to be understandable for and not to mention appealing to a wider audience beyond people who are already knowledgeable about CCS.

6.6 Remaining questions after information

To find out how balanced expert information and lay people beliefs interact, we explored the interaction between expert information in the ICQ and laypeople's beliefs in shaping people's eventual opinion about CCS and its consequences. The beliefs that people mention in the interview after having gone through the ICQ and processing the expert information, are mostly about safety of storage. Safety of storage is also one of the factors that is related strongly to uninformed attitudes towards CCS. Only few other beliefs or statements are mentioned by a substantial amount of people in the interviews after the ICQ. It might be possible that the information in the ICQ about safety of storage is not detailed enough, but given that this information was based on expert knowledge, it might be that people want more detailed information and more security than experts are able to give at the moment. This study cannot answer this question, but as the answer has important implications for the discussion of uncertainty and risk related to CCS, we plan to take up this issue in future research.

Another result from the interviews after the ICQ worth mentioning pertains to the issue of coal. In these interviews, people often mentioned the necessity to apply CCS to coal fired power plants as a downside of coal. This matches previous research into evaluations of CCS, which has shown people judge CCS options differently depending on the emissions source the CO_2 is captured from (De Best-Waldhober 2006;2008). People are more negative about CO_2 being captured from coal fired power plants than from hydrogen plants. In contrast, in the present study of uninformed beliefs, perceptions of the share of coal fired power in the Dutch energy mix seemed unrelated to people's attitudes on CCS. This could mean that without being informed, people do not think of relating coal to CCS (e.g. via electricity production).

6.7 Summary conclusions

Summarizing we can state that the results of these studies show several new and valuable insights in the public view on CCS with important implications for future policy and communication efforts. First of all, the knowledge and beliefs test made abundantly clear how much doubts and knowledge gaps there are amongst the general Dutch public regarding our energy system, CO_2, climate change and CCS. Only very few people understand how our current use of fossil fuels leads to CO_2 emissions which lead to climate change, even though almost all people state to know about global warming. Several misconceptions that were shared by a major percentage of people were revealed. Some of these also influenced the general attitude towards CCS, but attitude towards this technology was mainly related to perceived risks and benefits of CCS itself, as well as to more normative evaluations of the use of the technology. It can be argued that the knowledge gaps found in this study are not influential to attitudes towards CCS alone. If the general population does not understand the problem our society faces when we do not mitigate CO_2 emissions, it will be extremely hard to get their approval of any kind of CO_2 mitigation option, be it large wind turbine parks or home renovations to improve energy efficiency.

An important finding from the comparison with earlier CATO research is that public awareness of CCS does seem to have increased during the last two years, without being accompanied by an increase in public knowledge about CCS or related topics. The medialog that was kept for this study between mid 2009 and mid 2010 showed that the discrepancy between trends in public awareness and knowledge is consistent with what is described in newspaper articles mentioning CCS. Only very few articles explain the rationale for CCS, hardly mentioning climate change or the fact that over 90% of our energy comes from fossil fuels. Most often mentioned are specific CCS project plans without explanation of the technology itself. This is again confirmed by the public awareness survey outcomes. Most people that had heard about CCS, also stated to know about specific project plans.

The results of the Information-Choice Questionnaire (ICQ) shows that people who are carefully informed about aspects and consequences of several energy technologies, with information coming from a diverse set of experts and translated to lay language, develop a more well-informed, stable and consistent opinion, but not necessarily a more positive or negative one. Both the current and the 2007 survey showed that after being well-informed about several mitigation options, people were not that enthusiastic about CCS, but not many people objected to it either. Although people were in general positive about the quality of the information from experts, the interviews done right after the ICQ showed that almost half of people are still in doubt regarding safety of CCS. None of the misconceptions that were commonly found in the knowledge and beliefs test were mentioned by people in the interviews after the ICQ though, showing the usefulness of this instrument, not just for research purposes, but for informing people as well.

In general, the outcomes of these studies suggest a major lack of public awareness and knowledge regarding options, rationale and consequences of CO_2 mitigation in the Netherlands. From a democratic point of view one could argue that people should at least be aware of the rationale for CO_2 mitigation and the possible options and consequences for both society and individuals. Given the current lack of awareness, improving this will require significant efforts on a national scale.

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8 Appendices

8.1 Elaboration methodology ICQ

The sections presented below were previously published in the CATO-1 report "*How the Dutch evaluate CCS options in comparison with other CO2 mitigation options. Results of a nationwide Information-Choice Questionnaire survey"* (De Best-Waldhober, M., Daamen D.D.L., Hendriks, C., de Visser, E., Ramírez, A., Faaij, A., 2008) which was administered in 2007 amongst 995 respondents from a representative sample of the Dutch population. They give an overview of the potential of the ICQ as a measure of stable informed opinions as well as important aspects of the development of an ICQ, the process in formulating a relevant policy problem, the development of the information as well as the extended description of the ICQ method.

8.1.1 Information-Choice Questionnaire: Potential[4]

The ICQ was originally developed by Saris, Neijens and De Ridder 1983a (see e.g. Neijens, 1987; Neijens et al., 1992) to assess preferences for different ways of generating electricity in the Netherlands (but has since been used to assess preferences in other areas as well; see Neijens (1998) for a review). The aim of the ICQ is not only to provide respondents with the necessary information to reach an informed opinion, but also to help them make use of this information to form opinions about different policy options: part of its aim is to guide respondents' information processing. Before respondents in the ICQ choose between policy options, they receive information to make a more informed choice. First, the choice is explicitly framed as a decision problem and respondents are informed about the background of the decision problem (e.g., they are told why these specific options are included in the decision problem). Second, respondents are provided with information about the consequences of the different policy options. To stimulate information processing and to help respondents reach a decision, they are requested to give a quantitative evaluation of each consequence (a rating on a scale with nineteen response categories ranging from -9 "a very big disadvantage" via 0 "totally irrelevant" to + 9 "a very big advantage"). On the basis of these quantitative evaluations, the subjective utility of each option may be determined. If respondents base their choices on these evaluations of consequences, they will choose the alternative(s) with the highest subjective utility (Neijens, 1987; Neijens et al., 1992). The ICQ procedure, however, neither requires nor requests that respondents base their choices on their evaluations of consequences.

The effects and usefulness of the ICQ has been studied in extensive evaluation research (Neijens, 1987). Neijens shows that non-response in the ICQ is not substantially different from non-response in traditional opinion surveys (non-response is low and the group of non-respondents has the same profile as the group that does respond) and concludes that the ICQ may be used to collect opinions of representative samples of the general public. In addition, Neijens found that preferences of respondents in an ICQ survey differ from those in a traditional survey, i.e., ICQ respondents make different choices than respondents in a survey in which no information about the policy options is provided. Van der Salm, van Knippenberg and Daamen (1995) provide experimental evidence for the fact that ICQ respondents' preferences are affected

[4] Part of this section is taken from van Knippenberg and Daamen (1996).

by the information provided in the ICQ. Neijens' examination of the correspondence between evaluations of consequences of the options and choices suggests that ICQ respondents tend to base their choices – at least in part – on their evaluations of the consequences of the options. Moreover, comparison of evaluation-choice correspondence in the ICQ with evaluation-choice correspondence in a survey in which respondents first make their choice and then evaluate the consequences of the options shows that respondents' choices correspond more to their evaluations in the ICQ (Neijens et al., 1992). This suggests that the ICQ's effect on respondents' preferences is probably due to both the information provided – which may wholly or in part contain new information relevant to the decision problem – and to better integration of the available information (due to the ICQ's structuring of information processing). The fact that ICQ respondents may report different preferences than respondents in a more traditional survey shows that it may indeed be worth the trouble to use the ICQ in public opinion research. At the same time it implies that the results of an ICQ do not necessarily reflect *present* public support for a policy. Rather, the ICQ is especially suited to assess how public opinion may be *after* the public is informed about an issue or to assess the *potential* (i.e. after extra information is provided to the public) support for alternative policies.

8.1.2 Important aspects of development of an ICQ

The current study focuses on a complex environmental problem (global warming) and on the complex, future technologies that may contribute to solving this problem. When informing lay people about such complex matters via an ICQ, several precautions are needed to guarantee that the public is presented with a relevant policy problem and with valid and balanced information regarding a restricted set of viable options to solve this problem. These precautionary procedures are crucial when preparing an ICQ and will be discussed here.

First, it is essential to define a clearly specified and policy relevant choice problem that is not overly demanding for respondents. The policy problem should be *clear* regarding what, when, where and to what end (in the current ICQ for instance "Which combination of options is best to meet the expected Dutch energy demand in 2030 *and* reduce CO_2 emissions in the Netherlands by 50%?") and only *policy relevant* options to solve the problem should be presented, that is, options which are according to experts viable and not unlikely to be implemented (for a description of such options in the current ICQ, see section 1.4). Obviously, it is more worthwhile to predict public support (or lack of support) for feasible options than for unfeasible options. This restriction to policy relevant options also reduces the number of options, which helps to keep the choice problem manageable for lay people. However, to fully attain the latter goal (i.e., a choice problem tuned to the capabilities of lay people) a further reduction of options as well as some simplification of options may be needed. For instance, while preparing the current ICQ, the experts identified many energy options which could reduce CO_2 emissions. There are many new technologies that emit less CO_2 than current technologies or even emit no CO_2 at all. There are also many ways to reduce the use of energy (efficiency improvements as well as change of behaviour). These options may all be implemented to different degrees. There are a huge number of combinations of these options and each combination may solve the policy problem. Exclusion of options that were not policy relevant reduced the number of options. Furthermore, restriction of choice to combinations of options which were policy relevant also helped but still the choice problem was very complex. It was decided to confine choice to options that led to a substantial and equal emission reduction (40 Mt CO_2 per year) and to options where the energy conversion was situated in the Netherlands (in the current ICQ, respondents should choose three options out of seven to solve the policy problem and some choice restrictions are specified, see section 1.4).

Second, when informing people about the choice problem and about the consequences of the options that can solve this problem, it is essential that this information is valid and balanced. To compile this kind of information is a project on its own. The information that is generated this way should be extensive and detailed. However, when the need for a representative sample of the general public calls for the inclusion of respondents that are not very motivated or not highly educated, the amount of information that can be provided is limited. In the current ICQ, *the amount of information that can be given to respondents is one page per policy option*, for reasons that will be explained in section 1.6. In the case of complex topics this means that in order to keep the amount of information manageable for all respondents, one must make a selection of the available expert information. With relatively complex and controversial topics such a selection could arouse debate. It is therefore recommended that the information for an ICQ is compiled by experts from different backgrounds and different organizations and checked by another, similarly differentiated group of experts. This method also results in the avoidance of another possible problem that arises with controversial issues, namely the (lack of) credibility of the source of the information.

When the responsibility for the definition of the choice problem and the given information is not carried by a differentiated group of experts, an ICQ runs the risk of losing accuracy, balance and credibility in the eyes of the respondents. For these reasons, the task of defining the policy problem and the compilation of the expert information was carefully done by experts from different backgrounds and institutions. How this was done exactly and what measures were taken to ensure that the information was the most recent and accurate information available will be discussed in section 1.6.

The expert information that has thus been gathered and the translation of this expert information for lay people has been checked by a new, independent group of experts with different backgrounds. Only after their approval that this translated information is still valid and balanced, this information was inserted in the Information-Choice Questionnaire and administered to a representative sample of the Dutch population.

Defining a specific and relevant policy problem

As it was stated above, defining a specified policy problem is essential, sensitive and subject to debate. To ensure this was done correctly, the researchers took much care in the process of developing the policy problem. Three leading experts on energy and environment from NGO's were consulted (Greenpeace, The Netherlands Society for Nature and Environment and World Wildlife Fund) as were two leading experts from the CATO project (Ecofys and Utrecht University-Department of Science, Technology and Society). Several extensive meetings were held to define a concrete policy problem that was realistic and usable for an ICQ. Based on several long discussions with the experts and the researchers on this project the assumptions of the policy problem and the most likely options to solve this policy problem were defined. The policy problem was defined as:

"*How can the Dutch demand for energy be fulfilled in 2030 in such a way that emissions of carbon dioxide will be reduced by 50%?"*

Assumptions, criteria and points of attention

1. The Netherlands strives for a reduction of 50% of the current CO_2 emissions in order to limit global temperature increase to a maximum of 2ºC.

2. Other countries in the world also put optimal efforts in reducing emissions. It is taken into account that Western countries could and should achieve higher emissions reduction figures than non-western countries.
3. The geographical area where conversion takes place is the Netherlands.
4. The time frame considered is 2030.
5. The options must contribute significantly to the total energy supply during a substantial period of time, starting not later than 2030.
6. The application of three of the seven options should be enough to achieve a 50% reduction in the emissions of 2030 with respect to the emission levels of 2005.
7. Assuming current growth rates, the emission reduction goal of 50% corresponds to about 125 Million tonnes CO_2.
8. The reference year is 2005. The emission reduction goal has been estimated in relation to the status quo at the moment of carrying out the survey, and it concerns the Dutch situation.
9. The starting point for the selection of options is all economic sectors. On this basis, seven options have been selected:

    1. Improvement of energy efficiency;
    2. Improvement of energy efficiency and decreased use of material and energy;
    3. Electricity from wind turbines at sea;
    4. Conversion of biomass to car fuel and electricity;
    5. Large plants where coal or gas is converted into electricity with CCS;
    6. Large plants where gas is converted into hydrogen with CCS;
    7. Electricity from nuclear plants

As each option is set up to reduce 40 Mt CO_2, the respondents should select three of these options in order to (almost) achieve the goal of reducing 125 million tonnes CO_2. Additionally, it should be explained which combinations are not possible: it is only possible to choose for energy efficiency improvement and decreased use of material and energy when the first option of energy efficiency has already been selected. It is not possible to select more than two options that target electricity production, because otherwise the supply of electricity will exceed the demand for it. The options that deal with electricity production are: wind energy, nuclear energy, fossil fuel combustion with CCS and hydrogen production with CCS. It is also not possible to choose for more than one option that targets fuel for cars and other transportation vehicles.

8.1.3 Expert information on seven options for CO_2 emission reduction

In this section we provide the final descriptions of the seven carbon dioxide emission reduction options specified in section 1.4. This compilation of information is the result of a 6-month process, which can be summarized in three main steps:

1. A literature review of each of the emission reduction options which resulted in a first draft description of each option.
2. An internal review of each of the descriptions which resulted in a second draft.
3. An external review of the second drafts which resulted in the final versions that are shown in appendix 1.

The external review

A main restriction when collecting the information and writing the descriptions of each option is the fact that the information needs to be summarized as much as possible (since in the ICQ only one page of information per option will be given). The external review was therefore fundamental, not only for assuring that no relevant arguments were missing and that the information was accurate and balanced, but also for selecting relevant information.

The external review was made in written form by providing the experts with (i) a letter containing a detailed account of what it was required from them, (ii) the policy problem, assumptions and points of attention, and (iii) a questionnaire. The questionnaire provided the expert with a systematic way of evaluating each individual part of the description: Firstly, the expert was asked to read the whole description for the option. Secondly, he (or she) was asked to evaluate each individual part by answering the following questions:

1. Do you think this information is accurate?

0 YES

0 NO

If your answer was NO, can you underline the inaccurate and improve?

……………………………………………………………………………………

2. Do you think this information is complete?

0 YES

0 NO

Can you add or remove the information that you think is lacking or is unnecessary?

………………………………………………………………………………………

3. Do you think this information is essential, that is, to what extend do you think a layperson needs this information to make a well-informed decision?

Not at all necessary 1 2 3 4 5 Essential

4. Is there anything else you would like to comment on concerning this information?

………………………………………………………………………………………

These four questions were repeated for every part of the information given in each description. Finally, the experts were asked to evaluate the whole option by answering the following questions:

Do you think there are arguments missing from the description of this technology?

…………………………………………………………………………………………

Do you think there is information in this description that is unnecessary or redundant?

…………………………………………………………………………………………

Is there anything else you would like to comment on concerning this option?

…………………………………………………………………………………………

Short CVs of the external experts are presented in the interim report (Ramirez, Faaij, Hendriks, de Visser, de Best-Waldhober & Daamen, 2005). The comments made by the experts for each option are shown in the interim report as well, together with the answers to these comments (i.e., how the comment was taken into account, and if not, why). The final documents are shown in appendix 2.

Selection and translation of the expert information[5]

There were several demands for the information on the consequences of the policy options. The information on consequences had to apply to the specific options. The information aims to describe the most important consequences of the implementation of each of the options, given the assumptions of the choice problem.

Another demand for the information in the questionnaire is that it needs to be understandable for nearly all groups in Dutch society. When the need for a representative sample of the general public calls for the inclusion of respondents that are not very motivated or not highly educated, the amount of information that can be provided and understood is limited. To avoid dropout of groups like the elderly, who are usually slower completing questionnaires, the more difficult groups should not need more than two hours to complete. In that case the average sample will take 1 hour to complete. Half of this hour is needed for the instructions, the presentation of the problem and the information about current situation and global warming. This means that half an hour is left for seven options, 4.28 minutes per option. This time limit reduces the possible amount of information that can be given on one option to *a single page*.

After the experts had evaluated the importance of all the pieces of expert information, the following step was to establish which information is essential to the public according to the experts we consulted, keeping in mind that the information has to be valid, balanced, and does not exceed the ability and willingness of respondents to process this information. Several extra steps were taken to make sure that the information was limited enough and understandable for all

[5] As the method of the current study is very similar to our earlier ICQ study, several descriptions in this section are similar to the 2006 report as well (de Best-Waldhober, Daamen and Faaij, 2006)

respondents to process properly. First, the information on consequences was formulated per consequence, so that respondents are able to evaluate each consequence separately. In this way, respondents are able to evaluate one by one how much of an advantage or disadvantage they think the relevant consequences are. This method of giving respondents little "blocks" of information and asking them to evaluate this information helps respondents to process the information (Neijens, 1987). Second, the information on the consequences is preferably given relative to the status quo. For instance: "When this technology is implemented, the costs of power for households will be 10% higher compared to current costs". Relative information is preferable over absolute information because the latter is more difficult to process and results in extended processing (Chestnut, 1976; Van Raaij, 1977).

Information on consequences was omitted from the questionnaire when it was either non-discriminatory or a so-called null-effect. These two points will be explained in the next paragraphs.

Non-discriminatory information

When a consequence results from all options equally, the information on this consequence is not informative to the decision making process, because the information does not discriminate between options. For instance, an important consequence of all the options in the questionnaire is that they provide enough energy. This information does not help in making a choice, as it is true for all options.

Null-effects

With information on null-effects we mean information on the lack of a certain consequence. For instance "Studies so far show that movements of mammals and fish are not affected by wind turbine foundation". The information that was gathered by the experts contains several of such null-effects. Most null-effects concern information on consequences that do not differ from the status quo. A null-effect can be a consequence that lacks absolutely, it can also be a consequence that does not differentiate from the current consequences of energy production. There are several reasons to omit these kinds of information from the information on consequences that will be given to respondents. First, omitting this kind of information leads to less information to read and to process for respondents, but does not lead to much information loss. Even when null-effects are not added to the information, they are still implicitly assumed when options are compared. The contrast between options that do contribute to for instance bird deaths from wind turbines and options that do not remains present, as the consequence of actual contribution to bird deaths is still mentioned. (See also Neijens, de Ridder and Saris, 1988).

The second reason to omit null-effects is that if they are not omitted they count twice. For instance, when it is mentioned that the use of coal for generating power does contribute to more deaths in coalmines and that the use of wind turbines does not, this information is counted twice, namely as an advantage of wind turbines and as a disadvantage of coal. In this case, for reasons of equality, it would be fair to mention that the use of power from coal or gas does not contribute to the need for new vehicles that run on hydrogen or the production of radioactive waste. This would lead to the addition of great amounts of trivial information and it is also likely to annoy the respondents. Given all these negative results of null-effects, this kind of information will be omitted from the questionnaire.

Translation

To make the information understandable for lay people, we have translated the text from expert language to lay language. We have used several methods to adapt the text in such a way that lay people were able to understand it. First, we replaced expert terms with terms that were more understandable for lay people. For instance, the seventh package mentions an Advanced Light Water Reactor (ALWR). This terminology is not used in the lay version, but has been replaced by "an advanced nuclear power station", as most lay people have never heard of an "Advanced Light Water Reactor", let alone understand that this concerns nuclear energy. We also added extra explanation of processes or installations if we thought this might be unclear for respondents. These explanations could be redundant for experts and therefore not mentioned in the information, but necessary for lay people to understand and evaluate consequences.

Second, we converted the information, if necessary, from expert standard measures to measures that are understandable for lay people. For instance, instead of framing the costs of energy in terms of Euros per kWh or Euros per gallon of fuel, it is framed as the percentage people would have to pay more (or less) compared to what they pay now for the same amount of energy. Sometimes a frame of reference can be given to clarify quantification. For instance, when stating how many birds might die by flying into wind turbines, it could help people to evaluate this better if it is also stated how many birds die in general each year. Or the size of an installation might be clearly illustrated by stating that the amount of land it needs is comparable to three soccer fields.

