

# Deliberating emission reduction options

Identifying public perceptions to CCS using the Information  
Choice Questionnaire methodology

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## Executive summary

For more than 20 years there has been a concerted international effort toward addressing climate change. International conventions, such as the United Nations Framework Convention on Climate Change (UNFCCC; ratified in 1994), have been established by committed nations seeking to address global climate change through the reduction of greenhouse gases emitted into the Earth's atmosphere (Global CCS Institute, 2011). Long recognised as the most crucial of the greenhouse gases to impact global warming, the majority of carbon dioxide's anthropogenic global emissions are directly related to fuel combustion of which both Australia and the Netherlands' energy production is significantly reliant (Common and Salma, 1992; European Commission, 2007). Both these nations will need to consider many opinions and make hard decisions if alternative energy options are to be implemented at the scale that is required to meet international emission targets. The decisions that are required not only need to consider the many options available but also their consequences.

Along with politicians, policy developers and industry, the general public also need to be active participants in deciding which energy options, and their subsequent consequences, are acceptable for implementation at the national level. Access to balanced and factual information is essential in establishing informed opinions on the many policy options available.

Past research has used several methods to measure public perceptions and opinions yet for complex issues, such as emission reduction, some of these methods have shown to be problematic. For example, semi structured interviews can provide data that is flexible and context rich yet it does also come with the limitations such as it seldom provides a practical assessment that can be utilised from researcher to researcher, across disciplines and public participation techniques. Surveys on the other hand usually address these limitations but surveys that do not encourage comparison of information or ask participants to evaluate and choose between several options tend to lead to pseudo-opinions, incorrect assumptions and isolated responses.

In order to address these methodological issues, researchers in the Netherlands (e.g. Daamen, 2010) created an Information Choice Questionnaire (ICQ). The ICQ provides the respondent with: (1) the entire (complex) policy problem, (2) expert information that is independent and balanced, (3) in a way that is understandable for the general public, (4) is a comparative process, and (5) asks for an evaluation.

The aim of this research was to develop an online decision guide to aid public awareness, knowledge, deliberation and choice around carbon dioxide capture and storage (CCS) compared with other greenhouse gas mitigation options. More specifically, the objectives were to: a) compare the Australian survey results to Dutch respondents; and b) examine the most effective way to make online information and opinion formation more interactive and engaging. The research was an international collaboration between the Commonwealth Scientific and Industrial Organisation (CSIRO) in Australia and the Energy research Centre of the Netherlands (ECN) which addressed the following research questions:

**Research question 1:** How do Australian opinions on energy options differ from the Dutch when measured using the ICQ?

**Research question 2:** Is it possible to enhance the quality of the original ICQ by making the questionnaire an interactive application?

Building upon the original Dutch ICQ study, the research modified the existing survey to develop an appropriate policy response for the Australian setting. At the same time it also extended the reach of the original ICQ prepared for the Netherlands to investigate its applicability and effect when completed by a wider population of the Dutch general public. The ICQ was designed to measure stable, high quality and informed opinions through the provision of balanced, unbiased and factual information (Neijens, De Ridder and Saris, 1992). The way the information and its content is structured and presented and the method of delivery used is an essential consideration. Research intended to inform decision making has previously

been applied using focus groups or questionnaire formats (or combinations of both), or opinion surveys in combination with written information handouts, delivered via citizens panels or other panel services (de Best-Waldhober and Daamen, 2006). The ICQ, in this research, was redesigned into an interactive online platform which provided insights into website delivery of information and stability of opinion formation on energy options.

The first study investigated the choices the general Australian public made after receiving and evaluating expert information on the consequences of seven policy options. This was achieved through the development of an Australian ICQ, which included establishing a policy issue framed as a decision problem. Before being requested to choose between the policy options, respondents were provided information designed to assist in informing their decisions making processes.

Experts chose to define the policy problem for Australia around carbon dioxide emissions mitigation and provided the most optimal options available towards a solution. In order to reduce Australia's carbon dioxide emissions by 33% by 2030, the chosen seven options were:

- Energy efficiency in residential and commercial sectors;
- Efficiency in the manufacturing and mining industries;
- Replacing future planned coal-fired power stations with gas;
- Carbon dioxide capture and storage with coal;
- Deploying renewable sources;
- Participating in an international emissions trading scheme; and
- Nuclear power.

The original Dutch ICQ was replicated with a smaller sample size in order to test the consistency of the results found in 2007. The policy problem remained the same as the original study for the Netherlands to reduce carbon dioxide emissions by 50% by 2030. Dutch experts provided the following seven options to address this issue:

- Improvement of energy efficiency;
- Improvement of energy efficiency and decreased use of material and energy;
- Electricity from wind turbines at sea;
- Conversion of biomass to car fuel and electricity;
- Large plants where coal or gas is converted into electricity with CCS;
- Large plants where gas is converted into electricity with CCS; and
- Electricity from nuclear power plants.

The Australian results were similar to those found in the original and recent Dutch studies, both countries show a preference for energy efficiency options and renewables, and oppose nuclear energy. Although the consequences of the different options for the Netherlands and Australia were quite different, the overall grades were similar in relative terms. When taking a 5.5 as cut off point for a sufficient grade, the efficiency options, renewable sources and CCS score sufficient, while nuclear, coal to gas and the international trading scheme score insufficiently. From these results, the following recommendations are made for those attempting to improve understanding and perceptions:

**Recommendation 1: In order to improve acceptance of CCS technology, it should be presented as part of a portfolio of climate mitigation solutions**

The results of both the Australian and Dutch ICQs found that the CCS option was more favourable when it was combined with other solutions that were related to energy efficiency and renewable technologies. For example, 26% of Australian respondents indicated that they would choose CCS as one of the three preferred solutions if included with the energy efficiency options. It is recommended that for acceptance of CCS to be achieved in Australia and the Netherlands, the technology needs to be situated in a suite of solutions that also address energy efficiency in the residential, commercial and industrial sectors as well as renewable technology options.

## **Recommendation 2: Disseminating applied knowledge and information of Research and Development (R&D) outcomes for CCS**

When more R&D results are available in areas of uncertainty for CCS, they need to be communicated because it is the uncertainty that people react to not necessarily the technology itself. A large proportion of the information provided in the CCS related options were based on predicted outcomes due to the early stage of development for this technology. It is recommended that as more applied and evidence based information about the real costs, technical capabilities and risks of CCS become available that it be communicated widely, in a balanced and factual manner, drawing upon actual figures and examples as opposed to predicted and modelled data.

## **Recommendation 3: ICQ raises awareness but misses the mark on practicality**

In the array of tools available for raising awareness, the ICQ is more of a research methodology and there is a need to have a more practical way of getting the same outcomes. Simply providing more and better risk information in an attempt to educate the public is in itself insufficient to address concerns and form opinions on CCS. The public is not a passive audience to whom messages should be delivered but an active participant in interpreting information. It is recommended that the ICQ is developed into more of a two-way, truly interactive resource that involves information sharing and relationship building in an online platform..

The second study focused on the design and effectiveness aspects of the ICQ, which was delivered through an online website platform. Findings from this study revealed that the ICQ, in its current design, is too long to complete and is missing the interactive component respondents expected from an online delivery form. Various learning and recommendations can be drawn from this research, which include:

### **Recommendation 4: Length of current ICQ is too long for most**

Although people may be interested in the topic of climate change and carbon dioxide mitigation actions, respondents often indicated a belief that the length of the online ICQ was too long to complete voluntarily. It is recommended that future uses of the ICQ format be modified considerably and aim for a 20 minute survey design.

### **Recommendation 5: Different ICQ's for different target groups**

It was noted that the tool could achieve greater audience reach if it were to incorporate three options of choice, for example, 'light', 'medium', and 'expert', to satisfy the needs of the different interest groups. Though a valid point, such differentiation in content would require extensive time commitment on the part of experts to develop the different packages to the exacting quality required for the ICQ process, which in turn would incur extensive costs.

### **Recommendation 6: Avoiding technical difficulties and restraints**

In the current study, different limitations were experienced which prevented desired design elements from being realised as the project progressed. Therefore, it is recommended that future research teams have access to an Information Technology (IT) specialist in all stages of the project in order to achieve an easily accessible website with embedded survey response capturing features.

### **Recommendation 7: The combination of gathering data and making the website attractive is difficult**

The concept of informing people at the same time as gathering data proved to be quite challenging. Although the project team retained all the required information in written format, which is imperative for the ICQ method, it is recommended that some components be provided in short explanatory movies or film clips. This could significantly speed up the process while introducing an enjoyable element to the tool.

In addition to the copious amounts of written information provided, respondents also felt the survey process was uninspiring. It is recommended therefore to integrate the different survey components into the one website platform incorporating an engaging presentation format that is repeated across all components such that respondent interest is maintained which may result in an increase in the completion of the tool.

In conclusion, much learning was achieved through this research which provided insights into Australian and Dutch opinions on energy options and the delivery of policy information via an online tool. CCS was found to be more accepted when combined with other energy efficiency and renewable solutions as well as when provided with more consequences of the technology's impact. Respondents appeared to be positive about the information that was provided yet they also detailed several design flaws in the online design that could be improved in future developments. The most important feedback received was the use of a single website to integrate all ICQ components including preliminary and ongoing instructive information and the different survey elements; rather than delivery via separate website interfaces. This should result in a more stimulating and inspiring process for providing information to respondents and also employing additional IT elements, for example the use of images, figures or video's. Finally, in order to engage and hold the attention and interest of potential ICQ participants, it is essential that consideration be given to making the process shorter and pitched to different levels of understanding and interest that meet the needs of different target groups.



# Part I Introduction

# 1 Background to the Project

With around 95% of its energy production generated from fossil fuels, including an electricity sector that is heavily reliant on coal (BREE, 2012), Australia is one of the largest greenhouse gas emitters per capita with 394.88 MtCO<sub>2</sub> per year from fuel combustion emissions of any OECD country (International Energy Agency, 2011a; State of the Environment Committee, 2011). Population growth estimates for Australia of between 30 and 36 million by 2050 will see the nation's demand for energy continue to grow (State of the Environment Committee, 2011) along with associated carbon dioxide emissions. With Australia's coal fired electricity generation contributing around a third of Australia's carbon dioxide emissions the Australian Government announced "a new long-term target to cut pollution by 80% below 2000 levels by 2050" (Australian Government, 2012a). However, finite reserves of coal will eventually require Australia's reliance on coal for electricity production to be transformed (Garnaut, 2011).

In order to address Australia's growing demand for electricity and need for climate change action through carbon dioxide emission reductions, the Australian Government has committed to implementing energy efficiency policies and strategies to reduce energy demand (State of the Environment Committee, 2011). Which if successful should provide the necessary time for existing and new energy technology alternatives to pick up a greater share of the energy production load, and enable fossil fuel production to gradually reduce.

Similar to Australia, the Netherlands energy production is primarily produced from fossil fuels. With annual carbon dioxide emissions in 2009 of 176.11 MtCO<sub>2</sub> per year (International Energy Agency, 2011b), the Netherlands emissions represent approximately half that of Australia. Unlike Australia however, the Netherlands relies more heavily on gas generated electricity than on coal with natural gas providing approximately 60% of the nation's electricity while coal contributes around 23% (International Energy Agency, 2011c). With an anticipated population growth of between 17.6 and 20 million by 2050 (Statistics Netherlands, 2004) electricity consumption is expected to grow in line with increased population levels.

In order to manage the contribution carbon dioxide has toward the enhanced greenhouse effect; the European Union has identified clear goals to reduce carbon dioxide emissions in 2050 to between 80% and 95% compared to 1990 levels (Ministry of Economic Affairs, Agriculture and Innovation, 2011). In line with these goals, and toward transitioning to a low carbon-emission economy by 2050, the Netherlands Government announced in its Energy Report (2011) which specified strategies and policies to increase renewable energy sources in combination with cleaner fossil fuel energy production to achieve 20% carbon dioxide emissions reductions by 2020 through the deployment of CCS and cogeneration electricity production, i.e. natural gas with bio-fuels (Ministry of Economic Affairs, Agriculture and Innovation, 2011).

The success of climate policies as developed in Australia and the Netherlands depend heavily on the level of societal acceptance that sustainable energy technologies receive. Much research has been invested into gaining a better understanding of public opinion and attitude toward energy technologies and to determine what influence these may have on societal uptake (Ashworth, Paxton and Carr-Cornish, 2011; Sklyar, Smith and Stedman, 2006). Despite these efforts however a chasm continues to exist between what science and policy makers know and what is understood and perceived by society (Ashworth et al., 2011).

The aim of the current project was to investigate how to effectively involve the Dutch and Australian public in the complex policy problem of reducing carbon dioxide emissions through the use of multiple, nationally specific options. To achieve this aim an Information Choice Questionnaire (ICQ), originally developed for the Netherlands, was used as a base to develop an online ICQ for both the Netherlands and Australia through an interactive web based platform. Two studies were developed: a) study one examined whether a similar ICQ could be developed and tested in Australia and results were compared to Dutch respondents; and b) study two examined the most effective way to make the ICQ more interactive and engaging online.

## 2 Literature Review

Whilst researching public opinions and attitudes to CCS in the Netherlands, de Best-Waldhober and Daamen (2006) found that public awareness of the technology was low. And, where opinions existed, these were uninformed and unstable, making it difficult to predict public support or opposition across time and space (Daamen, 2010). Further, Daamen found that in order for well-considered informed stable opinions to be formed, people need to process information and that such information needs to be valid, relevant, balanced and comprehensible (Daamen, 2010). Such findings reflect research which found that in order for more supportive attitudes toward science to be formed higher levels of knowledge are necessary (Evans and Durant, 1995; Ashworth et al., 2011). Therefore, essential to providing the frameworks that support informed and stable opinion forming is an understanding of how people form opinions and the methods used to capture them.

### 2.1 How do people form opinions?

Lave (1998) infers that individuals learn and gain knowledge through a “community of practice” that supports and encourages the formation, construction and reflection of knowledge; such knowledge being context and situation influenced through social activities and practice. Social interactions and community participation providing the conduit for fundamental knowledge development, that once instilled and reinforced through cultural norms moves from the more external or extrinsic form of knowledge to become deeper more inherent and intrinsic (Smith, 2003; 2009). A constructivist perspective suggests that knowledge develops continually, based not only on prior understanding instilled by culture and social interactions and personal experience, but through the interchange of information. Thus, according to Russian psychologist Lev Vygotsky, knowledge is constantly being transformed, particularly so in regard to the gaining of knowledge on new concepts. The dynamics of an individual’s social interactions encourages collaboration and knowledge sharing to assist in connecting to new ideas and information (Plut, 1989, 1994; Smith, 2003; 2009).

Individual awareness of an issue and how they remain informed can be directly linked to the method of communication used for delivering information. Today’s Western society has multiple channels of information and news communication such as newspapers and magazine articles (Glock, 1952) books, documentaries, television programs, educational resources, promotional materials; and, delivered via the Internet (media websites, blogs, chat rooms, industrial and organisational sites, online learning sites and so on); as well in discussion and interaction with family, friends, associates and colleagues. Understanding the different functions and forms of the mass media and its role in communicating information is essential to understanding how opinions are formed. In addition, it is important to recognise that the information source may not always be easily identifiable and may be an opinion leader from the any of the various social, cultural, political and economic communities across which an individual moves (Glock, 1952); all of which are environments of influence in opinion formation. These environments nurture the norms, beliefs, moral values, traditions and superstitions individuals adhere to, which in turn influence their perceptions, attitudes and behaviours including day to day decision making. Further, Neijen and colleagues (1992) note that opinion forming on specific issues is based on the information available at the time and how representative this information is of the population it represents.

According to Price and Neijens (1997) the quality of an opinion can be determined by several indicators, i.e. consistency, stability and confidence. The consistency indicator refers to the strength of an evaluation; stability refers to the degree an individual’s opinion remains constant over time, while confidence refers to the “sense of conviction” an individual holds about an opinion (Daamen, 2010). As informing the public has been shown to lead to increased awareness levels, debunked long held beliefs, and increased individual confidence in the opinions held on different technologies, accurately informing the public and thus creating

a general baseline of knowledge may be useful for dissemination of information later on, for example for specific project plans (Ashworth, et al., 2011).

## 2.2 Information Choice Questionnaire (ICQ)

Now that it is apparent the public should be informed on policy decisions surrounding carbon dioxide emissions reduction, the next question is: *what is the best strategy to do so and how can a large audience be reached?* There are several strategies possible. Frequently used methods to investigate public perceptions are focus groups, surveys and interviews (Vaughan and Hogg, 2002). Focus groups have the advantage of supporting methodical information processing and assimilation, gives participants the opportunity to ask questions to experts, and facilitates the exchange of information. The disadvantage is that single opinions can dominate discussions provide a minority perspective; therefore representation of a population is unlikely (Daamen, 2010).

Open ended (semi-structured) interviews provide a flexible platform on which to source data, providing opportunity to delve and probe beyond an initial response to better understand the nuances behind a specific individual's opinions, attitudes and perceptions. Such flexibility is valuable and helps to build rich data in analysis. This flexibility, though one of the techniques greatest strengths, can also be limiting in that it seldom provides a practical assessment that can be utilised from researcher to researcher, across disciplines and public participation techniques. Surveys on the other hand usually adhere to a standardised design that is rarely altered beyond the pilot phase as doing so would risk loss of statistical integrity of the data (Halvorsene, 2001).

Although traditional public opinion surveys can be beneficial in informing on public acceptance (or otherwise) to policy and technology (de Best-Waldhober, Daamen, Ramirez, Faaij, Hendriks, and de Visser, 2008), the process does not necessarily take account of the public's knowledge, or lack of knowledge, of a given subject. The result may be that respondents to such surveys either refrain from responding or provide pseudo-opinions or non-attitude responses (Converse, 1970; de Best-Waldhober et al, 2008). Social scientists refer to pseudo opinions as opinions that "may accurately reflect a respondent's feelings at the time of the question or discussion, but are opinions that do not last over time (Wade and Greenberg, 2011).

The problem with using a simple survey for the complex issue of reduction of carbon dioxide emissions, is that surveys that do not encourage comparison of information, are reported to result in a lack of information and a corresponding lack of knowledge on the part of the respondent, which may in turn lead to pseudo-opinions. De Best-Waldhober and colleagues (2008) note that decisions made by policy makers usually involve choosing between potential options. Opinion survey respondents however are usually only asked to evaluate one particular option rather than to compare or choose between several options and can result in "isolated" responses and lead to incorrect assumptions and responses (de Best-Waldhober, 2008; Neuman, 1986).

To combat the problems with conventional methods of obtaining public perceptions, researchers in the Netherlands (e.g. Daamen, 2010) created an Information Choice Questionnaire (ICQ). The ICQ provides the respondent with the entire (complex) policy problem. The ICQ combines the benefits of various methods. First of all, it provides the respondent with expert information, which decreases the chance that people form pseudo-opinions. The information provides an independent and balanced overview of all the information on the policy problem at hand in a way that is understandable for the general public.

Additionally, the ICQ is setup as a comparative process. Respondents receive information in small amounts after which their evaluation is asked. After evaluating all the options, respondents receive an overview of their answers before giving an overall evaluation score. At the conclusion of the process, respondents are asked to make a choice between the options. In this way the disadvantage of a survey leading to "isolated" answers is addressed. Daamen (2012) demonstrated that the ICQ is an effective way of informing the public and obtaining perceptions when he conducted a study which compared focus group results with an ICQ. The ICQ was effective in its ability to collect informed opinions; processing and integrating information for evaluation; and, was effective in the delivery of complex information such that it encouraged a greater understanding. However, he also noted that the process did not include answerability affects synonymous

with focus group interactions or provide clarification opportunities, nor did it enable positive group practices that encourage thought provoking interactions (Daamen, 2010). Opinion consistency was higher for ICQ participants than for focus groups; opinions appeared more stable; and confidence levels generally were higher. In addition, Daamen reported that respondents opinions of the knowledge, quality of information (level of bias, balance, comprehension, validity, and usefulness), and credibility of experts (honesty and reliability) were more positive for ICQ participants than for focus group participants.

The ICQ thus has been shown to be a useful and effective tool to obtain informed public opinions on reducing carbon dioxide emissions. One of the aims of the current project was to develop a strategy to reach a large audience for the ICQ. Previous versions of the ICQ were distributed amongst the general public through citizen panels, with paid respondents. While this led to large, representative samples it failed to make available the ICQ to interested members of the wider public. As achieving this wider dissemination was one of the aims of the present research, a decision was made to develop an online version of the ICQ. The intent being to develop a useful tool for acquiring information for opinion forming on specific topics via a self-administered, open and interactive, and user friendly interface such as the Internet. In order to stimulate and engage participants the ICQ would need to incorporate visual appeal, be user friendly and provide motivational aspects in order to retain interest and desire for continued exploration of the information provided. To better understand how to achieve this, a literature review was conducted focussing on educational gaming and online learning.

## 2.3 Designing the ICQ as an online tool

Several distinct features became apparent in the literature for consideration when designing the online interactive ICQ process. These included the need to reflect adult preferences for information based educational games supported by information designed to enhance cognitive learning (Schaller and Allison-Bunnell, 2002). Learning that is intrinsically motivated, direct and without distraction. Similarly, young adults in advanced school levels would benefit from greater content focus on matters of relevance to the topic (McFarlane, Sparrowhawk and Heald, 2002). A view supported by the Elaboration Likelihood Model which suggests that the use of minimal distractions or superficial cues is necessary in order to direct participants into an information processing mode (Petty and Cacioppo, 1979). In addition, strong narrative (story telling) using a “central metaphor” such as a symbol or image was found to support engagement in learning (Astleitner and Wiesner, 2004; Clark, Nelson, Sengupta and D’Angelo, 2009; Dornan, 2004). While engaging the user in a ‘dilemma’, such as a policy problem incorporating limited choice toward resolution used in the ICQ, would support motivation and curiosity arousal (Dornan, 2004). In combination with a narrative, a story would begin to evolve motivating the user toward an end goal. The end goal itself being a strong motivational gaming feature (Balzac, 2007; Papastergiou, 2009; Schaller and Allison-Bunnell, 2002; Schank, Fano, Jona and Bell, 1994) providing a challenge and a pay-off once achieved (Schank, et al., 1994).

To maintain interest and to provide progressive feedback to the user, it is also suggested that self-assessment processes that inform of knowledge acquisition be incorporated into the gaming platform (Dornan, 2004; Mabrito, 2005; Moreno-Ger, Burgos, Martínez-Ortiz, Sierra and Fernández-Manjón, 2008; Papastergiou, 2009). This might include the use of quizzes or question marks that appear at intervals throughout the ICQ to test user knowledge and highlight inconsistency in information retention that may in turn motivate higher learning (Astleitner and Wiesner, 2006). This continued process of motivation is further considered to be enhanced through the provision of different levels of control over the learning process (Astleitner and Wiesner, 2006; Jovanovic, Starcevic, Minovic and Stavljanin, 2011; Prensky, 2001). Suggested control mechanism included modification to content (Moshirnia, 2007; Squire, Giovanetto, Devane and Durga, 2005) which may consist of user upload and content building. For the ICQ this might include freedom of choice of the evaluation order of the energy technology options available to address the policy problem or whether or not to alternate between short knowledge assessment quizzes and the main ICQ content.

Another feature considered important in motivating interest is the use of progressive difficulty as the user moves through the levels of a game (Carro, Breda, Castillo and Bajuelos, 2002; Kickmeier-Rust, Schwarz,

Albert, Verpoorten, Castaigne and Bopp, 2006; Shute et al., 2008). This would however prove a challenge for incorporation into the ICQ due to the fixed nature of the process. Likewise the incorporation of a competitive component to the ICQ, though considered highly motivational (Astleitner and Wiesner, 2006; Jovanovic et al., 2011; Prensky, 2001; Squire et al., 2005) would be difficult to embed as the ICQs primary goal is to encourage opinion formation and establish individual preferences, not to create a competitive environment with other participants.

The use of social presence in the form of discussion points throughout the gaming process is also considered a useful tool for promoting information processing and long term learning (Dornan, 2004; Lee, Jeong, Park and Ryu, 2011; Wild and Quinn 1997). Though not considered an option for the ICQ throughout the knowledge gaining and decision making phases of the ICQ, it was felt there may be room to incorporate a modified form of social presence to the beginning and final evaluative phases: for example, incorporating statements of previous participants into the home page, advising of the usefulness of the ICQ for knowledge gaining and opinion formation; and, a comparative view of a participant's policy problem choice against previously completed participants' choices from similar demographics.