Third, a real effort was made to specify to what extend a consequence might occur, as well as to specify the probability of occurrence. For instance, how high the chance was of something occurring, how much more this would happen compared to the current situation, or for a more literal example: how many accidents and deaths of miners would occur. Of course, sometimes expert knowledge is simply not yet available and then it is just not possible to get an exact number or even a quantitative estimate.

It is essential to realize that although many details that experts have given were not mentioned literally in the translation for lay people, these details were the basis for the consequences that were described in the translation for lay people. For instance, efficiency of a technology is an aspect that is frequently specified by experts. However, efficiency was not mentioned in the translation. It was taken into account for the specification of the price of energy, which was mentioned in the translation, mostly stated as the percentage customers have to pay extra for energy or fuel. This is something that is clearer and more important to lay people. Therefore, although it might seem that a lot of expert information has been omitted, this information has in fact been taken into account for the statements in the translation for lay people.

Adjustments following tests and reviews of the resonance committee

The resonance committee ("klankbordgroep")
Several translation checks were done with the help of students as well as a sample of the Dutch public. This translation process will be described in more detail in the paragraphs below. During this process of improving the translation of the expert information into lay language, we were advised by the resonance committee. This group consisted of 6 experts from different backgrounds most of whom had not participated during the gathering of information. The purpose of the resonance committee was to independently check the quality of the research that was being done. An important check was the check of the selection and translation of the expert information. Before the information was tested, the resonance committee checked the information on accuracy and balance. With their help, the text on all options was improved, as was the text regarding the consequences of global warming. The main reason for adjustments was the balance of the consequences, the resonance committee indicated that several options were out

of balance in relation to the others because their consequences were either stated too positively, or not positive enough. After the two tests, on VMBO (highschool) students and on a sample of the Dutch public, the resonance committee reviewed the researchers' improvements again. At this point, the resonance committee approved the ICQ information as being valid, impartial, and even-handed.

8.1.4 Tests of the ICQ

There are two main reasons for testing an ICQ. First, as an ICQ in general and our ICQ in particular tries to explain difficult subjects, it is essential to find out if explaining these subjects succeeds using the ICQ. Since one of the goals of the ICQ is to inform respondents, it is necessary to test how well respondents are informed. Second, the ICQ functions as a decision aid. Respondents are not only informed, but the way they are informed is such that it structures the decision making process. Respondents are asked to evaluate options by evaluating the consequences of an option, after which they are able to compare the options and their consequences and make an informed decision. Before evaluating consequences, however, respondents are given several suggestions and exercises to help them decide and evaluate more rationally. As the second goal of an ICQ is to structure the decision process, it is necessary to test if respondents understand these suggestions and exercises and if they make use of these suggestions when evaluating consequences.

Furthermore, as the ICQ entails a complex procedure as well as a lot of difficult information, it is expected that most respondents need quite some time to complete the ICQ. The amount of time that is needed to fill in a questionnaire can become a problem when the questionnaire takes so much time that certain groups of respondents will drop out (e.g. elderly respondents, less interested respondents, etcetera). As this will cause an unrepresentative sample, it is necessary to design a questionnaire that is short enough for all groups in the expected sample. Therefore, it is necessary to test how long it takes respondents to finish the questionnaire.

Test on VMBO students
After selecting and translating the information in the questionnaire to the level and proportion suitable for almost all respondents, we tested the information on 31 VMBO students. These students were between 14 and 16 years of age. VMBO is the lowest level of secondary vocational training in the Netherlands except for the level with students with serious learning problems. The questionnaire they were given contained information on the current Dutch use and sources of energy. Before the questionnaire was filled in, students were presented with information on global warming and the consequences of global warming. One of the researchers presented this information orally with some visual aids (in powerpoint). This was done because most of the text regarding global warming had already been tested in a previous study, on VMBO students as well as the general Dutch public. As the questionnaire is very long and we wanted the students undivided attention, we tested only the text regarding the energy options. Furthermore, since the purpose of this test was to measure the amount of time it would take the students to complete the questionnaire and to measure how understandable the test was, we were not interested in students' opinions on CCS, but rather recorded additional measures. We recorded the time students used to finish the questionnaire. Questions about the comprehensibility of the information were inserted multiple times after every few sentences of information that could be misunderstood. Students were asked to underline words or sentences that they did not understand, and were asked to rewrite parts they did not understand in their own words. After finishing the questionnaire, students were asked to answer a few knowledge questions that they should be able to answer after having seen the information in the questionnaire. The purpose of

these questions was twofold. On the one hand, it was another measure of the comprehensibility of the text. On the other, it was a measure of how seriously students had participated.

Although the text was found comprehensible for the most part, the students mentioned several sentences more than once as being difficult to understand. These sentences or the paragraphs containing these sentences were rewritten to become more comprehensible. When rewriting, we took into account what information had been misunderstood as apparent from the frequent wrong answers on the knowledge test. We were not able to avoid all difficult terms though, for instance "uranium" was mentioned a lot as being a difficult "word", but this term was well-explained and furthermore unavoidable in this questionnaire. The time it took students to finish the questionnaire gave no reason to shorten the questionnaire. Last but not least, most students seem to have done their absolute best at reading and processing all the information, as they answered the majority of the knowledge questions correctly.

Test on a sample of the Dutch public

The test of the complete ICQ was designed to test the comprehension of language and procedure as well as to measure the amount of time needed to finish the ICQ. In order to test the comprehension of language and procedure, we added two questions to every part of the questionnaire. After every bit of information or each small series of questions we asked respondents if they thought this information was clear, and if they thought it was not clear, we asked if they could state in their own words what wasn't clear. In order to measure the time needed to finish the questionnaire without all these extra questions, half of the respondents would receive a test ICQ with the extra questions and the other half of the respondents would receive a test ICQ as it was intended, without the extra questions. The test ICQ was a computer-assisted questionnaire, which was send to respondents by TNS-NIPO so they could fill in the questionnaire at home, on their own computer. The procedure of this test, the results of this test and the improvements that were made based on these results are described in appendix 1. The conclusions of the results were that the 109 respondents understood most of the text. The time it took respondents to finish the questionnaire was not too long. The language was mostly comprehensible, only a few pieces of text needed to be adjusted. The technical information seemed mostly comprehensible too, although some text had to be adjusted based on the objective measures of difficulty. The subjective measures of difficulty showed that respondents perceived the quality of the information in the test as quite good. The decision aid, the explanation at the beginning of the test about how to evaluate rationally, was either already being used or picked up by respondents. Most respondents were content with the method, although it was not evaluated as simple by most respondents. One explanation regarding the use of the evaluations of the consequences was unclear to a substantial percentage of respondents. This explanation was adjusted. One of the consequences of the biomass option was also unclear, this was adjusted with the help of a biomass expert. The consequences of the temperature rise due to the greenhouse effect were adjusted, not because of the reactions of respondents, but because the new report of the IPCC came out during this phase of improvement of the text. We adjusted the text with the help of two experts on this topic from Utrecht University and KNMI. All adjustments were approved by the resonance committee.

8.1.5 Explanation of the ICQ procedure (start of the ICQ)

Calibration and calibration of probability

After a quick introduction of the purpose of the ICQ and kind of task respondents could expect, respondents were given several exemplary questions and exercises to practice the ICQ procedure with. These examples and exercises were used to explain how to evaluate consequences. Respondents were given four negative consequences to evaluate on a scale of one to nine, one being a very small disadvantage, nine being a very big disadvantage. These four consequences differed on two dimensions; the negativity of the consequence and the chance the consequence would occur. The purpose of this was to explain to respondents that it would be logical to rate a certain more negative consequence as more negative, and that it would be logical to rate a chance of less than 100% on something negative (e.g. 50% chance on 100 casualties) as less negative than a certainty (100%) of the same thing occurring.

Evaluation of consequences

Respondents were then given an exemplary ICQ about painkillers. With this exemplary ICQ, respondents were explained how to fully evaluate consequences; For every consequence respondents were asked to state if they thought this consequence was an advantage, a disadvantage or not important. If the consequence was evaluated as an advantage or a disadvantage, respondents could state to what extend they saw it as an advantage or disadvantage on a scale of one to nine (1= "a very small disadvantage" or "very small advantage", and 9= "a very large disadvantage" or " a very large advantage"). After respondents had received 4 consequences of medicine "X", the computer would check if the respondent had evaluated all disadvantages as disadvantages. If this was not the case, the respondent received the following text: "You have evaluated one or more of the consequences of medicine "X" as an advantage. Although you are of course free to think so, something could be said for considering the possible side-effects of a painkiller to be a disadvantage."

Value and consistency

As one of the consequences in the exemplary ICQ about medicine "X" was the same as in the first four negative consequences, respondents that gave equal evaluations of this consequence were explained that this was the logical thing to do. Respondents that gave different evaluations to the same consequence were suggested to consider that equal consequences should receive equal evaluations.

8.1.6 Presentation of the choice problem and background information

After familiarizing respondents with some elements of the ICQ procedure, respondents were explained in detail what the questionnaire was about. They were told that the questionnaire had been made with the help of a diverse group of energy experts and that the information in the questionnaire was acknowledged by these experts as a trustworthy account of energy dilemmas and of the consequences of seven options to diminish CO_2 emissions. The respondents were given information on the current use of energy in the Netherlands and the current ways in which energy is produced in the Netherlands. Next, they were explained what the frequent use of oil, gas and coal mean for our climate, by explaining the role of carbon dioxide in global warming. They were then given 8 consequences to evaluate that are expected to occur when the earth's temperature rises as much as expected by scientists. They were also asked to state their overall evaluation on global warming. This overall evaluation was asked for twice; the respondents were asked to give their overall evaluation on a scale of 1 to 7, 1 being very bad and 7 being very good. They were furthermore asked to grade global warming on a scale of 1 to 10.

Knowledge test

Following the information on global warming, respondents were given information on ways to reduce emissions of carbon dioxide. It is explained that this questionnaire focuses on seven options that can help to reduce carbon dioxide emissions. Respondents were made clear that three of these seven options are necessary to reduce carbon dioxide emissions by 50%. Respondents received a summary of all the information they had to process at this point. As respondents have had a lot of information to take in so far, it was questionable if they remembered all of it. To test respondents' knowledge at this point and to fill in any omissions, respondents received 11 multiple-choice questions on information they had just been given to read. After respondents gave their answer, the right answer would always be displayed on screen once more.

General information on carbon dioxide capture and storage

In a previous ICQ, six CCS options were compared. Because all the options in this questionnaire were CCS options, part of the consequences of all options were the same (i.e. the consequences of the actual capture, transport and storage itself). To avoid asking the respondents about the same consequences six times in a row, these consequences were evaluated before any of the (consequences of) options were evaluated. In the current ICQ, there are other options besides CCS options. Therefore, a similar design would not be logical. However, we were interested if separating the consequences of CCS itself (just capture, transport and storage consequences) from the consequences of the rest of the chain (for instance consequences of use of coal or gas or consequences of end use) might have had an effect on the overall evaluations of the CCS options in the 2004 ICQ study. To be able to study this possibility, a fifth of the sample of the current ICQ received a similar design with just CCS consequences before any of the other options. Respondents received a general description of CCS and information on six aspects and consequences and were asked to evaluate these consequences and asked to provide their overall evaluation of CCS. This overall evaluation was asked for twice; the respondents were asked to give their overall evaluation on a scale of 1 to 7, 1 being very bad and 7 being very good; and the respondents were asked to grade CCS overall on a scale of 1 to 10.

More evaluation aid; explanation of accounting system

It was announced at this point that they would not only be asked to evaluate the options and their consequences, as they had done in an example before, but that they would also be asked to make a choice for three of the seven options. We used an exemplary choice procedure to explain what the real choice procedure would be like. Respondents were shown in a table, what evaluations they had given before in the earlier example of the ICQ procedure of "medicine X". Not only were their evaluations given, but also an explanation how adding these numbers would give respondents their overall scores of disadvantage and advantage of "medicine X". They were explained how to let the computer calculate these scores, and how these scores could be used to further evaluate the option (medicine X) overall.

8.1.7 Evaluating consequences of seven options

At this point, respondents would receive the information on each of the seven options in general as well as information on the consequences of each option. Per option, respondents would first get a description of the option. Descriptions of the option contained information on, for instance, the essence of the technologies, the amount and location of plants or fuel cells, conditions for implementation, or the kind of end use. After the general description, respondents were asked to evaluate all the consequences of the option in question.

The criteria for the information about the options was explained to respondents; first it was explained that the respondent would receive information on consequences that experts found important, but we added the comment that experts obviously could not decide for the respondent whether they thought a consequence was important or not. The second criterion for the information on consequences was relevance of a kind of consequence for a policy option. If the consequence of one option is an influence on sea life whereas the other option does not cause this, only the consequence of influence is mentioned. The third criterion was a difference from the status quo. For instance, if the consequences for air quality of an option do not differ from the consequences of the currently used option, these air quality consequences were not mentioned. Only if it was well known or expected that lay people expect a consequence that experts know will not occur, this was explicitly mentioned.

Another criterion was the level of knowledge of a certain consequence of all options. It was explained to respondents that certain consequences were studied or otherwise well known for some options, but not for others. These kind of consequences are likely to occur in several options, not just the ones experts studied. However, as it was impossible to give information about these consequences for some options, information about these consequences was not given for any of the options.

A last remark about the information on consequences that respondents received was that although the prices of all options seem to be higher in comparison with the current energy prices, energy prices are expected by experts to rise over time, indifferent of the origin of the energy.

The information about a consequence was given to respondents in such a way that it was possible for them to evaluate this consequence. As in the exemplary ICQ, respondents were asked to state for every consequence if they thought this consequence was an advantage, a disadvantage or not important. If the consequence was evaluated as an advantage or a disadvantage, respondents could state how much of an advantage of disadvantage on a scale of one to nine, with one being a very small disadvantage or very small advantage, and nine being a very large disadvantage or advantage. This way, respondents could evaluate all the relevant consequences of an option, one by one, as they had been practising with the exemplary ICQ. At this point, respondents were asked to accumulate all the evaluations of an option, and were asked to base their overall evaluation of the option on the resulting total.
They could do so by pressing a button above a table on screen with all the consequences and their evaluations. If a consequence had been evaluated as unimportant, this would presented as a “0” in white colour, if it had been evaluated as a disadvantage the evaluation would be presented in red colour, and if it had been evaluated as an advantage the evaluation would be presented in green colour. Respondents were now asked how they thought about the option as a whole, and were suggested to base this on their evaluations of the consequences and the total disadvantage and advantage score they calculated. They were asked to give an overall evaluation of the option on two different scales. First they were asked to state on a scale of one to

seven what they thought all in all, with one meaning "very bad" and seven meaning "very good". They were furthermore asked to grade the options on a scale of one to ten.

8.1.8 Choice of three out of seven options

When respondents had evaluated all seven options, a table would appear on screen with all options, their overall evaluations and total disadvantage and advantage scores. Respondents were told they could now change the overall evaluations if they wanted, having now read all of the information on the seven options. Following this respondents were asked which three options they preferred to be implemented on a large scale. They could choose three options. It was suggested that they could base their choice on their overall evaluations of the options and/or on the total disadvantage and advantage scores. They were furthermore informed that not all combinations of options were possible. The second efficiency option could only be chosen together with the first efficiency option. It was not possible to select more than two options that target electricity production, because otherwise the supply will exceed the demand. The options concerned are "electricity from wind turbines at sea", "large plants where coal or gas is converted to electricity with CCS", "large plants where gas is converted to hydrogen with CCS" and "electricity from nuclear plants". It was also not possible to choose for more than one option that targets fuel for cars and other transportation vehicles ("large plants where gas is converted to hydrogen with CCS" and "conversion of biomass to car fuel and electricity").
Respondents were subsequently asked if there were any options in the questionnaire of which they thought implementation on a large scale was absolutely unacceptable, to a level that they considered taking action if Dutch society considered implementing this option on a large scale.

To study the effect of the choice restrictions mentioned above, we also asked respondents to choose again assuming there were no restrictions, except the restriction that the second efficiency option could only be chosen together with the first efficiency option.

8.1.9 Perception of information

After the respondent had made a choice, the actual Information-Choice-Questionnaire was over. However, several additional measures were taken. First, fourteen questions were asked to evaluate whether – subjectively- the goal of the ICQ had been reached. These questions concerned the amount, the impartiality, the clarity and the completeness of the information. The questions furthermore concerned how the procedure of the ICQ had aided respondents' decision, how comprehensible it was and how complicated. Respondents were also asked if they had felt restricted in their choice for packages.

Second, respondents received five questions on opinion change due to the information in the questionnaire. For instance: "To what extend did the information in the questionnaire give you more arguments for your choice for one of the options to produce energy?"

8.2 Expert information ICQ

The sections presented below were previously published in the CATO-1 report "*How the Dutch evaluate CCS options in comparison with other CO2 mitigation options. Results of a nationwide Information-Choice Questionnaire survey"* (De Best-Waldhober, M., Daamen D.D.L., Hendriks, C., de Visser, E., Ramírez, A., Faaij, A., 2008).

8.2.1 Option 1: Energy Efficiency Improvement

Author: Andrea Ramírez Ramírez (Utrecht University)

The *goal* of this option is to reduce 40 million tonnes CO_2 in 2030 by increasing energy efficiency 1% per year. This 1% is additional to the 0.85% per year that is expected to occur as a consequence of autonomous developments (changes that would happen regardless of the policies applied).

Description of the option

Energy efficiency is defined as the reduction on the energy used to produce one unit of activity. In this option, it is only considered energy efficiency savings at the end-user side. For instance, in the energy used to heat one m^3 of heat space (e.g. by improving insulation and implementing better temperature control systems, it will be technically possible to reduce energy consumption in buildings by 50% in 2015 and by 100% between 2030 and 2040), to produce a tonne of steel (e.g., by using best available technologies) or to travel one kilometer by car (e.g., by decreasing the consumption of fuel from 11 liters per 100 km (2005) to 3 or less liters per 100 km by 2050).

In this option, it is not taken into account improvements in energy efficiency in power generation plants; energy savings because less material is produced or because services are used in different ways (e.g., taking the train instead of a car or turning off lights when leaving a building, etc.).

How much energy can we save in the long term?

In the next 50 years energy efficiency in the Netherlands can be improved by a factor of 3 to 4 (industrial processes 1.5-2, offices and household buildings 5-10, personal cars 2-3). Not all of such energy efficiency measures pay back rapidly. However, even if only measures are considered which result in net savings over the 'lifetime' of the measure, by 2020 already 70 million tons CO_2 could be saved (compared to the year 1995; technical potential), largely more than the 40 million required in this option by 2030. However, to achieve the 40 million tonnes, strong governmental interventions are required to stimulate the required private action. A strict energy efficiency policy will be followed, resulting in accelerated development and high penetration rates of energy efficiency technologies in all economic sectors.

Benefits of the option

Energy efficiency improvements reduce air pollution and carbon dioxide emissions by avoiding burning of fossil fuels. In many cases, it can also reduce noise, increase water savings and minimize waste. Many energy efficient appliances, devices and technologies also have a longer life than their inefficient equivalent. Though it takes relatively long time for those appliances to penetrate the market, their longer lifetime has environmental benefits in reducing extraction and processing of natural resources. Improvements in energy efficiency can also enhance the reliability of energy supplies by reducing system loads and stresses (for instance, by reducing consumer peak demand) and therefore decreasing the likelihood of blackouts and power shortages. It can also reduce the need for investments in energy infrastructure (plants and power lines). The general economy can benefit as well from improving energy efficiency since the money saved on fossil fuels can be spend otherwise and can create local employment. The European Commission has estimated that a 20% reduction in EU energy consumption can potentially create (directly or indirectly) as many as 1 million new jobs in Europe, especially in the area of semi-skilled labor in the buildings trade.

Policy measures at the sector level.

Consequences vary depending of the sector. In all cases, time and effort will have to be invested in finding and implementing energy efficient measures. This option requires strong government intervention in all sectors. A description of *possible* consequences follows:

Transport: There will be binding EU legislation requiring passenger cars to increase fuel consumption per liter from 10 liters/100 km in 2005 to about 5.5 liters/100 km in 2035. Additional measures such as road tolls (nowadays also refer to as congestion pricing) and fiscal incentives for clean cars will be in place. Car prices will be initially higher but it is expected that prices will decrease on time as a consequence of large-scale introduction of efficient cars. Heavy cars (e.g., SUVs) will become more much expensive.

Industry: Trading of CO_2 emissions among energy intensive industries, which is already common practice, will stay and allowed emissions will go down by for instance 1% p.a. There will be obligations for the non-energy intensive industry to increase energy efficiency. Possible measures are: binding standards for auxiliary equipment such as compressors units; market-based mechanisms for energy savings (white certificates), promotion of audit schemes and/or inclusion into emission trading. All industries will need to increase investments in energy efficiency but this will be compensated by fewer expenses for fossil fuels. No direct consequences for the consumer are predicted.