The use of rewards where participants have the ability to accumulate points by progressing through a game to a stage where their points are redeemed for a prize or reward was another feature for consideration for the ICQ. Such rewards considered to include visual enhancements to existing user icons (such as an Avatar), or a more tangible prize with specific value (Karat, Pinhanez, Karat, Arora, and Vergo et al., 2001). For the ICQ a potential reward system considered was the awarding of pieces to a puzzle at the completion of option evaluations that could then be used in combination to address the policy problem (building the finished puzzle). Finally, after completing the ICQ a participant could be provided with an opportunity to revisit the information content in order to enhance their deliberation and solidify knowledge gains. And to potentially further enhance their knowledge through incorporating links to relevant content elsewhere on the Internet or by providing 'Socreatian' questions that inspire deliberation of content: "...where questions are used to analyse concepts, to prod at the depth of knowledge, and to focus on principles, issues, or problems" (Anderson, 2011).

## 2.4 The current research

Keeping the above in mind, it was considered that the ICQ would need to be adapted to include built in gaming motivational elements. Such elements by necessity would need to incorporate skill and memory development, spatial and/or mathematical reasoning, and social skills (e.g. negotiation), with the information provided being the means to achieving these skills. Being strongly content focused and relatively rigid in design, the challenge for the research team therefore was to develop and incorporate a skills enhancement process into the ICQ using a gaming/online learning environment that supported the exploration of information without violating its balance, neutrality and factual integrity.

After developing the online ICQ for both the Netherlands and Australia, the aim was to test whether it is possible to successfully create an effective and useful online tool to inform the public on ways of reducing carbon dioxide emissions and obtain perceptions on the public preferences. For the Australian ICQ, it was decided to test whether it was possible to successfully create valid and balanced information through a representative sample. The results of this sample were to be compared to previous research, using the ICQ in the Netherlands, to see whether results are comparable. In addition, it was decided to extend the current research in the Netherlands to examine effective strategies to disseminate the online ICQ (rather than obtaining a representative sample) and utilise interviews to gather feedback on the online design. In summary, primary to the overall project objective to gain a better understanding of public opinion toward energy technology, and CCS more specifically, the research team has identified the following research questions:

**Research question 1:** How do Australian opinions on energy options differ from the Dutch when measured using the ICQ?

**Research question 2:** Is it possible to enhance the quality of the original ICQ by making the questionnaire an interactive application?

# Part II Methodology

## 3 Research Design

The purpose of this Part of the report is to discuss the major methodological issues pertinent to this research, present the general methods for data collection, matters concerning data analysis and ethical clearance. In order to address the areas of interest, the research was divided into two studies:

**Study One: The comparative study** – This study focussed on testing how Australian opinions on energy options differ from the Dutch when measured using the ICQ.

**Study Two: The ICQ online study** – This study focussed on investigating how an online design could enhance the quality of the original ICQ by making the questionnaire an interactive application.

The following sections detail each of the studies research designs.

### 3.1 Study One: The comparative study

**Aim:** This study investigated the choices the general Australian public would make concerning carbon dioxide emission reduction options after having received and evaluated expert information on the consequences pertaining to these options compared to the Dutch public's responses to their country specific options. Therefore, this study addressed the following research question:

**Research question 1:** How do Australian opinions on energy options differ from the Dutch when measured using the ICQ?

**Method and measures:** The method used was the ICQ survey tool, which assesses not only informed evaluations of, in this case, carbon dioxide reduction options; it also investigates the evaluations of the consequences of these options after information has been processed. The results from the survey give insight into which consequences influence the overall evaluation, rejection and choice of an option.

Before respondents in the ICQ choose between the policy options, they receive information to make a more informed choice (see Appendix A for the full set of Australian and Dutch options and consequences). First, the choice is explicitly framed as a decision problem and respondents are informed about the background of the challenge. Second, respondents are provided with information about the consequences of the different policy options which address the decision problem. To stimulate information processing and to help respondents reach a decision, they are requested to give a quantitative evaluation of each consequence. On the basis of these quantitative evaluations, the subjective utility of each option may be determined.

The figures below depict the first stages of the online ICQ process, in which respondents were asked to select which country they are from. They are then lead to information about carbon dioxide emission issues and their country specific decision problem.

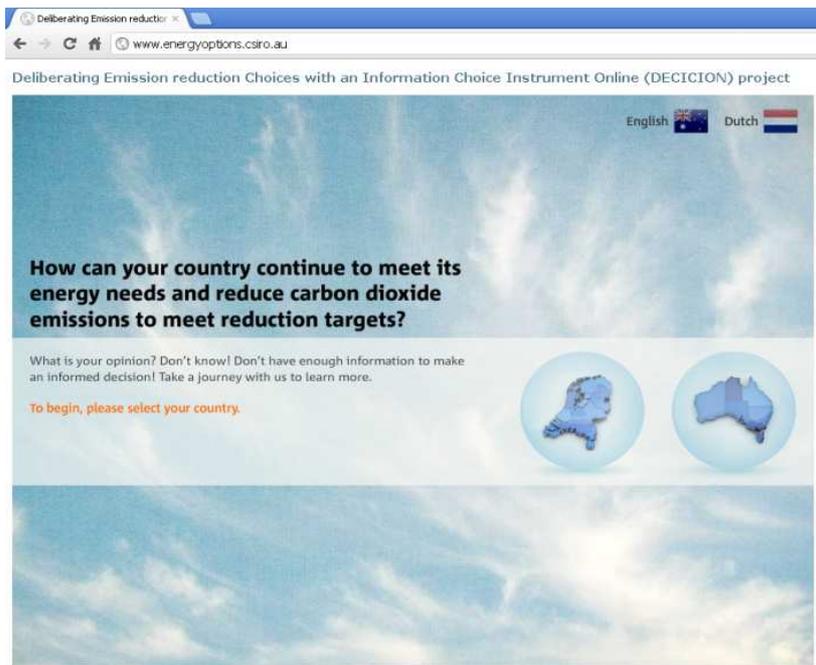


Figure 1. Selecting country specific information

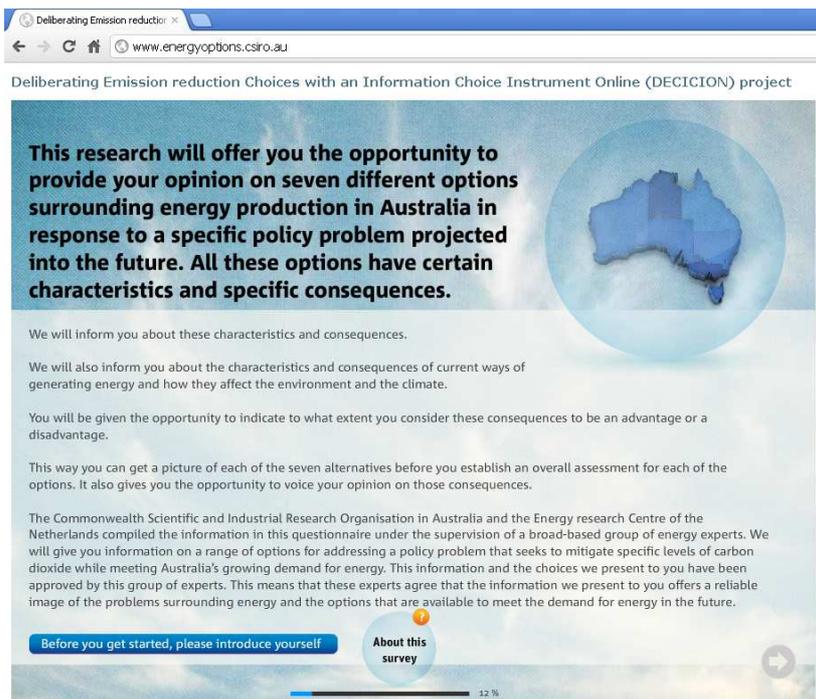


Figure 2. Presenting the policy problem, options and consequences

It is essential to define a clearly specified and policy relevant decision problem that is not overly demanding for respondents. Furthermore, when informing people about the decision problem and about the consequences of the options that can solve this problem, it is vital that this information is valid and balanced. Therefore, the information for the ICQ was compiled by experts from different backgrounds and different organisations and checked by another similarly differentiated group of experts. Only after their approval was given was the information included in the ICQ. This rigorous process provides not only accurate and balanced information but also credibility. Based on discussions with and between experts, the following seven options to solve the policy problem of ***how best can Australian demand for energy be fulfilled in 2030 in such a way that emissions of carbon dioxide will be reduced by 33% compared to 2000*** were defined as:

## Australian options and their aims

### Option 1: Energy efficiency in residential and commercial sectors

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by improving the energy efficiency in residential and commercial sectors focusing on changes to construction materials, technology and appliance use. Household electricity consumption has the potential to drop to just over 50% of today's electricity consumption by replacing lighting, old refrigerators and freezers, electric hot water systems, shower heads and taps and avoiding stand-by power use. Electricity efficiency in the commercial sector (which includes services such as finance, property and health, not heavy industry such as manufacturing and mining) can lead to a 60% reduction and has the potential for further decreases of up to 75%. Such reductions are possible in several ways, including the use of glazing, natural daylight, well maintained and efficient equipment, use of monitoring systems and a reduction in air conditioning usage. Energy efficiency improvement resulting in a 20% reduction in residential and commercial electricity consumption will be sufficient to achieve the reduction of 50 million tonnes of carbon dioxide.

### Option 2: Efficiency in the manufacturing and mining industries

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by increasing energy efficiency in manufacturing and mining industries by 11.4% and 10% respectively. This will require upgrade and replacement programs, improvements in heating systems, and the introduction of high efficiency technologies and controls, with opportunities for new technologies to provide additional potential for further energy efficiency.

### Option 3: Replacing future planned coal-fired power stations with gas

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by building new gas-fired power plants instead of new coal-fired power plants. Australia has vast reserves of most energy resources (with the exception of oil). Where coal is located, primarily in the larger Eastern states, it is the preferred electricity generation fuel because of its lower cost. Currently, 77% of Australia's electricity is produced by 38 coal-fired power stations and 15% is generated by 26 gas-fired power stations. Gas-fired power plants emit less carbon dioxide than coal-fired power stations, so there is an opportunity to reduce greenhouse gas emissions by building gas-fired instead of coal-fired power stations in the future. In order to achieve the 50 million tonne reduction by 2030 around 50% of all Australia's electricity needs will have to be produced from gas-fired power generation. This will effectively mean all new power stations are gas fired and that existing coal plants retire at their expected end of life.

Gas reserves in Australia are sourced from underground natural gas reservoirs and coal seams. Australia's Gas Industry has experienced substantial growth in the development of coal seam gas extraction technology over the past ten years and is set to continue to expand its use over the coming decades. With production of coal seam gas occurring already in Queensland and New South Wales, significant potential exists into the future.

### Option 4: Carbon dioxide capture and storage with coal

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by capturing, transporting and storing geologically emissions from flue gas emitted by coal-fired power plants in Australia. Carbon dioxide emissions can be captured, compressed into a liquid, transported and permanently stored deep beneath the Earth's surface. This process is called carbon dioxide capture and storage or CCS and allows for a continued use of fossils fuels in a low-carbon economy. In order to achieve the aim of this package Australia would require CCS to be installed at a quarter of the existing coal-fired power plants which make up 77% of current electricity generation; although it can be used in combination with gas-fired power plants as well. Presently, CCS is limited to a few industrial-scale projects related to the oil and gas industry. Australian CCS development for power sector applications is comparable to overseas progress and includes a range of pilot and demonstration projects across the nation.

### Option 5: Deploying renewable sources

This option aims to reduce 50 million tonnes of carbon dioxide by 2030, by increasing the use of a range of renewable energy generation technologies (e.g. solar, wind, geothermal, biomass). Currently most of Australia's energy is generated from fossil fuels (92%) with renewable sources contributing around 8%. To achieve the aim of this option, the share of renewable electricity in the total electricity production has to grow to approximately 23% in 2030.

The largest existing renewable sources are hydroelectricity (5%) and wind (2%). In the future, both solar and wind electricity generation resources have the potential to contribute over 100% of Australia's electricity needs but their supply will be less secure with their generation output being driven by the climate (such generation is called "intermittent"). Sustainably produced biomass would not be intermittent but its resource is more limited such that it could only produce 30% of power needs each year. Geothermal energy is not intermittent and is available on the scale of solar and wind resources. Consequently, while the technology is less proven, it has a strong potential to increase the share of renewable sources in electricity generation.

### Option 6: Participating in an international emissions trading scheme

This option aims to reduce 50 million tonnes of carbon dioxide by 2030 by buying international emission permits. This would typically be introduced as part of a national emissions trading scheme that would induce abatement in many sectors across the economy and such is the case in Australia from July 2015 (following on from a fixed price scheme starting in July 2012). A domestic carbon price scheme is one of many policy initiatives that could be used to encourage people to take up abatement options and can be targeted to achieve any level of abatement (the Australian Government's target is 80% below 2000 levels by 2050). However in this abatement option we are strictly only interested in the part of the emissions trading scheme that allows the purchasing of emissions permits from overseas which can substitute for taking domestic abatement action.

When Australia introduces emissions trading there will be a limited number of permits available in Australia and the scheme will allow the option to buy permits internationally to cover emission liabilities. The purchasing of international permits will be limited to only 50% of a business's annual emissions under Australian emissions trading scheme rules. In order for Australian businesses to participate in purchasing international permits, the Government would need to agree to link its carbon trading scheme with other countries trading schemes. Presently no such agreements exist but the Australian Government foresees international linking at the start of its flexible price cap-and-trade scheme from 1 July 2015 onward.

### Option 7: Nuclear power

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 through the introduction of nuclear powered electricity. In order to achieve this Australia would need to install five new nuclear power plants. The next generation of nuclear power plants would have a 60 year lifespan and use automated safety systems which are a significant improvement on some existing nuclear power plants. Currently Australia has no working nuclear power facilities; however, there is a research nuclear reactor in Sydney for research and medical purposes.

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The 2012 Dutch ICQ options were developed by experts similar to a previous Dutch ICQ study conducted in 2007 by de Best-Waldhober, Daamen, Ramirez, Faaij, Hendriks and Visser (2008). The policy problem was to **reduce the Netherlands emissions by 50% by 2030**. The seven Dutch options were defined as:

#### Dutch options and their aims

##### Option 1: Improvement of energy efficiency

This package aims to reduce carbon dioxide emissions with 40 million tonnes 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 needed to heat a medium-sized house. Or, the energy needed to produce a tonne 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, less energy will be needed to get the same result. Without extra measures the energy saving improves every year. To save 40 million tonnes of carbon dioxide emission, an additional energy efficiency increase of 1% per year needs to be realised for appliances, cars, houses and factories. To achieve this additional 1 % of energy saving per year, the government has to take mandatory measures. These measures are needed to ensure that companies and civilians make an effort to increase the energy efficiency of their appliances, cars and houses and to optimise the production of goods. Because this package requires less energy to get the same result, less fuel is needed to generate energy.

### Option 2: Improvement of energy efficiency and decreased use of material and energy

This package aims to reduce the emission of carbon dioxide by 40 million tonnes in 2030. This package is an addition to the first package “Improved energy efficiency”. This first package aims to reduce the emission of carbon dioxide with 40 million tonnes, by improving the efficiency of appliances, cars and houses with 1% per year. This second package is an addition to the first package and aims to reduce another 40 million tonnes of carbon dioxide by improving the efficiency with another 1% per year. The first and second package together lead to a reduction of carbon dioxide emission by 80 million tonnes in 2030. To implement this package the government has to take extremely tough and compulsory measures, even tougher measures than in 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, very strict government policies such as deposits, taxes and fines will have to force people to reduce the use of energy and materials.

### Option 3: Electricity from wind turbines at sea

This package aims to reduce the emission of carbon dioxide with forty million tonnes 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.

### Option 4: Conversion of biomass to car fuel and electricity

This package aims to reduce the emission of carbon dioxide by forty million tonnes by powering a share of the cars using fuel converted from biomass and by making power plant use biomass as a fuel for the generation of electricity. Biomass is a term used for a variety of organic materials such as wood, grass, organic waste, etc. Biomass can be used to generate electricity, but also to create fuel for cars. When plants grow they withdraw carbon dioxide from the air. This carbon dioxide is released again when biomass is being burned. By burning plants, the amount of carbon dioxide that is released is not lower than the amount of carbon dioxide that has been withdrawn by the plants during growth. Therefore biomass is carbon dioxide neutral. This package is not completely carbon dioxide neutral because of the need for transportation and handling of the biomass. To reduce forty million tonnes of carbon dioxide by the year 2030 by using biomass, approximately 80 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. Biofuel factories will have to be built where biomass can be converted into fuel. A share of the currently used oil refineries, where crude oil is converted to petrol and diesel oil, may gradually be converted into or replaced by biofuel factories. In that case a small portion of this biomass in the Netherlands will be converted into electricity by three or four large power plants in seaports like Rijnmond, Eemshaven or Terneuzen.

### Option 5: Large plants where coal or gas is converted into electricity with CCS

This option aims to decrease carbon dioxide emissions with 40 million tonnes by capturing carbon dioxide that is produced by coal-fired and gas-fired power plants and storing it underground in the Netherlands or under the Dutch part of the North Sea. Carbon dioxide capture can take place at existing power plants or be integrated into new plants. It is expected that, by 2030, about half of the power plants with carbon dioxide 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 carbon dioxide 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 on safety and availability will be needed to determine if all this storage space can be used. Research may, however, show that more space is available than currently expected.

### Option 6: Large plants where gas is converted into electricity with CCS

This package aims to reduce carbon dioxide emissions with 40 million tonnes by producing hydrogen and capturing and storing the carbon dioxide 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, or to replace natural gas in households. About 20 to 25 large hydrogen factories will be built for this package. The carbon dioxide that is produced during the conversion of natural gas into hydrogen will be captured and stored underground in the Netherlands and under 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 adjusted 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 heat 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 carbon dioxide 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 on the safety and availability will be needed to determine if all this storage space can be used. However, research could also show that there is more space available than currently expected. It is

likely that alternative uses can be found for the infrastructure (such as installations, fuel stations and the pipeline grid) after this time, because by then other ways will have been developed to produce hydrogen without natural gas.

### Option 7: Electricity from nuclear power plants

This package aims to reduce the emission of forty million tons of carbon dioxide by generating electricity in five large nuclear power plants by the year 2030. Nuclear power plants use uranium as fuel. Uranium is extracted from uranium mines. Generating electricity with uranium does not produce carbon dioxide. 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 thus increase global use. It is very likely that new uranium sources will be discovered, in which case the nuclear power plants can be supplied for a long time.

The website's front end information was heavy with ethical clearance related information in line with guidelines stipulated by the Australian National Statement on Ethical Conduct in Human Research ([www.nhmrc.gov.au](http://www.nhmrc.gov.au)). This information pre-empted the commencement of the ICQ resulting in several introductory pop up six screens needing to be viewed prior to instructions for completion of the ICQ became visible. Participants were required to confirm that they understood the and agreed with the conditions of the website, e.g., they understood it to be anonymous, voluntarily, and that data sourced via the ICQ would be used in reporting on the research findings, including but not limited to publications in several journals, and that the findings would be made available to them should they require. A brief overview of the two organisations conducting the research was provided, including contact details for corresponding representatives prior to a participant commencing the ICQ. The figure below depicts how this information was provided to the respondents.

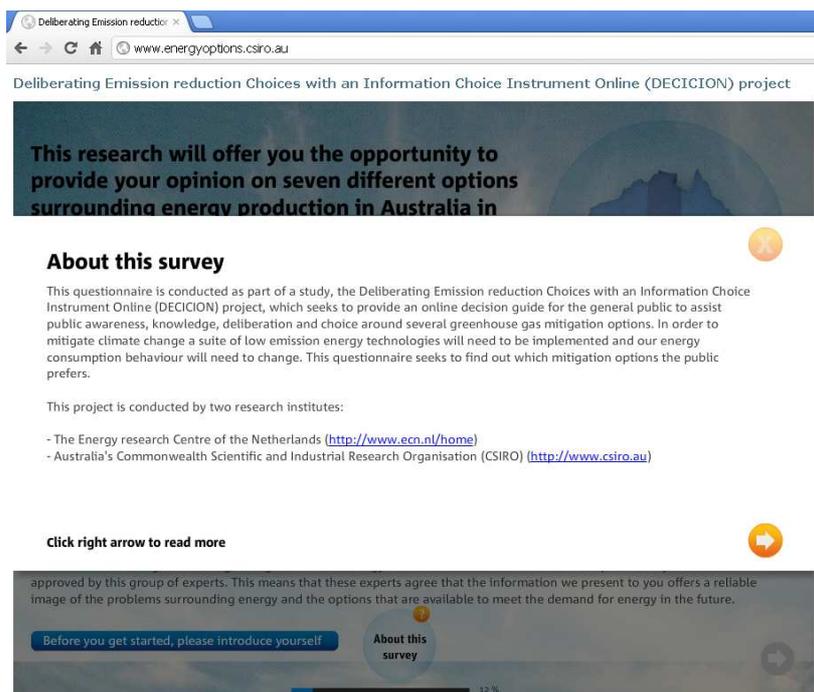


Figure 3. Project and organisation information and ethical consent

Once participants had received information on the organisations and consent was provided, they were invited to register by creating a log in name using a unique URL provided to them in an invitation to complete the ICQ; the URL to be used to assess each of the different components of the ICQ (11 in total). The impetus behind this requirement was an inability to integrate all aspects of the ICQ into one single website. As a result, respondents were directed to an online survey company's website at predetermined points throughout the ICQ host website via visual links.

In order to ensure that data collection from the different components of the website were readily identifiable to one respondent, the log in name was mandatory and once completed triggered background programming to register data from the survey in a panel using the log in name to denote the respondent.

Each component hosted by the online survey company website included this requirement. This imposed some difficulty for respondents. Other implications and consequences of the use of this design will be discussed in the second study.

The respondents were given information on the current use of energy and ways in which energy is produced. Next, they were explained what the frequent use of oil, gas and coal means for the climate, by explaining the role of carbon dioxide in global warming. Respondents were given 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. The series of figures below show how this formation was provided to the respondents.