Buildings (service sector, households): There will be strict regulation for new buildings and for electrical appliances. Energy use in old buildings/houses will be taxed according to performance (the less efficient the more taxes). Financial incentives will also be necessary (e.g., to subsidy insulation of existing buildings). Several types of measures will be accompanied by an increase in energy prices, which initially will reduce energy consumption and in the longer term will encourage greater energy efficiency. The 40 million tonnes required in this option can be achieved using cost-effective measures (involving zero or negative costs), which mostly have payback periods shorter than 3 years. Hence, it is expected that energy savings in this option will lead to net cost savings for energy consumers. Analyses for the European Union show that an average EU household could save between €200 and €1000 per year, depending on its energy consumption.

Sources: See Reference Section

8.2.2 Option 2: Energy Efficiency And Volume Reduction

Author: Andrea Ramírez Ramírez (Utrecht University)

The goal of this option is to reduce 40 million tons CO_2 in 2030 by increasing energy efficiency a further 1% per year (additional to the 0.85% per year that is expected to occur as a consequence of autonomous developments (changes that would happen regardless of the policies applied) and the 1% p.a. of Option 1. The total energy efficiency improvement will therefore be 2.85% p.a.).

Description of the option

This option is composed, in first place, of the energy efficiency measures applied in Option 1 but with more strength. Additionally, this option includes the implementation of breakthrough technologies, e.g. introduction of new technologies in the industrial sector can reduce energy use by half or more; reducing the weight of cars so that less fuel is needed (a 30% weight reduction will result on 20% lower vehicle's fuel consumption)); energy efficiency improvements in the material chain (e.g., by implementing material cascading, material substitution, including the use of biomass-derived materials); and energy savings due to changes in consumption (e.g., by reducing the amount of material produced in the manufacturing sector, by using public transport, by reducing consumption of energy intensive products, etc.). In this option, improvements in energy efficiency in power generation plants are not included.

Situation in 2030

Energy efficiency will be a main development criterion for new technologies. Low operation costs, combined with strict legislation restricting the use of energy, encourage users to implement new technologies. This results in an enhanced penetration rate of energy-efficiency technologies. This option also requires strong governmental intervention in other aspects of daily life, for instance, for steering certain forms of behavior (e.g., encourage the use of public cars, increase recycling rates, etc.).

Benefits of the option

Besides the benefits already named in Option 1, a substantial decrease in the energy demand can make the transition to an energy system with a substantial share from renewable sources much easier. In addition, by increasing the use of energy efficient products, decreasing the amount of products manufactured, and changing consumer behavior, fewer natural resources are required for manufacture, transport and distribution.

Policy measures at the sector level

A stricter energy policy than in Option 1 will be applied to all economic sectors. Following there is a description of some of the possible consequences by sector.

Transport: For passenger transport, only light vehicles will be available, therefore limiting the choice of the consumer. Measures, such as road pricing, will promote the use of public transport and affect freight transport, which in turn will increase the price of goods. Additional taxes could also be applied to non-seasonal, non-regional products (e.g., kiwis from New Zealand or bananas from Guatemala). External costs will be included in the price of air tickets, for instance, by raising air passenger duty, introducing VAT on the prices, or considering emission trade for aviation. Depending on the journey length, levying the emissions on a flight may cost an additional 8 to 40 euro per journey.

Industry: Increasing energy efficiency by about 2% p.a. in the industry will require the development and implementation of breakthrough technologies, involving higher investment costs than Option 1 (Option 1 was composed of the cheapest energy efficient technologies). An important challenge is to create a financial environment where is attractive to invest in complete process revisions/changes. Since breakthrough technologies tend to be more expensive than current designs, the implementation of these technologies will initially increase production costs. However, due to high energy prices these measures could still be cost effective or implemented at low costs. In the case of cost increases, these costs -or part of them- could be transferred to the consumer (e.g., by increasing the price of goods). There is no information available about the potential impact of high costs and future price uncertainty on economic growth.

There will be binding legislation that will assign to industries the responsibility for the waste produced after factory-gate (i.e., used products will go back to the industry for recycling) and reduce the use of excessive packaging. Legislation will also be in place that forces the consumer to recycle.

Buildings (service sector, households): Strict legislation will demand that new buildings are designed with almost zero energy consumption and that old buildings diminish their consumption significantly, for instance, by a factor 5 to 9 compared to current consumption. This implies that consumers will have to modernize their buildings, with the consequent high investments, and/or suffer from loss of comfort (e.g., use less fuel by decreasing the temperature at which houses are heated in winter). Additional economic measures could be in place to encourage the use of the most efficient appliances. For instance, by assigning a cap for electricity consumption to each household (consumption over the cap will be more expensive). In any case, the price of energy will be higher than for Option 1.

Sources: See Reference Section

8.2.3 Option 3: Electricity Produced By Offshore Wind Turbines.

Author: Chris Hendriks (Ecofys)

The goal of this option is to reduce 40 million tons of CO_2 in 2030 by installing offshore wind turbines with a total generation capacity of 15,000 MWe.

Description of the current situation

Wind power is renewable, which means that we will not run out of this energy source. Most wind turbines are grouped together and are located at windy places where steady and strong winds blow. Currently, most wind turbines are situated on land. A relatively new development is to place them offshore. To date, in Europe almost 1500 MW offshore and near shore wind power capacity is operating. The total global installed wind capacity amounts to 158,000 MW. The international wind energy market grew by 31% in 2009 (Global Wind Energy Council, 2009).

In the Netherlands, two offshore wind farms have been built in the North Sea. The first Dutch offshore wind farm OWEZ (Offshore Wind farm Egmond aan Zee) was constructed near the coast at Egmond aan Zee. This near shore wind farm, located at a distance of 9-16 km off the coast, has an installed capacity of 108 MW (36 turbines with a capacity of 3 MW) and has been operational since end of 2006. The equivalent of over one hundred thousand households are supplied with electricity from the wind farm. Another wind farm, the Prinses Amalia wind farm, is constructed some 23 kilometers off the coast of IJmuiden. This 120 MW wind farm has been operational since summer 2007. Thus, total current offshore wind capacity is 228 MW.

The Dutch government had set targets for offshore and onshore wind energy capacity. The target of 6000 MW offshore capacity and 6000 MW onshore capacity in 2020 is left behind, but a gradual implementation of offshore and onshore wind is aimed at. The Dutch government will provide subsidies for 950 MW offshore wind farms for the coming 5 years. The installation of far away offshore wind farms is currently under discussion. Currently onshore wind energy accounts for 2000 MW (EWEA, 2008). The Dutch government has set a target to have 4000 MW onshore wind capacity permitted by the end of 2012.

Situation in 2030

40 Mt reduction of the greenhouse gas CO_2 in 2030 can be achieved by the installation of 15,000 MW offshore wind power capacity. The average size of wind farms may increase from 300 to 500 MW by 2020 (Ecofys, 2010) and to 1000 MW or more by the year 2030 (Ecofys, 2010). Especially on locations in the deeper sea larger wind farms can be built. With an expected average capacity for offshore wind farms of 750 MW by 2030, about 20 wind farms need to be installed in the North Sea. The 15,000 MW offshore wind capacity generates 60 TWh[6], which is about 30% of the total estimated electricity production in the year 2030.

Technology development

Average size of wind turbines will increase in the future, from 3 MW_e at the moment to above 10 MW_e in 2030 (Ecofys, 2010). Today, prototypes with a capacity of 6 MW are already built and 10 MW plans are under development.

The technology of wind turbines is still improving. Research and development efforts are mainly related to the re-design of wind turbines, such as smart electronics and tower improvements. Also, the prediction of short-term wind-electricity production and the integral design of wind farms are being subject to studies. Other trends next to the ongoing technology improvements are the mass production and standardization of wind turbines. Offshore wind technology is not mature and we are just in a starting phase. Further development and research is needed on turbines (dedicated offshore turbines), installation technologies, O&M strategies, and optimisation of the electrical infrastructure.

Changes in the infrastructure

[6] Based on 4000 full load hours per year as of 2012 (Ecofys, 2010)

Wind energy is a variable energy source, which means that the amount of electricity produced varies according to the supply of wind (wind speed). In a period with lack of wind supply, an alternative source of energy is required. Supply can be secured by implementing also other renewables, improvement of European grid connections, increasing back-up capacity or apply temporal storage, e.g., compressed air, batteries or hydrogen. The electricity grid is designed for and used to deal with these variations in load and supply. It is expected that the existing electricity grid is able to cope with an extra capacity of a few thousand MW. The connection of higher capacities requires construction of extra and reinforced grids to assure the stability and transport capacity of the grid. Improved European interconnection will be required to better match demand and supply of wind energy. Storage of wind energy is a further possibility to cope with the variable supply. Several concepts to store wind power during a certain period in time are being developed, like compressed air storage and hydrogen storage.

Long-term perspective

Two third of Europe's wind energy potential is situated in the North Sea (The Netherlands Ministry of Economic Affairs, 2004). The large areas of shallow water, which facilitates the construction of wind turbines, and the large wind resources make the Dutch part of the North Sea, with a surface area of about 57.000 km^2, a suitable area for wind energy capacity (Kooijman et al., 2003). A capacity of 15,000 MW_e offshore wind requires a surface area of somewhat more than 2000 km^2, which is about 6% of the surface area of the Netherlands (35,054 km^2). Figure shows a situation of what 15,000 MW_e offshore wind capacity in the North Sea could look like. Theoretically, the North Sea area is available, but other competitive claims, of which ships and military training zones are most important, have to be taken into account. More spatial claims for the North Sea comprise pipes and cables for the production of oil and gas, telecom, sludge dumping and the location of several areas with particular ecological value (Friese Front, de Klaverbank and Doggersbank).

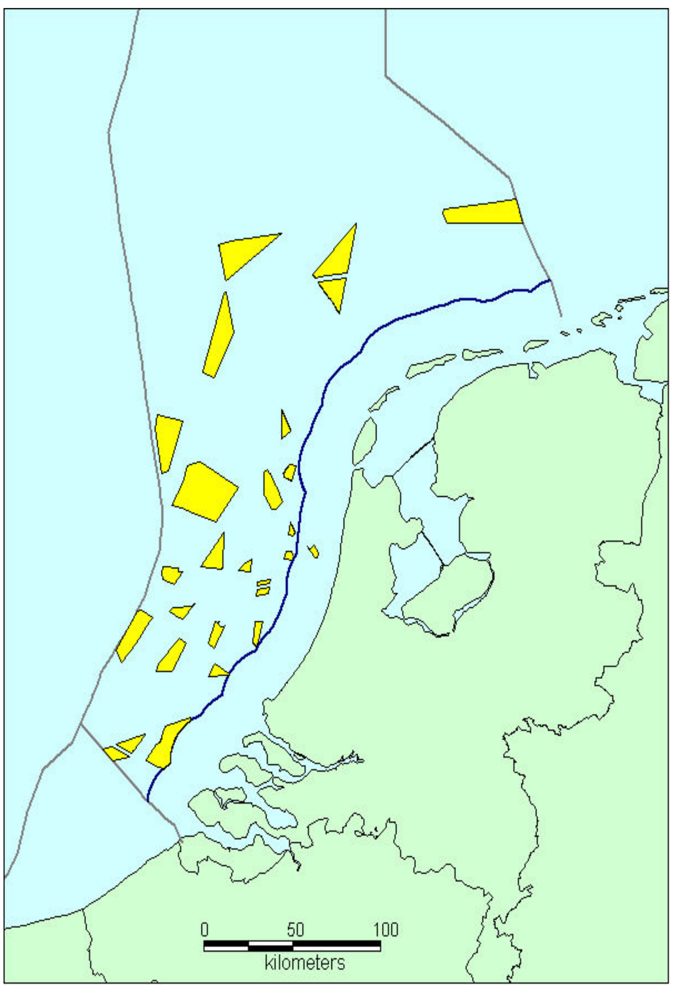

Figure A1 overview of 15,000 MW offshore wind in the Dutch part of the North Sea

If a total capacity of 15,000 MW offshore wind has to be installed, other priorities need to be set for the North Sea area than have been in place up to now (Personal communication, 2005). However, with careful study and sitting, wind energy should be able to complement other functions.

Environmental consequences

Impacts on birds and visual effects are the most important concerns with regard to offshore wind as it is assumed that for sea mammals and fish the effects will be minor or positive.

Bird and wildlife impacts. Bird impacts are very site specific and involve collision with wind turbines and interruption of migration routes. A study on bird fatalities by wind turbines in the Netherlands shows that 1,700 wind turbines cause about 50,000 bird deaths a year (ANP, 2005). For comparison, over one million birds are killed in the traffic in Denmark, and that the total number of staging and migrating birds in Denmark is 400 - 500 millions.

Besides bird fatalities due to collision with wind turbines, the habitat of birds could also be disturbed. Disturbance of birds occurs to birds that have their local habitat (resting, breeding etc.) or to flying birds. The effects of wind turbines on the habitat of birds are site and species specific. The distance at which disturbance plays a role is generally limited to 250-800 meters. Long barricades of wind turbines might prolong flying distance both during feeding and migration. Therefore, long uninterrupted wind farms are not favorable. Studies so far show that movements of mammals and fish are not affected by wind turbine foundation (aside from the period that the farm is built), providing that their habitat is not fragmented by placing the wind farms. There is also a lot of discussion on the electromagnetic interference with fish from the submarine cables. Consequences for marine ecology are not very well known at the moment.

Fishery. Placing wind turbines in the North Sea might reduce the area that is available for fishing. The presence of wind turbine farms and the exclusion zones around them make that the area available for fishery becomes smaller. These wind turbine structures might have a positive impact on the recovery of fish stock when functioning as artificial reefs and safe havens (Greenpeace, 2003).

Flickering and noise. Other environmental effects are flickering and noise. Rotating turbine blades can cast moving shadows, which cause a flickering that can affect residents living nearby (EWEA, 2003). This argument might be of less importance for human beings because most wind turbines could not be seen from the coast. The effect of flickering on mammals, fish and birds is not known at the moment.

Noise from wind turbines comes from turning blades and from the gearbox, generator and hydraulic systems, but this mechanical noise is reduced to almost zero in modern wind turbines. There is evidence that noise will affect fish.

Economic aspects

Investment costs. Investment costs for offshore wind farms are currently 2000-2200 €/kW (EWEA, The economics of Wind Energy, 2009), but will reduce in 2030 by approximately 35 to 50% (Junginger, 2004. For the deep North Sea investment costs are higher. Widespread application of wind power, such as 15,000 MW, may reduce the costs even further. A range of final electricity costs for existing offshore wind farms ranges from 6-9 €ct/kWh. Current electricity production costs of 10.3 €ct/kWh are given by the Dutch wind energy association and somewhat higher costs are presented in the Reference Projection 2005-2020, namely 12-14 €ct/kWh.

Compared to a current production costs of 3-5 €ct/kWh for fossil fuel-based electricity, electricity from wind tends to be about two to three times as expensive as electricity produced by conventional power plants. Electricity from wind power becomes competitive to conventional power in the period 2015 to 2020 when large capacities of wind power are installed and conventional power costs increase. With a goal of 15,000 MW_e offshore wind energy capacity additional investments need to be made for new infrastructure that transports the generated electricity to the mainland and further into the mainland. The feed of extra electricity to the grid will impose high demands on the grid onshore. However, adjustments are needed anyway because of the higher consumption and the change of the electrical organization in the power sector. Possibilities exist to implement changes jointly, such as improvements in transport capacity between countries. Wind power is a variable source of power production, which actually says that the output varies with the wind speed. The variable nature of wind power supply and the varying loads ask for additional provisions. Costs need to be made to cope with these aspects, e.g. by adding storage capacity, adding back-up power and/or by enforcement of the (international) grid connections. Storage concepts are costly at the moment and technology is not mature.

External costs. The costs of electricity from wind cannot easily be compared to the cost of electricity from conventional sources when external costs are not dealt with. External costs are the costs to human health and environment that are not accounted for in the price of electricity. Wind energy technology is environmental friendly with respect to emissions of pollutions like SO_2, NO_x and dust particles and with respect to greenhouse gas emissions. The variability of external costs of wind energy depends on noise, amenity impacts and the upstream processes (production). The external costs of wind energy vary between 0 and 0.25 €ct/kWh. For comparison, the external costs of coal are lowest in Finland with 2-4 €ct/kWh and highest in Belgium with 4-15 €ct/kWh (European Commission, 2003).

Creation of jobs

Studies show that offshore wind is likely to have a positive effect on employment. Jobs created in construction and installation depend on the rate of installation of new wind turbine farms. Jobs in operation and maintenance will exist for the time wind farms are operating. EWEA estimates are given of direct employment to develop offshore wind farms. All sectors together, like project design and development, component supply, assembly, installation and operation and maintenance, result in a creation of 215,000 jobs by the year 2030, following the EWEA scenario amounting to an installed offshore capacity of 150 GW (EWEA, Pure Power, December 2009).

Sources: See Reference Section

8.2.4 Option 4: Biomass

Author: André Faaij (Utrecht University)

The goal is to have 4000 MWe capacity in 2030 for biomass-fired power plants (primary biomass fuel use about 180 PJ) and 250 PJ for car fuels (primary biofuel use about 420 PJ) (shares of each can be adjusted).

Global outline

Biomass is organic material such as wood, grass, organic waste, straw, etc. It can be used as fuel for the production of electricity, heat and as a fuel for cars such as ethanol (an alternative for gasoline) or (synthetic) bio-diesel. When biomass is produced in a sustainable manner, its use does not contribute to CO_2 emissions due to the fact that during their growth plants take as much CO_2 from the atmosphere as it is released when converting them into energy.

In 2030, less than 10% of the national energy demand in The Netherlands can be supplied by the efficient use of available organic waste, residues and, for a small part, by wood (i.e., willows) cultivated in The Netherlands on agricultural ground no longer in use (e.g., buffer areas in nature reservation areas and in water retention areas close to rivers).

To be able to obtain in the year 2030 a CO_2 emission reduction of 40 Mt, an (extra) contribution of about 600 PJ from biomass is needed (this on top of the current use of biomass). In 2030, this amount of biomass (or fuel produced from biomass) will have to be imported because the Netherlands does not have the land needed for the cultivation of large-scale energy crops. The production of biomass will, therefore, take place in regions such as Brazil-Uruguay, Argentina, the South of Africa (e.g., Mozambique and Zambia), and East Europe (e.g., Ukraine, Rumania and Russia).

Most of the imported biomass (in the form of pellets or raw biofuels produced in the exporting country) will be efficiently converted into high quality transport fuels and, for a smaller part, into electricity in a couple of big plants in seaports like Rijnmond, Eemshaven, or Terneuzen. An important share of the current oil refinery capacity will be replaced. About two thirds of the demand for transport fuels in The Netherlands will be replaced by biofuels. A part of the energy production from biomass will take place in modern coal-fired power plants, in efficient waste treatment units based on gasification, and a smaller part of biogas production by means of anaerobic fermentation.

Economic Impacts

In 2030 the production costs of biofuels will be roughly the same as the cost of gasoline and diesel made from oil. Bio-electricity will also be competitive.

Environmental impacts

If compared with gasoline and diesel, the use of biofuels will lead to significant lower emissions of dust, carcinogenic hydrocarbons (soot), NOx, SO_2 material and smog produced by cars. Electricity production will be as clean as that produced from fossil fuels and it will comply with the strict environmental regulations of 2030.

Biomass production in other world regions will require large cultivation areas. The ecological and social-economic impacts of energy crops can be positive if biomass is cultivated in a responsible manner within strict criteria. This can be achieved by implementing an internationally accepted certifying system, which should be in place and widely accepted in 2030. This certification, in conjunction with good practice guidelines, must guarantee the principles of sustainable use of land, water management, nature conservation and 'fair trade'. At best, biomass production can lead to abatement of poverty in rural regions, regenerate degraded lands and lead to more sustainable agriculture. If this cannot be guaranteed, large-scale biomass production could, in the worst of cases (e.g., by introduction of large scale monocultures), generate serious consequences in relation to water reserves, increasing pressure on agricultural land and forests, as well as the exclusion of small farmers.

LAND USE FOR ENERGY PRODUCTION

Biomass production requires land. Relatively conservatively, the productivity for a perennial crop (like Willow, Eucalyptus or Switchgrass) lies between 8 - 20 tons dry matter per hectare per year depending on location, climate and soils. The heating value of dry clean wood amounts about 19 GJ/ton (HHV). This is gross energy yield, and the energy inputs for cultivation, fertilizer, harvest, etc, amounting about 5%, should be deducted). One hectare can therefore produce about 150 – 350 GJ/ha net per year. 1 PJ would require 3,000 - 7,000 ha.

The amount of fuel needed to fire a 600 MWe base load power plant (7000 full load hours) with 40% efficiency is 38 PJ per year. This would require 115,000 - 260,000 ha.

Supplying one quarter of the world's current energy consumption, i.e. about 100 EJ, would require about 300 - 700 million hectares (Mha), which is a quarter to half of the present worldwide land use for agriculture and equals 2% - 5% of the total world land surface. The total land surface of the Netherlands amounts 3.4 Mha, and the present Dutch energy demand is about 3000 PJ. Covering one quarter (750 PJ) of the national energy demand with (imported) biomass would require about 2 – 5 Mha.

Energy balance: By transforming biomass into materials with a high density (like pellets or oil) or direct fuel production in the producing countries, the energy balance is positive; production and international transport of biomass demands no more than 10 % of the total energy produced (which is comparable coal or gas production chains).

Energy supply reliability

Increasing the share of biomass in the Dutch primary fuel mix will increase diversity, which is advantageous for the reliability of the energy system. In particular, the dependency on oil will decrease. This is of great strategic importance given the expected oil world shortage during the first half of this century.

Furthermore, it is possible to produce biomass in different parts of the world. Potentially, important export regions will be: Latin America, The South and East of Africa, East Europe/Russia and Oceania.

Changes in infrastructure

Biofuels can be produced in the main sea harbors without fundamental changes. However, the required conversion capacity will have to be aligned with the capacity of existing refineries. With a gradual introduction over the coming decades, there should not be fundamental problems.

In the coming decennia, large scale availability of high quality fuels for transport will assist the introduction of more efficient and cleaner cars into the market (with the so-called flexible fuel concept). Policies are needed to support the introduction of such cars and fuels into the market. Also the conversion technology development will need support, be it that technologies are especially developed by companies outside the Netherlands. It is important that logistic capacity is developed in seaports for the transport and conversion of biomass and biomass products.

Total potential of this option/ long term perspective

Within this century, the potential for the production of biomass on a global scale is very large. Estimations for 2050 are in the range of 20 to 50 % (200 to 500 EJ) of the global energy demand.

If produced in a sustainable way, biomass as a renewable energy source, is a desirable alternative in the long-term.

The potentially most important constraint lays on the stagnation of efficiency improvements in the agricultural sector, especially in developing countries. Lower efficiency developments imply that land requirements to fulfill food demand stay high. A part of the long-term potential of biomass is thus dependent on the speed at which such efficiency improvements will be implemented. In turn, however, the introduction of biomass production can also accelerate this development process.

The potential technical developments and experience with (sustainable) production systems can decrease the production costs of biofuels, and the price may become lower than that of gasoline and diesel fuel at this moment (i.e., 60 US$/barrel). Biofuels can also be used in new generation cars, for instance new and efficient hybrid cars and fuel cell cars.

Technology innovations

The technology development that is necessary (for conversion and pre-treatment) will take place in the coming 10 to 20 years in the international arena, with a potentially interesting role for the Dutch industry.

The most important condition for this option is the implementation of an international market for biomass (that is sustainable produced). Various (trade) barriers need to be removed and an international level playing field created. Also, sufficient logistic capacity (ships, transfer and storage capacity in harbors) must be available.

Sustainable production should be integrated in the current agriculture of different regions and circumstances in the world. The introduction of internationally recognized certificates and monitoring, the development of a global market and the implementation of logistic capacity in potentially important export regions, are the major boundary conditions. This is an area where the Netherlands could play a leading and innovative role.

Development costs

These costs are not of fundamental importance. The development trajectories for key technologies are relatively certain. In addition, there is already vast (commercial) experience with bioenergy, especially for power and heat production.

Macroeconomic consequences

In 2030, imported biomass will not necessarily be more expensive than gas or oil. It is expected a 'more stable' price will develop once companies offer their products in the world market, leading to stable energy prices, which on the long-term can be more advantageous for the economy.

For a considerable group of developing countries (Africa and Latin-America) and East Europe, the possibility of large-scale export of renewable fuels could represent a source of significant revenues as well as increasing labour opportunities in rural areas. However, when biomass demand competes with food production, also increases in land and subsequently food prices could be observed. This should be avoided and secured by certification and good governance of land use.

The value of 600 PJ imported and processed biomass (equivalent to the possible Dutch demand in 2030) amounts over one billion Euro (in the range of 40-60 Euro/ton). In particular, the chemical industry and the transport sector can benefit in economic terms from large-scale imports and the construction of new factories that also produce renewable materials such as biochemicals.

Sources: See Reference Section

8.2.5 Option 5: Carbon Capture And Storage From Power Plants

Author: Chris Hendriks (Ecofys)

The goal of this option is to reduce 40 million tons of CO_2 in 2030 by capturing and storing the emissions from power plants with a total capacity of 8000 MWe.

Description of the current situation

Carbon dioxide (CO2) can be isolated from a combustion process and subsequently stored in underground layers instead of today's situation of emitting it into the atmosphere. Storage concepts have been proven by several projects. Since 1996 a Norwegian oil company stores annually one million tons of CO_2 in underground layers in the North Sea. Currently, nice CCS projects are operating storing annual a few million tones of CO2. Monitoring is carried out to find out what happens with the carbon dioxide and whether it behaves as predicted. In the Dutch part of the North Sea, over more than six years GdF-Suez stores annually 20.000 tons in a nearly empty gas field. CO_2 is also pumped underground in hydrocarbon reservoirs to enhance the recovery of oil or natural gas. Although not for the purpose of reducing CO_2 emissions, this process is frequently used in the United States. Capture of CO_2 is common practice in the chemical industry and gas industry. Large-scale CO2 capture from power plants has not yet been demonstrated. Transport of CO_2 is regularly applied and is technically possible.

Situation in 2030

The 40 Mt emission reduction of the greenhouse gas CO_2 in 2030 will be achieved by equipping 8000 MW_e of power plant capacity with capture facilities. This is about 15-20% of the total installed capacity of power plants in 2030. Capturing technology is mainly integrated in new established plants. A small part of the target could also be achieved at existing power plants by retrofitting the plant. This however is a less economic operation.

Technology development

Capture of carbon dioxide from large-scale power plants has not been applied yet on a commercial scale. Test and pilot projects are going on to see if carbon capture and storage is practically and economically applicable. Currently, two small-scale demonstration projects are being developed to store CO2 underground. One in an empty gas fields in Barendrecht and one near Geleen. Recently, the project in Barendrecht attracted a lot of attention because of concerns of the local community. In Rijnmond, in 2015 a large demonstration plant will be operating, capturing and storing CO2 from a mid-sized power plant.
Worldwide there are almost 100 CCS projects ongoing and proposed.. In most of these projects existing capture technologies are applied (IEA, 2005). No major technological bottlenecks are expected, although uncertainties exist regarding costs, energy use and environmental performance of the capturing process. Transport of the captured CO_2, especially by pipelines, is technically feasible and demonstrated in various countries.

The injection of carbon dioxide in underground reservoirs poses little technical problems, because the same technologies are used in oil and gas exploration and production. Once the CO_2 is injected it is stored in the underground. Well-drilling, injection, computer simulation of storage reservoir dynamics and monitoring methods are well developed. There is however uncertainty on the behaviour of the stored CO_2 on the longer term (leakage) and substantial research and development efforts should be dedicated to this issue.

Changes in the infrastructure

No major infrastructural changes are needed for or expected for the implementation of capture to power plants. The energy system will continue to rely on fossil fuels. Carbon capture and storage is a viable option to contribute to mitigation of CO_2 in the way that it creates flexibility in achieving greenhouse gas emission reductions.

In principle, CO_2 can be captured from all installations that combust fossil fuels provided that the scale of the emission source is large enough. Carbon capture from electricity plants offers the best initial potential for capturing CO_2, because large streams of CO_2 become available (IEA, 2005). A possible shift towards small-scale units will become less attractive. For the planning of new plants also possible storage locations for CO_2 need to be taken into account.

The application of carbon capture technology does not affect the transmission of electricity. But next to the power infrastructure, also a CO_2 transport infrastructure will be required to transport the captured CO_2 to the reservoirs. Large-scale application in the Netherlands will require in the order of two to three thousand kilometers of new pipelines. The construction of pipelines could disturb normal life when for example, streets are blocked during construction of underground pipelines.

Long-term potential

Over 80% of the Dutch energy supply relies on fossil fuels. For the next decades, fossil fuels will remain the dominant energy source to meet the energy demand. CCS will make it possible to continue using fossil fuels with reduced emissions of CO_2. Fossil fuels are abundantly available. Studies show that worldwide 3000 Gt C (equal to 11,100 Gt CO_2) can be extracted at costs lower than 20 € per barrel (Turkenburg and Hendriks, 1999). Globally, emissions of CO_2 from fossil fuel use in the year 2000 were about 30 Gt CO_2 per year (8 GtC per year)[7] (IPCC, 2005). Power generation, represented mostly by large point sources, is responsible between 30 and 40 percent of these global CO_2 emissions.

Less certain is how much storage capacity for CO_2 is available. Studies show that it is likely[8] that there is a global storage capacity of at least 2000 Gt CO_2 (IPCC, 2005). This capacity is sufficient to store 80 times the global CO_2 emissions in 2005 from fossil fuel use. In the Netherlands there are many empty gas and oil fields relatively nearby. Gas fields have by far the largest potential in the Netherlands. Up to 2050 the proved potential of empty gas fields is calculated at 2750 $MtCO_2$. When the gas field in Groningen is exhausted, after 2050, some additional amount of 7350 Mt CO_2 can possibly be stored (TNO, 2007). The capacity of oil fields is rather limited with 40 Mt CO_2 to be stored. The storage potential worldwide in saline aquifers might be in the order of hundreds to thousands Mt CO_2, these capacities are uncertainty and research is being carried out to

[7] 1 Gt C = 1 billion metric tons of carbon equivalent = 3.7 Gt CO_2
[8] 'likely' suggests a probability of 66% to 90%

establish their real potential. Storage capacity could turn out to be somewhat less if reservoirs if alternative uses are planned, e.g., for underground gas storage (UGS).

Environmental consequences

Capture of CO_2 from power plants will not only reduce emissions of CO_2 but could lead to reduction of other pollutants such as SO_2, NO_x and particulates per kWh, depending on the technology applied. In some cases it might lead to additional emissions. It is technically possible to construct near-zero CO_2 emission plants, without harmful emissions, but 80-90% capture of CO_2 on a per plant basis is more attractive from an economic point of view. Extraction and transporting fossil fuels causes greenhouse gas emissions, mainly methane from coal mining. Depending on the mine, this is 5 to 10% of total greenhouse gas emissions per produced kWh.

Safety issues

Extraction. When applying carbon capture and storage the use of fossil fuels is continued. At the start of the chain for fossil fuel use, fossil fuels are extracted from the earth. Health and safety issues are mainly related to coal mining. When half of the Dutch plants, equipped with carbon capture and storage, will run on coal, mining will cause yearly about three deaths.

The risks related to carbon capture and storage can be divided into local and global related risks. Local risks are related to possible impacts of CO_2 release on people, animals and the local environment. The effectiveness of carbon capture and storage to reduce global carbon dioxide emissions and therefore climate change is an indication of the global risks of the process of CO_2 capture and storage.

Capture process. In industry the process steps of absorption and compression of CO_2 are common practice. CO_2 is used in various applications like cooling, drinking water treatment, foam production etc. The operational risks associated with capturing carbon dioxide from the production process are generally well known and manageable using standard engineering controls and procedures (IPCC, 2005). However, risk issues associated with degraded amine waste-products are not yet well-known.

Transport of CO_2. The main risk involved with transportation of carbon dioxide is leakage. Carbon dioxide might leak gradually from pipelines or escape in a short time by large amounts, e.g. because of a pipeline rupture. CO_2 leaking from a pipeline is a potential asphyxiate for humans and animals. Concentrations of 7-10% of CO_2 in air can cause lethal effects in human beings (IPCC, 2005). A characteristic of CO_2 that needs to be considered when selecting a pipeline route is the fact that CO_2 is denser than air. The CO_2 accumulates at the point of emission and might also accumulate to potentially dangerous concentrations in low-lying areas. According to the Environmental Impact Assessment for CO2 pipeline for Barendrecht, the local risk is negligible (Haskoning, 2008) . Experts expect that the consequences in case of leakage are smaller than in the case of natural gas.

The incidence rate of pipeline failure is relatively small. Studies show that the incidence of failure has markedly decreased, and most of the incidents refer to very small pipelines, principally in gas distribution systems. When CO_2 escapes from a pipeline it will be dispersed by the prevailing wind. This behavior of the released CO_2 might be a positive circumstance for the Dutch situation. Statistics on pipeline incidents indicate that CO_2 pipelines are no less prone to incidents than natural gas pipelines. In 2008, there was about 5800 km CO_2 pipeline infrastructure in the United States (in not densely populated areas), some 14 accidents happened between 1990 and 2004 without any injuries or deaths, corresponding to a frequency of approximately 3.10^{-4} incidents per km year (Gale and Davison, 2003).

Injection of CO_2. The major risk associated with injection is a wellhead failure, which could have different causes like, unsuitable construction, leaking pipe connections, defective materials and collapse of the well. Corrosion of injection equipment is one of the reasons for leakage during injection. Blocking of the wellbore (e.g. by formation of ice or hydrates) represents a different risk. In the majority of failures the amount of CO_2 released would equal the content of the well. Monitoring systems detect the leak and prevent the CO_2 from escaping the well. The frequency of blowouts from CO_2 wells is considered equal to those from natural gas and is calculated. The probability of a well blow-out is calculated at once per 10,000 years (CMPT, 1999) or once per 1000 years (DNV, 2003). Other study showed a chance of for blowout of operational sites of 0.03% (Jordan, 2008) The potential consequences from a well blow-out are casualties (lethal, injuries) among operators and economic damage caused by temporal disruption of the system.

Storage. The stored CO_2 in the geological reservoir might migrate out of the reservoir through the subsurface into the atmosphere. The likelihood of accidental releases of CO_2 from geological storage reservoirs has not been quantified today, especially for the longer term. Effects on the quality of groundwater, soil, energy and mineral sources are less understood compared to health effects on humans. CO_2 leakage may also harm flora and fauna, drinking water reservoirs and the environment. Fresh, potable ground water, located at 100-200m below the surface, could be contaminated by leakage of CO_2. Leakage into surface water would increase acidity (pH is lowered) and could therefore affect ecosystems.

On a global level, leakage of CO_2 would become a diffuse source of greenhouse gas, which is difficult to control. The effectiveness of storing CO_2 in the underground is being reduced when CO_2 migrates out of the reservoir. In several countries studies are done, to develop more knowledge on leakage from underground reservoirs. For example, soil gas measurements taken at the Rangely Weber oil field, where CO_2 is injected for enhanced oil recovery, indicates that about 3,800 t/y of CO_2 leak out of the reservoir over an area of 78 km^2, which corresponds to 0.012% of the overall annual CO_2 injection rate. The mechanisms involved are not understood (Klusman 2003). Monitoring of current storage locations did not yet observe any leakage (Weyburn and Sleipner project). Large uncertainties still do exist on the long-term consequences of CO_2 storage. Experts believe that careful selection of the sites and adequately regulated monitoring will reduce leakage rate considerable.

Economic aspects

Electricity production costs will increase from 45-60 €/MWh without CO_2 capture to 70-85 €/MWh with CO_2 capture, including transport and storage costs. The electricity price for small consumers will increase by between 10 and 25%, assuming all other costs remain equal.

The capture step typically bears the largest costs; about 60 to 80% of the costs. Transport is costly when the CO_2 has to be transported over large distances to the storage location, through difficult accessible areas (e.g. highly populated areas) or when only small volumes are transported. The cost for storage is relatively small compared to the other cost components. Sometimes even existing infrastructure could be used.

Commercial experience is limited in configuring the various components into an integrated carbon capture and storage system. Costs of carbon capture, transport and storage will reduce over time by improvements in performance or finding less expensive ways to build and operate the capture equipment. Improvements in performance refer to the separation and compression step, which are the most important cost factors.

Cost reduction of carbon capture and storage systems is driven by the experience gained with the technology during deployment. Experts expect that carbon capture and storage systems show similar cost reductions compared to other emission control systems in related industries. An average learning rate of 12% is assumed for the expected capital cost decline of carbon capture and storage technologies, which says that with every doubling of installed capacity the capital costs decline with 12% (Rubin, 2004). Largest cost reductions however could be obtained by changing the method of capturing or to change the entire process. On the long term, economies of scale in plant construction and plant sizes can reduce the costs further. Some authors expect cost reduction up to 25% towards 2030 and 50% towards 2050 when full- scale application of carbon capture and storage is applied (Hendriks et al., 2004).

Sources: See Reference Section

8.2.6 Option 6: Carbon Capture And Hydrogen Production

Author: Chris Hendriks (Ecofys)

The goal of this option is to reduce 40 million tons of CO_2 in 2030 by capturing and storing the emissions from hydrogen production plants for use in cars and in households

Description of the current situation

Hydrogen is an energy carrier which is currently produced and used mostly in the chemical industry. Another application of hydrogen may be to power cars equipped with fuel cells. Fuel cells are able to transform the energy from the hydrogen directly into mechanical energy, thus avoiding the inefficient combustion step in ordinary motors.

Large-scale hydrogen plants use the Steam Methane Reforming (SMR) process for the production of hydrogen from natural gas. This is the most common and least expensive method. Worldwide 48% of the hydrogen is produced from natural gas (U.S. Department of Energy, 2005). Hydrogen is also produced by gasification of coal and in small amounts by electrolysis of water. Carbon dioxide is already separated from the hydrogen production process. To capture the carbon dioxide for storage underground, these processes need minor modifications to collect the carbon dioxide in pure and compressed form.

In the chemical industry, hydrogen gas is used to make chemicals, such as ammonia and methanol. Refineries are also a large market for hydrogen. For these large-scale chemical processes such as oil refining, steam reformers produce 25 to 100 million standard cubic meters of hydrogen per day. To compare, with this amount of hydrogen a fleet of about 225,000 to 900,000 fuel cell vehicles, each driving 11,000 km a year, could be powered (Ogden, 2002). An extended pipeline infrastructure for hydrogen is present in the south of the Netherlands and Belgium. Use of hydrogen in households and cars is virtually non-existent. In households, hydrogen could be added to the natural gas up to a percentage of 10-20 volume-% (Protonchemie, 2005) safely and without need for modifications of appliances. Higher hydrogen content in the gas mixture requires new or modified appliances. Cars equipped with fuel cells are in an early stage of development; some demonstration vehicles are on the road.

An important feature of a hydrogen use is that CO_2 is no longer produced by the end-user, for instance by the car, but is produced during the hydrogen production process. Carbon capture techniques downscaled to individual cars might be very expensive, but carbon capture at plant level, where a large stream of CO_2 is emitted, is viable. In a hydrogen plant with carbon dioxide capture emissions are reduced with 85% or more compared to the use of natural gas or the use of gasoline. The captured carbon dioxide is compressed and stored underground. The consequences of this are described in option E.

Situation in 2030

In the Netherlands potential markets for hydrogen are the transport sector (passenger cars), households and industry. In order to avoid 40 Mt CO_2 emissions per year, 675 PJ natural gas and motor fuels[9] have to be replaced by hydrogen. Half of the 40 Mt target is achieved by replacing motor fuels by hydrogen in the transport sector and half by introducing hydrogen to replace natural gas in households. Hydrogen based fuel cells and micro CHP systems (systems that produce both electricity and heat) have higher efficiencies compared to the technologies they substitute. On the other hand, handling of hydrogen (compression, storage and transport) are less efficient than natural gas. This option is based on the assumption that 1 PJ hydrogen replaces 1 PJ natural gas. With these assumptions projections up to 2030 are more straightforward, but efficiency improvements in underlying technologies are not covered.

Large hydrogen production units typically have a capacity of 1000 MW and produce about 30 PJ per year. The number of plants needed to fulfill the demand of 675 PJ accordingly is about 20 to 25.

Hydrogen in the transport sector. The total Dutch fleet of passenger cars in the year 2008 amounts to 7.4 million, emitting about 20 Mt CO_2. According to projections of RIVM, the car fleet may increase to over 10 million in 2020. If this trend continues, the passenger car fleet might be over 11 million by the year 2030. Accounting for efficiency improvement in cars the emissions could rise to between 23 and 27 Mt of CO_2 in 2030. A reduction of 20 Mt CO_2 emissions emitted by passenger cars could be achieved by fuelling between 75 and 85% of the cars on hydrogen in 2030.

Hydrogen in residential areas. By replacing natural gas use in households with hydrogen, the net emission reduction is calculated at 2500 to 3800 kg CO_2 per dwelling (De Groot & Jeeninga, 2003). To reduce 20 Mt of carbon dioxide between 5.4 and 8.0 million households need to shift from natural gas to hydrogen use. The number of households in the Netherlands is forecasted to grow from 7.3 million in 2009 to between 8.2 to 9.2 million in the year 2030 (PBL/ECN/CPB, 2006). According to these numbers, 65% to 97% of the households need to shift from natural gas to hydrogen use to achieve the 20 Mt reduction target.