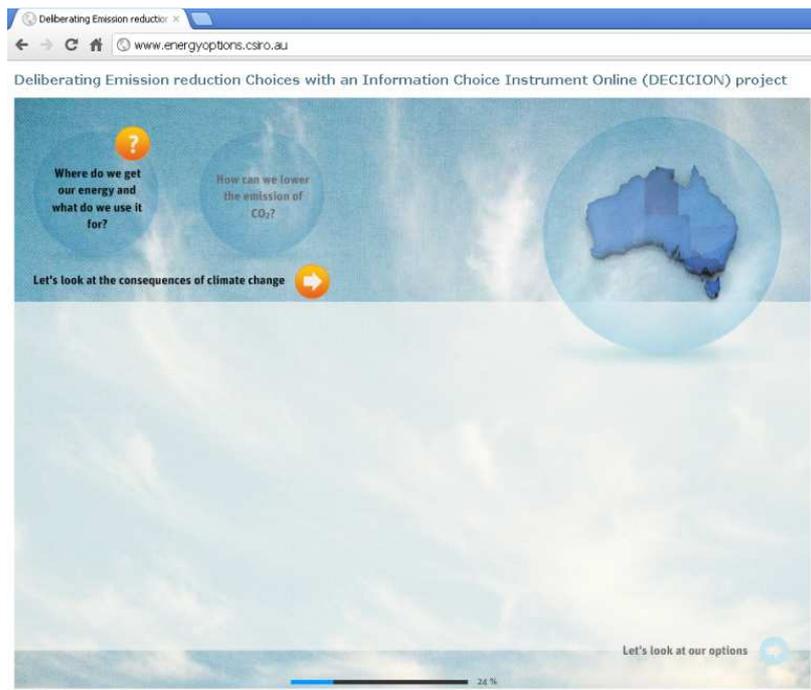


Figure 4. First screen to link to information on energy and its uses

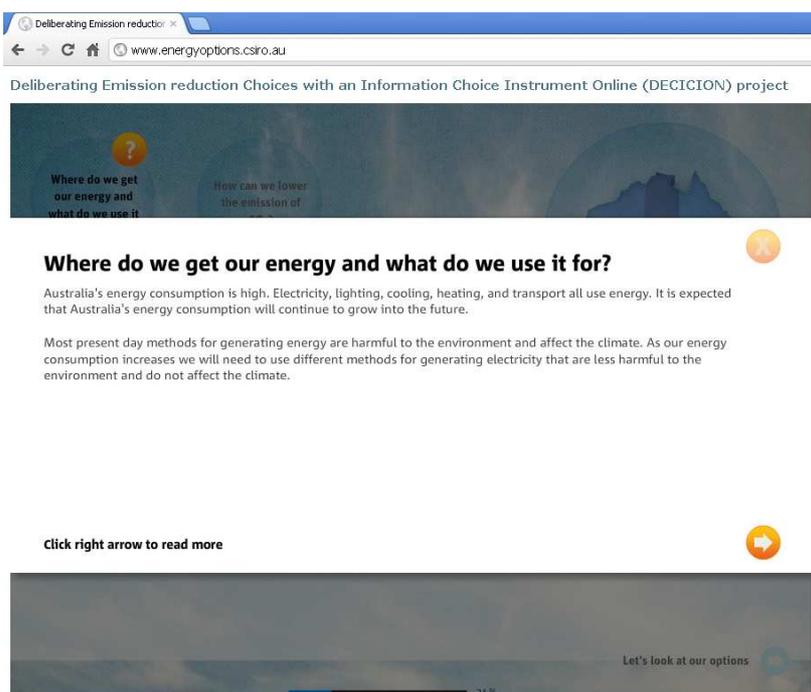
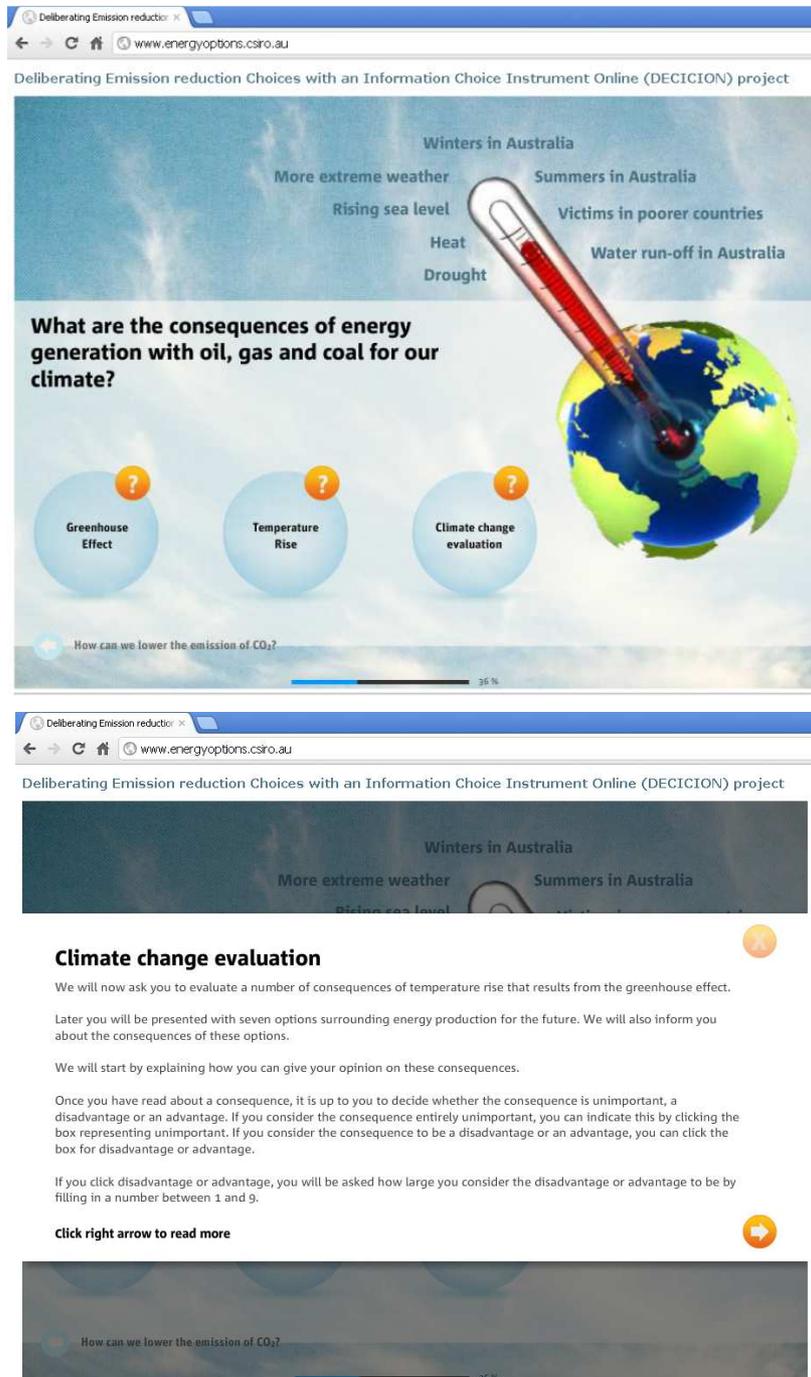


Figure 5. Pop up tabs were used to provide information on energy production and use

Preliminary to the information on global warming, respondents were given information on ways to reduce emissions of carbon dioxide. It was explained that this questionnaire focused on seven options that can help to reduce carbon dioxide emissions. It was made clear to the respondents that **three of the seven options were necessary** to reduce carbon dioxide emissions (by the required amount - Australia by 33% and the Dutch by 50%) needed in order to address the policy problem. The figures below depict how information was provided for the climate change and global warming topics.



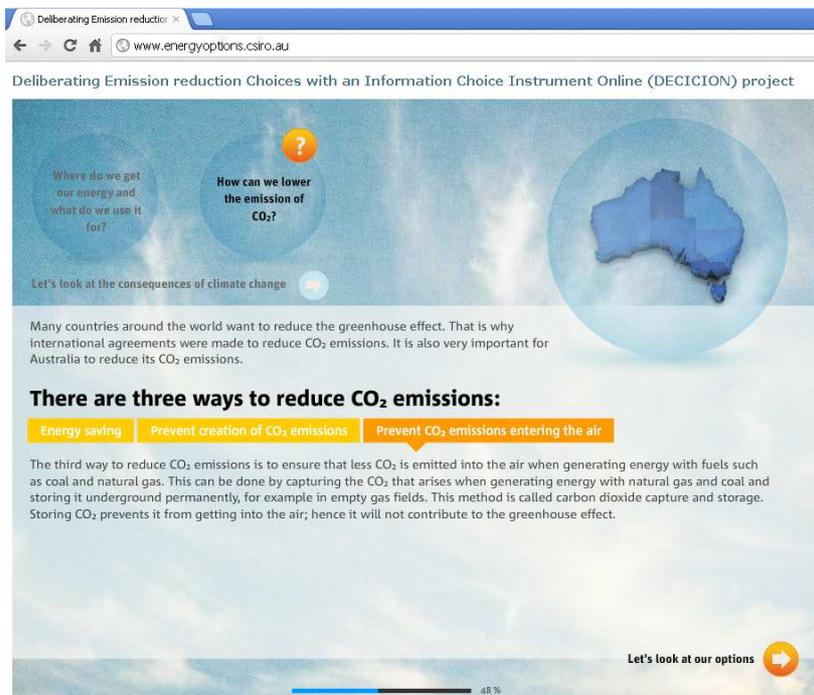
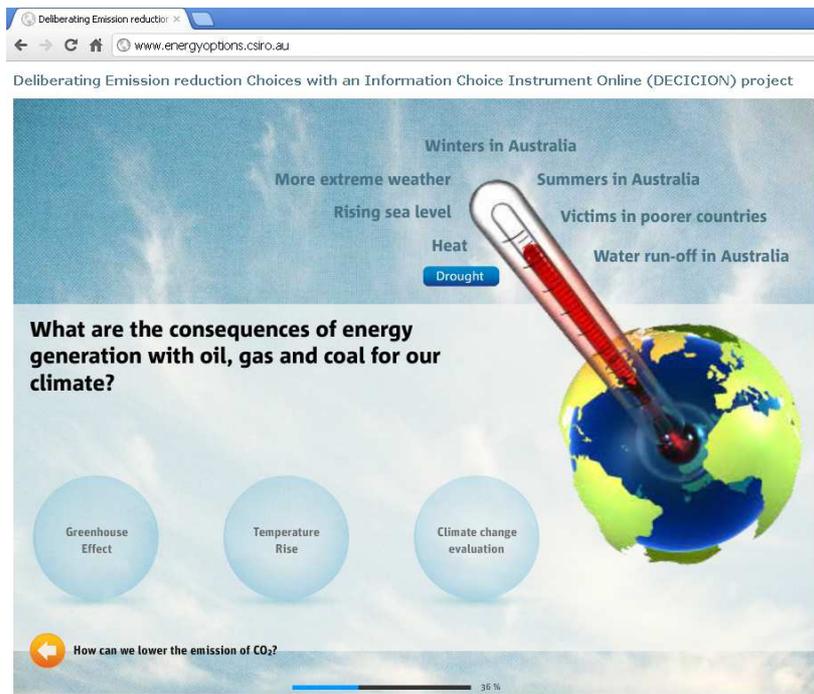


Figure 6. Climate change and global warming information

After this information, an overview page of pictures with a reference to the seven options was provided. Care was taken to keep the pictures as neutral as possible. For example, the option ‘Electricity from wind turbines at sea’ was depicted by a picture of a wind turbine. In addition to a picture, the description of the option was provided, and a question regarding the content of the option to invoke curiosity to find out more about the specific option. To continue the example, for the option ‘Electricity from wind turbines at sea’ the question: ‘what height will the wind turbines have, that are necessary for this option?’ was added. The figures below demonstrate how respondents navigated to the each of the seven options.

Deliberating Emission reduction Choices with an Information Choice Instrument Online (DECICION) project

To reduce the risk of a strengthened greenhouse effect, it will be necessary to reduce CO<sub>2</sub> emissions significantly. In 2050 this needs to be 60 to 80 percent lower than our current emissions. This way temperature rise may be limited to 2 degrees Celsius. This is the maximum allowed rise that experts believe will lead to calculable consequences. It is assumed that rich countries will do more to limit their emissions than poor countries.

One option to reach a 60 to 80 percent reduction target by 2050 could be to reduce our emissions by 33 percent by 2030 compared to our current emissions. Earlier we explained the three methods for reducing CO<sub>2</sub> emissions: energy saving; replacing CO<sub>2</sub> emitting fuels with other energy sources, such as renewable and nuclear energy; and preventing the release of CO<sub>2</sub> into the air with CO<sub>2</sub> capture and storage. For this scenario seven options have been selected that could work together to reduce CO<sub>2</sub> emissions by 33 percent in 2030, using these energy saving methods.

Although each option may offer significant reductions in CO<sub>2</sub> emissions by 2030, one single option may not be enough to realise the envisaged reduction. For this scenario it will take three options to realise the reduction.

A 33 percent reduction in CO<sub>2</sub> emissions requires a decrease of approximately 150 million tonnes of CO<sub>2</sub>. Each of the options addressed aims at decreasing CO<sub>2</sub> emissions by approximately 50 million tonnes. Combining three of these options together will reduce CO<sub>2</sub> emissions by approximately 150 million tonnes (3 x 50 million).

**The seven options are:**

- 1 - Energy efficiency in residential and commercial sectors
- 2 - Efficiency in the manufacturing and mining industries
- 3 - Replacing future planned coal-fired power stations with gas
- 4 - Carbon dioxide capture and storage with coal
- 5 - Deploying renewable sources
- 6 - Participating in an international emissions trading scheme
- 7 - Nuclear power

Please click here to learn more about the information that will be presented to you in each of the seven options

Go to the 7 options

Deliberating Emission reduction Choices with an Information Choice Instrument Online (DECICION) project

To reduce the risk of a strengthened greenhouse effect, it will be necessary to reduce CO<sub>2</sub> emissions significantly. In 2050 this needs to be 60 to 80 percent lower than our current emissions. This way temperature rise may be limited to 2 degrees Celsius. This is the maximum allowed rise that experts believe will lead to calculable consequences. It is assumed that rich countries will do more to limit their emissions than poor countries.

One option to reach a 60 to 80 percent reduction target by 2050 could be to reduce our emissions by 33 percent by 2030 compared to our current emissions.

**Information you need to know about the seven options**

While compiling the information about the consequences of these options, the experts made certain assumptions. For example, they assumed that Australia is not the only country where CO<sub>2</sub> emissions are reduced; all countries have the same aim.

Later on, when you select three options, you will need to take the combination of the options into account. Not every combination of options is logical or possible. Before we ask you to make your choice, we will give you more information about this.

The information about the consequences of these options has been compiled by experts. This means that the consequences that are shown to you are considered important by experts. However, these experts cannot determine whether you find the consequences important and to what extent you consider a certain consequence to be a disadvantage or an advantage. That is why we are asking you.

Click right arrow to read more

5 - Deploying renewable sources  
6 - Participating in an international emissions trading scheme  
7 - Nuclear power

each of the seven options

Go to the 7 options

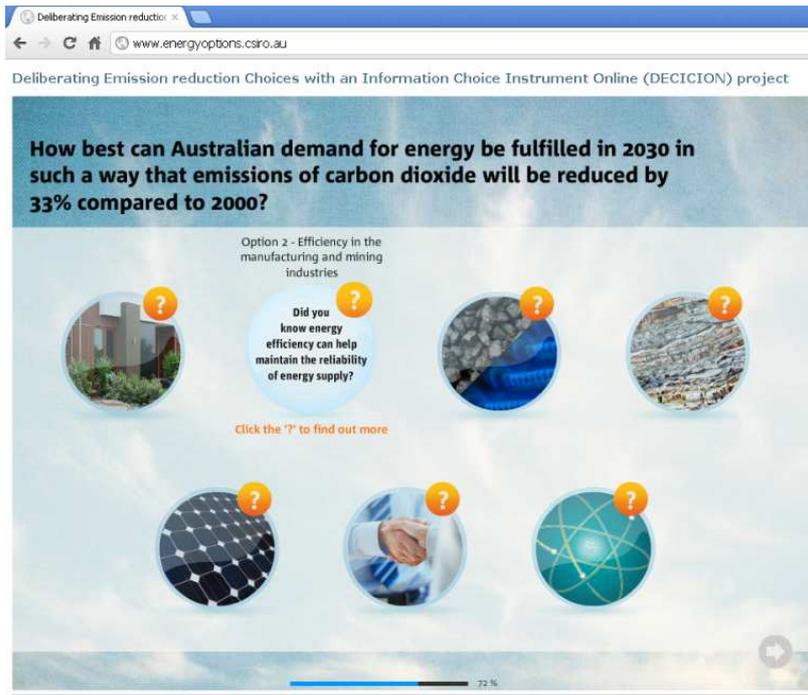


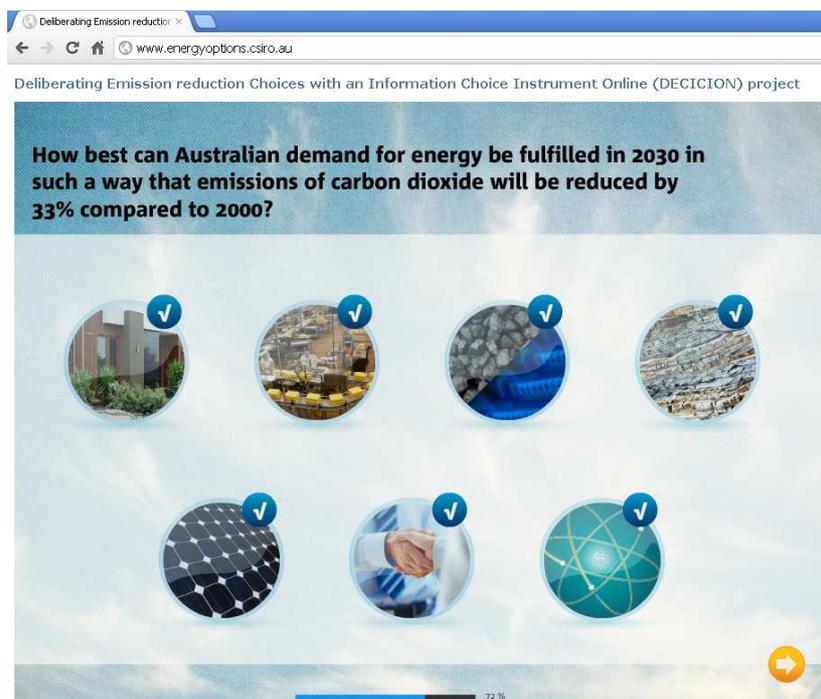
Figure 7. Website pages that lead to the seven policy options

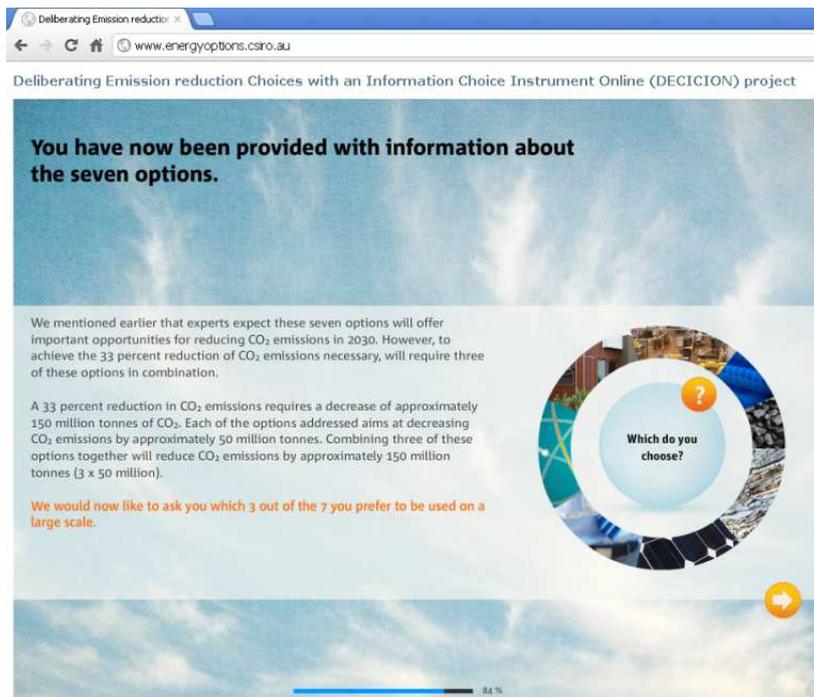
Once participants chose one of the seven options to evaluate, respondents received a description of the option. Descriptions of the options contained information on, for instance, the essence of the technologies, the amount and location of plants or fuel cells, conditions for implementation, or the kind of end use. After the general description, respondents were asked to evaluate all the consequences of the option in question.

Respondents were asked to state for every consequence if they thought the consequence to be 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 or disadvantage they thought the consequence to be. This was asked on a 9-point scale, with one being a very small advantage or disadvantage, and nine being a very large advantage or disadvantage. This way, respondents could evaluate all the relevant consequences of an option one by one. After rating all the consequences separately respondents were then given the opportunity to provide their overall evaluation by providing a report mark for the option, on a scale of one to 10 (1 = not favourable to 10 = very favourable).

Once all seven options had been assessed, respondents were directed to a pop up screen containing introductory text relating to the three out of the seven options selection requirement. Following this, respondents received an overview of all the options, their overall evaluations and total disadvantage and advantage scores. Respondents were told that, at this point, having read all the information on the seven options, this was their opportunity to change their opinions if they desired. Once any changes were made, respondents were then asked which three of the options they preferred to be implemented on a large scale. A reminder was provided which stated that they could base their choice on their overall evaluations of the options and/or on the total disadvantage and advantage scores.

Following this process, respondents were subsequently asked if there were any options in the questionnaire they thought was absolutely unacceptable if implemented on a large scale. To be defined as 'unacceptable' the respondent would need to consider taking action if the Australian or Dutch society considered implementing this option on a large scale. The figures below show the selection of the three options process in order to address the policy problem.





**Figure 8. Selecting the three options to address the policy problem**

After respondents had provided their overall evaluations and selected their three option preferences, they were asked to give an opinion of the online ICQ, with questions posed focused on the amount, impartiality, clarity and completeness of the information provided. Furthermore, it was asked whether respondents thought the procedure of the ICQ had aided them in making a decision between the different options, whether it was comprehensible, or complicated. Respondents were asked if they had felt restricted in their choice for packages. Finally, respondents were asked what they thought of the website itself; whether they would recommend it, and what they liked or disliked.

For this research the service of a panel recruitment company was used. Participants were paid (AUD \$15.13 or EUR €10) to complete the full survey. As the Australian ICQ was newly developed, the necessity of finding sufficient participants was important; the aim therefore was to collect 400 responses from a representative sample of the Australian population. Since the Dutch ICQ had been extensively tested previously, the aim was to gather a minimum of 100 responses in order to test the consistency of the previous Dutch findings.

**Data analysis:** For the first study, the evaluation of consequences in relation to overall option evaluation scores was analysed. Before respondents made a choice between the seven energy options, they evaluated, one by one, all the consequences of the seven energy options. Respondents stated whether they thought the consequence was an advantage, a disadvantage or not important. When the consequence was thought to be an advantage or disadvantage, they evaluated how much of an advantage or disadvantage the consequence was on a scale of one to nine. In the results section, the average evaluations of consequences and their relation to the overall evaluation of an option are presented and discussed per option. The evaluations of the consequences were recalculated in a way that each consequence was evaluated on a scale of -9 to 9, with -9 meaning a very big disadvantage, 0 meaning neutral and 9 meaning a very big advantage.

Results are provided in a table for each option which includes: the multiple correlation (R), the average evaluation of the specific consequence, the overall evaluation score and the correlations between the evaluation of the individual consequences and the overall evaluation of the option. The correlations give some insight to the relative influence of the different consequences on the overall evaluation score decision. A correlation can vary between -1 and 1, with 0 meaning no relationship 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.

The multiple correlations (R) 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 closer the multiple correlation is to 1, the more the evaluations of the consequences explain the evaluation of the option, in other words, how much the evaluation of the option is based on the overall information provided. Linear regression analyses were conducted to investigate these relationships.

Although there were multiple consequences for each option, not all were significant influences on decision making with regards to the policy options. Therefore, to avoid long and irrelevant discussions, only the consequences with high correlations to the overall evaluation (or unexpectedly low correlations) are explained and discussed.

## 3.2 Study Two: The effectiveness of the ICQ online study

**Aim:** The current project's secondary aim was to develop an interactive online ICQ tool in order to investigate various design and delivery aspects and its ability to attract and retain users for the duration of the process. Therefore, this study addressed the following research question:

**Research question 2:** Is it possible to enhance the quality of the original ICQ by making the questionnaire an interactive application?

**Method and measures:** In order to capture the data for the second study, a set of semi-structured interviews were conducted throughout an "out a loud" test of the online interaction with the Dutch ICQ. The following factors were the focus of the interview questions:

### Education Focus

- Is there interest in the topics of climate change and ways of addressing carbon dioxide emissions mitigation?
- ICQ – is it education friendly and have the potential for discussion?
- Is the information provided independent and multiple-angled?

### Policy Focus

- Does the ICQ provide local, concrete and practical consequences?
- How best is a tool like the ICQ disseminated or used in policy development?
- Is there a link between the study's website with their information purpose?

### Technical Aspects

- Is the website and survey user-friendly and a visually pleasing interface?
- Did the website develop a narrative and storyline to support the content?
- Did the website present a clear goal for the user with feedback about the progress?
- Did the website provide the user with some control?
- Did the website create a social presence?
- Did the website make use of questions to instil curiosity and enhance deliberation after the policy advice was been given?
- Did the website create rewards and competition?

**Data analysis:** For the second study content analysis was used to analyse the responses from the interview data. Summations are provided for each of the interview questions in the results section of Study two.

### 3.3 Ethical Considerations

Ethical clearance was approved for all data collection (CSIRO Social Science and Human Research Clearance Number: 012/11). In this research the matching of survey components was essential and therefore, all attempts were made to preserve the confidentiality of the project respondents through the use of a coding system. In addition, all respondents signed consent forms and received information regarding the project's focus, aims, data collection techniques and confidentiality.

# Part III Results and Discussion

## 4 The Comparative Study

The first study was divided into five components:

- The original Dutch ICQ;
- The Australian ICQ;
- The recent Dutch ICQ;
- Survey feedback; and
- A comparison between the Australian and Dutch ICQs.

### 4.1 The Original Dutch ICQ

#### 4.1.1 ORIGINAL SAMPLE

The original ICQ was administered in May of 2007 in the Netherlands. The sample for the ICQ consisted of 971 respondents of at least 18 years of age and was a representative sample for the Dutch population. This sample was tested to find if there were any differences in the most common demographic variables between this sample and the Dutch population. The distributions of all demographic variables that were tested (sex, age, education) were the same for the original ICQ sample and the Dutch population, which means that the ICQ sample was representative for the Dutch population.

#### 4.1.2 SUMMARY OF ORIGINAL ICQ RESULTS

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 graded relatively low compared to some of the other technology options. The first CCS option was graded 5.34, while the second CCS option was graded just below 6 on average (5.92). In comparison, respondents evaluated most of the other options in the questionnaire more favourably. The first efficiency option was evaluated 7.33 on average, the wind energy option was evaluated 7.15 on average and the biomass option was evaluated 7.41 on average. Respondents were also less positive about the second efficiency option and the nuclear energy option, which on average were evaluated 5.84 and 5.29 respectively. Although the average overall evaluation of one of the CCS options (5.34) is not very different from the average overall evaluation of the nuclear energy option, the results show that the distribution of evaluations is different. The nuclear energy option was evaluated as very negative or very positive by substantially more respondents than the CCS option. In Table 1 an overview is provided of the overall evaluations of the options, percentages of rejection and choice of the options.

**Table 1. Original ICQ - Percentages of grades, mean grades, percentages of rejection and choice**

Option	1-3	4-5	6-7	8-10	Mean	Reject %	Choice%
Improvement of energy efficiency	0.7	5.5	47.7	46.0	7.33	0.4	90.2
Improvement of energy efficiency and decreased use of material and energy	7.1	32.3	47.9	12.8	5.84	5.9	24.0
Electricity from wind turbines at sea	1.7	8.7	46.5	43.2	7.15	1.9	75.4
Conversion of biomass to car fuel and electricity	1.3	5.0	42.2	51.4	7.41	1.5	70.0
Large plants where coal or gas is converted into electricity with CCS	11.2	41.0	41.3	6.4	5.34	11.0	6.9
Large plants where gas is converted into hydrogen with CCS	6.1	28.8	53.1	12.1	5.92	6.8	10.6
Electricity from nuclear power plants	19.4	31.1	36.9	12.7	5.29	20.0	22.9

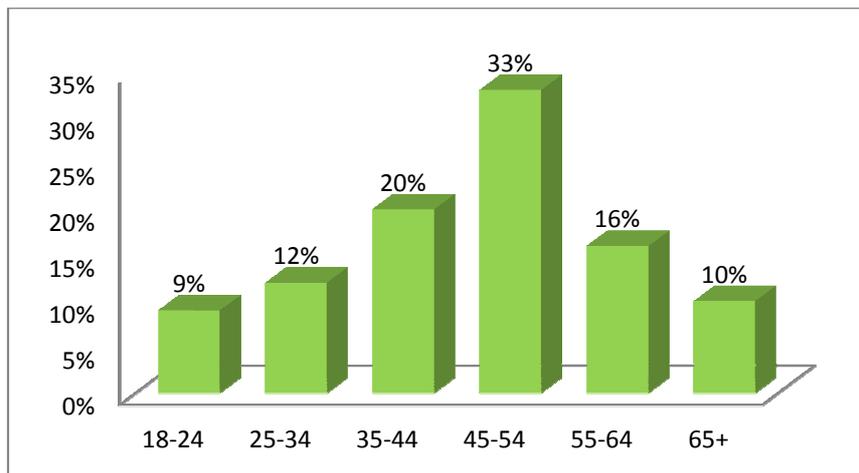
More sophisticated analyses were also done to see how specific consequences were evaluated and how this relates to the evaluations of the options overall. The details of these analyses are discussed in Section 4.3 and compared with the Dutch sample taken for the current study to avoid repetition.

## 4.2 The Australian ICQ

### 4.2.1 AUSTRALIAN SAMPLE

Of 984 initial responses to the Australian online ICQ, 369 respondents (37.5%) completed the full survey. Of these 10 respondents were identified as not seriously participating (for example, all consequences were judged to be unimportant, or all options were rated with the grade of a 10). These cases were therefore excluded from further analyses. The final number of completed surveys equalled 359.

Of the respondents, 146 (40.7%) were male and 213 (59.3%) were female. Age distribution is depicted in Figure 9. Most participants resided in the state of New South Wales (32.3%) or Victoria (28.7%). A large proportion of participants (46.5%) have completed a tertiary education (Bachelor/Master degree/Doctorate). Furthermore, most were working as an employee in the private sector (30.6%).



**Figure 9. Age distribution for Australian respondents**

When asked what their interest is in the topic of energy and climate change, most respondents (78.3%) answered that they have a general interest in the subject. Furthermore, when asked for their motivation to use the tool, most answered that they believed the tool could help them to form an opinion on the subject of energy and carbon dioxide emissions (56.5%) and that they wanted to know more about one or more of the subjects (40.9%). An important note to these results, however, is that respondents were recruited and paid by a panel service company. As a result, respondents’ motivation to use the tool may have been largely influenced by the financial incentive instead of intrinsic motivations. This option was however not covered in the answer categories, as it was not anticipated that respondents would be paid to complete the survey.

#### 4.2.2 EVALUATION AND CHOICE OF OPTIONS

The following sub-sections provide the findings for the percentage of respondents that took the opportunity to change their original decision on rating each of the consequences. The average grade for each option is also provided, along with the options identified as being ‘unacceptable’ as well as the preferred options. Table 2 provides a summary of the statistical results for each of these four areas.

##### Change

After receiving all the information and having evaluated all the consequences for each option, respondents were again confronted with their overall evaluation of each option. They were then given the opportunity to change these grades. Only 37 respondents (10.3%) chose to change their initial evaluations. The following analyses are based on the final ratings provided by all respondents.

##### Grades

On average, people tended to grade the options around the mean of the scale. The options that received a grade of a 5.5 or higher (usually considered to be a “sufficient” grade, while lower than 5.5 is considered “insufficient”) were the two efficiency options, the option on renewables and the CCS option. Table 2 contains the distribution of the Australian overall evaluations per option (%) and the mean overall evaluation given by respondents.

##### Rejection

Respondents were given the option to indicate whether they perceived any of the options to be unacceptable. About half of the respondents (N = 182, 50.7%) indicated they did find one or more options to be unacceptable. The option that was most often perceived as unacceptable by respondents was Nuclear power (36.2%). The other options were mostly perceived as acceptable.

## Choice

After evaluating all the options, respondents eventually were asked to choose three out of the seven options for which they preferred. Three options were clearly preferred over the others: efficiency in residential and commercial sectors (78.8%), efficiency in the manufacturing and mining industries (65.2%) and deploying renewable sources (60.4%).

In addition, an analysis of the chosen combination frequency was conducted. Most often (26.5%) of respondents chose the combination of the three most popular options. When CCS was amongst the chosen options, this was most frequently combined with efficiency in residential and commercial sectors and efficiency in the manufacturing and mining industries (7% of all combinations that were chosen), with efficiency in residential and commercial sectors and renewable sources (3.9%) or with efficiency in the manufacturing and mining industries and nuclear (2.8%).

**Table 2. Australian ICQ - Percentages of grades, mean grades, percentage of rejection and choice**

Option	1-3	4-5	6-7	8-10	Mean	SD	Reject %	Choice %
Energy efficiency in residential and commercial sectors	3.9	18.1	34.8	43.2	<b>6.97</b>	1.82	4.5	78.8
Efficiency in the manufacturing and mining industries	6.1	20.6	43.5	29.8	<b>6.50</b>	1.87	1.1	65.2
Replacing future planned coal-fired power stations with gas	21.4	31.2	31.0	16.4	<b>5.36</b>	2.14	7.8	23.7
Carbon dioxide capture and storage with coal	15.9	29.5	35.4	19.2	<b>5.69</b>	2.15	10.3	26.5
Deploying renewable sources	8.9	27.9	34.0	29.2	<b>6.28</b>	2.06	2.5	60.4
Participating in an international emissions trading scheme	23.4	26.7	29.8	20.1	<b>5.39</b>	2.44	9.2	18.7
Nuclear power	33.1	20.7	20.3	25.9	<b>5.19</b>	2.82	36.2	26.7

### 4.2.3 RELATIONSHIP BETWEEN THE CONSEQUENCES AND OVERALL EVALUATION FOR EACH POLICY OPTION

This section will provide the results for each of the policy options with regards to the relationship between the average evaluation of each consequence and the respondents overall evaluation of the options. Respondents to the Australian ICQ received information on each of the options, first receiving a description of the option, then information on the consequences relevant to each of the options. Respondents were asked to evaluate these consequences as described in the methodological section above. Finally, they were presented with their evaluations of all the consequences and asked to provide an overall evaluation on a scale from one to 10, like a grade. This process is repeated for each option and corresponding consequences.

### Option 1: Energy efficiency in residential and commercial sectors

Table 3 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the first option on energy efficiency in residential and commercial sectors. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .39$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option ranged from moderate to low. The consequences that correlate highest were “policy and regulatory initiatives” ( $r = .32$ ) and “Reliability of energy supply” ( $r = .30$ ), indicating that these consequences had the most influence on the overall evaluation of the option. Particularly the reliability of energy supply consequence appears to be something that respondents considered to be a benefit of this option, which had a moderate but positive effect on the overall evaluation.

The consequences that correlate lowest with the overall evaluation were “Costs” ( $r = .18$ ) and “redirecting savings to energy intensive activities” ( $r = .08$ ). This means that these consequences had very little influence on the overall evaluation. As both evaluations of these consequences were around the midpoint of the scale, it also seems that respondents saw these consequences as neither an advantage nor a disadvantage.

Overall, respondents appeared to be moderately positive about this option, grading it with a 6.97. This indicates that respondents seemed to consider that efficiency in the residential and commercial sector as an attractive option for mitigating climate change.

When compared with the 2007 Dutch ICQ results on the energy efficiency option, although all evaluations tended to be lower, the results are quite similar. For example, reliability of energy supply was evaluated as positive in 2007 as well, and had a similar correlation with the overall evaluation as found in the current results for the Australian sample.

**Table 3. Option 1: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Energy efficiency in residential and commercial sectors	.39		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	1.0	.18	6.97
Economic impacts	3.3	.23	
Greenhouse gas emissions	4.7	.22	
Environmental impacts	4.7	.23	
Policy and regulatory initiatives	2.1	.32	
Reliability of energy supply	4.9	.30	
Consumer commitment	2.2	.28	
Redirecting savings to energy intensive activities	0.1	.08	

\* Correlation between average evaluation and average overall evaluation score

## Option 2: Energy efficiency in the manufacturing and mining industries

Table 4 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the second option on energy efficiency in the manufacturing and mining industries. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .38$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were mostly low. The consequences that correlated highest were “costs” ( $r = .27$ ), “redirecting savings to energy intensive activities” ( $r = .27$ ) and “Industry commitment” ( $r = .27$ ), indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were however rated around the midpoint of the scale, indicating that respondents neither perceive these consequences as being an advantage nor a disadvantage.

The consequences that correlated lowest with the overall evaluation were “Economic impacts” ( $r = .12$ ) and “Environmental impacts” ( $r = .14$ ). This indicates that these consequences had very little influence on the overall evaluation. The economic impacts option was evaluated as having a slight disadvantage, while the environmental impacts option was evaluated rather more positively.

Overall, respondents were moderately positive about this option, grading it with a 6.50. This indicates that respondents seemed to consider efficiency in the manufacturing and mining industries as a moderately attractive option for mitigating climate change.

When compared to the 2007 Dutch ICQ the option, “improved energy efficiency and decreased use of material and energy option would appear the most comparative, both having been aimed at industry rather than consumers. This might explain why several consequences were rated on midpoint of the scale, being perhaps less relevant to consumers. In both the Dutch and Australian option, the overall evaluation for these options was moderately positive, which would appear to be explained best by evaluations of consequences that were rate as neutral or moderate disadvantages, such as costs for manufacturers.

**Table 4. Option 2: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Efficiency in the manufacturing and mining industries	.38		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	0.9	.27	6.50
Redirecting savings to energy intensive activities	0.2	.27	
Greenhouse gas emissions	5.6	.17	
Environmental impacts	5.5	.14	
Policy and regulatory initiatives	0.8	.22	
Reliability of energy supply	5.0	.25	
Industry commitment	1.6	.27	
Economic impacts	-1.3	.12	

\* Correlation between average evaluation and average overall evaluation score

### Option 3: Replacing future planned coal-fired power stations with gas

Table 5 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the third option on replacing future planned coal-fired power stations with gas. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .40$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were mostly low. The consequences that correlated highest were “infrastructure requirements” ( $r = .30$ ), “water use and safety” ( $r = .28$ ) and “costs” ( $r = .27$ ), indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were evaluated as moderate disadvantages, indicating that these consequences had a negative impact on the overall evaluation.

The consequence that correlates lowest with the overall evaluation was “Greenhouse gas emissions” ( $r = .02$ ). This indicates that this consequence had very little influence on the overall evaluation. The consequences for greenhouse gas emissions were evaluated as a moderate advantage, but did not appear to influence the overall rating of the option.

Overall, respondents evaluated this option around the midpoint of the scale, grading it with a 5.36. This indicates that respondents did not appear to consider that replacing coal-fired stations with gas to be an attractive option for mitigating climate change. As there is no option in the Dutch ICQ that compares with this option, it is not possible to draw any comparative conclusions for this option.

**Table 5. Option 3: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Replacing future planned coal-fired power stations with gas	.40		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	-3.4	.27	5.36
Economic impacts	-4.3	.20	
Policy and regulatory initiatives	0.5	.15	
Safety of gas pipelines and wellheads	-2.2	.22	
Water use and safety	-2.9	.28	
Greenhouse gas emissions	4.1	.02	
Reliability of energy supply	2.9	.21	
Infrastructure requirements	-1.1	.30	
Environmental impacts	-1.4	.15	

\* Correlation between average evaluation and average overall evaluation score

#### Option 4: Carbon dioxide capture and storage with coal

Table 6 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the fourth option on CCS with coal. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate to high,  $R = .46$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option are moderate to low. The consequences that correlated highest were “reliability of fuel supply” ( $r = .32$ ) and “availability of storage sites” ( $r = .29$ ). These consequences had the most influence on the overall evaluation of this option. As these consequences are rated as moderate benefits of the option, they appear to have positively affected the overall rating of the option.

The consequences that correlated lowest with the overall evaluation were “Environmental impacts” ( $r = .08$ ) and “Greenhouse gas emissions” ( $r = .12$ ). This indicates that these consequences had very little influence on the overall evaluation. The environmental impacts consequence was evaluated as a slight disadvantage, while the greenhouse gas emissions consequence was evaluated rather more positively. However, these evaluations did not appear to have an influence on the overall rating of the option.

Overall, respondents evaluated this option around the midpoint of the scale, grading it with a 5.69. This indicates that respondents seemed to consider CCS with coal as neither an attractive nor an unattractive option for mitigating climate change. When compared to the 2007 Dutch ICQ results, similar overall ratings were given to the option of CCS with coal or gas (5.34). Reliability of the energy supply was also amongst the best predictors of the overall rating.

**Table 6. Option 4: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Carbon dioxide capture and storage with coal	.46		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	-2.4	.26	5.69
Economic impacts	2.8	.22	
Greenhouse gas emissions	4.6	.12	
Environmental impacts	-3.2	.08	
Policy and regulatory initiatives	1.0	.21	
Reliability of fuel supply	3.9	.32	
Availability of storage sites	3.0	.29	
Pipeline infrastructure	-3.1	.17	
Safety of carbon dioxide pipelines, wellheads and storage	-3.0	.27	

\* Correlation between average evaluation and average overall evaluation score

## Option 5: Deploying renewable sources

Table 7 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the fifth option on deploying renewable sources. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .40$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were moderate to low. The consequences that correlated highest were “Economic impacts” ( $r = .29$ ) and “reliability of energy supply” ( $r = .25$ ). These consequences would appear therefore to have been the greatest influence on the overall evaluation of the option. However, as these consequences were rated as only minor benefit of the option, any positive effect they had on the overall rating of the option was small. .

The consequences that correlated lowest with the overall evaluation were “Greenhouse gas emissions” ( $r = .13$ ) and “Costs” ( $r = .18$ ). This indicates that these consequences had very little influence on the overall evaluation. The consequences of this option for greenhouse gas emissions were evaluated as having a slight advantage, while the “Costs” consequence was evaluated as a moderate disadvantage, however these evaluations did not influence the overall rating of the option.

Overall, respondents were moderately positive about this option, grading it with a 6.28. This indicates that respondents seemed to consider deploying renewables as a moderately attractive option for mitigating climate change. It is difficult to compare this option with the Dutch ICQ as there were no comparative option exists. .

**Table 7. Option 5: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Deploying renewable sources	.40		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	-4.6	.18	6.28
Environmental impacts	1.8	.23	
Greenhouse gas emissions	3.7	.13	
Economic impacts	2.1	.29	
Policy and regulatory initiatives	0.9	.19	
Reliability of energy supply	1.9	.25	
Land mass requirements	-1.7	.24	

\* Correlation between average evaluation and average overall evaluation score

## Option 6: Participating in an international emissions trading scheme

Table 8 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the sixth option on participating in an international emissions trading scheme. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate to high,  $R = .51$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were all moderate. The consequences that correlated highest were “safeguards when linking with other international schemes” ( $r = .44$ ) and “costs” ( $r = .38$ ). These consequences therefore exerted greater influence on the overall evaluation of the option. The safeguards were evaluated as a minor advantage while the costs were evaluated as neutral. These options therefore provided a minor positive effect on the overall rating of the option.

The consequences that correlated lowest with the overall evaluation were “Limiting the number of available international permits able to be purchased” ( $r = .25$ ) and “environmental impact” ( $r = .29$ ). Note however, that these correlations were similar to the highest correlations between the consequences and overall rating of other options. These consequences therefore have a lower correlation with the overall rating. This indicates that these consequences had less influence on the overall evaluation. As both options were rated around the midpoint of the scale, they had neither a positive impact nor a negative impact on the overall rating of the option.

Overall, respondents evaluated this option around the midpoint of the scale, grading it with a 5.39. This indicates that respondents appeared to consider that participating in an international trading scheme for emissions was neither an attractive nor unattractive option for mitigating climate change. As there was no option in the Dutch ICQ that compared with this option, it was not possible to draw any comparative conclusions for this option.

**Table 8. Option 6: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Participating in an international emissions trading scheme	.51		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Limiting the number of international permits able to be purchased	-0.78	.25	5.39
Economic impacts	0.18	.32	
Greenhouse gas emissions	0.72	.35	
Environmental impacts	0.61	.29	
Costs	0.57	.38	
Safeguards when linking with other international schemes	2.01	.44	

\* Correlation between average evaluation and average overall evaluation score

## Option 7: Nuclear power

Table 9 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the final option on nuclear power. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate to high,  $R = .48$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were moderate to low. The consequences that correlate highest were “policy and regulatory initiatives” ( $r = .37$ ) and “safety and risks” ( $r = .37$ ). These consequences therefore exerting the most influence on the overall evaluation of the option. As these options were rated as moderate disadvantages of the option, they had a small negative effect on the overall rating of the option.

The consequences that correlated lowest with the overall evaluation were “reliability of fuel supply” ( $r = .13$ ) and “Greenhouse gas emissions” ( $r = .21$ ). This indicates that these consequences had only very little influence on the overall evaluation. The consequences for the reliability of the fuel supply was evaluated as a slight advantage, while greenhouse gas emissions were evaluated around the midpoint of the scale, but these evaluations did not appear to influence the overall rating of the option.

Overall, respondents evaluate this option a little bit below the midpoint of the scale, grading it with a 5.19. This indicates that respondents did appear to consider that electricity from nuclear plants to be an attractive option for mitigating climate change.

When comparing this to the 2007 Dutch ICQ results, the overall evaluation of the Australian nuclear option is somewhat lower. The correlations of the Australian consequences are lower compared to the 2007 Dutch ICQ. One of the most negative evaluated consequences of both the 2007 Dutch and the current Australian ICQ results was the consequence which focused on nuclear weapons.

**Table 9. Option 7: Multiple correlation, average evaluation scores and correlations (Australia)**

Option	Multiple correlation (R)		
Nuclear power	.48		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Costs	-0.9	.26	5.19
Economic impacts	-2.6	.32	
Greenhouse gas emissions	-0.02	.21	
Reliability of fuel supply	3.7	.13	
Safety and risks	-1.7	.37	
Environmental impacts	-4.1	.30	
Policy and regulatory initiatives	-1.6	.37	
Skills and qualifications	-0.8	.36	
Nuclear weapons production	-3.9	.32	

\* Correlation between average evaluation and average overall evaluation score

#### 4.2.4 SUMMARY OF THE AUSTRALIAN RESULTS

The results show consistency for the three preferred options by the respondents, with the majority of consequences evaluated as positive. In particular, the consequences of 'energy supply', 'environmental impacts' and 'greenhouse gas emissions' received high evaluations. It seems these topics are important to respondents, as the topic of 'security of supply' and 'greenhouse gas emissions' also received positive evaluations for the CCS option, as did 'replacing future planned coal-fired power stations with gas'. As some topics were evaluated more positively, the topic of 'costs' was in many options negatively evaluated, as was the topic of 'safety'. This might be explained by the fact that these negatively evaluated consequences contained more negative messages; costs of energy being likely to increase - resulting in consumers having to pay more, which was considered likely to be evaluated as negative. For the options containing the topic of safety, it is possible respondents evaluated risks (however small they might be) more negatively, as compared to options without a safety consequence.

For the CCS option an interesting result was the variety in positive and negative evaluations of the different consequences. The consequences on 'costs', environmental impact', 'safety of pipelines, wellheads and storage' were evaluated negatively. This is interesting considering the development of CCS has been designed to address environmental issues. The ICQ provided a balanced view of known and potential environmental impacts based on available scientific information. This information included both positive and potentially negative consequences. It is possible that respondents' negative perceptions were weighted more heavily toward the less desirable consequence, resulting in this negative effect. Whereas 'greenhouse gas emissions', 'reliability of fuel supply', 'economic impacts' and 'availability of storage sites' all scored positively. Although there was some variety in the evaluation of these consequences, the average overall score was neutral; with three options distinctly evaluated positively and three negatively. Due to the clear distinction made between what was seen as a positive consequence and what was a negative consequence, compared to the other options, respondents demonstrated stronger opinions and decisiveness when it came to the consequences of CCS. This might be confirmed when looking a table 2; as 10% of the respondents rejected the option, but about 26% chose the option as one of the three preferred options.

For the renewable resources one might state the consequences did not influence the opinion of respondents as much as other options. Only two consequences were evaluated with higher values; on the positive side, the consequence of 'greenhouse gas emissions' consequence, where as the 'costs' consequence was evaluated very negatively. One reason for the possible negative evaluation might be the use of percentages of the rise of costs for solar energy agreed by the experts. It is stated these costs will rise by around 256%, this could be perceived as 'intimidating' for respondents and therefore evaluated negatively. Although the cost of renewables received a strong negative response while other consequences received moderately high positive responses, respondents' overall evaluation for the renewable option was high. Therefore, opinion on the use of renewable sources would appear to be formulated by other information more so than the clear negative reaction to cost. This is corroborated by the rather low multiple correlation for this option.

## 4.3 Recent Dutch ICQ

### 4.3.1 DUTCH SAMPLE

To be able to compare the results of the Australian online ICQ, it was decided to run an extra sample of Dutch respondents on the ICQ. An online panel service was contacted for this purpose, resulting in the recruitment of 148 respondents, of which 104 respondents (70.3%) completed the questionnaire.