The transition from a fossil fuel based energy system to a hydrogen based energy system needs time. The time horizon for the hydrogen economy, comprising new ways of energy production, distribution and storage, is at least 20 years away for developed countries. Conversely, demonstration projects of carbon capture and storage are already going on.

Technology development

Technologies are used in various steps in the hydrogen chain: production, transport, and (intermediate) storage of hydrogen. Towards 2030 the efficiency will improve and costs will reduce for each step of this chain.

Production of hydrogen: currently hydrogen is produced mainly from natural gas with efficiencies varying from 70% to 85%. In 2030, optimization of the hydrogen production process results in efficiencies up to 90%. Radical improvements in hydrogen production technologies with CO_2 capture are foreseen in the use of inorganic membranes, replacing the pressure swing absorption unit for hydrogen separation and absorption columns for CO_2 separation.

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[9] With an average emission factor of 66 kg CO_2/GJ_{LHV} and a capture efficiency of 90%.

Transport of hydrogen: Before the hydrogen is transported it is compressed or liquefied. Transport of hydrogen could be done by pipeline or truck, depending on the quantities to be transported and distances.

Storage of hydrogen: Because of the relatively low energy content per volume for hydrogen, the storage volume needs to be large. If there are no limitations to the scale of storage, no stringent problems exist. Hydrogen storage in cars with fuel cells is more problematic, because of the volume needed to store an amount of hydrogen with the same energy content as petrol, is much larger. The weight of the storage tank is much larger compared to the weight of the hydrogen that is stored. This problem especially plays with 'onboard' storage of hydrogen in cars. Development will focus on the improvement of the storage capacities. Pressurized hydrogen or hydrogen captured in hybrids are promising storage technologies for future applications.

End-use of hydrogen: Fuel cells that convert hydrogen into electricity could be used to facilitate the use of hydrogen in the transport sector. Fuel cell technology is in the early stage of commercialization; in Japan, US and Europe some cars are already on the road. The proton exchange membrane (PEM) fuel cell, with typical efficiencies of 50% to 68%, is the most likely candidate for application in vehicles.

The conversion efficiency from hydrogen in a fuel cell vehicle is 38%. The fuel efficiency is 16% for a gasoline vehicle. However, for each 100 GJ of natural gas extracted, 58 GJ hydrogen is delivered to the tank, while for each 100 GJ oil 88 GJ gasoline is delivered to the tank ('well-to-tank' efficiency). In the end, fuel cell vehicles use less energy per kilometer driven (ECN, 2004).

In the period 2020-2030 fuel cell vehicles might be introduced in substantial numbers. Experts believe that beyond 2030, hydrogen fuelled vehicles could increase in numbers and take over conventional cars. The European vision on a hydrogen economy stipulates that in 2020 fuel cells become competitive for passenger cars and by 2040 fuel cell technology is dominant in transport (EC, 2003). The most important barriers that prohibit large-scale commercialization of the fuel cell technology in vehicles are the current high costs, the lack of a refueling infrastructure and the limited storage capacity in vehicles (De Groot & Jeeninga, 2003).

Changes in the infrastructure

Additional infrastructure and supporting facilities are required for the large-scale implementation of hydrogen in society. Storage facilities, pipelines, refueling stations for hydrogen supply, but also trained personnel are necessary. A fine knitted pipeline network might be constructed, especially when hydrogen is transported to residential areas and refueling stations. The most pinching problem is that the success of hydrogen strongly relates to the large-scale use of this energy carrier. For example, people will not buy a fuel cell driven- vehicle while there is just one refueling station in the near surroundings. Large investments have to be made in a system that will not be used by its full potential during the start-up phase. This issue could partly be solved by decentralized production of hydrogen, which matches the supply and demand in a better way.

Environmental consequences

The conversion of hydrogen in fuel cell vehicles and household appliances only produces water vapor that is emitted to the atmosphere. This improves the local air quality to a significant extent. Also, fuel cell vehicles do not produce engine noise. Sound levels in urban and residential areas are brought down from 85 dB (average road way noise) to 70 dB or less and as a consequence sound pollution is reduced.

Safety issues

Hydrogen differs in physical properties from conventional fuels like gasoline and oil. Therefore, new ways of storage, distribution and use of the hydrogen are required. The immediate dangers are those of fire and explosion, since hydrogen burns over a wide range of concentrations in air. In confined spaces hydrogen is highly explosive, but in open areas an explosion is almost impossible because it dissipates rapidly into the atmosphere. When hydrogen is used in the built environment it is transported to the residential area and stored close to or in houses and buildings. Especially in the built environment the risk of leakage of the hydrogen should be addressed. The high diffusivity of the hydrogen makes that hydrogen leakage occurs more easily than natural gas leakage. Possibly, in houses this might involve higher risks and therefore more safety measures should be taken. It is important to develop equipment standards for hydrogen systems in residential areas. At the moment, experts do not agree on safety aspects of transport systems for hydrogen in residential areas (Hoogenraad, 2004). Risks associated with hydrogen storage in cars are considered equal to risks associated with natural gas and LPG.

Economic aspects

Production costs. The estimated cost of hydrogen produced by large-scale steam reforming with CO_2 capture is 8-10 €/GJ, but varies strongly depending on the gas price and location. Carbon capture increases the costs of hydrogen production with 11 to 21% depending on the case (NAE, 2004). Carbon capture reduces the efficiency of large-scale plants by about 10% (NAE, 2004). Main part of the costs, up to 50-75%, is made up of the fuel costs (natural gas). The costs of hydrogen are approximately three times as high as compared to the costs of natural gas.

Transportation. The cost of hydrogen is not solely determined by the production costs, but also the storage and distribution of hydrogen add to the costs. Costs for distribution of the hydrogen vary widely according to the method used. Hydrogen transport via pipelines is the lowest cost option when high volumes need to be transported. A large-scale hydrogen network could be similar to an existing natural gas network. Costs might be 50% higher due to the use of different materials and special design of pumping stations. Also pipelines should have a larger diameter because hydrogen has a lower volumetric density than natural gas. Other studies suggest that the costs for pipeline transport could be similar to the costs of pipeline transport of natural gas.

Infrastructure. The shift to a hydrogen economy definitely has infrastructural consequences in the way that large investments are required for implementation of a hydrogen infrastructure. A new infrastructure brings with it additional costs that are not counted for in the 'business-as-usual' scenario. The government would have to intervene to allow accounted investment in a new infrastructure for hydrogen.

End use. Typical costs of hydrogen (in €/GJ) for house-holds might be 18-20 €/GJ (Damen, 2007), whereas the price of natural gas for house-holds increased from 10 €/GJ in 2003 to over 20 €/GJ in 2009

The end use costs of hydrogen for transportation might result in higher costs because of additional requirements as storage and liquefaction of the hydrogen. In 2010, costs of gasoline (without taxes) is about 14-16 €/GJ and over 45 €/GJ including taxes. The additional costs to produce and deliver hydrogen at the fuelling stations are about 10 to 20 €/GJ; but the exact costs are not clear yet.

Fuel cell vehicles will be more expensive than gasoline based internal combustion engine vehicles (ICEV), due to the cost of the fuel cell and necessary electricity system. In 2010, a fuel cell vehicle costs are typically twice as expensive as conventional diesel or gasoline hybrid car. In the year 2030 a fuel cell vehicle will cost 1.500 to 2.000 € more than a diesel or gasoline hybrid car (Kromer & Heywood, 2007). Projected costs per kilometer driven are more or less the same for both types of cars.

Reliability of energy supply

The energy supply remains relying on fossil fuels when hydrogen will be produced from natural gas, oil or coal. Importing fossil fuels from other countries might become less reliable in the future, especially from geopolitical unstable regions. Importing LNG from other countries can enhance the security of supply. On the longer-term also renewable energy sources, such as biomass, wind, hydro and solar, could be introduced for conversion to hydrogen.

Societal aspects

Introducing hydrogen as an energy carrier affects people's personal lives, when the electricity and heat supplied into their houses comes from hydrogen combustion or when they drive fuel cell vehicles. People will have to get familiar with new vehicle technology and for example refueling techniques. Also the implementation of hydrogen combustion technology in houses and companies ask for acceptance of the users. In urban areas new installations have to be placed in all houses to replace the existing central heating systems.

Sources: See Reference Section

8.2.7 Option 7: Electricity Produced By Nuclear Power

Author: Andrea Ramírez Ramírez (Utrecht University)

The goal of this packet is to reduce 40 million tonnes CO_2 in 2030 by increasing the amount of electricity produced by nuclear power, from 450 MW_e in 2004 to 7350 MW_e in 2030.

Comparison Current Situation-Situation in 2030

In the Netherlands there is one working nuclear facility producing electricity: Borssele. In 2008, the electricity production of Borssele was 4.2 TWh_e (4% of the total electricity produced in the Netherlands). Current plans are to keep the Borssele unit open until the end of 2034. This is under the condition that the operator ensures that the facility will continue to belong to the 25% safest water-cooled and water moderated power reactors in the EU, USA and Canada. A reduction of 40 Million tonnes CO_2 in 2030 would require that new nuclear plants are installed with a total capacity of 7350 $MW_{e.}$ This could be done in 5 large plants. The most likely technology will be the Advanced Light Water Reactor (ALWR). Trends in the design of ALWR are the use of passive safety systems (do not require immediate operator intervention in case of malfunction) and the long life span of the plants (e.g., 60 years). An example of an ALWR is the Evolutionary Pressurized Water Reactor (currently being built in Finland).

Long- term potential

For the next century there are no resources constraints concerning uranium foreseen. Identified exploitable reserves of uranium (reasonable assure and inferred) available at less than $40/kgU are calculated to be about 3 million metric tonnes and between 7-24 million metric tonnes for total uranium resources available at less than $130/kgU (current use is about 69100 tonnes/year; current prices (2009) for uranium are in the order of 100$/kgU). The latter amount includes speculative resources such as commercial inventories, excess defense inventories, re-enrichment of depleted uranium tails, etc. In the future, new exploitable mines are likely to be discovered and in case of shortages, uranium could be exploited from seawater (uranium can be found in the world's ocean at a concentration of about 3-4 ppb, with a estimate cost of recovery 5 to 10 higher than land uranium mining).

Environmental consequences

Emissions. Nuclear energy emits zero emissions of greenhouse gases during operation. If the total chain of activities for nuclear power production is accounted for (mining operations, nuclear fuel conversion, nuclear power plant operation, decommissioning, transportation and waste disposal) life cycle analyses estimate CO_2 emissions are significantly lower than those produced by fossil fuels (about 15% of the emissions in a natural gas combined cycle plant and 6% of the emission of a pulvorized coal plants) but larger than the emissions of some renewable sources (e.g., 6 times higher than emissions of wind offshore). Nuclear energy does not produce local or regional air pollution (NO_x or SO_x). It releases, however, radioactive emissions from nuclear power plant operation and fuel cycle facilities. These emissions are strictly regulated and are found to be below natural background radiation. Due to this, the effects of accumulation of radioactive emissions in the atmosphere have received little attention up to now and are not completely known.

Land use. Nuclear energy has low land requirements. An ALWR (1000 MWe) would occupy an area of no more than 3 football fields. This amount is in the same order of magnitude that those required by fossil fuel plants but it is significantly lower than for power generation based on renewables (for the generation of 1000 MWe, it is required solar parks between 20-50 km^2 or, in the case of on-shore wind fields, areas between 50-150 km^2).

Nuclear Waste Disposal. Radioactive waste production occurs at basically every step of the nuclear state cycle, however it is the management of high-level radioactive spent fuel what is considered the main problem of nuclear energy. Although it is a relatively small amount (in 2004, Borssele produced about 1.3 m^3 of high-level radioactive spent fuel), this kind of waste generates heat until years after having been de-loaded from the reactor core while remaining highly radioactive for several thousand years. No country has yet successfully implemented a system for permanently disposing of this waste. Plans for future waste disposal will most probably be based on reprocessing and eventual placement in deep geological repositories. Currently Finland, France and Sweden are considering geological storage as an option for the medium- long term (after 2020). The main issue concerning geological storage is whether geological isolation offered by underground layers will be sufficient in the very long-term (over hundred thousand years). The main fear is that canisters will start to leak as a result of corrosion after many centuries or thousands years, and consequently if there is lack of geological containment, contaminate ground water. In theory, technology can be used to decrease the time that nuclear waste will remain radioactive (e.g., from 100.000 years to 200-300 years). These technologies are at an experimental stage and some estimate that when (if) available in the market they will increase the electricity price by about 20-30%.

Safety risks

Nuclear Reactor Safety. If compared with other fuel cycles, the consequences of a nuclear accident can be significantly larger: more fatalities per accident; hereditary effects; radioactive contamination of areas surrounding the reactor with the consequent loss of land and land use, and impact on the populations of existing ecosystems. ALWRs have been designed with the specifications that the consequences of such an accident should be limited to the reactor premises. It is estimated that in case of an accident, about 1.5 km around the reactor should be evacuated and that 20*40 km^2 of land around the reactor will be unusable for several years (one year being the most optimistic scenario). The probability that such an accident happens is rather small. Statistically, the chance of a core damage accident in a current LWR has averaged 1 per 1.000.000 per reactor per year. Furthermore, since ALWRs operate with passive safety systems, they are expected to operate with even lower levels of risk to the public than current LWRs. Due to these low levels of risk probability, the total mortality of nuclear fuel cycle operation is estimated to be significantly lower than for other fuel cycles. A historical analysis for the period 1961-2000 shows that the *immediate* fatalities associated with the full energy chain are the lowest for nuclear energy (e.g., 6 deaths/TWh_e for nuclear, 93 deaths/TWh_e for gas, 876 deaths/TWh_e for coal). The estimated risk for *latent* fatalities is in the order of 10-1000 deaths/TWhe (other fuel chains do not have *latent* fatalities).

Nuclear Weapon Proliferation. Some experts hold that increasing world civil nuclear power could increase weapon proliferation (fusion devices and radiological 'dirty' bombs), whereas others hold that there is no causal relation. The risk is associated with the development of nuclear knowledge, nuclear installations (including enrichment facilities) with inadequate controls, transfer of technologies and increase availability of separated plutonium that could be used for weapons. A nuclear weapon can be produced with materials separated from the spent fuel of civilian power reactors or, more likely, from uranium enrichment facilities. It is, however, recognized that the elimination of civil nuclear power does not eliminate the possibility of a country embarking on a nuclear weapons program. An additional source of concern has risen since 'September 11': the possibility of terrorist attacks on nuclear installations (power plants and spend fuel cooling ponds).

Economic aspects

The plant construction costs of an ALWR are about 1.5-5 times higher than an equivalent capacity conventional power plant based on natural gas (investments costs for an ALWR are reported between 3500 and 4800 $/kWe (decommissioning of the plant are not included). The competitiveness of nuclear energy produced by ALWRs in 2030 will depend in the capacity of the industry to lower investment costs and construction time as well as the inclusion of external costs in the electricity prices of all fuel cycles. It is estimated that, if the price of electricity were to include the consequences of health and environmental damage, the price of electricity produced by nuclear power would increase about 0.4 euro cents/kWh (0.2-0.7 cent averages in different European countries), while for coal it would be over 4.0 cents (2-10), gas ranges 1.0-4.0 cents and only wind shows up better than nuclear, at 0.05-0.25 cents/kWh.

Nuclear energy is less subject to supply security issues than fossil fuels both with respect to supply disruptions (uranium supply is geographically and politically diverse) and price volatility. For instance, a doubling of natural gas price would generate a 65-75% increase kWhe price, while doubling uranium price would only increase the kWhe price by 5-9% (fuel costs in a nuclear energy account for about 10% of the electricity costs while in a natural gas power plant the share is about 80%).

Sources: see Reference Section

8.3 English translation information ICQ

8.3.1 Consequences of the increase in temperature caused by the greenhouse effect.

Drought

The expected increase in temperature has consequences for the climate of the entire world. Some regions of the world may experience extreme drought as a result of global warming. The chances are fair to high that global warming will lead to an increase of failed crops and famine, especially in regions where temperatures are already high.

Warmth

In areas where the temperature is currently low, for instance Siberia, the climate may be less cold. Earnings from agriculture may become higher there. New wildlife area's may develop in some parts of the world.

More extreme weather

The greenhouse effect may lead to changes in extreme occurrences such as heavy rainfall, snowfall and storms. Experts expect the violence, duration and intensity of these occurrences to increase. Storms all over the world, including hurricanes, will in all probability become more violent en cause more damage. The chance of floods will increase in many areas due to heavy rainfall, snowfall and storms.

Sea level rise

The increase in temperature will cause part of the polar cap to melt and the oceans to expand, which will cause the sea level to rise. The sea level in the entire world may rise 18 to 59 centimeter on average between 2007 and 2099. In some area's local sea currents can cause a higher sea level at the coastline. Around The Netherlands the rise in sea level may accumulate to 85 centimeter between 2007 and 2099. Area's in the world that are just above sea level now may be submerged. For example, countries that consist of groups of small islands are expected to be partially or completely submerged in the course of this century as a result of the rise in sea level. Nature will be affected all over the world, and natural habitats will disappear as a result of the increase in temperature and the rise in sea level. As a result, many species of plants and animals may face extinction. Coral reefs are very vulnerable and may disappear because of the global rise in temperature. In the Netherlands, the Wadden isles and surrounding natural habitats may be lost. Overall, vulnerable countries or wildlife area's may be affected or may disappear.

Rising water in and around the Netherlands

In the Netherlands, the increase in temperature on earth could mean that the Dutch will more often be confronted with rivers flooding because of heavy rains, which will diminish the area available for living and working. To avoid this, the government has decided to dedicate areas as flood meadows to cope with temporary excesses of river water. The establishment of these area's and the increase in flood-risk areas will diminish the areas available for living and working. Measures will have to be taken to protect the coastline from the rise of the sea level and the heavy storms. The coastal defences must be strengthened, for instance by increasing the height of the dykes. In addition, river dykes will need to be built up to prevent flooding. Overall, protective measures may be necessary and the Dutch areas for living and working may be diminished.

Victims in poorer countries

Not all countries will have the possibilities to make adjustments. The poorest countries of the world are probably the least able to take adequate preventative measures. They will therefore suffer the most from the consequences of the increase in temperature. Floods, for example, already cause tens of thousands of deaths worldwide on an annual basis, and this number may increase exponentially over the course of the century. These deaths will, for the most part, occur in poorer countries. Developing countries will also be increasingly exposed to threats such as famine and infectious diseases. Because of this, many people in poorer countries may be forced to emigrate.

Summers in The Netherlands

In The Netherlands, the summers will be warmer due to an increase of extreme weather situations. There will be more heat waves. People in poor health (for example the elderly) will more often be ill and die of heat and of the increase in germs. The warmer summers may cause an increased incidence of tropical diseases in the Netherlands. Expectations are that more allergies will occur and that more diseases will be spread by insects, such as Lyme's disease.

Winters in the Netherlands

The winters in The Netherlands will be less cold. There will be fewer cold fronts, so that less people will fall ill or die because of the cold.

8.3.2 Improvement of energy efficiency

This package aims to reduce CO_2 emissions by 40 million ton in 2030, by making appliances, cars, houses and the production of goods more energy efficient. "Energy efficiency" is the decrease of energy that is necessary for an equal result. For instance, the energy that is necessary to heat a medium house. Or, the energy needed to produce a ton of steel; or the energy needed to drive 1 kilometer with a car. For instance, by developing more efficient technologies or better isolated houses or more efficient cars there is less energy needed for the same result. Without extra measures the energy saving improves every year. To save 40 million ton of CO_2 emission, extra energy efficiency of 1% per year on appliances, cars, houses and factories has to be established. To achieve this 1 % of energy saving per year, the government has to take mandatory measures. These measures will have to make sure that companies and civilians make an effort to create more energy efficient appliances, cars, houses and to optimize the production of goods. Because this package requires less energy for the same result, there is less fuel needed to generate energy.

Contribution to air quality

When this package of measures for energy efficiency is applied, the amount of air pollution caused by the use of energy will decrease, because less fuel will be used for cars, electricity and industry. Due to this package people's health will improve because of cleaner air.

Use of natural sources

For this package appliances and machines will be developed which are not only more efficient, but also have a longer life span. By doing so, appliances and machines have to be replaced less often. This reduces the use of materials needed to make these appliances and machines. It also reduces the amount of waste, because materials are used more efficiently and because appliances and machines are not discarded as quickly as before.

Reliability of the energy supply

Because less energy will be needed for appliances, houses and manufacturing, The Netherlands will become less dependent of the import of fuel from other countries, such as the Middle-East.

Economic consequences

Because of the decreasing demand for energy, less money will have to be invested in new power plants and power cables. The consumption of crude oil, gas and coal will also decrease. The money that will come available with these efficiency measures can be used for other purposes. Some experts think that this package will possibly create hundreds of thousands additional employments within the European Union, especially in construction

Measures to reduce fuel use for transportation

This package will lead to European legislation demanding that cars can drive for 18 kilometers on 1 liter of fuel by the year 2035. In 2005 cars could drive approximately 10 kilometers on 1 liter of fuel. At first the price for these efficient cars will be much higher, but experts predict that with mass-production of these cars, prizes will eventually drop. These cars are more efficient in use. Heavy cars (like for instance SUVs) will become more expensive. Instating toll roads and additional taxes for polluting cars are other examples of government policies which can be taken to reduce fuel use. Taking everything into account, for people using a lot of fuel the costs for car use will probably increase.