Of the respondents, 49 (47.1%) were male and 53 (51.0%) were female. Age distribution is depicted in Figure 10. Most respondents indicated having achieved higher education (MBO or vocational education, 26.0%, HBO/WO or university level education, 24.0%) and to be working as an employee in the private service (16.3%).

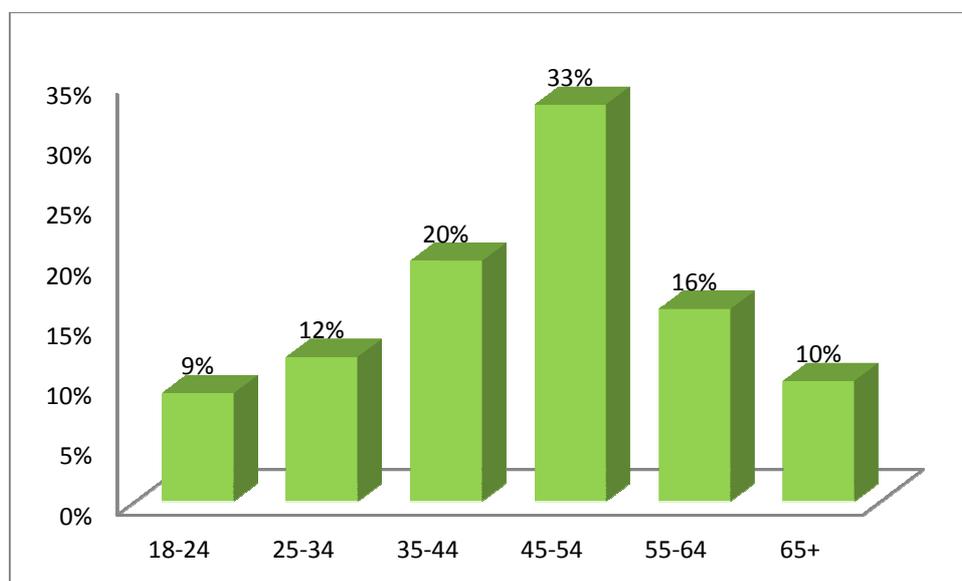


Figure 10. Age distribution for the recent Dutch sample

When asked what their interest is in the topic of energy and climate change, most respondents (76.0%) answered that they had a general interest in the subject. Furthermore, when asked for their motivation to use the tool, respondents answered that they wanted to know more about one or more of the subjects (37.5%); and, that they believed the tool could help them to form an opinion on the subject of energy and carbon dioxide emissions (30.8%). An important note to these results, however, is that respondents were recruited and paid by a panel service company. As a result, respondents' motivation to use the tool may have been largely influenced by the financial incentive instead of intrinsic motivations. This could also be concluded from the fact that 39.4% of the respondents indicated that they did not have a specific motivation to use this tool.

The demographics of the Dutch sample were, although the sample is much smaller, similar to the Australian sample. Also, the motivations that people had for using the tool were similar.

### 4.3.2 EVALUATION AND CHOICE OF OPTIONS

In line with the analysis conducted for the Australian study, the following sub-sections provide the findings for the percentage of respondents that took the opportunity to change their original decision on rating each of the consequences for the recent Dutch data. The average grade for each option is also provided, along with the options identified as being 'unacceptable' as well as the preferred options. Table 10 provides a summary of the statistical results for each of these four areas.

## Change

After receiving all the information and having evaluated all the consequences, respondents were again confronted with their overall evaluation of each option. They were then given the opportunity to change these grades. Twenty respondents (19.2%) chose to change their initial evaluations. The following analyses are based on the final ratings provided by all respondents.

## Grades

On average, people tended to grade the options around the mean of the scale. The only options that received a grade lower than a 5.5 (usually considered to be an “insufficient” grade) were the option of coal converted to energy with CCS and electricity production in nuclear power plants. This differs from the Australian results, which showed that Australian respondents were more positive about the CCS option. The difference are small, however, Table 10 contains the distribution of the overall evaluations per option (%) and the mean overall evaluation given by respondents.

## Rejection

Respondents were given the option to indicate whether they perceived any of the options to be unacceptable. A little less than half of the respondents (N = 46, 44.2%) indicated they found one or more options to be unacceptable. The option that was most often perceived as unacceptable was Nuclear power; 30.8% of the participants thought that this was an unacceptable option. The other options were mostly perceived as acceptable, although the two CCS options were also slightly higher than the other options (12.5% thought the coal with CCS option was unacceptable, 14.4% thought the gas with CCS option was unacceptable). Unacceptable scores for the other options ranged from 5.8% to 2.9%.

Dutch respondents therefore, seemed slightly more negative regarding deploying CCS than the Australian respondents. Care should however be taken in drawing conclusions from these scores due to the relatively small Dutch sample size.

## Choice

After evaluating all the options, respondents eventually were asked to choose three out of the 7 options which they preferred to invest in. Two options were clearly preferred over the others. Those were improving energy efficiency (88.5%) and energy from wind turbines at sea (82.7%). Following were the efficiency and decreased use of material and energy (49%) and biomass (49%).

Similar to the findings of the Australian sample, options related to renewables and efficiency was more frequently preferred by respondents. Percentages differ somewhat, however, but was most likely influenced by the relative comparison between the options, which differ from the Australian sample.

In addition, chosen combination frequency was analysed. Most often (36.5%) of respondents chose the combination of the options efficiency, wind energy and biomass. Second, respondents chose the combination of both efficiency options and wind energy (28.8%).

**Table 10. Recent Dutch ICQ - Percentages of grades, mean grades, percentage of rejection and choice**

Option	1-3	4-5	6-7	8-10	Mean	SD	Reject %	Choice %
Improvement of energy efficiency	6.7	9.7	38.5	45.2	<b>6.91</b>	1.91	2.9	88.5
Improvement of energy efficiency and decreased use of material and energy	13.5	26.0	37.5	23.1	<b>5.92</b>	2.03	5.8	49.0
Electricity from wind turbines at sea	7.7	12.5	42.3	37.5	<b>6.79</b>	1.93	2.9	82.7
Conversion of biomass to car fuel and electricity	8.7	9.6	35.6	46.1	<b>6.92</b>	2.04	4.8	49.0
Large plants where coal or gas is converted into electricity with CCS	27.9	37.5	28.8	5.8	<b>4.69</b>	1.97	12.5	5.8
Large plants where gas is converted into hydrogen with CCS	18.3	32.7	35.5	13.4	<b>5.41</b>	2.02	14.4	6.7
Electricity from nuclear power plants	27.9	34.6	25.0	12.5	<b>4.89</b>	2.19	30.8	18.3

### 4.3.3 RELATIONSHIP BETWEEN THE CONSEQUENCES AND OVERALL EVALUATION FOR EACH POLICY OPTION

This section will provide the results for each of the policy options in regards to the relationship between the average evaluation of each consequence and the respondents overall evaluation of the options for the recent Dutch ICQ. In order to replicate exactly what occurred in the original and Australian ICQs, respondents in the recent Dutch ICQ received information on each of the options first receiving a description of the option, then information on the consequences relevant to each of the options. Respondents were asked to evaluate these consequences. Finally, they were presented with their evaluations of all the consequences and asked to provide an overall evaluation on a scale from one to 10, like a grade. This process is repeated for each option and corresponding consequences.

## Option 1: Improvement of energy efficiency

Table 11 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the first option on improving energy efficiency. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option is high,  $R = .71$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option differ from high to low, but most correlations are high. The consequences that correlated highest were “contribution to the greenhouse effect” ( $r = .62$ ), “contribution to air quality” ( $r = .60$ ) and “economic consequences” ( $r = .59$ ), indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were evaluated as advantages, indicating that these consequences had a positive impact on the overall evaluation.

The consequence that correlates lowest with the overall evaluation was “price” ( $r = .13$ ). This indicates that the consequence hardly had any influence on the overall evaluation. The consequences for ‘price’ were evaluated as a disadvantage, but did not influence the overall rating of the option.

Overall, respondents evaluate this option rather positively, grading it with a 6.92. This indicates that respondents seemed to consider that improving energy efficiency is an attractive option for mitigating climate change. As both Australian options concerning efficiency were also evaluated positively, one might argue there is a common favourability for choosing energy efficiency options in both Dutch and Australian public.

Although most evaluations of the recent ICQ tend to be lower, these results are quite similar to the results found in the Dutch ICQ in 2007 for the energy efficiency option. For example, ‘price’ was the only negatively evaluated consequence in 2007 and had a similar correlation with the overall evaluation as found in the current results for the Dutch sample.

**Table 11. Option 1: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Improvement of energy efficiency	.71		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Contribution to air quality	5.9	.60	6.92
Use of natural sources	5.4	.39	
Reliability of the energy supply	6.1	.47	
Economic consequences	5.8	.59	
Measures to reduce fuel use for transportation	2.5	.26	
Consequences for manufacturers	4.1	.56	
Consequences for houses and buildings	4.0	.46	
Price	-1.8	.13	
Contribution to the greenhouse effect	5.2	.62	

\* Correlation between average evaluation and average overall evaluation score

## Option 2: Improvement of energy efficiency and decreased use of material and energy

Table 12 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the second option on improving energy efficiency and decreasing the use of materials and energy. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option were high,  $R = .62$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were moderate or somewhat low. The consequences that correlated the highest were “consequences for manufacturers” ( $r = .45$ ), “contribution to air quality” ( $r = .42$ ) and “contribution to the greenhouse effect” ( $r = .42$ ) and “economic consequences” ( $r = .38$ ), indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were evaluated as advantages, indicating that these consequences had a positive impact on the overall evaluation.

The consequence that correlates lowest with the overall evaluation was “price” ( $r = .20$ ). This consequence therefore had the least influence on the overall evaluation. The consequences for ‘price’, ‘consequences for houses and buildings’ and ‘consequences for transportation’ were evaluated as a disadvantage, but did not influence the overall rating of the option.

Overall, respondents evaluate this option positively, around the midpoint of the scale, grading it with a 5.92. This indicates that respondents did seem to think that improving energy efficiency and decreased use of material and energy was an attractive option for mitigating climate change, but not as good an option as the first energy efficient option. As both the other Dutch energy efficiency options and the Australian options concerning efficiency were also evaluated positively, one might argue a common favourability existed for choosing energy efficiency options in both Dutch and Australian public.

Most evaluations of the recent ICQ tended to be lower for this option. These results were somewhat similar to the results found in the 2007 Dutch ICQ for this second energy efficiency option. For example, all evaluations of the consequences remained consistent with evaluations of the consequences for the 2007 ICQ.

**Table 12. Option 2: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Improvement of energy efficiency and decreased use of material and energy	.62		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Contribution to air quality	5.2	.42	5.92
Economic consequences	2.9	.38	
Consequences for transportation	-1.9	.26	
Consequences for manufacturers	0.7	.45	
Consequences for customers	0.4	.29	
Consequences for houses and buildings	-0.1	.32	
Price	-3.6	.20	
Contribution to the greenhouse effect	4.6	.42	

\* Correlation between average evaluation and average overall evaluation score

### Option 3: Electricity from wind turbines at sea

Table 13 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the third option on electricity from wind turbines at sea. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderately high,  $R = .50$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option differed from moderate to low. The consequences that correlated the highest were “contribution to the greenhouse effect” ( $r = .40$ ), and “consequences for employment” ( $r = .38$ ), indicating that these consequences had the most influence on the overall evaluation of the option.

The consequence that correlated lowest with the overall evaluation were “consequences for the fishery” ( $r = -.06$ ), “dealing with fluctuations in electricity production” ( $r = .08$ ), and “price” ( $r = .09$ ). This indicates that these consequences had a smaller influence on the overall evaluation. The consequences for price, the fishery, and fluctuations in electricity production, were evaluated as being a disadvantage or a small disadvantage, but they did not influence the overall rating of the option.

Overall, respondents evaluate this option very positively, grading it with a 6.79. This indicates that respondents seemed to consider that wind turbines at sea are an attractive option for mitigating climate change, but not as good an option as the first energy efficiency option. The Australian ICQ had a ‘Renewables’ option which also evaluated positively, making it plausible to conclude that Dutch and Australian respondents hold positive attitudes towards renewable energy.

When compared to results from the 2007 Dutch ICQ on the electricity from wind turbines at sea option, correlations of both the ICQ’s tended to differ per consequence; some are higher in the 2007 ICQ, while other consequences correlated higher in the recent ICQ. This is different from the consistency experienced with the correlations of the two energy efficiency options. The overall evaluation of this option being lower when compared to the 2007 ICQ. Although some evaluations of consequences in the recent ICQ tended to be lower, these results were also somewhat similar to the results found in the 2007 Dutch ICQ. For example, evaluation of the consequences for employment, and ‘dealing with fluctuations in electricity production’ remained consistent with results of the 2007 ICQ.

**Table 13. Option 3: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Electricity from wind turbines at sea	.50		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Effects to the view	1.5	.30	6.79
Consequences for birds	2.1	.28	
Consequences for ocean fish and mammals	3.6	.33	
Consequences for the fishery	-0.9	-.06	
Dealing with fluctuations in electricity production	-0.2	.08	
Consequences for employment	6.1	.38	
Price	-3.6	.09	
Contribution to the greenhouse effect	5.0	.40	

\* Correlation between average evaluation and average overall evaluation score

#### Option 4: Conversion of biomass to car fuel and electricity

Table 14 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the fourth option on conversion of biomass to car fuel and electricity. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was high,  $R = .66$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were moderate or high. The consequences that correlated highest were “contribution to air quality” ( $r = .54$ ), “contribution to the greenhouse effect” ( $r = .50$ ) and “economic consequences” ( $r = .48$ ), indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were evaluated as advantages, indicating that these consequences had a positive impact on the overall evaluation.

The consequence that correlated lowest with the overall evaluation was “use of land for biomass without certificate” ( $r = -.27$ ). This indicated that this consequence had a smaller influence on the overall evaluation. This same consequence’ was the only one evaluated as a disadvantage, but did not influence the overall rating of the option.

Overall, respondents evaluate this option positively, grading it with a 6.92. This option was evaluated highest of all options. This indicates that respondents did consider the use of biomass for car fuel and electricity as a very good option for mitigating climate change. As there was no option in the Australian ICQ that was comparable with this option, it was not possible to draw any comparative conclusions.

For this option, correlations in 2007 tended to be only slightly higher per consequence and the overall evaluation was also higher (6.92 compared to 7.41). The evaluations of the consequences varied individually when compared to the 2007 ICQ. Some evaluations of the recent ICQ tended to be lower, but again these results were also somewhat similar to the results found in the 2007 Dutch ICQ. For example, the only negatively evaluated consequence was ‘use of land for biomass without certificate’, whereas all other consequences in both ICQ’s were evaluated positively.

**Table 14. Option 4: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Conversion of biomass to car fuel and electricity	.66		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Contribution of air quality	5.3	.54	6.92
Use of land for biomass with certificate	3.1	.44	
Use of land for biomass without certificate	-4.7	-.27	
Influence on food production	1.6	.35	
Reliability of the energy supply	3.7	.35	
Expansion of seaports	4.1	.43	
Necessity of new vehicles	3.1	.49	
Economic consequences	5.6	.48	
Price	5.4	.43	
Contribution to the greenhouse effect	5.4	.50	

\* Correlation between average evaluation and average overall evaluation score

## Option 5: Large plants where coal or gas is converted into electricity with CCS

Table 15 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the fifth option on large plants where coal or gas is converted into electricity with CCS. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .47$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were mostly low. The consequence that correlate highest were “safety of carbon dioxide transport in pipelines” ( $r = .35$ ) and “safety of carbon dioxide underground storage” ( $r = .34$ ), indicating that these consequences had the most influence on the overall evaluation of the option. Most of the consequences were evaluated as disadvantages, indicating that these consequences had a negative impact on the overall evaluation, seeing as this option was graded lower compared to most of the other options.

The consequence that correlated the lowest with the overall evaluation was “contribution to pollution due to coalmining” ( $r = .11$ ). This indicates that this consequence had minimal influence on the overall evaluation. The following consequence was evaluated positively; “contribution to the greenhouse effect”, which is in line with the main purpose of CCS technology.

Overall, respondents evaluated this option around the midpoint of the scale, grading it with a 4.69, indicating that respondents did not appear to consider CCS as an attractive option for mitigating climate change. When compared with the Australian CCS option, the Dutch respondents seemed to judge CCS more negatively, assigning it the lowest evaluation whereas the Australian CCS option was evaluated as average. As the Australian CCS option’s consequences were more extensive than the Dutch equivalent, it is possible the Australian CCS option was perceived more positively. The Australian option had four consequences which were evaluated positively out of 10, whereas the Dutch had only the one positively evaluated option out of six. As a result, consequences of the Dutch and Australian CCS options appear to differ quite significantly, and are therefore not completely comparable but could demonstrate the requirement to better explain the potential consequences of this technology.

In addition, when compared with the 2007 Dutch ICQ, the correlations tended to be reasonably similar for the consequences, however the overall evaluation was lower (5.34 in 2007 compared to 4.69 in 2012). The evaluations of the consequences were also somewhat similar when compared to the 2007 ICQ. For example, the only positively evaluated consequence was contribution to the greenhouse effect, whereas all other consequences in both ICQ’s were evaluated negatively.

**Table 15. Option 5: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Large plants where coal or gas is converted into electricity with CCS	.47		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Contribution to pollution due to coal mining	-4.9	.11	4.69
Safety of carbon dioxide transport in pipelines	-1.2	.35	
Safety of underground carbon dioxide storage	-2.8	.34	
Reliability of the energy supply	-0.5	.17	
Price	-3.8	-.14	
Contribution to the greenhouse effect	4.2	.19	

\* Correlation between average evaluation and average overall evaluation score

## Option 6: Conversion of natural gas into hydrogen in large plants with CCS

Table 16 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the sixth option on conversion of natural gas into hydrogen in large plants with CCS. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was high,  $R = .58$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were mostly moderate. The consequences that correlated highest were “safety of carbon dioxide transport in pipelines” ( $r = .37$ ), “reliability of energy supply” ( $r = .34$ ) and “safety of use of hydrogen in daily life” ( $r = .33$ ), indicating that these consequences had the most influence on the overall evaluation of the option.

The consequence that correlated lowest with the overall evaluation were “new vehicles needed” ( $r = .13$ ) and “price” ( $r = .14$ ), and “new pipelines needed” ( $r = .16$ ). This means that these consequences had very little influence on the overall evaluation.

Overall, respondents evaluate this option around the midpoint of the scale, grading it with a 5.42. This indicates that respondents appear to consider that hydrogen with CCS to be an attractive option for mitigating climate change. As there was no option in the Australian ICQ that is comparable with this option, it is not possible to draw any comparative conclusions for this option.

When compared the 2007 Dutch ICQ results correlations of both the ICQ’s tended to be mostly similar for the consequences; with the overall evaluation being somewhat similar to the original ICQ. The evaluations of the consequences were also somewhat the same when compared to the 2007 ICQ; however the positive evaluated consequences tended to be higher of those in the original ICQ. For example, all consequences which were evaluated positively or negatively in 2007 had a positive or negative evaluation in the current ICQ.

**Table 16. Option 6: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Conversion of natural gas into hydrogen in large plants with CCS	.58		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
New pipelines needed	-3.0	.16	5.42
New vehicles needed	-0.8	.13	
Contribution to air quality	5.4	.25	
Contribution to noise	4.0	.28	
Safety of hydrogen plants	-1.7	.23	
Safety of use of hydrogen in daily life	1.1	.33	
Safety of carbon dioxide transport in pipelines	-0.6	.37	
Safety underground carbon dioxide storage	-2.3	.30	
Reliability of the energy supply	2.8	.34	
Economic consequences	-1.8	.30	
Price	-2.3	.14	
Contribution to the greenhouse effect	4.4	.30	

\* Correlation between average evaluation and average overall evaluation score

## Option 7: Electricity from nuclear power plants

Table 17 below provides the multiple correlation, average evaluation and correlations to the average overall evaluation analyses for the final option on electricity generation from nuclear power plants. The multiple correlation between the evaluations of the consequences and the overall evaluation of this option was moderate,  $R = .45$ .

The “single” correlations between the evaluations of the consequences and the overall evaluation of the option were moderate to low. The consequences that correlated highest were “safety of nuclear power plants” ( $r = .40$ ), “background radiation during normal operation” ( $r = .38$ ) indicating that these consequences had the most influence on the overall evaluation of the option. All these consequences were evaluated as moderate or large disadvantages, indicating that these consequences had a negative impact on the overall evaluation.

The consequence that correlated lowest with the overall evaluation was “price” ( $r = .13$ ). This indicates that this consequence had very little influence on the overall evaluation. The consequences for the price of electricity of nuclear energy were evaluated as a disadvantage, but did not influence the overall rating of the option.

Overall, respondents evaluate this option below the midpoint of the scale, grading it with a 4.90. This indicates that respondents did not appear to consider that nuclear is an attractive option for mitigating climate change. When comparing the Dutch nuclear mitigation option to the evaluation of the Australian, the Australian was evaluated only somewhat more positively. Both Dutch and Australian respondents did not evaluate the nuclear option as positive, and it might be concluded therefore that neither groups of respondents considered nuclear energy an attractive option.

Correlations of the ICQ 2007 were higher for all the consequences compared to the correlations of the consequences of this ICQ. In addition, the overall evaluation was lower compared to the 2007 ICQ. In line with previous ICQ results, all consequences evaluated positively or negatively in 2007 received positive or negative evaluations in the current ICQ.

**Table 17. Option 7: Multiple correlation, average evaluation scores and correlations (Dutch)**

Option	Multiple correlation (R)		
Electricity from nuclear power plants	.54		
Consequence	Average evaluation (-9 to 9)	Correlation (-1 to 1) *	Average overall evaluation (1 to 10)
Background radiation during normal operation	-3.2	.38	4.90
Nuclear waste	-3.8	.37	
Safety of nuclear power plants	-0.7	.40	
Production of power plants against terrorist attacks	-1.4	.37	
Nuclear power plants and nuclear weapons	-3.7	.32	
Reliability of the energy supply	2.2	.24	
Price	-3.1	.13	
Contribution to the greenhouse effect	4.2	.17	

\* Correlation between average evaluation and average overall evaluation score

## 4.4 Survey Feedback

### 4.4.1 SUBJECTIVE EVALUATIONS CONCERNING THE QUALITY OF THE INFORMATION AND THE METHOD OF THE ICQ

At the end of the ICQ respondents were asked to give their feedback on the survey. Six questions were asked concerning the information in the ICQ (Table 18) and four questions concerning the method of the survey and use of the tool (Table 19). Questions were asked on a 7-point scale. In addition, respondents were provided an opportunity to contribute qualitative comments and feedback about the information and survey process as a whole. Example statements related to the evaluation questions are also provided below.

#### Information

In order to provide feedback on the information provided in the ICQs, respondents were asked to provide evaluation on six key areas: sufficiency, impartiality, clarity, needs, appropriateness and helpfulness. Table 18 below provides the average results for each of these areas for both the Australian and recent Dutch ICQs as well as example qualitative statements taken from Australian respondents.

Table 18. Feedback on information provided

	Australia		the Netherlands	
	Mean	SD	Mean	SD
Sufficient information to make a choice between the options	6.03	1.12	5.63	1.55
Impartial information	5.22	1.47	4.92	1.73
Clear information	5.70	1.21	5.55	1.55
Information needs on the topic	5.73	1.18	5.21	1.64
Appropriate amount of information	4.37	0.94	4.30	0.97
Information was helpful in forming an opinion	5.02	1.83	5.14	1.65

On average, all respondents indicated that they felt they had sufficient information to make a choice between the options (Australia: M = 6.03, SD = 1.12; Dutch: M = 5.63, SD = 1.55). Qualitative comments also supported this finding, for example:

*Informative and information packed.*

*I learnt so much from the information provided, thank you.*

*I had no idea how much I did not know before this survey. The information provided helped me understand. Thank you.*

Respondents felt the information received was mainly impartial (Australia: M = 5.22, SD = 1.47; Dutch: M = 4.92, SD = 1.73), clear (Australia: M = 5.70, SD = 1.21; Dutch: M = 5.55, SD = 1.55), and that the text primarily met their information needs on the topic (Australia: M = 5.73, SD = 1.18; Dutch: M = 5.21, SD = 1.64). Although the majority were in agreement with the level of impartiality, clarity and information needs, for example:

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*Easy to understand and use - good information.*

*Great survey, very informative and user friendly. Learned a great deal about the topic and the information provided was easy to understand and follow.*

*The survey and website are well-informed and easy to follow. It is good to have all of the political rhetoric stripped away so that we are only left with the pros and cons of reducing greenhouse emissions.*

*Very interesting I learnt a lot about different forms of energy production and the consequences of each. Also helped me understand more about emissions trading.*

*Job well done with this survey - it was very detailed, creative, informative and interactive. It took longer than expected though, and is a bit of a tall ask to do within one sitting.*

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... the qualitative statements below identify the key areas of concern regarding impartiality and clarity of the information provided.