Consequences for manufacturers

By implementing this package manufacturers will be forced by strict rules and legislation to improve the efficiency of their equipment and technologies. For instance equipment used for propulsion and cooling will have to be made more efficient. These kinds of equipment and technologies will be more expensive but because of the decreased energy use, overall they will be equally expensive as less efficient technologies and equipment.

Consequences for houses and buildings

This package will result in strict policies which will force new houses and buildings to be built more efficient. By providing allowances for isolation or by applying taxes the improvement of existing, badly isolated houses and buildings will be stimulated.

Price

This package will result in additional taxes being applied in order to stimulate people to reduce the energy consumption. This will result in higher energy prices, but to what account is not known. It's possible that the government will use the increased income from these taxes to lower other taxes. Houses and equipment will become more efficient and therefore use less energy. Because of this decrease in energy consumption experts think that households will be presented with lower energy bills, but it's also possible that these bills will be higher.

Contribution to the greenhouse effect

The contribution to the greenhouse effect of CO2 emissions would be greatly reduced by this package. The emission of CO2 into the air would be 17% less than the amount that is currently being emitted.

8.3.3 Improvement of energy efficiency and decreased use of materials and energy

This package aims to reduce the emission of CO_2 by forty million tons in 2030. This package is an addition to the first package "Improved energy efficiency". This first package aims to reduce the emission of CO_2 by forty million tons, by improving the efficiency of appliances, cars and houses with 1 percent per year. This second package is an addition to the first package and aims to reduce another forty million tons of CO2 by improving efficiency another 1 percent per year. The first and second package together lead to a reduction of CO_2 emission by eighty million tons in 2030. To implement this package the government has to take extremely tough and stringent measures, even tougher than necessary for the first package. These measures have to make sure that companies as well as individuals will do their absolute best to make their appliances, cars and houses more efficient. In addition, strict government policies such as deposits, taxes and fines will have to force people to reduce the use of energy and materials.

Contribution to air quality

Because in this package less energy is required for the same kind of use, less fuel is needed to generate energy. When this package of efficiency measures will be implemented the air quality will be improved because less car fuel will be burned. Around five thousand people a year die early in the Netherlands due to consequences of poor air quality caused by traffic exhaust gasses. When this package will be implemented, people's health will be improved, even more than with the first efficiency package.

Economic consequences

Because of the decreasing demand of energy, less money has to be spent for new power plants and power cables. The use of coal, gas and oil will decrease. It's not certain that these cost reductions will have a positive effect because of the need of great investments in houses, industrial sector, appliances and cars.

Consequences for transportation

For this package car engines will not only have to become much more efficient, but cars also have to be made out of different, lighter materials. Cars can therefore become more expensive but consume less fuel. Toll roads will be instated so that public transportation will cost people less than traveling by car. Also the goods-traffic will have to deal with these increasing costs. Products imported from far away like kiwis and bananas for instance will become more expensive. Prices of Air travel will also rise because of the obligation to use more efficient but therefore more expensive airplanes, which costs will be recharged to the ticket prizes. Depending on the travel distance a flight could become 8 to 40 Euros more expensive if CO_2 emissions are taxed. Taking everything into account, most ways of transportation will be more expensive.

Consequences for manufacturers

To be able to implement this package, very innovative technologies are needed. These will cost more money and will therefore be more expensive for the manufacturing industry. It's possible that because of the extra costs involved for production, some products will be more expensive for the consumers.
In this package the manufacturers are held responsible for disposing and recycling of packing materials and end products. One example is the institution of a deposit, not only for soda bottles, but for more sorts of packaging materials. Also measures have to be brought in place to make people increase their level of recycling, for instance by informing the people or implementing fines when people don't recycle their waste.
To make sure that this package will be effective, strict rules have to be applied to manufacturers.

Consequences for consumers

Because consumer products have to be much more energy efficient for this package, it's possible that certain products will be difficult to bring to market or become very expensive. Products possible will become less luxury, smaller in size or less beautiful. For instance very large cars, jacuzzis or waterbeds will be very hard to get a hold off or be very expensive.

Consequences for houses and buildings

By implementing this package strict measures have to be taken to force the improvement of energy efficiency of houses and buildings. New houses and buildings will be designed in such a way that energy consumption is brought back to an absolute minimum. For older buildings the energy consumption has to be drastically reduced (for example between 70 and 90%). The modifications needed will cost quite a lot of money. For this package people either have to invest largely in energy efficiency measures, or drastically change their behavior (for instance by lowering the temperature in their houses).

Price

By implementing this package higher taxes will be applied to energy in order to stimulate people to reduce energy consumption. As long as a household doesn't cross a certain level of energy consumption, an energy unit is not that expensive, but when a household rises above this level, energy will become a lot more expensive per unit. The pricelevel of energy will be higher than the level mentioned in the first efficiency package. Expectations are that electricity will be at least 20 to 40% percent more expensive than nowadays.

Contribution to the greenhouse effect

The contribution to the greenhouse effect would be greatly reduced by this package. The emission of CO_2 into the air would be 17% less than the amount that is currently being emitted.

8.3.4 Electricity from windturbines at sea

This package aims to reduce the emission of CO_2 by forty million tons by the year 2030 by generating electricity using approximately twenty clusters of wind turbines in the Dutch North sea. These clusters will be placed at several locations in the sea along the whole Dutch coast at least twenty kilometers from the coast.

Effects to the view

For this package 20 parks of wind turbines with a total of 1500 to 3000 wind turbines will be placed in the Dutch North sea. These wind turbines will be approximately 150 meters in height, including the up to 60 metres long wings. During a few days per year that are very clear, it's possible that some of the wind turbines will be visible from the coast.

Consequences for birds.

Sometimes birds fly into the wings of wind turbines located on land and most of the times, they don't survive this. Nowadays approximately 50.000 birds die each year because they fly into wind turbines. As a comparison: every year more than 2 million birds die in traffic. By implementing this package the amount of wind turbines will increase, but because of their location far from the coast, expectations are that these wind turbines will kill less birds than the wind turbines currently located on land.

Consequences for ocean fish and mammals

Research shows that the movements of ocean fish and sea mammals are not influenced by wind turbines at sea, as long as their habitat isn't interrupted too much by large clusters of wind turbines. It is yet unknown which amount of interruption causes hinder to fish and mammals. Wind turbines can act as artificial reefs and offer protection to fish, which can lead to an increased fish population in the Dutch North sea.

Consequences for the fishery

By placing parks of windmills at sea, the amount of Dutch fishing grounds decreases. The windmill parks will approximately take up one twentieth of the Dutch North sea. There is a chance that the whole area in which the wind turbines are placed, including a safety zone, won't be accessible for the fishery any more. The most important consequences for the fishery will be loss of parts of the fishing grounds and possible increase of sailing times to reach areas where fishing is allowed.

Dealing with fluctuations in electricity production

Because of the wind-dependency of wind turbines, sometimes they don't produce enough electricity, sometimes too much. It's possible to intercept an electricity surplus by pumping water in a buffer area. When more electricity is needed than can be produced, water can be released from the buffer through a turbine which produces electricity. To transport an electricity surplus the electricity infrastructure has to be improved. A small amount of additional power cables will be necessary.

Consequences for employment

To implement this package, approximately 1500 to 3000 wind turbines have to be built and maintained. Some experts think that around the year 2030 this will have resulted in tens of thousands additional full-time jobs, mainly in The Netherlands.

Price

In the year 2030 electricity produced by wind turbines will be approximately 10-15% more expensive than nowadays. The Dutch industry will have to pay approximately 25-30% more for electricity.

Contribution to the greenhouse effect

The contribution to the greenhouse effect would be greatly reduced by this package. The emission of CO_2 into the air in the Netherlands would be 17% less than the amount that is currently being emitted.

8.3.5 Conversion of biomass tocar fuel and electricity

This package aims to reduce the emission of CO_2 by forty million tons by making a share of the cars use fuel converted from biomass and by making power plant use biomass as a fuel for the generation of electricity. Biomass is a term which defines a variety of organic material such as wood, grass, organic waste, etc. Biomass can be used to generate electricity but also to create fuel for cars. During the growing process plants withdraw CO_2 from the air. This CO_2 is released again when biomass is being burned. By burning plants, the amount of CO_2 that is released is not lager that the amount of CO_2 that has been withdrawn by the plants during growth. Therefore biomass is CO_2 neutral. This package is not completely CO_2 neutral because of the need for transportation and handling of the biomass. To be able to reduce forty million tons of CO_2 by using biomass by the year 2030, approximately eighty percent of the biomass will have to be imported. Most of this biomass will be converted into modern biofuel for cars, partly abroad, partly in The Netherlands. For the conversion of biomass into fuel, biofuel factories have to be built. Also there's a change that a portion of currently used oil refineries, where crude oil is converted to petrol and diesel oil, slowly will be converted to or replaced by biofuel factories. In that case in The Netherlands a small portion of this biomass will be converted into electricity by three or four large power plants in seaports like Rijnmond, Eemshaven or Terneuzen.

Contribution to air quality

Vehicles burning biofuel emit less toxic gasses and this leads to better air quality in cities compared to the current situation. In The Netherlands around 5000 people a year die early from the consequences of poor air quality caused by traffic exhaust gasses. When this package is realized on a large scale by the year 2030, air quality in The Netherlands will be greatly improved. This may improve the health of many people.

Use of land for biomass with certificate

Land is needed to obtain biomass. To be able to obtain sufficient amounts of biomass for this package, land is needed in amounts which vary from half of the surface of The Netherlands to a surface larger than The Netherlands. Therefore most of the required biomass will have to be imported from regions such as Latin America, South and Eastern Africa, Eastern Europe/Russia and the vicinity of Australia. Biomass which is produced in a responsible manner (for instance by using grass or trees) will be certified (just like the certificates for hardwood). Responsibly produced biomass can result in an increase of income and employment and a decrease in poverty for the afore-mentioned regions. In addition the cultivation of these kind of crops can result in an improvement of the cultivating ground which in turn can result in a more lasting and during form of agriculture.

Use of land for biomass without certificate

Some experts think that The Netherlands will be able to import sufficient amounts of certified biomass needed for this package. Other experts think that this may become problematic, especially when other countries start importing large amounts of biomass too. Uncertified biomass isn't always produced in a responsible way which can have serious implications for the areas where the biomass is being produced. Worst case scenarios include exhaustion of water reserves, destruction of other cultivating grounds and/or forests and the banishment of small independent farmers.

Influence on food production

When a large amount of countries start using biomass, there is a possibility that the need for cultivated land will be of such proportions that the amount of cultivated land available for food production will become too small. By improving agriculture in areas where the production is low, the same amount of food can be grown with a smaller amount of land so that more land will become available for the cultivation of biomass. Biomass can also be bred on grounds which are unusable for food growth. By cultivating biomass on these grounds, in some cases the breeding of biomass results in an improved quality of the cultivated land in such a way that it becomes possible to cultivate food on grounds which were not suitable before. The surpluses of forestry and agriculture which normally aren't used (such as leftover wood, saw-dust, straw) can be used as biomass.
Cultivation of biomass can lead to rivalry with the cultivation of food, but breeding biomass can also lead to improved management of cultivating grounds and stimulate an improved efficiency when it comes to cultivating food.

Reliability of the energy supply

Experts place a great deal of importance on the reliability of the energy supply. This means that there should, at any given time, be enough energy available. The fuels needed for energy production partly have to be imported, but without being dependent of a small number of supplying countries (such as our current dependency of the Middle-East when it comes to crude oil). Biomass can be imported from lots of different countries on different continents. Some experts think that certified biomass can be imported from less countries. The change that the biomass needed for this package can't be imported in sufficient amounts is very small. Because biofuels replace crude oil the dependency towards the import of crude oil decreases. Therefore the reliability of the energy supply is reasonably good.

Expansion of seaports

To be able to import and process the biomass necessary for this package larger seaports are required. Therefore the available seaports have to be expanded. The expansion of the seaports will result in additional employment. The increase in employment by this package will be larger than the decrease in employment resulting from a decreased use of coals and oil.

Necessity of new vehicles

Most of the current cars are equipped to handle fuel which is partly biofuel (for these cars the biofuel is mixed with petrol or diesel). For this package approximately two thirds of all cars gradually have to be replaced by the year 2030 with cars that are equipped to handle pure biofuel. These cars have already been developed and are identical to the current cars apart from the fuel needed.

Economic consequences

In this package biofuel replaces crude oil. Because biofuels, in time, will be less expensive than crude oil, less money will leave The Netherlands. This will have a positive result on the future trade balance of The Netherlands. This can have positive results on the Dutch economy.

Price

The price of electricity produced from biomass is expected to be equal. The price of car fuel based on biofuel is expected to be a little lower. When the same level of taxes will be applied, in 2030 biofuel will be priced the same or possible 20% per liter lower than petrol currently is.

Contribution to the greenhouse effect

The contribution to the greenhouse effect of CO_2 emissions would be greatly reduced by this package. The emission of CO_2 into the air would be 17% less than the amount that is currently being emitted.

8.3.6 Large plants where coal or gas is converted into electricity with capture and storage of CO2

This option aims to decrease CO_2 emissions by 40 million ton, by capturing CO_2 that is produced by coalfired and gasfired power plants and storing it underground in The Netherlands or under the Dutch part of the North Sea. CO_2 capture can take place at existing power plants or be fitted into new plants. It is expected that by 2030 about half of the power plants with CO_2 capture and storage will be coal fired and the other half will be gas fired. This package can be implemented temporarily because the space available for CO_2 storage will get full and natural gas and coal will eventually run out. The current knowledge of the subsoil leads to the expectation that there will be storage space for about 100 to 300 years. More research into the safety and availability will be needed to determine if all this storage space can be used. Research might however show that there is more space available than currently expected.

Contribution to pollution due to coal mining

The coal needed for the 20 plants will be mined abroad. The area around the coal mines is highly polluted in some countries, less in others. The degree of pollution of the land, water, and air will vary from little to very high in the area surrounding the mines, depending on the countries from which The Netherlands imports the coal needed for this package.

Safety of CO_2 transport in pipelines

Too much CO_2 in the air is hazardous and can even be lethal. During the transportation of CO2 in pipelines, the pipeline may spring a leak, causing the CO_2 to be emitted into the air. There is a small chance that a cloud of CO_2 which is dangerous for people, animals and plants, will keep hanging in the air without dispersing. The chance of leakage is comparable to the chance of gas leakage in the current underground gas pipelines in The Netherlands. Approximately 2000 kilometers of pipelines will be needed for this package. For this amount of pipelines, it can be expected that accidents will occur about once every two years, but this will not always lead to the escape of CO_2. Expectations are that by placing good systems for monitoring the chance of leakage of CO_2 from pipelines will become very small.

Safety of underground CO_2 storage

Subsoil storage of CO_2 can cause minor earthquakes similar to those caused by natural gas mining. This might cause small ruptures in buildings in the area. Once CO_2 is stored in the underground storage space, it might leak away through poorly sealed wells, and tears and cracks in the sealing layer of the underground storage space. When an underground storage space keeps leaking for years, this will for the most part undo the emission reduction effect of this package. Although experts are not sure how much CO_2 would be released into the air, quantities are likely to be extremely small. In addition, there is a very small chance that the leaked CO_2 would accumulate in low lying closed spaces such as cellars. This would be hazardous and possibly lethal for humans, animals and plants occupying this type of space. There is a small chance that CO_2 leakage acidifies the surrounding groundwater. If this is used for drinking water, it will only be potable after additional treatment. Expectations are that good monitoring will make the risk of CO_2 leakage from underground storage space very small.

Reliability of the energy supply

Experts place a great deal of importance on the reliability of the energy supply in that it is important that we will always be able to generate enough energy. Part of the fuels necessary for this must be imported from other countries. We do not wish to be dependant on the politics of only a few countries, such as the dependence on the Middle East for oil. Coal can be imported from several countries in several parts of the world. The chance that the coal needed for part of this package cannot be imported is therefore very small. The reliability of the energy supply from part of the power plants is, therefore, high. The use of natural gas as fuel is less reliable if it has to be imported from other countries.

Price

If electricity is generated in power plants with CO_2 capture and storage, businesses will have to pay about 20% more for their electricity in 2030. Households will have to pay approximately 5% to 10% more.

Contribution to the greenhouse effect

The contribution to the greenhouse effect of CO_2 emissions in the Netherlands would be greatly reduced by this package. The emission of CO_2 would be 17% less than the amount that is currently being emitting.

8.3.7 Conversion of natural gas into hydrogen in large plants with CO_2 capture and storage

This package aims to reduce CO_2 emissions by 40 million ton, by producing hydrogen and by capturing and storing the CO_2 that is produced in this process. Hydrogen is a gas that releases energy in the process of combustion. Hydrogen can be used to generate electricity. It can also be used as fuel for cars, and in households to replace natural gas. About 20 to 25 large hydrogen factories will be built for this package. The CO_2 that is produced during the conversion of natural gas into hydrogen, will be captured and stored underground in The Netherlands and under the bottom of the North Sea. The hydrogen from the 20 to 25 factories will be used in part to provide most of the cars in the Netherlands in 2030 with fuel. Current fuel stations will have to be altered for this in such a way that hydrogen can be stored and withdrawn there. The hydrogen will also be used in part to provide the majority of households and industry with hydrogen, where the hydrogen can be converted into electricity and warmth in small installations. In households, such an installation is comparable to a central-heating boiler. This package can be implemented temporarily because the space available for CO_2 storage will get full and natural gas and coal will eventually run out. The current knowledge of the subsoil leads to the expectation that there will be storage space for about 100 to 300 years. More research into the safety and availability will be needed to determine if all this storage space can be used. Research might however show that there is more space available than currently expected. It is likely that the infrastructure (such as installations, fuel stations and the pipeline grid) can be used after this time, because by then other ways will have been developed to produce hydrogen without natural gas.

New pipelines needed

The hydrogen would have to be transported to businesses and to hundreds of thousands of homes and buildings. This would necessitate a dense network of many underground pipelines. The realization of this network will be massive and time-consuming, and will cause inconvenience due to excavations, including in residential areas.

New vehicles needed

The implementation of this package necessitates the replacement of all cars by hydrogen fuelled cars. These cars could be more expensive in 2030 than a car that runs on gas, but it is expected that fuel cell cars will become less expensive over time.

Contribution to air quality

Vehicles powered by hydrogen emit almost no poisonous substances, and improve the air quality in the cities greatly. In The Netherlands, approximately 5000 premature deaths are caused by poor air quality due to traffic exhaust. When this package is realized on a large scale in The Netherlands around 2030, thousands of lives will be saved annually in the Netherlands because of the cleaner air.

Contribution to noise

Engines from cars and other vehicles that run on hydrogen, do not make any noise. The implementation of this package will lead to a decrease in the level of noise in cities and residential areas from 85 decibel to 70 or less decibel. (For example: 85 decibel is about the level of noise from a crowded intersection in the city, 70 decibel is about the level of noise from a calm intersection).

Safety of hydrogen plants

There has been a lot of experience gained in the last decades in the industry with the conversion of natural gas into hydrogen. The designs of these factories and the necessary safety precautions are standard. Experts do not always agree if hydrogen factories can be made as safe as current gas fired plants.

Safety of use of hydrogen in daily life

Experts believe that transporting hydrogen through pipelines and using hydrogen in homes can be made as safe as the existing transport and use of natural gas. Costs for technical safety measures are, however, probably higher. Accidents caused by asphyxiation, fire or explosion will not occur more often than at present. Safety measures would make the use of hydrogen in fuel stations, buses and trucks just as safe as the current use of petrol.

Safety of CO_2 transport in pipelines

Too much CO_2 in the air is hazardous and can even be lethal. During the transportation of CO_2 in pipelines, the pipeline may spring a leak, causing the CO_2 to be emitting in the air. There is a small chance that a cloud of CO_2 which is dangerous for people, animals and plants will keep hanging in the air without dispersing. The chance of leakage is comparable to the chance of gas leakage in the current underground gas pipelines in the Netherlands. Approximately 2000 kilometers of pipelines will be needed for this package. For this amount of pipelines, it can be expected that accidents will occur about once every two years, but this will not always lead to the escape of CO_2. Expectations are that by placing good systems for monitoring the chance of leakage of CO_2 from pipelines will be very small.

Safety underground CO_2 storage

Subsoil storage of CO_2 can cause minor earthquakes similar to those caused by natural gas mining. This might cause small ruptures in buildings in the area. Once CO_2 is stored in the underground storage space, it might leak away through poorly sealed wells, and tears and cracks in the sealing layer of the underground storage space. When an underground storage space keeps leaking for years, this will for the most part undo the emission reduction effect of this package. Although experts are not sure how much CO_2 would be released into the air, quantities are likely to be extremely small. In addition, there is a very small chance that the leaked CO_2 would accumulate in low lying closed spaces such as cellars. This would be hazardous and possibly lethal for humans, animals and plants occupying this type of space. There is a small chance that CO_2 leakage acidifies the surrounding groundwater. If this is used for drinking water, it will only be potable after it additional treatment. Expectations are that good monitoring will make the risk of CO_2 leakage from underground storage spaces very small.

Reliability of energy supply

Experts place a great deal of importance on our being able to generate enough energy. Parts of the fuel necessary for this package must be imported from other countries. We do not wish to be dependent on the politics of only a few countries, such as the dependency on the Middle East for oil. In order to ensure high reliability it is possible to store reserves of gas for later use. It is also possible to produce hydrogen from other fuels than natural gas, such as coal or biomass.

Economic consequences

The Netherlands would have to invest a great deal of money in all of the changes necessary for the implementation of this package, including new installations and vehicles, and numerous CO_2 pipelines. It is unknown what the effect of these investments would have on the economy.

Price

The costs of hydrogen for households will be approximately 25-35% higher than that of natural gas. Producing hydrogen is about twice as expensive as petrol. Because of this, the car fuel price will rise with about 20%. Electricity generated from hydrogen with this technology will cost the industry approximately twice as much as it does now. The fuel costs for road traffic will probably rise much less because hydrogen fuelled cars will be more efficient. It is expected that the costs for driving a hydrogen fuelled car in 2030 will be equal to the costs of driving a diesel car.

Contribution to the greenhouse effect

The contribution to the greenhouse effect of CO_2 emissions in The Netherlands would be greatly reduced by this package. The emission of CO_2 would be 17% less than the amount that is currently being emitting.

8.3.8 Electricity from nuclear plants

This package aims to reduce the emission of forty million tons of CO_2 by generating electricity in five large nuclear power plant by the year 2030. In nuclear power plants uranium is used as fuel. Uranium is dug from uranium mines. Generating electricity by using uranium doesn't produce CO_2. The amount of uranium required for this package will be available for at least one hundred years, even when more countries will start to use uranium and with that the global use increases. It's very likely that new uranium sources will be discovered, in which case the nuclear power plants can be supplied for a long time.

Background radiation during normal operation

During normal operation of a nuclear power plant very small particles are released which produce very small amounts of radioactive radiation. The amount of radiation is even less than normally present in the area by nature. This amount of radiation will not cause any health problems on the short term. Some experts think that on the long term there will not be any risk of health problems due to this very small amount of radiation. Other experts think that we do not have enough knowledge to make predictions about this.

Nuclear waste

In the process of preparing uranium for the use in nuclear power plants, but especially when using uranium in the actual power plants, nuclear waste is produced. A portion of this nuclear waste will be very radioactive for thousands of years; it will produce a lot of radiation. In this package the nuclear waste will probably be stored in heavily secured barrels in deep underground storage facilities. Experts know that this method of storage is safe for the first couple of centuries and that there will be no leakages of any kind. Experts think that after this initial period the risk of leakage is very small, but they acknowledge the existence of uncertainties, because it's hard to predict what happens underneath the ground. Some experts think that as of 2030 it will be possible to treat nuclear waste in such a way that it will be strongly radioactive for a maximum period of 200 to 300 years. Other experts doubt whether this technology of nuclear waste treatment will be developed enough in 2030 to be able to use it at that time. Leakage of nuclear waste can produce health problems with plants, animals and people in cases where for instance the leakage occurs in the vicinity of the ground water. This may be prevented by making sure that the storage of the nuclear waste does not take place in the vicinity of ground water, but there's no way to be sure that in thousands of years the ground water will not get closer to the nuclear waste. Taking everything into account, experts predict that the risk of health problems for plants, animals and people caused by leakage of nuclear waste is very small.

Safety of nuclear power plants

The nuclear power plants mentioned in this package are build in such a way that human interference is unnecessary regarding checking the system for failures or resolving these failures. A protective dome will be constructed around the nuclear power plant. Therefore these power plants are safer than the current nuclear power plants and much safer than for instance the former nuclear power plant in Tsjernobyl. The nuclear power plants mentioned in this package are just as safe as the current chemical industry in The Netherlands. The chance of a serious accident is very small. An example of a very serious accident with the power plant in this package is an accident with the reactor. People living within one and a half kilometer of the power plant have to be evacuated. An area with a radius of 20 by 40 kilometers around the power plant will be completely unusable for at least one year, but possibly a lot longer. The chance of an accident like this happening is less than once in two hundred thousand years. The chance of accidents with even more serious consequences is much less.

Protection of power plants against terrorist attacks

Some people are concerned about terrorist attacks on nuclear power plants with devastating results. The power plants mentioned in this package are very efficiently protected. Accidents with the reactor using bombs or airplane crashes on top or in the close vicinity of the power plant are very hard to accomplish. Sabotage by employees is not impossible, but difficult.

Nuclear power plants en nuclear weapons

Spreading of nuclear weapons means that either countries currently not in possession of nuclear arms will be enabled to produce them or that nuclear weapons fall into the hands of terrorists. According to some experts, the spreading of nuclear arms will be more likely because of the development and use of nuclear power plants. Some experts think that when knowledge is being developed about nuclear technology for power production, this generates more knowledge about nuclear weapons as well. In addition to that, some expert think that the development of materials needed for the power plants leads to availability of materials used in the production of nuclear weapons. Other experts state that there is no connection between the development and deployment of nuclear power plants and the spreading of nuclear weapons.

Reliability of the energy supply

Experts place a great deal of importance on the reliability of the energy supply. This means that there should, at any given time, be enough energy available. The fuels needed for energy production have to be imported, but without being dependent on a small number of supplying countries (such as our current dependency of the Middle-East when it comes to crude oil). Uranium can be imported from lots of different countries on different continents. Therefore the chance will be very small that the uranium needed for the nuclear plants cannot be imported. Besides that, building reserves of uranium is very easy because of the small amount of space uranium takes. Taking this into account, the overall reliability of energy coming from these plants will be good.

Price

Some experts expect that the price of electricity produced by nuclear power plants will be roughly the same as the current price of electricity produced by coalfired power plants. The price will increase when additional security measures have to be taken or when the nuclear waste from the plants has to be treated to reduce the period of radio-activity. Some experts estimate that due to these measures the price of electricity coming from nuclear power plants will be twenty percent higher. The costs involved in building a nuclear power plant are very high, but if and in what amount this has an effect on the price of electricity is unknown.

Contribution to the greenhouse effect

The contribution to the greenhouse effect of CO_2 emissions would be greatly reduced by this package. The emission of CO_2 into the air would be 17 % less than the amount that is currently being emitted.

8.4 The Knowledge and Beliefs Test (Dutch)

Onderzoeksinstituut ECN voert in samenwerking met de Universiteit Leiden en de Universiteit Utrecht een onderzoek uit naar uw mening over een aantal onderwerpen. De resultaten van dit onderzoek worden in een rapport verwerkt, dat bijvoorbeeld regering en parlement kan helpen beslissingen te nemen over beleid op deze gebieden.

CO_2

De volgende vragen gaan over CO_2, ook wel kooldioxide of koolstofdioxide genoemd.

1 Hebt u wel eens gehoord van CO_2?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

2 Hierna volgt een aantal stellingen over eigenschappen van CO_2. Deze stellingen kunnen waar of onwaar zijn. Geef voor elke stelling aan in hoeverre u zeker weet dat deze stelling waar of niet waar is.

CO_2 is hetzelfde als koolmonoxide

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 kun je ruiken

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is brandbaar

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is zichtbaar

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is een gas dat in de natuur voorkomt

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is explosief

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 versteent na een tijd

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is een broeikasgas

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 geeft schadelijke straling af

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is giftig

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 zit in de lucht om ons heen

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

3 Hierna volgt een aantal stellingen over effecten van CO_2. Deze stellingen kunnen waar of onwaar zijn. Geef voor elke stelling aan in hoeverre u zeker weet dat deze stelling waar of niet waar is.

CO_2 veroorzaakt zure regen

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is kankerverwekkend

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 beïnvloedt het klimaat

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 veroorzaakt smog

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is nodig voor de groei van bomen en planten

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 tast de ozonlaag aan

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 is schadelijk bij huidcontact

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 maakt een leefbaar klimaat op aarde mogelijk

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

4 Hierna volgt een aantal stellingen over waar CO_2 vandaan komt. Deze stellingen kunnen waar of onwaar zijn. Geef voor elke stelling aan in hoeverre u zeker weet dat deze stelling waar of niet waar is.

CO_2 komt vrij als je uitademt

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij de verbranding van hout

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij gebruik van spuitbussen met haarlak en deodorant

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt tijdens het autorijden uit de uitlaat

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij lekkage uit oude batterijen en accu's

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij verwerking van afval

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij de productie van staal

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het afsterven van bomen en planten

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het opwekken van energie uit aardgas

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het opwekken van energie uit kolen

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het opwekken van energie uit olie

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het opwekken van energie met behulp van wind

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

CO_2 komt vrij bij het opwekken van kernenergie

Ik weet zeker van niet				Ik weet zeker van wel
1	2	3	4	5

6 Hierna volgt aantal steeds tegengestelde uitspraken over CO_2. Kies alstublieft de uitspraken die uw mening over CO_2 het beste weergeven, door steeds 1 van de 7 antwoordmogelijkheden te kiezen. Hoe dichter uw antwoord bij één van de uitspraken ligt, hoe beter die uitspraak bij uw eigen mening past.

Ik vind CO_2:

Positief	1	2	3	4	5	6	7	Negatief
Vreemd	1	2	3	4	5	6	7	Vertrouwd
Goed	1	2	3	4	5	6	7	Slecht
Onnatuurlijk	1	2	3	4	5	6	7	Natuurlijk
Schoon	1	2	3	4	5	6	7	Vies
Eng	1	2	3	4	5	6	7	Niet eng
Nuttig	1	2	3	4	5	6	7	Nutteloos
Gevaarlijk	1	2	3	4	5	6	7	Ongevaarlijk

Projectplannen

Nu volgen enkele vragen over mogelijke projectplannen.

7 Hebt u wel eens gehoord van zwavel-verduwing?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

8 Weet u van plannen om in Nederland zwavel-verduwing toe te passen?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

9 Hebt u wel eens gehoord van CO_2 afvang en opslag?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

10 Weet u van plannen om in Nederland CO_2 afvang en opslag toe te passen?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

CO2 afvang en opslag

De volgende vragen gaan over CO2 afvang en opslag. Nu volgen eerst enkele vragen over het afvangen van CO2.

11 Voor toepassing van CO_2 afvang en opslag moet CO_2 worden afgevangen op plaatsen waar veel CO_2 vrij komt. Hieronder staat een aantal mogelijkheden voor CO_2 afvang genoemd. Geef hieronder alstublieft aan welke bronnen volgens u geschikt zijn om CO_2 van af te vangen. Meerdere antwoorden mogelijk.

CO_2 kan afgevangen worden bij:
- ☐ Elektriciteitscentrales
- ☐ Auto's met een filter op de uitlaat
- ☐ Waterstofcentrales
- ☐ Verffabrieken
- ☐ Olieraffinaderijen
- ☐ Kerncentrales
- ☐ Staalfabrieken
- ☐ Gaswinninginstallaties
- ☐ Ammoniakfabrieken
- ☐ Intensieve veehouderij

12 Waarom zouden wij CO_2 afvang en opslag toepassen? Kruis hieronder aan welke doelen u denkt dat met CO_2 afvang en opslag bereikt zouden kunnen worden in Nederland. Meerdere antwoorden mogelijk.

Doelen van CO_2 opslag kunnen zijn:
- ☐ Om de luchtkwaliteit in Nederland te verbeteren
- ☐ Om de CO_2 later mogelijk als energiebron te gebruiken
- ☐ Om de ozonlaag te beschermen
- ☐ Om de CO_2 later mogelijk als grondstof voor producten te gebruiken.
- ☐ Om klimaatverandering tegen te gaan
- ☐ Om zure regen tegen te gaan
- ☐ Om milieuvervuiling in de omgeving van de fabriek te verminderen
- ☐ Om de temperatuurstijging op aarde te beperken
- ☐ Om de aarde weer te kunnen verwarmen bij een volgende ijstijd
- ☐ Om versterking van het broeikaseffect tegen te gaan
- ☐ Anders, vul in [open invulveld]

13 Waarom zouden wij CO_2 afvang en opslag niet toepassen? Vul hieronder in wat u denkt dat een reden zou, of redenen zouden kunnen zijn om CO_2 afvang en opslag **niet** toe te passen.
[open invulveld]
- ☐ Ik weet het niet

14 CO_2 afvang en opslag is bedoeld om de CO_2 uitstoot naar de lucht te verminderen. Voor toepassing van CO_2 afvang en opslag moet de CO_2 voor lange tijd worden opgeslagen. Hierna volgt een aantal stellingen over de manier waarop CO_2 voor lange tijd zou kunnen worden opgeslagen. Deze stellingen kunnen waar of onwaar zijn. Geef van elke manier aan hoe waarschijnlijk u het vindt dat de CO_2 op die manier opgeslagen zal worden.

CO_2 zal worden opgeslagen in grote vaten, tanks, of containers
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal ondergronds worden opgeslagen in het daar aanwezige gesteente
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal worden opgeslagen in ondergrondse bunkers met dikke, ondoordringbare wanden
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal worden opgeslagen in lege zoutmijnen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal worden opgeslagen in onderaardse grotten en grote holtes
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal worden opgeslagen onder de zeebodem
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal worden opgeslagen in oude kolenmijnen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

Poreuze aardlaag

15 Wat betekent de term 'poreuze aardlaag' volgens u?
☐ Dat is de bovenste grondlaag die in contact staat met de lucht en zo de grond van zuurstof voorziet
☐ Dat is een aardlaag onder de grond met een groot aantal zeer kleine gaatjes
☐ De term verwijst naar kwetsbare steenlagen in de grond die gemakkelijk afbrokkelen
☐ Ik weet het niet

Energieopwekking

De volgende vragen gaan over energieopwekking in Nederland.

16 Hieronder ziet u een lijst met energiebronnen. Daarvoor kunt u aangeven voor welk percentage u denkt dat elk van deze energiebronnen in Nederland gebruikt wordt om onze **elektriciteit** op te wekken. De percentages moeten optellen tot 100%. Het is mogelijk om bronnen 0% toe te kennen als u denkt dat deze in Nederland helemaal niet gebruikt worden.

__ Kolen
__ Aardgas
__ Olie
__ Windenergie
__ Zonne-energie
__ Biomassa (planten en bomen)
__ Waterkracht
__ Kernenergie
__ Aardwarmte
☐ Ik weet het niet

17 Hoeveel procent van de **elektriciteit** die wij jaarlijks in Nederland gebruiken verwacht u dat **in 2050** opgewekt zal worden met behulp van fossiele energiebronnen (kolen, aardgas, olie)?
[open invulveld; numerieke waardes max 100, daarachter het woord 'procent'. Indien mogelijk de respondent tonen wat hij/zij bij kolen, aardgas en olie heeft ingevuld in vraag 16]

Klimaatverandering

De volgende vragen gaan over klimaatverandering.

18 Hebt u wel eens gehoord van klimaatverandering?
☐ Nee
☐ Een beetje
☐ Ja

19 In hoeverre bent u ervan overtuigd dat het klimaat op aarde de komende eeuw gemiddeld warmer zal worden?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

20 In hoeverre bent u overtuigd dat opwarming van de aarde het gevolg is van CO2 uitstoot door de mens?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

21 In hoeverre bent u overtuigd dat de opwarming van de aarde wordt overdreven?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

22 In hoeverre bent u overtuigd dat de opwarming van de aarde door de mens nog afgeremd kan worden?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

CO2 afvang en opslag

CO_2 is een broeikasgas dat een grote bijdrage levert aan de temperatuurstijging op aarde. De Nederlandse overheid maakt daarom plannen de CO_2-uitstoot in Nederland te verminderen. CO_2 afvang en opslag wordt gezien als een mogelijkheid om de hoeveelheid CO_2 in de lucht te beperken.

Hierna volgt een aantal stellingen over mogelijke gevolgen van CO_2 afvang en opslag in Nederland. Geef alstublieft voor elk van deze stellingen aan hoe onwaarschijnlijk of waarschijnlijk u deze vindt.

CO_2 zal het grondwater verzuren
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 zal vanuit de opslagplaats naar de oppervlakte ontsnappen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

De opgeslagen CO_2 kan via een lek naar boven komen bij het slaan van heipalen voor nieuwbouw
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

Mensen zullen stikken als CO_2 vrij komt via een lek
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

Een CO_2 opslagplaats kan doelwit worden van terroristische aanslagen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

De CO_2 opslag ontploft omdat deze onder hoge druk staat
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

De CO_2 opslag ontploft omdat de CO_2 vlam vat
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

Opslag van CO_2 voorkomt bodemverzakking
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

De kosten van CO_2 opslag zullen worden doorberekend aan consumenten
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 opslag vertraagt de ontwikkeling van hernieuwbare vormen van energie, zoals windenergie en zonne-energie
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

CO_2 opslag toepassen geeft meer tijd om hernieuwbare vormen van energie, zoals windenergie en zonne-energie, te ontwikkelen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

Investeren in CO_2 afvang en opslag geeft Nederland een belangrijke technologische voorsprong op andere landen
Zeer onwaarschijnlijk 1 2 3 4 5 6 7 Zeer waarschijnlijk

24 Hieronder ziet u een aantal stellingen over CO_2 afvang en opslag. Geef alstublieft voor elk van deze stellingen aan hoe oneens of eens u het hiermee bent.

CO_2 opslag is noodzakelijk om de temperatuurstijging op aarde te beperken
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

Van een CO_2 opslag installatie in de buurt zul je nauwelijks last hebben.
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

De veiligheid van CO_2 opslag voor de omgeving zal nooit voldoende gegarandeerd kunnen worden
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

CO_2 onder de grond stoppen is het probleem verplaatsen
Zeer oneens 1 2 3 4 5 6 7 zeer eens

CO_2 opslag heeft teveel risico's voor de volksgezondheid
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

CO_2 opslag is voor Nederland een voor de hand liggende oplossing door de al aanwezige lege aardgasvelden die geschikt zijn om CO_2 in op te slaan.
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

CO_2 opslag levert bedrijven die het toepassen veel geld op
Zeer mee oneens 1 2 3 4 5 6 7 Zeer mee eens

Hierna volgt een aantal steeds tegengestelde uitspraken over CO_2 afvang en opslag. Kies alstublieft de uitspraken die uw mening over CO_2 afvang en opslag het beste weergeven, door steeds 1 van de 7 antwoordmogelijkheden te kiezen. Hoe dichter uw antwoord bij één van de uitspraken ligt, hoe beter die uitspraak bij uw eigen mening past.

Ik vind CO_2 afvang en opslag:

Positief	1	2	3	4	5	6	7	Negatief
Vreemd	1	2	3	4	5	6	7	Vertrouwd
Goed	1	2	3	4	5	6	7	Slecht
Eng	1	2	3	4	5	6	7	Niet eng
Schoon	1	2	3	4	5	6	7	Vies

Gevaarlijk	1	2	3	4	5	6	7	Ongevaarlijk
Veilig	1	2	3	4	5	6	7	Onveilig
Nutteloos	1	2	3	4	5	6	7	Nuttig

Actualiteit

We leggen u nog een aantal onderwerpen voor, omdat we willen weten van welke onderwerpen u wel eens gehoord hebt en wat u hiervan vindt.

Hebt u wel eens gehoord van het IPCC, oftewel het Intergovernmental Panel on Climate Change?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

Wat vindt u van het IPCC, oftewel het Intergovernmental Panel on Climate Change?
- ☐ 1 Zeer slecht
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 Zeer goed
- ☐ Geen mening

Hebt u wel eens gehoord van de plannen voor CO2 opslag in Barendrecht?
- ☐ Nee
- ☐ Een beetje
- ☐ Ja

Wat vindt u van de plannen voor CO2 opslag in Barendrecht?
- ☐ 1 Zeer slecht
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 Zeer goed
- ☐ Geen mening

In de afgelopen twee maanden is in een aantal televisieprogramma's aandacht besteed aan CO2 afvang en opslag. Geef van de volgende programma's aan of u deze geheel, gedeeltelijk, of niet gezien hebt.

Zembla van zondag 28 maart 2010
- ☐ Ja, heb ik helemaal gezien
- ☐ Ja, ik heb een deel gezien
- ☐ Nee, heb ik niet gezien
- ☐ Weet ik niet meer

Netwerk van dinsdag 6 april 2010
- ☐ Ja, heb ik helemaal gezien

☐ Ja, ik heb een deel gezien
☐ Nee, heb ik niet gezien
☐ Weet ik niet meer

Mediagebruik

Hieronder volgt een aantal vragen over de mate waarin u verschillende media gebruikt.