### **Impartiality**

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*Fantastically designed survey. Obviously quite long but that was explained upfront. The one problem was some of the consequences seemed to be favoured.*

*The information and studies in the survey are more theories and lack of actual evidence. It gives partial support on the arguments for the people to agree in the survey but it can't convince 100% to the readers to support the argument. It should give more references from media and other information in the survey to let the readers know the points are valid not trying to prove something is right or wrong. Let the readers to choose.*

*I was slightly disappointed the information provided was not 100% impartial.*

*Thank you for inviting me to participate in this survey. It is shown that your researching teams have put a lot of effort to set up the project including finding information, designing the format of the survey. Even though there is some bias in some of the solution from my point of view, such as in using nuclear and trading greenhouse gas, I still really appreciate this kind of high standard questionnaire.*

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### **Clarity**

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*Some of the narrative descriptions were a bit long and the size of the font made it quite difficult to read and comprehend.*

*Some of the consequences did not indicate clearly what the advantages and disadvantages were. For instance, a number of consequences were described as a need to develop policy. This is what Governments do - it's their job. It is not clear what the expected effect of this consequence is, and it is therefore not possible to decide whether it is an advantage or disadvantage. Evaluating it as an advantage or disadvantage on the basis of the effects of those policies results in a circular discussion.*

*Some of statements did not clearly allow for a disadvantage, advantage differentiation. They appeared to be statements with both positive and negative connotations.*

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When asked whether the amount of information provided was appropriate, the average rating was around the scale midpoint (Australia: M = 4.37, SD = 0.94; Dutch: M = 4.30, SD = 0.97). This indicates that people neither felt they had received too much nor too little information, but felt the amount of information was just right. The balanced split in this result also provided qualitative statements that supported both perspectives. Some believed there was too much information and others requested more.

*Again I would like to say too much information provided in an unexciting format to use.*

*There is too much information together needs to be broken up into parts to try to understand each and every part equally and individually to be able to make an informed.*

*I would like some more in depth information to be available, I found it was too general and simple.*

Respondents were also slightly positive when asked whether the information tool had helped them to form an opinion on the topic. On a scale from 1 – 7 (= not very helpful and 7 = very helpful), respondents on average indicated that the tool was quite helpful (Australia: M = 5.02, SD = 1.83; Dutch: M = 5.14, SD = 1.65).

*I enjoyed this, found it very useful to compare the various options. I feel I am now better equipped for decision-making.*

*The information provided was enough to assist me in making a decision on all questions asked.*

*Thanks - the whole process has been a great learning curve for me - helped bring a lot of fractured bits and pieces of information I had together, so I more fully understood a lot of the concepts I have been exposed to over the past few years.*

## Method

In order to provide feedback on the ICQ method, respondents were asked to provide evaluation on four key areas: simplicity, pleasantness, recommend to others and learning. Table 19 below provides the average results for each of these areas for both the Australian and recent Dutch ICQs as well as example qualitative statements taken from Australian respondents.

**Table 19. Feedback on the ICQ method**

	Australia		the Netherlands	
	Mean	SD	Mean	SD
Simplicity	3.52	1.79	3.17	1.66
Pleasantness	5.23	1.45	5.38	1.59
Recommend to a friend or colleague	5.06	1.57	4.56	1.59
Use the ICQ again to learn	5.37	1.58	5.07	1.66

To the question whether respondents found the method of the ICQ simple or complicated, respondents answered that they found it moderately simple (Australia: M = 3.52, SD = 1.79; Dutch: M = 3.17, SD = 1.66).

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*Easy to use and very informative. Thank you.*

*This survey was great. I found the website easy to navigate and interact with.*

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However, these sentiments were not shared by all the respondents.

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*I found the process tedious and the information difficult to follow in some places (I had to re-read some sentences to try to make sense of them). There seemed to be sufficient information. However I just can't believe that the average person would be engaged by this tool.*

*The going back and forth between the website and survey was confusing. Need to make this process simple and easy to follow.*

*For a professional survey, I couldn't believe that there were actually spelling mistakes in it. I also didn't find the information to be presented as clearly and in as entertaining a manner as it could have been. I would have preferred watching short videos rather than reading lots of dry facts. It took a lot of concentration and effort to keep reading through all the dry facts.*

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Respondents also thought that the survey was reasonably pleasant to use (Australia: M = 5.23, SD = 1.45; Dutch: M = 5.38, SD = 1.59), thought it was rather likely they would recommend the tool to a friend or colleague (Australia: M = 5.06, SD = 1.57; Dutch: M = 4.56, SD = 1.59) and indicated it is likely they would use a tool like the ICQ again to learn about a topic (Australia: M = 5.37, SD = 1.58; Dutch: M = 5.07, SD = 1.66).

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*Found it enjoyable, rewarding and educational all at the same time.*

*I have never seen this type of before today so I think this is one of my best survey that provide best and interesting matter to do very sufficient answer thank you.*

*Excellent way to learn re a topic which I was confused about prior to commencement of using tool.*

*This was very easy to use and provided great information and is a very good hot topic of many peoples interest and it's good to have some background information on issues that we all need to consider.*

*This is a complex topic that requires careful and in-depth research. The method employed in this study goes a long way to enlightening us all.*

*Very interesting tool and I found it informative; I would feel hesitant to recommend to others though as I can't imagine many other people who would go to the trouble. I'm already quite interested in these issues, whereas many I know are not as proactive.*

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Respondents also reflected on the survey's ability to challenge their opinions, consider alternative energy options as well as pose their own policy options.

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*This survey was excellent - really informative and surprised me by changing my opinion about renewable energy. I always thought this was the best way to go but the information about intermittent supply made me rethink things. As did the idea of storing carbon dioxide. The survey itself was easy to use and obviously a lot of thought and research went into its making - so thank you for a highly educational experience. Let's hope the world can pull together to work through this vital issue and save our beautiful environment while we still can!*

*The Questionnaire was fine but I have a solution. If we build a nuclear Reactor in the middle of the Australian desert and use treated water from sewerage to keep the plant cool. We then build it in its own massive dome to stop any leakage possibilities and store the waste next to the same location in an underground dome. The impact on the environment would be little and the resource is readily accessible.*

*If we could utilize the land in the middle of Australia where no one lives to put pipes or wind generators and such then my answer would be different than if it had to be on the coasts.*

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Overall, it can be concluded that respondents were quite positive about the information and the method of the ICQ. It is, however, important to note that these scores are based on the evaluations of respondents who actually completed the entire ICQ. Conclusions with regard to these evaluations should therefore be made with caution.

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*I knew pretty much nothing about this topic, I learnt a lot but I did struggle to take it all in there was so much to read it took me a few hours to do I struggled to understand a bit but I got there it has definitely made me more aware of the way I use my electricity and changes I can make in the home.*

*Thank you, it was a very interesting and informative survey. I learned a lot about climate change and solutions. I am very positive that we can adequately address the climate change dilemma beginning now and in the future.*

*When I started the survey I had a strong leaning towards Renewable Energies - and whilst I still believe they play a large part in reducing our carbon dioxide emissions, I now understand that there are other options that are just as good if not better.*

*Overall a good survey, informative and accounts for a wide range of community perspectives on the complex topic of Climate change and suggested methods of mitigation and adaptation.*

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## 4.5 Discussion: Comparing the Dutch and Australian ICQs

Overall, similar option preferences emerged when comparing the Australian and Dutch results. Both countries for example showed a preference for the efficiency and renewables options. Even though it is not possible to compare the consequences of the Dutch and Australian efficiency options exactly, it is possible to conclude that being more efficient with energy and materials was a preference of respondents in both countries. Similarly, respondents seemed to agree that utilizing renewable energy resources is an attractive option when aiming to mitigate climate change. These findings also reflect similar results from other international research which investigated the preferences for energy technologies to address climate change (e.g., Hobman, Ashworth, Graham and Hayward, 2012).

Not only was there a commonality in the most preferred options to mitigate climate change, the least preferred options also showed similarities. In both countries nuclear energy was not considered a preference as a mitigation option, as its advantages and in particular its disadvantages are highly debated in both Dutch Australian and Dutch societies. Also, CCS was generally not preferred by respondents in both countries when compared to other mitigation options like energy efficiency measures and renewables. Once again, this finding is consistent with other research (e.g., Ashworth, Jeanneret, Stenner and Hobman, 2012).

Concerning CCS it is apparent that this was not the preferred option by the public when it comes to mitigating carbon dioxide emissions. However a difference exists between the Dutch and Australian sample. Whereas the Dutch respondents graded CCS with coal among their least preferred options, the Australian respondents ranked CCS as an average option, scoring above “Nuclear energy”, “replacing future planned coal-fired power stations with gas” and “participating in an international emissions trading scheme”. A possible reason for this difference in evaluation could be the use of more consequences in the Australian ICQ in an attempt to provide a more nuanced array of climate change mitigation options. The Australian CCS option contained 10 consequences for CCS of which half were evaluated positively, compared to only one positively evaluated consequence out of six in the Dutch ICQ. This difference in information density might be the reason for the different CCS evaluations.

An alternative explanation could be associated with the conclusions drawn in a recent study on knowledge and perceptions of carbon dioxide and CCS acceptance (Itaoka, Saito, Paukovic, de Best-Waldhofer, Dowd, Jeanneret, Ashworth and James, 2012). This study found greater awareness for CCS in the Netherlands which was explained by the mass national coverage of a CCS project in the town of Barendrecht. In this case, public protests were held about the project which eventuated in the project being cancelled. Therefore, a more negative result in this research could also be related to an overall negative reaction to the Barendrecht situation. This interpretation could also be reflected in another way. If one compares only the CCS evaluation of the 2007 Dutch ICQ with the Australian ICQ, the differences are fewer, because Dutch respondents evaluated CCS higher in 2007. These results suggest a possible negative trend towards CCS from Dutch respondents. Keep in mind though that the 2012 sample was small, and the difference might reflect the smaller second sample size instead of a trend, or might reflect the difference in the CCS options and consequences.

As the nuclear energy option provided several practical examples of how this mitigation option may pose a threat to public health, it is not surprising that this option was evaluated most negatively. While this was not the case for CCS, respondents of both countries did show negative evaluations of the safety aspects related to transport and storage of carbon dioxide, as well as the environmental impacts of CCS. As stated earlier, this result is interesting when we consider that CCS has been developed as an environmental mitigation technology. As the ICQ provided a balanced view of known and potential environmental impacts based on available scientific information, both positive and potentially negative, it is possible that the less desirable consequences may have outweighed the more positive due to CCS being in the early stages of commercial development with many as yet unknown impacts. Respondents could have negatively evaluated CCS because of the uncertainty of possible risks and consequences in key areas, such as transporting carbon dioxide and storing it as well as the environment, because of the lack of actual impact data available from demonstration projects.

Support or opposition to new technology by members of the public can be influenced substantially by their perceptions of the risks and benefits of a technology and how they perceive it will impact their lives (Fischhoff, 1995). Even though all the individual aspects of CCS have been applied in other industries for decades, as a new technological concept it still requires more proving at industrial scale and more research into its potential impacts on the longer term. According to Hobman and colleagues (2012), knowledge greatly influences the perception of various technologies; the more respondents feel they know about a technology, the more confident they often are in their assessment of this technology. With a combination of a lack of knowledge as well as technological uncertainty, these elements could go some way to explaining the lower ratings seen for the CCS options.

Finally, comparison of the rejection rates of the Dutch and Australian samples indicate that the results were quite comparable. For efficiency and renewable options rejection rates were low compared to options involving CCS or where coal is converted to gas rejection (around 10% of the respondents stated that these options are unacceptable). It was stated earlier that the information provide on the consequence of using renewable energy sources on electricity prices was rated as highly negative, yet price seems to have less of an impact on overall opinion formation in these hypothetical scenarios than a potential health risk or other uncertainties of other options. This is an interesting finding when costs are currently the main topic of debate in Australia (e.g., recent public outrage against the carbon tax and the assumed link to higher electricity prices) (Australian Broadcasting Corporation, 2012).

The most frequently rejected option was the one involving nuclear energy. The percentage of people that rejected this option was around 30% for the new ICQ studies and slightly lower (20%) for the Dutch 2007 ICQ. Recent events in Fukushima may have influenced these preferences however based on the data gathered through the ICQ processes it is not possible to make this statement conclusively.

Across all three ICQ studies it was found that CCS, as a policy solution, becomes a more favourable option to respondents when they are partnered with options that relate to energy efficiency and renewable technologies. Increased acceptance of CCS, as part of a suite of solutions that addresses the urgency and challenges of climate change, is also supported by other research such as Shackley et al (2009).

## 5 The Effectiveness of the ICQ Online Study

### 5.1 Study sample

The first task in this second study was to identify the right sample to test the online platform. In order to reflect users that would utilise the site outside of a research context, participants had to be self-motivated in completing the survey and unpaid. Due to the length of the ICQ (takes an hour or more to complete) and the topic, some ideas on who might be interested in the online ICQ were formed. The following target groups were sourced as respondents of this research phase:

1. Students and teachers of post high school education;
2. Teachers and students of senior years in high school (16-18 years old);
3. Policy makers (municipalities, provinces and national government); and
4. Citizens interested in the topics of climate change, energy production and policy in general.

### 5.2 Potential as an education tool

As the ICQ addresses a complex topic with high information density, the educational potential of this tool was considered. Due to the length, topic, and previously tested language comprehensibility of the tool, it was considered to be well suited for a range of educational organisations. Students from all post high school educational levels were asked to examine the online ICQ and provide their opinion of the tool.

#### 5.2.1 THE TOPIC GENERATES INTEREST AMONGST STUDENTS AND TEACHERS

Twenty students of all educational levels were approached, of which all showed at least some interest in the topic of climate change and ways of addressing carbon dioxide emissions mitigation. The respondents stated that they thought the topic to be important for current and coming generations and for their own personal future. There was a clear personal interest in gaining knowledge, which confirms the existing online ICQ's potential for educational purposes. Teachers were quite enthusiastic; several high school teachers indicated that there was insufficient lesson material on the topic, emphasizing the importance to educate about the topic and its applicability to several existing high school level subjects. Teachers recommended the project team contact publishers of educational books and programs from which (High) schools source lesson material in the belief that these publishers would be interested to integrating the ICQ tool into existing lesson material. Furthermore, teachers suggested that — as they also look for lesson material online— making the ICQ tool easy to find online may assist in reaching these potential target groups.

Consideration was also given to organisations that function as an 'educational umbrella'. These organisations have the potential for the dissemination of the ICQ to different universities or high schools through their networks. The broad reach of such educational organisations may increase interest as potential sources for reaching out to target groups. This was the experience of the project team when it contacted one of these educational umbrella organisations which provided an opportunity to offer the online ICQ to a group of teachers from twenty different universities and other post-high school organisations. The organisation contact person believed the ICQ to be valuable for spreading knowledge throughout their network and a welcome educational method.

While both students and teachers indicated that they thought the length of the ICQ (approximately an hour to complete) was adequate when used as lesson material, students stated that they thought it too long for

voluntary participation (at home). In addition, suggestions were offered for making distinctions in time and information density, which will be discussed further in the recommendation section.

## **5.2.2 THE ICQ METHOD IS USER FRIENDLY AND THE POTENTIAL FOR DISCUSSING RESULTS IS A GREAT COMMODITY FOR EDUCATIONAL PURPOSES**

Various scholars agreed that the grading of the different policy options and the process of choosing three preferred options following this has merit. Not only did students work through the ICQ consequences of the options quite easily, they also had discussions about it as they progressed; communicating their opinion on the given information and ‘provoking’ reactions from their fellow students to raise discussion on the topic. This was observed for post-high school education as well as for university students filling in the online ICQ. This position was also backed by teachers — should sufficient time exist for teachers to discuss the results and prompt intensified discussion on a certain topic — noting that it would be a good opportunity for engaging students in learning about a topic. One teacher stating: “These days you need to stimulate students by practical and interactive content, and this tool would be a useful way of educating.”

## **5.2.3 INDEPENDENT, MULTIPLE-ANGLED INFORMATION IS ‘KEY’ FOR TEACHERS**

During explanations about the background of the ICQ and the way information was generated, several teachers stated this was important to them. Because of the careful and balanced construction of the content of the ICQ they were more willing to try the tool, and perceived it as responsible lesson material. One particular teacher explicitly requested information about all the organisations and experts involved in constructing the ICQ, as he wanted to be assured that there was no possibility of biased information being provided to students. Fifteen students indicated that they thought some of the consequences had a somewhat ‘dull’ character. This led to students perceiving the information as ‘meaningless’ due to the ‘overbalanced’ or ‘boring’ information of some consequences.

## **5.3 Potential for policy makers and interested citizens**

### **5.3.1 POLICY MAKERS WANT MORE LOCAL, CONCRETE, PRACTICAL CONSEQUENCES**

Contact was made with several layers of government to determine interest in the website as a tool for informing them, their colleagues, or citizens concerning the topic. Governmental employees of the Province of Utrecht, the municipality of Utrecht and city of Utrecht were approached. As project team members explained the concept of the online ICQ and showed policy makers some of the consequences for rating, it became clear they found the information too general for disseminating to citizens; or, did not believe it to be their role to make such information accessible to the public. One interviewed policymaker of the city of Utrecht expressed an interest in the ICQ being purpose designed for citizens of his city, with consequences identified situated near the city of Utrecht. A policy maker working at the province department stated that she believed it was the role of the national government to inform citizens with this kind of information, and not that of a province. She advised the team to approach non-governmental organisations that have the common goal of informing the public concerning such a topic. A common theme among the policy makers was that they are interested in local practical problems and answers, and in communicating to citizens what they might do as individuals to improve their local living environment; and what role specific policy makers may have to assist citizens in achieving this, in this case the province, municipality or city.

The online ICQ was generally considered to be a too “broad [a] topic” by policy makers both for use as a tool for informing citizens, and for their own work. As a municipality employee stated: “It shows me possible consequences, but not what practical advice as a policy maker I can give, or look at. And as a policy maker I would — for example — like to have a more detailed idea on how we can stimulate local sustainable mobility, not a selection of common consequences for reducing carbon dioxide emissions.” Policy makers also indicated they would be interested in information on economic incentives which may

help stimulate regional or local sustainability or information on how certain emission reduction options could be implemented for economic advantage.

### **5.3.2 DISSEMINATION THROUGHOUT GOVERNMENT CAN BE TIME CONSUMING AND WOULD BE BEST COMING FROM THE TOP-DOWN**

There is a dispersed network of governmental and semi-governmental organisations which work on energy related issues across the Netherlands at various scales (i.e. local, provincial and national levels). These organisations do tend to have areas of specialisation but sometimes work together to address energy matters. Attempting to contact certain local authorities proved to be a time consuming activity. For example, attempts were made to contact several local community governmental organisations that share a common website for information on local energy efficiency and environmental issues. After several telephone calls and emails, communication was received from the organisation requesting the provision of additional information about the online ICQ so that it could make contact to discuss further. Follow up contact on the part of the project team failed to achieve the promised feedback.

In addition to all our attempts to contact various agencies, a policymaker at a provincial department advised the team to contact appropriate policy makers in the national government for dissemination of the online tool, as many local and provincial levels of government source information from the national level. It was believed therefore that a more efficient way to disseminate the ICQ was to use a top down method. That is, the use of large networks with broad and multiple governmental levels, such as the national government, as a disperser of the tool rather than trying to secure local authority participation.

### **5.3.3 POTENTIAL WEBSITES DID NOT SEE THE LINK WITH THEIR OWN MESSAGING**

Contact was made with several large, well-known non-governmental organisations. These organisations indicated they did not believe the online ICQ provided the practical information the organisation supported, with one organisational representative noting that: “we miss the consumer perspective of what an individual can change in their own daily life to be more sustainable.”

It is our belief that the probability of people spending more than 20 minutes on the ICQ is unlikely, even when an expressed interest in the topic exists. Online ‘consumers’ prefer short snippets of information that require no more than 20 minutes to process. After this period of time most people tend to lose interest. Several Dutch websites were identified that provided information on energy, however when contacted none of the websites returned emails or responded to telephone messages, nor showed any interest in the online ICQ.

## **5.4 Technical issues with the online version**

As described in the method section and based on the literature review, certain requirements and elements were considered important for the implementation of the online ICQ; subject to boundary conditions of the content and method of the ICQ:

1. Develop a user-friendly and visually pleasing interface.
2. Develop a narrative and storyline to support the content. Proposed narrative is that of a Policy Advisor who has received a request to advise on the topic of carbon dioxide reduction.
3. Present a clear goal for the user with feedback about the progress. The goal in the ICQ is the policy advice and progress can be monitored by acquiring necessary puzzle pieces and assessing one’s own knowledge through optional knowledge tests.
4. Provide the user with some control. Despite the relatively linear design of the ICQ method, the user can for instance choose which option to evaluate next.

5. Try to create social presence. Even though social interaction is not possible within the scope of this project, the user can in the end compare his/her score to that of others.
6. Make use of questions to instil curiosity and enhance deliberation after the policy advice has been given.
7. Create rewards.
8. Create competition.

#### **5.4.1 DEVELOP A USER-FRIENDLY AND VISUALLY PLEASING INTERFACE**

Unfortunately developing a user friendly interface proved challenging. While assisting Dutch ICQ respondents to fill in the survey, one researcher observed respondents experiencing several problems. A large majority of respondents experienced difficulty in navigating between screens in the introduction segment of the ICQ. Where highlighted arrows were employed for participants to click on to move to the next screen, respondents appeared to misunderstand the instructions provided, resulting in them needing to ask for help in order to progress. This was more frequently the case when required to click on a 'back' arrow as opposed to a forward arrow. Although instructions at the bottom of the website screen noted the use of both forward and back arrows, respondents appeared to find the process illogical and therefore frustrating. Feedback received would infer that use of the word 'next' in the arrows may help to alleviate this problem, as would making more noticeable on screen exactly where a respondent should click to move to the next screen. It is considered that the high attrition rate, with respondents failing to complete the survey, was a direct result of these ambiguities.

Respondents noted the introduction was quite long, implying that it made them anxious wondering when they might finally start answering questions. With the first ten 'clicks' on the website moving respondents through mandatory information pages, respondents noted this as too much for them to hold their interest. Besides the pre-requisite ethical clearance information necessary to launch the website, there is a raft of introductory information on the topic itself; climate change. An additional ten clicks; are required before a respondent gains access to information specific to the policy problem where they finally get the opportunity to give an opinion for solving the problem. One respondent stated that "At home I would have left the website after two or three introduction pages, because I don't care about this, and just want to start." When asked if an introduction movie might better serve this purpose, all teachers and students indicated that this might prove more user-friendly, and potentially save time. In addition, it was considered that the length of the introduction may have contributed to respondents leaving the ICQ early before attempting to complete the questionnaire. When observing a group of nine students a Dutch researcher noted that eight of the student had only managed to progress to the actual options and consequences packages after some 45 minutes in the ICQ. This was considered too long a period by teachers and student for a student's interest to be held.

The necessity for a password to access the different survey components was not considered to user friendly by many ICQ respondents. In the initial stages of building the ICQ on the online survey company's website it became obvious that delivering the ICQ to respondents via an interactive website would require the ICQ to be split into multiple components. This would enable transition between background and instructive information to be housed on the website and the survey aspects of the ICQ developed on the survey company's website. The ability to seamlessly move between these different components became a challenge. As it was not possible to communicate bilaterally between the online survey company's network and the website hosts network due to conflicting security policies, in order to enable a participant to move freely between the website information and the survey components of the splitting of the ICQ enable a unilateral connect between the two websites through URL linkages. However, this one way communication process created other connection issues, for example, how to ensure respondents navigated back to the main website without loss of progress and identification of respondent data across the different survey elements. To address the issue of navigation between the ICQ website and the online survey company's website the ICQ website developer incorporated a list of instructions on how to navigate through the website that would appear at the bottom of all website screens for respondents' ease of reference.

To resolve the issue of identification of respondent data across all ICQ components, the online survey company recommended the use of a unique identifying password that once established in the early stages of the ICQ would then link respondent data into one universal data panel. However, most internet browsers retain in “history” specific information (such as “cookies”) that permit computers to recognize past contact to different websites to speed up connection and website navigation. This history also enables websites to identify a computers past activities on the website, such as previously used passwords. Some respondents experienced problems when their internet browser’s security features blocked the use of their unique identifying password after several attempts to open the same online survey. Without an understanding of how this browser history can be deleted, a respondent would be locked out of the survey and unable to complete it.

In addition to this, internet browsers have a security feature that has the ability to prevent “pop ups” occurring on individual computers. This is a user controlled feature however a respondent would need to have knowledge of the feature’s disabling process in order to switch it off. As the website design for the ICQ was an Adobe Flash Player platform that uses pop-up windows rather than separate website pages to move visitors through information, for some respondents the ability to move freely through the website was lost after the initial introductory screens. As the issue was user controlled it was outside the remit of the online survey company and the website host developer to address. Without a solution that pre-empted this issue, respondents with pop up restrictions enabled on their computers who were unaware of how to disable the feature were prevented from moving beyond the initial stages of the ICQ. As result, it was necessary for the researcher observing student respondents completing the ICQ to assist them by advising how to remove the pop-up restriction on their computers. It is believed that this issue may have been a contributing factor in the failure of a large majority of Dutch ICQ respondents not completing the survey.

The issue experienced with the pop ups as a result of the use of the Adobe Flash Player platform also caused access issues for respondents wishing to use an IMac or similar electronic device to complete the ICQ. Another aspect of the delivery mechanism considered not user friendly by Dutch respondents.

#### **5.4.2 DEVELOP A NARRATIVE AND STORYLINE TO SUPPORT THE CONTENT**

In the creative development stage of the research the project team proposed that the website could provide narratives of a Policy Advisor who’s been requested to provide advice on the topic of carbon dioxide reduction. Budget constraints made it difficult to properly integrate this concept due primarily to the degree of technical complexity required to develop the feature. When asked if they would appreciate such a feature, 11 (55%) Dutch respondents indicated that it would make the online ICQ more attractive.

#### **5.4.3 PRESENT A CLEAR GOAL FOR THE USER WITH FEEDBACK ABOUT THE PROGRESS**

The design idea was to have individual policy advice and progress monitored by respondents acquiring necessary “puzzle pieces” and assessing one’s own knowledge through optional knowledge tests. As two-way communication between the ICQ website host network and the online survey company’s network was not possible, the integration of a respondent progress feature was limited to a progress bar on each of the individual survey components hosted by the online survey company, and a percentage of completion progress-bar at the bottom of the ICQ website screen. The use of two separate progress features was considered by several Dutch respondents to be confusing.

#### **5.4.4 PROVIDE THE USER WITH SOME CONTROL**

Despite the relatively linear design of the ICQ method, the user can for instance choose which option to evaluate next. The ICQ website identified on a single screen the seven different options available to address the policy problem using pictorial representations. Access to the survey was imbedded into the pictorial representations requiring the respondent to click on the picture to navigate to the corresponding online survey link. The order of completion of the options was at the control of the respondent. This flexibility was considered by Dutch respondents to be positive. Being able to ponder the pictures and read the pop up

overview that appeared when a respondent hovered over the picture using their computer pointer, provided respondents with the ability to choose the option they wished to complete and the order in which they wished to complete them. Respondents commented they liked this feature as it allowed them choose options as the perved their interest.

#### **5.4.5 TRY TO CREATE A SOCIAL PRESENCE**

Even though social interaction is not possible within the scope of this project, the user can in the end compare his/her score to that of others. The ability for an individual respondent to compare his score to overall opinion across all demographics in an open forum format on the website was considered problematic, as this could enable negative feedback targeted to specific demographic groups. It was felt that this may have a negative influence on other individual's responses. To counter this and still permit feedback to respondents on where their opinion sat in with line other respondents' opinion, the concept of providing peer feedback was considered. It was felt that this feature would enable a respondent to receive feedback specific to his peer group, and limit access to other peer group information. Unfortunately, the incorporation of this feature would prove to be too time consuming and carry costs that the project's timeline and budget could not support. Interviewed Dutch respondents displayed an interest in what others answered, so this feature may be a valuable inclusion if a second online ICQ was to be realised.

#### **5.4.6 MAKE USE OF QUESTIONS TO INSTIL CURIOSITY AND ENHANCE DELIBERATION AFTER THE POLICY ADVICE HAS BEEN GIVEN**

Our options were limited by time constraints, and the structure and technical capability of the site. Therefore, we wouldn't have been able to implement this feature to its full potential, such as allowing respondents to select a response to a multiple choice question or be given feedback on whether they had answered correctly or not. As the design process progressed this feature was scaled back to fit within these limitations.

Initially, to address this, it was thought that we could have a multiple choice question appear in relation to climate change consequences and alongside each of the policy options. The questions were to be related to and the answers found within the 'consequences' information provided in the option packages. Although respondents would not immediately be able to 'answer' the question as such, the question would provide a 'teaser' or incentive for the respondent to continue and find out the answer. However, in the final design the space available for this feature was limited and the additional content was thought to make the web pages overly busy and complicated visually. Therefore, this feature was reduced to a 'teaser' in the form of a 'did you know' statement or fact derived from the information in the policy options. This statement was designed to appear/hover in each 'policy option button' whenever a respondent hovered over it.

#### **5.4.7 CREATE REWARDS**

This feature was considered as a means for providing incentive for respondents to continue through the ICQ and as a possible visual confirmation of a respondent's progress. The thought being that a piece of a puzzle might be awarded to respondents as they completed each of the seven options survey components which could then combine to create a completed puzzle. Unfortunately it wasn't technically possible to create the reward system due to the lack of two-way communication between the website host network and the online survey company network which would be required in order to trigger the awarding of the reward.

#### **5.4.8 CREATE COMPETITION**

The inability to communicate between the website host network and the online survey company's network, real time feedback to permit a respondent to compare his responses to others. Without this feature it was not possible to incorporate competitive elements into the online ICQ.

Overall, the dissemination of the Dutch ICQ was not successful in obtaining sufficient respondents to be able to analyse the data. Eventually, only 11 participants completely finished the online ICQ voluntarily. This inability to voluntarily engage ICQ respondents in the Netherlands resulted in a decision to financial compensate Australian participants in order to achieve a reasonable response rate.

It is the belief of Dutch researchers that many respondents failed to complete the online ICQ due primarily to issues associated with the first point identified above and the corresponding perceptions of interviewed respondents that these issues resulted in a tool that was not user-friendliness. Respondents indicate that they became 'lost' navigating the introductory pages on the website and were frustrated by pop up restriction experienced by some in these early pages. Which, when coupled with complications experienced by respondents whose internet browsers' security history features restricted access to survey components after repeated use of a password, created substantial frustration for many Dutch respondents. These issues and other barriers already mentioned made it impossible to realise many of the initial concepts considered beneficial for delivering the online ICQ in a fun and interactive manner. As a result many respondents indicated they found the ICQ to be somewhat boring.

# Part V Conclusions and Recommendations

## 6 Conclusions and Recommendations

This research project investigated the use of the ICQ as a potential tool for people wishing to become better informed about future energy options. Consisting of two components, the first focused on developing an ICQ for Australian and Dutch citizens, the second focused on the adaptation of an existing Dutch ICQ for use as an online information tool, investigating the possibilities for a more interactive and engaging version and the reaction of different groups in society to such a tool. This section provides conclusions based on these components as well as recommendations for the CCS industry.

### 6.1 Conclusions

#### 6.1.1 THE AUSTRALIAN AND DUTCH ICQS

This area of the project investigated the choices the general Australian and Dutch public made after receiving and evaluating expert information on the consequences of these choices. This was achieved through the use of the existing Dutch ICQ and the development of an Australian ICQ. Firstly, respondents were advised of a policy issue framed as a decision problem and provided with background information. Next, they were provided with information about the consequences of seven policy options, designed to assist in informing their decision-making process. Finally, respondents were asked to evaluate each consequence and option before choosing their preferred options.

Essential to this design is the need for valid, balanced information. To this end, information for the ICQ was compiled by experts from different backgrounds and organisations which were then checked by another, similarly differentiated group of experts. The process to ensure that accurate and balanced information was provided to participants was an extremely difficult task. The aim was to have consensus amongst the experts in the information that was provided as well as having the text communicated in a way that was succinct and understandable by laypeople. Due to the very technical and complex issues being addressed in each of the options, and their subsequent consequences, consensus between the experts on what information was to appear was near impossible to achieve as well as having recognition of word length and technical language use. The input our experts made was invaluable but we deeply misjudged the amount of time and the level of complexity in compiling the options and consequences information. In the end, our experts chose to define the policy problem for Australia around carbon dioxide emissions mitigation and provide the most optimal options available toward solving the problem. In order to reduce Australia's carbon dioxide emissions by 33% by 2030, the chosen options were:

- Energy efficiency in residential and commercial sectors;
- Efficiency in the manufacturing and mining industries;
- Replacing future planned coal-fired power stations with gas;
- Carbon dioxide capture and storage with coal;
- Deploying renewable sources;
- Participating in an international emissions trading scheme; and
- Nuclear power

The Dutch were to reduce the Netherlands's carbon dioxide emissions by 50% by 2030, by choosing between the following seven options:

- Improvement of energy efficiency;

- Improvement of energy efficiency and decreased use of material and energy;
- Electricity from wind turbines at sea;
- Conversion of biomass to car fuel and electricity;
- Large plants where coal or gas is converted into electricity with CCS;
- Large plants where gas is converted into electricity with CCS; and
- Electricity from nuclear power plants.

The results showed that even though Dutch and Australian respondents live on different sides of the world, their preferences for carbon dioxide mitigation options contain similarities. Both countries show a preference for energy efficiency options and renewables, and oppose nuclear energy. Although the consequences of the different options for the Netherlands and Australia were quite different, the overall grades were similar in relative terms. When taking a 5.5 as cut off point for a sufficient grade, the efficiency options, renewable sources and CCS score as sufficient, while nuclear, coal to gas and the international trading scheme score as insufficient.

### **6.1.2 LENGTH OF CURRENT ICQ TOO LONG FOR MOST**

Although people may be interested in the topic of climate change and carbon dioxide mitigation actions, respondents often indicated a belief that the length of the online ICQ was too long to complete voluntarily. For the Dutch online ICQ this was conveyed in the reactions received from teachers and students who implied that to concentrate for an hour, or longer, in order to complete the survey was too long. Further, that the way the information was presented was felt to lack stimulation and variety.

Similarly, respondent evaluation of the Australian ICQ indicated an overall belief that the tool to too long. This perception appears to be reinforced by the degree of attrition experienced in Australia with only 37.5% of respondents (paid) finishing the online ICQ.

### **6.1.3 DIFFERENT ICQ'S FOR DIFFERENT TARGET GROUPS**

Feedback received from several of the Dutch online ICQ target groups indicates that a higher level of completion may be realised by varying the length and information density of the ICQ specific to a particular target group. A shortened ICQ in general would be welcomed, and, for chose of information to be directed by the respondent. Feedback from university students indicated a desire to know more of the facts behind the consequence as without these the content often raised more questions than provided answers. High school teachers stated they thought the information level was good or sufficient. However, it was noted that the tool could achieve greater audience reach if it were to incorporate three options of choose, for example, 'light', 'medium', and 'expert', to satisfy the needs of the different interest groups. Though a valid point, such differentiation in content would require extensive time commitment on the part of experts to develop the different packages to the exacting quality required for the ICQ process, which in turn would incur extensive costs.

### **6.1.4 AVOIDING TECHNICAL DIFFICULTIES AND RESTRAINTS**

One of the constraints experienced by the project team has been a lack of knowledge of IT issues that accompany the development of an online tool for delivering the ICQ, specifically, a lack of understanding of the different and varied technical options that might be available and their limitations. Without access to an IT specialist in the early stages of the project, different limitations were experienced which prevented desired design elements from being realised as the project progressed.

In addition, several project setbacks experienced as a result of a lack of understanding of IT processes may have been avoided if a different approach had been taken around IT issues. . Ideally, all IT and technical

theoretical concepts and ideas should be addressed with the potential IT candidates prior to securing their services. Although the overall objective of the project's intent were discussed with and believed to have been adequately addressed by the online survey service company retained to deliver the survey, it was realised as the survey was being developed that the mechanism for delivery did not provide the degree of flexibility the ICQ required. Realisation of the limitations of the survey mechanism prior to commencement of this aspect of the projects development may have resulted in the reconsideration of the contracted provider. As a result, it is recommended that any future project looking to address an online delivery of the ICQ incorporate a Performance-based Building Design or Statements of Requirements (SoR), for discussion with potential contractors, with the choice of final contracted service provider reflecting an ability to meet all stated requirements or practical solutions. The use of a SoR for future projects may alleviate such difficulties experienced what was essentially a social science dominated project team.

### **6.1.5 THE COMBINATION OF GATHERING DATA AND MAKING THE WEBSITE ATTRACTIVE IS DIFFICULT**

The concept of informing people at the same time as gathering data proved to be quite challenging. Restricting the volume of information required to that sufficient to inform while preventing interest loss due to too much information created further difficulties. Ethical guidelines that require upfront provision of information about the project's background and participant rights increased what was already a significant volume of reading prior in the ICQ's preliminary stages. . In addition, in order to ensure similar baseline knowledge levels for all respondents, information on global warming is provided before the questionnaire component of the ICQ is commenced. Though imperative for the ICQ method, this reading may be better delivered via a short explanatory movie or film clip. This could significantly speed up the process while introducing an enjoyable element to the tool. In accordance with this, several respondents indicated they felt the design of the questionnaire delivered by the online survey company to be rather dull and uninspiring. It is recommended therefore to integrate the different survey components into the one website platform incorporating an engaging presentation format that is repeated across all components such that respondent interest is maintained which may result in an increase in the completion of the tool.

These technical difficulties tended to cloud the design component of the project. As a result ideas conceived early in the project's development intended to enhance the ICQ to make it more attractive to potential participants, were not realised. This lack of realization of planned outcomes makes reflection of the soundness of these ideas difficult. For example, a lack of continuity of access due to a constraint imposed by the complexity and length of the ICQ resulting in the survey's different components being developed as separate elements. These elements require to be linked for data collection purposes in the online survey company's software via the use of a unique password. This required participants to move in and out of the website to access the different components. Another involving the online survey company's software prevented users of Macintosh computers, Smartphones or Tablet computers (e.g. iPads) and some internet browsers, from completing the ICQ.

In conclusion, while there was significant potential for delivering the ICQ via an online tool the end product did not achieve desired outcomes and there would appear to significant room for improvement. As the results of the Australian ICQ would demonstrate that the information provided in the ICQ via the website is not in need of extensive change. These results reflect similar findings from previous ICQs conducted in other countries. People appear to be positive about the information that is provided. However, the design would benefit from several improvements. Most important of which is the use of a single website to integrate all ICQ components including preliminary and ongoing instructive information and the different survey elements; rather than delivery via separate website interfaces. This should result in a more stimulating and inspiring process for providing information to respondents, and employ additional IT elements, for example the use of images, figures or video's. Finally, in order to engage and hold the attention and interest of potential ICQ participants, it is essential that consideration be given to making the process shorter and pitched to different levels of understanding and interest that meet the needs of different target groups.

## 6.2 Recommendations

### **6.2.1 RECOMMENDATION 1: IN ORDER TO IMPROVE ACCEPTANCE OF CCS TECHNOLOGY, IT SHOULD BE PRESENTED AS PART OF A PORTFOLIO OF CLIMATE MITIGATION SOLUTIONS**

The results of both the Australian and Dutch ICQs found that the CCS option was more favourable when it was combined with other solutions that were related to energy efficiency and renewable technologies. For example, 26% of Australian respondents indicated that they would choose CCS as one of the three preferred solutions if included with the energy efficiency options. It is recommended that for acceptance of CCS to be achieved in Australia and the Netherlands, the technology needs to be situated in a suite of solutions that also address energy efficiency in the residential, commercial and industrial sectors as well as renewable technology options.

### **6.2.2 RECOMMENDATION 2: DISSEMINATING APPLIED KNOWLEDGE AND INFORMATION OF R&D OUTCOMES FOR CCS**

When more R&D results are available in areas of uncertainty for CCS, they need to be communicated because it is the uncertainty that people react to not necessarily the technology itself. A large proportion of the information provided in the CCS related options were based on predicted outcomes due to the early stage of development for this technology. It is recommended that as more applied and evidence based information about the real costs, technical capabilities and risks of CCS become available that it be communicated widely, in a balanced and factual manner, drawing upon actual figures and examples as opposed to predicted and modelled data.

### **6.2.3 RECOMMENDATION 3: ICQ RAISES AWARENESS BUT MISSES THE MARK ON PRACTICALITY**

In the array of tools available for raising awareness, the ICQ is more of a research methodology and there is a need to have a more practical way of getting the same outcomes. Simply providing more and better risk information in an attempt to educate the public is in itself insufficient to address concerns and form opinions on CCS. The public is not a passive audience to whom messages should be delivered but an active participant in interpreting information. It is recommended that the ICQ is developed into more of a two-way, truly interactive resource that involves information sharing and relationship building in an online platform.

### **6.2.4 RECOMMENDATION 4: LENGTH OF CURRENT ICQ TOO LONG FOR MOST**

Although people may be interested in the topic of climate change and carbon dioxide mitigation actions, respondents often indicated a belief that the length of the online ICQ was too long to complete voluntarily. It is recommended that future uses of the ICQ format be modified considerably and aim for a 20 minute survey design.

### **6.2.5 RECOMMENDATION 5: DIFFERENT ICQ'S FOR DIFFERENT TARGET GROUPS**

It was noted that the tool could achieve greater audience reach if it were to incorporate three options of choice, for example, 'light', 'medium', and 'expert', to satisfy the needs of the different interest groups. Though a valid point, such differentiation in content would require extensive time commitment on the part of experts to develop the different packages to the exacting quality required for the ICQ process, which in turn would incur extensive costs.

## **6.2.6 RECOMMENDATION 6: AVOIDING TECHNICAL DIFFICULTIES AND RESTRAINTS**

In the current study, different limitations were experienced which prevented desired design elements from being realised as the project progressed. Therefore, it is recommended that future research teams have access to an IT specialist in all stages of the project in order to achieve an easily accessible website with embedded survey response capturing features.

In addition, if you do not have an IT programmer in your project team and a third party provider for IT support is required, it is recommended that any future project looking to address an online delivery of the ICQ incorporate a Performance-based Building Design or Statements of Requirements (SoR), for discussion with potential contractors, with the choice of final contracted service provider reflecting an ability to meet all stated requirements or practical solutions. The use of a SoR for future projects may alleviate such difficulties experienced what was essentially a social science dominated project team.

## **6.2.7 RECOMMENDATION 7: THE COMBINATION OF GATHERING DATA AND MAKING THE WEBSITE ATTRACTIVE IS DIFFICULT**

The concept of informing people at the same time as gathering data proved to be quite challenging. Although we retained all the required information in written format, which is imperative for the ICQ method, it is recommended that some components be provided in short explanatory movies or film clips. This could significantly speed up the process while introducing an enjoyable element to the tool.

In addition to the copious amounts of written information provided, respondents also felt the survey process was uninspiring. It is recommended therefore to integrate the different survey components into the one website platform incorporating an engaging presentation format that is repeated across all components such that respondent interest is maintained which may result in an increase in the completion of the tool.

# Appendix A Australian and Dutch Energy Options

The following appendix provides all of the Australian and Dutch options and consequences for all seven policy solutions as well as the climate change consequences for each country. The list below details what is located in each section of Appendix A.

Australian options and consequences	Dutch options and consequences
<p><b>Climate change</b></p> <ul style="list-style-type: none"> <li>• Drought</li> <li>• Heat</li> <li>• Extreme Weather</li> <li>• Sea-level Rise</li> <li>• Water run-off in Australia</li> <li>• Victims in poorer countries</li> <li>• Summers in Australia</li> <li>• Winters in Australia</li> </ul>	<p><b>Climate Change</b></p> <ul style="list-style-type: none"> <li>• Drought</li> <li>• Heat</li> <li>• More extreme weather</li> <li>• Sea level rise</li> <li>• Rising water in and around the Netherlands</li> <li>• Victims in poorer countries</li> <li>• Summers in the Netherlands</li> <li>• Winters in the Netherlands</li> </ul>
<p><b>Option 1 – Energy efficiency in residential and commercial sectors</b></p> <ul style="list-style-type: none"> <li>• Costs</li> <li>• Economic impacts</li> <li>• Greenhouse gas emissions</li> <li>• Environmental impacts</li> <li>• Policy and regulatory initiatives</li> <li>• Reliability of energy supply</li> <li>• Consumer commitment</li> <li>• Redirecting savings to energy intensive activities</li> </ul>	<p><b>Option 1 - Improvement of energy efficiency Contribution to air quality</b></p> <ul style="list-style-type: none"> <li>• Use of natural sources</li> <li>• Reliability of the energy supply</li> <li>• Economic consequences</li> <li>• Measures to reduce fuel use for transportation</li> <li>• Consequences for manufacturers</li> <li>• Consequences for houses and buildings</li> <li>• Price</li> <li>• Contribution to the greenhouse effect</li> </ul>
<p><b>Option 2 - Efficiency in the manufacturing and mining industries</b></p> <ul style="list-style-type: none"> <li>• Costs</li> <li>• Economic impacts</li> <li>• Greenhouse gas emissions</li> <li>• Environmental impacts</li> <li>• Policy and regulatory initiatives</li> <li>• Reliability of energy supply</li> <li>• Industry commitment</li> <li>• Redirecting savings to energy intensive activities</li> </ul>	<p><b>Option 2 - Improvement of energy efficiency and decreased use of materials and energy</b></p> <ul style="list-style-type: none"> <li>• Contribution to air quality</li> <li>• Economic consequences</li> <li>• Consequences for transportation</li> <li>• Consequences for manufacturers/industry</li> <li>• Consequences for consumers</li> <li>• Consequences for houses and buildings</li> <li>• Price</li> <li>• Contribution to the greenhouse effect</li> </ul>
<p><b>Option 3 - Replacing future planned coal-fired power stations with gas</b></p> <ul style="list-style-type: none"> <li>• Costs</li> <li>• Economic impacts</li> <li>• Greenhouse gas emissions</li> <li>• Environmental impacts</li> <li>• Water use and safety</li> <li>• Policy and regulatory initiatives</li> <li>• Reliability of energy supply</li> <li>• Infrastructure requirements</li> <li>• Safety of gas pipelines and wellheads</li> </ul>	<p><b>Option 3 - Electricity from wind turbines at sea</b></p> <ul style="list-style-type: none"> <li>• Effects to the view</li> <li>• Consequences for birds</li> <li>• Consequences for ocean fish and mammals</li> <li>• Consequences for the fishery</li> <li>• Dealing with fluctuations in electricity production</li> <li>• Consequences for employment</li> <li>• Price</li> <li>• Contribution to the greenhouse effect</li> </ul>

**Option 4 - Carbon Dioxide Capture and Storage with Coal**

- Costs
- Economic
- Impacts
- Greenhouse gas emissions
- Environmental impacts
- Policy and regulatory initiatives
- Reliability of fuel supply
- Availability of storage sites
- Pipeline infrastructure
- Safety of carbon dioxide pipelines, wellheads and storage

**Option 4 - Conversion of biomass to car fuel and electricity**

- Contribution to air quality
- Use of land for biomass with certificate
- Use of land for biomass without certificate
- Influence on food production
- Reliability of the energy supply
- Expansion of seaports
- Necessity of new vehicles
- Economic consequences
- Price
- Contribution to the greenhouse effect

**Option 5 - Deploying renewable sources**

- Costs
- Economic impacts
- Greenhouse gas emissions
- Environmental impacts
- Policy and regulatory initiatives
- Reliability of energy supply
- Land mass requirements

**Option 5 - Large plants where coal or gas is converted into electricity with capture and storage of carbon dioxide**

- Contribution to pollution due to coal mining
- Safety of carbon dioxide transport in pipelines
- Safety of underground carbon dioxide storage
- Reliability of the energy supply
- Price
- Contribution to the greenhouse effect

**Option 6 - Participating in an international emissions trading scheme**

- Costs
- Economic impacts
- Greenhouse gas emissions
- Environmental impact
- Limiting the number of international permits able to be purchased
- Safeguards when linking with other international schemes

**Option 6 - Conversion of natural gas into hydrogen in large plants with carbon dioxide capture and storage**

- New pipelines needed
- New vehicles needed
- Contribution to air quality
- Contribution to noise
- Safety of hydrogen plants
- Safety of use of hydrogen in daily life
- Safety of carbon dioxide transport in pipelines
- Safety underground carbon dioxide storage
- Reliability of energy supply
- Economic consequences
- Price
- Contribution to the greenhouse effect

**Option 7 - Nuclear power**

- Costs
- Economic impacts
- Greenhouse gas emissions
- Environmental impacts
- Policy and regulatory initiatives
- Skills and qualifications
- Reliability of fuel supply
- Safety and risks
- Nuclear weapons production

**Option 7 - Electricity from nuclear plants**

- Safety of nuclear power plants
- Background radiation during normal operation
- Nuclear waste
- Protection of power plants against terrorist attacks
- Nuclear power plants and nuclear weapons
- Reliability of the energy supply
- Price
- Contribution to the greenhouse effect

## Australian Options and Consequences

### Climate Change

Next you will be asked to assess several consequences of rising temperatures due to the greenhouse effect.