Televisie
Hoeveel tijd besteedt u gemiddeld per dag aan televisie kijken?

O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur
O (Weet niet)

Hoeveel van de tijd die u gemiddeld per dag naar de televisie kijkt, kijkt u naar nieuws of programma's over politiek en actualiteiten?
O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur
O (Weet niet)

Radio
Hoeveel tijd besteedt u gemiddeld per dag aan naar de radio luisteren?
O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur

Hoeveel van de tijd die u gemiddeld per dag naar de radio luistert, luistert u naar nieuws of programma's over politiek en actualiteiten?
O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur

O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur

Kranten
Hoeveel tijd besteedt u gemiddeld per dag aan het lezen van kranten, zowel gedrukt als online?

O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur

Hoeveel van de tijd die u gemiddeld per dag aan het lezen van kranten besteedt, zowel gedrukt als online, leest u over politiek en actualiteiten?
O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur

Internet
Hoeveel tijd besteedt u gemiddeld per dag aan het gebruik van internet voor privé-doeleinden?
O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur
O (Weet niet)

Hoeveel van de tijd die u op internet doorbrengt voor privé doeleinden bezoekt u pagina's met nieuws of informatie over politiek en actualiteiten?

O Geen tijd
O Minder dan een ½ uur
O Van een ½ uur, tot hoogstens 1 uur
O Meer dan 1 uur, tot hoogstens1½ uur
O Meer dan 1½ uur, tot hoogstens 2 uur
O Meer dan 2 uur, tot hoogstens 2½ uur
O Meer dan 2½ uur, tot hoogstens 3 uur
O Meer dan 3 uur
O (Weet niet)

Kranten titels
Welke van de volgende kranten leest u wel eens? Kruis alle antwoorden aan die van toepassing zijn.

O AD / Algemeen Dagblad
O Agrarisch Dagblad
O De Telegraaf
O De Volkskrant
O NRC Handelsblad
O NRC.NEXT
O Trouw
O Het Financieele Dagblad
O Reformatorisch Dagblad
O Nederlands Dagblad
O Het Parool
O Metro
O Spits!

WelkeKrant21. Hoe vaak leest u [dagblad x]?
☐ … dagen per week (invulveld waardes 1-7)
☐ Minder dan 1x per week

U hebt de rest van het scherm voor uw op en aanmerkingen!

Hartelijk dank voor het invullen van deze vragenlijst. Deze vragenlijst is een onderdeel van een groter onderzoek naar de kennis, ideeën en meningen van Nederlanders over klimaat en energie. Sommige vragen of stellingen in de vragenlijst zijn gebaseerd op wat andere mensen eerder in interviews geuit hebben over energie en klimaat. Met de vragenlijst proberen we onder andere te onderzoeken hoeveel mensen ook deze vragen of meningen hebben. Niet alle vragen of stellingen in de vragenlijst zijn echter feitelijk correct. U hoeft zich bijvoorbeeld geen zorgen te maken over plannen in Nederland voor zwavel-verduwing, omdat zwavel-verduwing niet bestaat.

Mocht u betrouwbare informatie willen over CO_2 afvang en opslag die samengesteld is door deskundigen uit milieuorganisaties, het bedrijfsleven, de wetenschap en de overheid kunt u kijken op
www.co2afvangenopslag.nl

8.5 The Knowledge and Beliefs Test (English)

The Energy research Centre of the Netherlands in cooperation with University Leiden and University Utrecht is conducting a study into your opinion non several topics.

CO_2

The following questions are about CO_2, also known as carbon dioxide.

1 Have you ever heard of CO_2?
- ☐ No
- ☐ A little bit
- ☐ Yes

2 Following statements are about possible characteristics of CO_2, which can be true or untrue. Please indicate for each to what extent you are convinced the statement is true or untrue.

CO_2 is the same as carbon monoxide

I'm sure it is not				I'm sure it is
1	2	3	4	5

You can smell CO_2

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is flammable

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is visible

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is a gas that can be found in nature

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is explosive

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 turns to stone in time

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 is a greenhouse gas

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 emits hazardous radiation

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 is toxic

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is in the air around us

I'm sure it is not				I'm sure it is
1	2	3	4	5

3 Following statements are about possible effects of CO_2, which can be true or untrue. Please indicate for each to what extent you are convinced the statement is true or untrue.

CO_2 causes acid rain

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 causes cancer

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 influences the climate

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 causes smog

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 is necessary for the growth of plants and trees

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 erodes the ozone layer

I'm sure it does not				I'm sure it does
1	2	3	4	5

CO_2 is harmful if in contact with skin

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 makes a habitable climate on earth possible

I'm sure it does not				I'm sure it does
1	2	3	4	5

4 Following statements are about possible sources of CO_2, which can be true or untrue. Please indicate for each to what extent you are convinced the statement is true or untrue.

Co2 is released when you exhale

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released when wood is burned

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released when spray cans with hair spray or deodorant are used

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released from the exhaust pipe when a car is driving

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released when old batteries leak

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during waste disposal

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during the production of steel

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released when plants and trees decompose

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during energy production from natural gas

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during energy production from coal

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during energy production from oil

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during energy production from wind

I'm sure it is not				I'm sure it is
1	2	3	4	5

CO_2 is released during energy production from nuclear power

I'm sure it is not				I'm sure it is
1	2	3	4	5

6 Following are scales with opposing adjectives describing CO_2. Please choose the adjective that most closely reflects your opinion of CO_2 by choosing one of the seven answer categories. The closer your answer is to one of the adjectives the more this adjective describes your opinion.

Ik vind CO_2:

Positive	1	2	3	4	5	6	7	Negative
Unfamiliar	1	2	3	4	5	6	7	Familiar
Good	1	2	3	4	5	6	7	Bad
Unnatural	1	2	3	4	5	6	7	Natural
Clean	1	2	3	4	5	6	7	Dirty
Scary	1	2	3	4	5	6	7	Not scary
Useful	1	2	3	4	5	6	7	Useless
Dangerous	1	2	3	4	5	6	7	Safe

Project plans

Following questions are about project plans

7 Have you ever heard of sulfur pushing?
- ☐ No
- ☐ A little bit
- ☐ Yes

8 Have you heard of plans to employ sulfur pushing in the Netherlands?

- ☐ No
- ☐ A little bit
- ☐ Yes

9 Have you ever heard of CO_2 capture and storage?

- ☐ No
- ☐ A little bit
- ☐ Yes

10 Have you heard of plans to employ CO_2 capture and storage in the Netherlands?

- ☐ No
- ☐ A little bit
- ☐ Yes

CO_2 capture and storage

The following questions are about CO_2 capture and storage . First are some questions about CO_2 capture.

11 To employ CO_2 capture and storage the CO_2 needs to be captured at points where a lot of CO_2 is emitted. Below several possibilities for CO_2 capture are mentioned. Please indicate which sources you think are suitable to capture CO_2 from. Multiple answers are possible.

CO_2 can be captured at:

- ☐ Electricity plants
- ☐ Cars with a filter on the exhaust pipe
- ☐ Hydrogen power plants
- ☐ Paint factories
- ☐ Oil refineries
- ☐ Nuclear power plants
- ☐ Steel factory
- ☐ Natural gas extraction installations
- ☐ Ammonia factories
- ☐ Intensive farming sites

12 Why would we employ CO_2 capture and storage? Select below which aims can be met using CO_2 capture and storage in the Netherlands. Multiple answers are possible.

Aims of CO_2 storage can be:
- ☐ Improve air quality in the Netherlands
- ☐ To use the CO_2 as an energy source in the future
- ☐ Protect the ozone layer
- ☐ To use the CO_2 as a raw material for products in the future
- ☐ Mitigate climate change
- ☐ Prevent acid rain
- ☐ Reduce pollution near factories
- ☐ Limit rise in temperatures on earth
- ☐ To warm the earth during the next ice age
- ☐ To limit the increase of the greenhouse effect
- ☐ Other…

13 Why would we not employ CO_2 capture and storage? Please fill in below what you think a reason could be *not* to employ CO_2 capture and storage.
[open]
- ☐ Ik don't know

14 The aim of CO_2 capture and storage is to decrease CO_2 emissions in the air. To employ CO_2 capture and storage the CO_2 has to be stored underground for a very long time.

Following are several statements about possible ways CO_2 could be stored for a long time. These statements can be true or untrue. Please indicate for each how likely you believe it is the CO_2 will be stored in the way presented in the statements
.

The CO_2 will be stored in large barrels, tanks or containers
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored underground in the existing rock formations
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored in underground bunkers with solid, impermeable walls
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored in empty salt mines
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored underground in caves and large cavities
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored under the sea bed
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 will be stored in old coal mines
Very unlikely 1 2 3 4 5 6 7 Very likely

8.5.1 Porous rock

15 What do you believe the term 'porous rock' means?
- ☐ It is the upper earth layer in contact with air that provides the ground with oxygen
- ☐ It is an earth layer underground with a lot of very tiny holes
- ☐ The term refers to fragile rock layers in the ground that crumble easily
- ☐ I don't know

Energy production

The following questions are about energy production in the Netherlands.

16 Below you see a list of energy sources. In front of each you can indicate how large the percentage is of each fuel used to produce **electricity** in the Netherlands. The percentages should add up to 100%. It is possible to state an energy source makes up 0% of the mix if you believe this source is not used in the Netherlands.

__ Coal
__ Natural gas
__ Oil
__ Wind energy
__ Solar energy
__ Biomass (plants and trees)
__ Hydro power
__ Nuclear energy
__ Geothermal energy
☐ Ik don't know

17 What percentage of our Electricity mix in the Netherlands in 2050 do you believe will be made up of fossil fuels? (coal, natural gas, oil)?
[open field]

Climate change

18 Have you ever heard of climate change?
- ☐ No
- ☐ A little bit
- ☐ Yes

19 To what extent are you convinced the climate on earth will become warmer on average?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

20 To what extent are you convinced global warming is a result of CO_2 emissions by human actions?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

21 To what extent are you convinced global warming is being exaggerated?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

22 To what extent are you convinced global warming can be stopped?

Helemaal niet overtuigd 1 2 3 4 5 6 7 Zeer overtuigd
☐ geen mening

CO_2 capture and storage

CO_2 is a greenhouse gas strongly contributing to the rise in average temperatures on earth. The Dutch government therefore aims to reduce emissions of CO_2 in the Netherlands. CO_2 capture and storage is considered as a possibility of limiting the amount of CO_2 in the air.

Following are statements about possible consequences of CO_2 capture and storage in the Netherlands. Please indicate for each statements to whether you believe this is likely or unlikely to be a consequence of CO_2 capture and storage.

CO_2 will acidify the ground water
Very unlikely 1 2 3 4 5 6 7 Very likely

CO_2 will leak from the storage to the surface
Very unlikely 1 2 3 4 5 6 7 Very likely

The stored CO_2 will leak to the surface during pile driving work
Very unlikely 1 2 3 4 5 6 7 Very likely

People will suffocate when CO_2 is released
Very unlikely 1 2 3 4 5 6 7 Very likely

A CO_2 storage can become a target of terrorist attacks
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 storage will explode because it is under pressure
Very unlikely 1 2 3 4 5 6 7 Very likely

The CO_2 storage will explode because the CO_2 catches fire
Very unlikely 1 2 3 4 5 6 7 Very likely

CO_2 storage will prevent ground subsidence
Very unlikely 1 2 3 4 5 6 7 Very likely

The costs of CO_2 storage will be charged to consumers
Very unlikely 1 2 3 4 5 6 7 Very likely

CO_2 storage will slow the development of renewable energy sources such as wind and solar energy
Very unlikely 1 2 3 4 5 6 7 Very likely

Implementing CO_2 will give us time to develop renewable energy sources such as wind and solar energy
Very unlikely 1 2 3 4 5 6 7 Very likely

Investing in Carbon capture and storage will give the Netehrlands a technological advantage over other countries
Very unlikely 1 2 3 4 5 6 7 Very likely

24 Following are statements about CO_2 capture and storage. Please indicate to what extent you agree with each statement.

CO_2 storage is necessary to mitigate the rise in average temperature on earth
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

A CO_2 storage in the neighbourhood will cause hardly any inconvenience.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

The safety of CO_2 storage for the surroundings can never be sufficiently guaranteed
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Putting CO_2 under the ground is shifting the problem
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

CO_2 storage carries too many risks for public health
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

CO_2 storage is an obvious solution for the Netherlands because of the existing depleted gas fields suitable for storing CO_2
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

CO_2 storage will bring in a lot of money for companies that will employ it
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Following are scales with opposing adjectives describing CO_2 capture and storage. Please choose the adjective that most closely reflects your opinion of CO_2 capture and storage by choosing one of the seven answer categories. The closer your answer is to one of the adjectives the more this adjective describes your opinion.

I believe CO_2 capture and storage is:

Positive	1	2	3	4	5	6	7	Negative
Unfamiliar	1	2	3	4	5	6	7	Familiar
Good	1	2	3	4	5	6	7	Bad
Unnatural	1	2	3	4	5	6	7	Natural
Clean	1	2	3	4	5	6	7	Dirty
Scary	1	2	3	4	5	6	7	Not scary
Useful	1	2	3	4	5	6	7	Useless
Dangerous	1	2	3	4	5	6	7	Safe

Current events

Have you ever heard of the IPCC, or het Intergovernmental Panel on Climate Change?
- ☐ No
- ☐ A little bit
- ☐ Yes

What is your opinion of the IPCC, or het Intergovernmental Panel on Climate Change?
- ☐ 1 Very bad
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 Very good
- ☐ No opinion

Have you ever heard of plans for CO2 storage in Barendrecht?
- ☐ No
- ☐ A little bit
- ☐ Yes

Wat vindt u van de plannen voor CO2 opslag in Barendrecht?
- ☐ 1 Very bad
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 Very good
- ☐ No opinion

In teh past months several broadcasts have been dedicated to teh topic of CO_2 capture and storage. Please indicate whether you have seen the following broadcasts:

Zembla Sunday 28 March 2010
- ☐ Yes, I have seen the complete broadcast
- ☐ Yes, I have seen a part
- ☐ No I have not seen it
- ☐ I don't remember

Netwerk Tuesday 6 April 2010
- ☐ Yes, I have seen the complete broadcast
- ☐ Yes, I have seen a part
- ☐ No I have not seen it
- ☐ I don't remember

Media use

Televisie

How much time do you spend watching television a day on average?

O No time
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

How much of the time you watch television a day on average do you spend watching broadcasts about news or current events and politics?
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

Radio

How much time do you spend listening to the radio a day on average?

O No time
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

How much of the time you listen to the radio a day on average do you spend listening to broadcasts about news or current events and politics?
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

Kranten

How much time do you spend reading newspapers a day on average?

O No time

O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

How much of the time you read newspapers a day on average do you spend reading about news or current events and politics?
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

Internet
How much time do you spend on the internet a day on average?

O No time
O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

How much of the time you spend on the internet a day on average do you spend reading about news or current events and politics?

O Less than ½ hour
O Between ½ uur, to a maximum of 1 hour
O More than 1 hour to a maximum of 1½ hour
O More than 1½ hour to a maximum of 2 hours
O More than 2 hours to a maximum of 2½ hours
O More than 2½ hours to a maximum of 3 hours
O More than 3 hours
O (I don't know)

Kranten titels
Which of teh following newspapers to you read?

O AD / Algemeen Dagblad
O Agrarisch Dagblad
O De Telegraaf

O De Volkskrant
O NRC Handelsblad
O NRC.NEXT
O Trouw
O Het Financieele Dagblad
O Reformatorisch Dagblad
O Nederlands Dagblad
O Het Parool
O Metro
O Spits!

How often do you read [newpaper x]?

8.6 Appendix results ICQ

Order effects

To avoid the possible influence of order effects on the overall evaluations, the order in which respondents received the information on consequences of the seven options was not the same for all respondents. Six versions of the ICQ were made with different orders. The order of the first version was p1 ("Improvement of energy efficiency"), p2 ("Improvement of energy efficiency and decreased use of material and energy"), p3 ("Electricity from windmills at sea"), p4 ("Conversion of biomass to car fuel and electricity"), p5 ("Large plants were coal or gas are converted into electricity, with CCS"), p6 ("Large plants were gas is converted into hydrogen with CCS"), p7("Electricity from nuclear plants"). The order of the second version was p4-p7-p6-p1-p2-p3-p5. The order of the third version was p7-p6-p5-p4-p3-p1-p2. The order of the fourth version was p5-p1-p2-p6-p3-p7-p4. The order of the fifth version was p3-p5-p4-p7-p1-p2-p6. The order of the sixth version was p6-p4-p1-p2-p7-p5-p3. By varying the order in which respondents evaluated the options, the chance that an option receives higher or lower evaluations than the other options purely based on its position in the questionnaire becomes very small. A table with the average overall evaluations of the seven options per version of the questionnaire is presented below.

Table A8.6 1 Evaluation of the options based on the order in which they were presented. Some options were presented in the same position twice.

	Position						
Option	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Efficiency	7.33	7.73	7.48	7.50	7.42	7.40	
Efficiency plus		5.83	5.87	5.57	6.23	5.37	6.45
Wind	7.37		7.61		7.65 6.97	7.73	7.67
Biomass	7.50	7.24	7.79	7.00 7.85		7.13	7.50
Powerplants + CCS	4.97	4.95	5.75		4.78	5.00	4.77
Hydrogen + CCS	6.43	6.55	5.81	5.47		5.28	6.05
Nuclear	6.25	5.08		5.16	5.19	5.47	5.17

Overall evaluations on two different scales

The overall evaluations of global warming, carbon dioxide capture and storage (CCS) and the seven options were all measured with two different scales. Respondents were asked to give their overall evaluations on a scale ranging from 1 "very bad" to 7 "very good". They were furthermore asked to grade on a scale of one to ten. This means that there are two measures for all overall evaluations. To find out if respondents evaluate differently depending on scale type or size, we analyzed the correlations between these two measures for global warming, CCS and the seven options. The correlations were high, ranging from .72 to .88, indicating that these measures were quite similar. This conclusion is supported by the results of the previous ICQ from 2007 which used a much larger sample. Table Appendix A8.6_2a shows the evaluations based on the seven point scale, Table Appendix A8.6_2b shows the evaluations based on grading on a scale of one to ten to compare.

Table A8.6 2a Overall evaluations of the options on a 7-point scale. 1 "very bad" and 7 "very good".

	% of respondents selecting answer category								
Option	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Mean**	**St. Dev.**
Efficiency	0	0	0.7	7.5	25.4	36.6	29.9	5.9	1.0
Efficiency plus	0.7	5.9	18.7	23.9	28.4	20.1	2.2	4.4	1.3
Wind	0	1.5	1.5	9.0	22.4	45.5	20.1	5.7	1.0
Biomass	0	2.2	1.5	9.7	20.9	44.0	21.6	5.7	1.1
Powerplants+ CCS	1.5	12.7	24.6	28.4	20.9	11.9	0	3.9	1.3
Hydrogen + CCS	1.5	4.5	14.2	26.1	30.6	20.9	2.2	4.5	1.2
Nuclear	6.7	14.2	15.7	20.9	25.4	12.7	4.5	4.0	1.6

Table A8.6 2b Overall evaluations of the options on a scale from 1 to 10

Option	**1 to 3**	**4 to 5**	**6 to 7**	**8 to 10**	**Mean grade**	**St. Dev.**
Efficiency	0.7	3.7	41.1	53.7	7.48	1.26
Efficiency plus	7.4	29.3	47.8	15.6	5.90	1.58
Wind	3.6	1.4	38.8	50.8	7.47	1.49
Biomass	2.2	2.3	45.5	50.0	7.39	1.30
Powerplants + CCS	17.2	41.8	36.6	4.5	5.02	1.56
Hydrogen + CCS	6.7	30.5	48.6	13.4	5.90	1.54
Nuclear	17.2	32.9	35.1	14.9	5.38	2.03

8.7 Appendix results Knowledge and Beliefs Test

Table A8.7 Demographic variables in the Knowledge and Beliefs Test sample compared to the Dutch population in 2008

	Dutch population 2008		Knowledge and Beliefs Test sample	
	N	%	N	%
Sex				
Male	8,112,073	49.4%	205	51.1%
Female	8,293,326	50.6%	196	48.9%
Age				
< 20	3,940,450	24.0%	12	3.0% (18+)
20-40	4,267,063	26.0%	127	31.7%
40-60	4,787,781	29.2%	147	36.7%
60-80	2,794,616	17.0%	110	27.4%
80+	615,489	3.8%	5	1.2%
Province	16,405,399	100%		
Groningen	573,459	3.5%	10	2.5%
Friesland	643,189	3.9%	15	3.7%
Drenthe	488,135	3.0%	9	2.2%
Overijssel	1,119,994	6.8%	21	5.2%
Flevoland	378,688	2.3%	9	2.2%
Gelderland	1,983,869	12.1%	48	12.0%

Source: CBS Kerncijfers 2011 www.cbs.nl