#### Consequence

##### 1. Drought

Expected temperature rise has the potential to significantly affect the World's climate. Some regions are likely to get wetter while other regions become drier. Australia is expected to experience more frequent drought conditions in southern regions and uncertain rainfall changes in the north. The south is likely to experience an increase in the number of dry years and a reduction in wet years, but daily rainfall across most of Australia is expected to be heavier during wet periods. As a result of increased drought and reduced wet years in southern Australia and some other parts of the globe, regional and seasonal conditions for crops and livestock management may change. For example, in areas of high latitude in the northern hemisphere, agriculture may increase due to warmer and wetter conditions and an increase in carbon dioxide. It is also possible that some regions of the world may experience higher incidences of crop loss and an increased potential for famine, particularly those that are already experiencing high temperature levels.

##### 2. Heat

The World is expected to continue to experience long term warming due to the enhanced greenhouse effect and natural, year-to-year climate variations. Recording increases of up to 1 degree Celsius since 1960 in some areas, Australia's warming trend remains in line with global trends with each decade since the 1950s being warmer than the one before. Record hot days (exceeding 40 degrees Celsius) have increased since 1990, more than double the number of record cold days experienced in the same period. With Australia's average temperatures projected to rise by 0.6 to 1.5 degrees Celsius by 2030, these trends will result in increased hot days and warmer nights, a decline in cool days and cold nights (including frosts) which in turn will likely alter existing agricultural practices and permanently change wildlife habitat.

##### 3. Extreme Weather

The enhanced greenhouse effect may lead to changes in the frequency, severity and duration of extreme occurrences such as heatwaves, fires, droughts, floods, snowfall and storms. Australia is anticipated to experience an increase in the number of droughts in the country's southern regions and increased daily rainfall intensity and floods over most of Australia. The frequency of tropical cyclones near Australia is expected to decrease, however of those that do form, the intensity and severity are expected to increase. Heatwaves and fires are expected to increase in frequency and intensity.

##### 4. Sea-level Rise

Over the past several decades, temperature levels of the World's oceans have increased resulting in corresponding increases in ocean water volume. Global sea-levels in 2011 were 210mm above 1880 levels, with an average annual rise of 3mm per year from 1993 to 2011. Australia's sea-surface temperatures are increasing at a faster pace than global averages, with corresponding increases in sea-level of between 7 to 11mm per year in northern and north western coastal regions. Central and southern coastal regions sea-level increases are likely to remain within global averages. Projected rates of sea-level rise are highly uncertain, with a range of 180-590mm by 2100, relative to 1990, with up to 200mm more if ice sheets continue to discharge water at recent rates. In some coastal regions, local ocean currents and tides contribute to higher sea-levels and may intensify the impact of sea-level rise as a result. These impacts may include erosion and loss of habitat. As the Earth's sea-levels continue to rise, areas of the world that are currently just above sea-level may become submerged.

## **5. Water run-off in Australia**

In recent decades northern Australian has experienced increased monsoonal rainfall during the spring and summer months. In contrast, reductions in rainfall in late autumn and winter have been experienced across the country's south. There is uncertainty about projected changes in rainfall in northern Australia. For southern Australia, we expect increased drought periods, fewer wet years and more intense rain events in some regions. Although increased intensity of wet weather events may result in more short-term flooding in some regions, the reduction in rainfall in southern regions would lead to less water availability.

## **6. Victims in poorer countries**

Not all countries will be in a position to adapt to climate change consequences. 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 an increase in temperature. Floods, for example, already cause tens of thousands of deaths worldwide on an annual basis, and this number may continue to increase over the course of the century. These deaths are likely, for the most part, to 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.

## **7. Summers in Australia**

By 2030, Australia is likely to experience a 10% to 50% increase in the number of summer days over 35 degrees Celsius with more frequent heat waves. Heat related deaths are likely to rise. Fires are likely to become more frequent and intense. Energy consumption for air conditioning is expected to increase, with a higher risk of black-outs. Some insect and animal carried, water carried and food carried disease are more likely to become more common.

## **8. Winters in Australia**

Australian winters are likely to become warmer, with reduced rainfall in the south. This means less frost damage to sensitive crops, but inadequate chilling for some fruit. The snow-covered area is expected to shrink 10% to 40% by 2040, relative to 1990.

## **Information Package Option 1 – Energy efficiency in residential and commercial sectors**

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by improving the energy efficiency in residential and commercial sectors focusing on changes to construction materials, technology and appliance use. Household electricity consumption has the potential to drop to just over 50% of today's electricity consumption by replacing lighting, old refrigerators and freezers, electric hot water systems, shower heads and taps and avoiding stand-by power use. Electricity efficiency in the commercial sector (which includes services such as finance, property and health, not heavy industry such as manufacturing and mining) can lead to a 60% reduction and has the potential for further decreases of up to 75%. Such reductions are possible in several ways, including the use of glazing, natural daylight, well maintained and efficient equipment, use of monitoring systems and a reduction in air conditioning usage. Energy efficiency improvement resulting in a 20% reduction in residential and commercial electricity consumption will be sufficient to achieve the reduction of 50 million tonnes of carbon dioxide.

### **Consequences**

#### **1. Costs**

Energy consumption in both residential and commercial buildings can be reduced by improving energy efficiency. Investment required for energy efficient options are usually higher than for less efficient alternatives and larger outlay would be needed to achieve greater efficiency targets. For example, to achieve a 22% energy reduction in an existing residential dwelling an investment of approximately \$417 would be required; yet to achieve a 50% reduction the investment is approximately \$1,866. Upfront investments however can be offset over time through savings in energy consumption expenses. Lower energy efficiency options usually pay for themselves within a four year period while higher energy efficiency options tend to be offset over a longer period of around eight years. As such, investment by consumers in efficiency measures will result in immediate savings on energy bills and contribute over time to the repayment of the upfront investment made. Similarly, the commercial sector can benefit from investing in energy efficiency measures; however the upfront investment required would be substantially higher and companies typically expect the returns to repay within approximately six to seven years.

#### **2. Economic impacts**

It is predicted that future economic growth for Australia will lead to an increase in energy consumption. However, this does not necessarily have to be the case. Energy efficiency options have the potential to counter this prediction through increased use of technological and behaviour change improvements. For the residential and commercial sectors this would require greater uptake of energy efficient technologies as well as changes to inefficient behaviour, which could be supported by incentives and the growth in market share of more energy efficient options which will make options more accessible and affordable. Over the longer term, once these measures are implemented and any upfront costs have been recovered they reduce business costs and thereby increase the productivity of the economy.

#### **3. Greenhouse gas emissions**

The residential and commercial sectors are responsible for approximately half of all electricity consumption. By improving energy efficiency through the introduction of high energy rated building materials, technologies, and appliances, the use of electricity in the residential and commercial sectors can be reduced. A 20 percent reduction in electricity consumption in these sectors means power stations use less fuel to produce electricity which reduces their overall emissions of greenhouse gases by 50 million tonnes.

#### **4. Environmental impacts**

The use of energy efficient materials, appliances, devices and technologies with longer life spans than their inefficient equivalents across the residential and commercial sectors, can benefit the environment by reducing the extraction and processing of natural resources and reduce landfill.

## **5. Policy and regulatory initiatives**

To assist households and businesses to overcome barriers to uptake of energy efficiency opportunities there needs to be continued development of government standards and policies. For example, expansion of the current Minimum Efficiency Performance Standards and energy performance labelling requirements on appliances; development of a new law addressing Greenhouse and Energy Minimum Standards; and the phasing-out of inefficient hot water systems.

For households, this would require policy that encourages behaviour change, sustainability reporting when selling a house, and an increase in energy efficient technologies. Improvements in the commercial sector require policies that are designed to overcome market barriers. This may include a range of incentives, toughening the performance standards for equipment such as refrigeration and cold rooms, replacement schemes for inefficient equipment and further support for research and development. The introduction of such policies would impose upon households and business an obligation to meet policy requirements.

## **6. Reliability of energy supply**

Energy efficiency can reduce system (peak) loads and other stresses which help to maintain the reliability of energy supply. This assists to minimise the chance of blackouts and power shortages which in turn can avoid loss of productivity. It also lessens the need for investment in energy infrastructure.

## **7. Consumer commitment**

Time and effort will need to be invested by individuals in the home and workplace to find and implement energy efficient measures. Residential and commercial uptake of energy efficient appliances, practices and services may be hampered by many barriers such as access to information, cost and motivation. To address this, use of energy bill benchmarking, appliance labels, tailored energy audits, and the introduction of higher efficiency standards may provide a way for households and businesses to deal with these barriers.

## **8. Redirecting savings to energy intensive activities**

In order to achieve a 50 million tonne reduction in carbon dioxide by 2030, the residential and commercial sectors need to reduce consumption of energy through energy efficiency. One key benefit of energy efficiency improvements is a reduction in energy costs to the household or business. Yet an issue arises when those energy savings are redirected to other energy intensive activities in the household or business, such as purchasing other energy consuming appliances because now there is more money to do so. This is called a rebound effect and it can mean that, as energy costs decline those financial resources are redirected towards activities which use energy and as a result no net reduction in energy consumption is achieved. However, this only occurs where ownership or use of some energy using appliances is not already near saturation point.

## **Information Package Option 2 - Efficiency in the manufacturing and mining industries**

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by increasing energy efficiency in manufacturing and mining industries by 11.4% and 10% respectively. This will require upgrade and replacement programs, improvements in heating systems, and the introduction of high efficiency technologies and controls, with opportunities for new technologies to provide additional potential for further energy efficiency.

### **Consequences**

#### **1. Costs**

In order to achieve the 50 million tonne reduction of carbon dioxide by 2030 additional investment into energy efficiency alternatives will need to be made by the manufacturing and mining industries. However, any increased investment can be offset over time through annual cost savings that result from reduced energy use. For modifications made to existing machinery and equipment businesses usually expect investment 'repay' periods within approximately two years. In deciding to replace their existing machinery and equipment, industries need to carefully consider the age of existing plant. Some industrial plants are designed to last for decades. Replacing plant before the end of their natural life can represent a substantial loss of return on investment and may not ultimately be economically viable. As such upgrading and modifying existing equipment will usually be preferable, where possible. As more plant approaches its end of life, more uptake of energy efficiency will occur in the manufacturing and mining industries.

#### **2. Economic impacts**

It is predicted that future economic growth for Australia will require an increase in energy consumption. However, this does not necessarily have to be the case. Energy efficiency options have the potential to counter this prediction through increased use of technological and behaviour change improvements. Compared to the situation where energy is used inefficiently, energy consumption costs are lower. If fuel prices rise, investments in efficiency measures increase the competitive advantage of Australian businesses and provide an opportunity for them to reduce expenses and be open to the possibility of job creation or passing savings onto consumers. For the manufacturing and mining industries this would require greater uptake of energy efficient technologies as well as changes to inefficient behaviour, supported by incentives and growth in their market share of more energy efficient options. However, if too stringent energy efficiency improvements are imposed through regulation, it is possible that industries may not be viable due to the high cost of plant replacement and may close down.

#### **3. Greenhouse gas emissions**

Improved energy efficiency in these industries reduces their demand for heat and electricity supply. When less electricity is used, power stations require less fuel to produce electricity which reduces their overall emissions of greenhouse gases.

#### **4. Environmental impacts**

The use of more energy efficient industrial plant will typically also result in plant that uses less resources and produces fewer waste streams. For example, a more efficient plant may require reduced non-energy inputs such as water which may then become available for environmental purposes. Also, reduced fossil energy consumption also typically results in, not only fewer greenhouse gas emissions, but fewer emission of pollutants gases such as heavy metals and sulphur and nitrogen dioxides..

#### **5. Policy and regulatory initiatives**

Improving energy efficiency in the manufacturing and mining industries will require stronger government policies than those that currently exist. Research has identified several barriers to implementation. These include the tendency for organisations to focus on short-term profits, a lack of management commitment to make the required changes, and a general lack of skills in energy efficiency. There is also a recognised need for incentives through tax concessions and clear targets for

energy efficiency requirements. Such new policies need to carefully manage the balance between keeping industry close to energy efficiency best practice but on the other hand recognising that much equipment is long lived and cannot be replaced in short time frames without significant economic losses.

#### **6. Reliability of energy supply**

Energy efficiency can reduce system loads and other stresses which help to maintain the reliability of energy supply. This assists to minimise the chance of blackouts and power shortages which in turn can avoid loss of productivity. It also lessens the need for investment in energy infrastructure.

#### **7. Industry commitment**

Substantial time and effort will need to be invested by the manufacturing and mining industries to find and implement energy efficient measures. Industry uptake of energy efficient processes would need to cover all aspects of the production process, all of which have their own unique requirements and potential barriers. Some of the barriers are access to information, time for research, availability of technologies and the required capability and skills to implement changes. In order to support commitment companies would need to incorporate energy efficiency plans and targets throughout their business, including objectives, budgets, energy reporting and skills development.

#### **8. Redirecting savings to energy intensive activities**

In order to achieve a 50 million tonne reduction in carbon dioxide by 2030, the manufacturing and mining industries need to reduce consumption of energy through energy efficiency. One key benefit of energy efficiency improvement is a reduction in energy costs to the organisation. Yet an issue may arise when energy savings achieved are redirected to other energy intensive activities in the business. This is called a rebound effect and can mean that as energy costs decline financial resources saved are redirected towards alternative activities with increased energy demands which may result in no net reduction in energy consumption being achieved. However, such activities would only be possible where free capacity to expand is available.

### **Information Package Option 3 - Replacing future planned coal-fired power stations with gas**

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by building new gas-fired power plants instead of new coal-fired power plants. Australia has vast reserves of most energy resources (with the exception of oil). Where coal is located, primarily in the larger Eastern states, it is the preferred electricity generation fuel because of its lower cost. Currently, 77% of Australia's electricity is produced by 38 coal-fired power stations and 15% is generated by 26 gas-fired power stations. Gas-fired power plants emit less carbon dioxide than coal-fired power stations, so there is an opportunity to reduce greenhouse gas emissions by building gas-fired instead of coal-fired power stations in the future. In order to achieve the 50 million tonne reduction by 2030 around 50% of all Australia's electricity needs will have to be produced from gas-fired power generation. This will effectively mean all new power stations are gas fired and that existing coal plants retire at their expected end of life.

Gas reserves in Australia are sourced from underground natural gas reservoirs and coal seams. Australia's Gas Industry has experienced substantial growth in the development of coal seam gas extraction technology over the past ten years and is set to continue to expand its use over the coming decades. With production of coal seam gas occurring already in Queensland and New South Wales, significant potential exists into the future.

#### **Consequences**

##### **1. Costs**

Gas-fired power generation is more costly than coal-fired power generation, particularly in those states where coal is more readily accessible. This cost difference is dependent on the future development of gas and coal prices. There is an expectation that gas prices may rise more quickly than coal prices in the future because Australia's domestic gas supply industry may be more greatly influenced by higher international prices due to the expected opening up of a gas export industry on the east coast of Australia. International pricing pressures are currently confined to the west coast where the result there has been higher domestic gas prices. The required capital investments for gas-fired plants are lower, but the higher fuel costs generally more than the offset this advantage in comparison to coal. Consequently comparable gas fired power is estimated to be 30 to 40% higher cost than coal.

##### **2. Economic impacts**

Development of gas-fired power plants to meet growing electricity demand and replace retiring coal-fired plants would require less upfront investment than most other power plant types including coal. However, once up and running, the power plants would have higher operating costs. From an economy-wide perspective this plant investment strategy would reduce the demand for business investment financing. However, it will raise the electricity costs of households and businesses in the long term relative to continuing with a majority of coal-fired power plant development.

##### **3. Greenhouse gas emissions**

The efficiency of power plants varies, depending on the type of fuel used and the specific design of the power plant. Although significant greenhouse gas emissions are produced during mining and transportation of coal, the greatest volume of greenhouse gases produced by coal-fired energy generation is at the power plant. New, efficient gas-fired power plants are estimated to emit around 40% less carbon dioxide than new coal-fired power plants. Greenhouse gas emissions produced from gas-fired power plants occur during fuel combustion, processing, well venting and pipeline transportation. The emissions from gas extraction from coal seams is less well known than from traditional oil and gas wells, so currently no conclusion can be made about its relative merits. Emissions arising during construction and decommission of a gas-fired power plant are considered to be low. Overall, the replacement of coal-fired power stations with gas-fired power stations in Australia will reduce our greenhouse gas emissions.

#### **4. Environmental impacts**

Pollutants from burning fossil fuel sources contribute to poor air quality and other environmental impacts. Natural gas emits minimal air pollutants such as soot, ash, metals, or other airborne particles into the atmosphere. Emissions of air pollutants from natural gas combustion are 90% lower than generated from burning coal. The extraction of natural gas from conventional underground reservoirs typically has a small footprint. However, where the reservoir is in an offshore marine environment, accidental gas leakages, explosions or spills of materials used on board the drill rig can result in impacts to marine ecosystems. Issues have also been raised in regard to coal seam gas production, these include: use of water and waste water disposal; use of fracking (fracturing of the coal seam to enable gas extraction) and the uncertainty around possible seismic activity resulting from this process; potential ground water and soil contamination, salinity, pollution and the impacts these may have on agricultural production, the food industry and to the Australian country way of life. Although natural gas extraction has a history of safe operation in Australia, the long term impacts of coal seam gas are yet to be fully realised. It should be noted that while there are environmental issues associated with gas production, coal mining, which this option seeks to reduce and replace, also involves production of a number of environmental emissions and waste streams.

#### **5. Water use and safety**

The burning of gas to create electricity requires very little water but some processing systems do require water for cooling purposes. Minimal water is required for natural gas production however coal seam gas extraction can involve significant use of water and produce waste water. Access to underground water resources and ongoing stringent management of waste water after use are necessary to ensure the potential for negative impacts to the environment are kept to a minimum. When gas is extracted from coal seams careful geological studies need to be carried out to avoid the potential for damage to or the mixing of ground water sources. Additionally, there are some chemicals used in the extraction process which need to be managed to ensure they do not escape into the environment. The ground water itself also contains chemicals that can harm the surface environment.

#### **6. Policy and regulatory initiatives**

Currently there are a number of Federal and State Government policy initiatives that support development of gas-fired power plants. The majority of these policies aim to achieve greater diversity in their energy mix and a reduction in greenhouse gas emissions which supports an increase in the use of gas. However, there are practical issues that future policies will need to address which include uncertainty around the extent and location of gas reserves and setting of clear environmental targets and community engagement processes for the development and operation of coal seam gas mines.

#### **7. Reliability of energy supply**

Australia has significant reserves of natural gas which ensures security of supply for many decades to come. There may be some competition between domestic and international demand for our gas resources. If a significant portion of gas supply is tied up in long term export contracts then it could eventually limit expansion of domestic gas use or at the very least raise the cost of securing long term domestic gas supply contracts. To some extent the coal industry faces similar international price pressures, however, gas contracts have typically been shorter and international gas prices are traditionally more closely linked to oil prices than coal. On the other hand, gas-fired electricity generation is more capable of responding to peak demand conditions and can complement intermittent renewable energy resources, such as wind or solar, by providing a flexible source of reserve power supply increasing the reliability of the power system as a whole.

#### **8. Infrastructure requirements**

More than 90% of Australia's conventional natural gas reserves (not including coal seam gas) lie offshore in the northwest in challenging deepwater environments with relatively high production costs. Due to the often remote location of gas reserves this option will require significant pipeline and processing infrastructure. Development of pipe laying technologies that reduce the cost of deployment

could be considered. Some technologies exist but still require demonstration and piloting at commercial scale as well as adaptation to Australian conditions. The closer proximity of coal seam gas to the electricity grid has increased investment in that source of gas and Queensland already uses a significant amount of coal seam gas in power generation.

#### **9. Safety of gas pipelines and wellheads**

Natural gas is flammable and can be explosive under certain conditions. Concentrated levels of gas in the air can be hazardous and potentially lethal. The chance of a pipeline gas leakage in Australia is considered low. Australia has a rigid regulator system in place that monitors and ensures the continued safe construction, maintenance and management of the pipeline industry in Australia. A risk associated with extraction of gas from the Earth is failure at the drill site well head. A well head is the section of a drill site that sits above the ground containing equipment including an assembly of pipes, flanges, valves and pressure gauges used in the gas separation process. A well head failure can result in either the slow gradual or sudden release of gas into the air – where a sudden release occurs this can result in an explosion that can cause injury and loss of life. In order to reduce the occurrence of wellhead failures, monitoring systems installed in the well detect leaks and aim to prevent gas from escaping. The probability of a well head failure is estimated to be one every 10 years.

## Information Package Option 4 - Carbon Dioxide Capture and Storage with Coal

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 by capturing, transporting and storing geologically emissions from flue gas emitted by coal-fired power plants in Australia. Carbon dioxide emissions can be captured, compressed into a liquid, transported and permanently stored deep beneath the Earth's surface. This process is called carbon dioxide capture and storage or CCS and allows for a continued use of fossils fuels in a low-carbon economy. In order to achieve the aim of this package Australia would require CCS to be installed at a quarter of the existing coal-fired power plants which make up 77% of current electricity generation; although it can be used in combination with gas-fired power plants as well. Presently, CCS is limited to a few industrial-scale projects related to the oil and gas industry. Australian CCS development for power sector applications is comparable to overseas progress and includes a range of pilot and demonstration projects across the nation.

### Consequences

#### 1. **Costs**

The capture, transport and storage of carbon dioxide from coal-fired power stations will require additional investments. The capture component represents the largest expenditure of a coal-fired power plant incorporating CCS in its energy production processes; installation of CCS is anticipated to increase electricity production costs as a result. The costs for electricity produced by a coal-fired power station incorporating CCS in 2030 are expected to average around 100% more than the cost of electricity produced by a coal-fired power station without CCS capability. However, these costs have the potential to reduce over time through improved performance and capture processes.

#### 2. **Economic impacts**

The coal industry contributes significantly to Australia's economic growth through low cost domestic power, exports, use in other industries (e.g. cement) and significant employment in regional areas. With an abundance of coal resources and high demand internationally for exports, it is expected that the industry will continue to provide Australia with long term economic development. A shift in the use of coal domestically from low cost coal plants without CCS to higher cost but lower emission coal plants with CCS will maintain the coal industry's role in providing economic growth and employment in Australia.

#### 3. **Greenhouse gas emissions**

Existing coal-fired power plants have relatively high carbon dioxide emissions. The emissions depend on the type of coal used and the specific design of the power plant. When capture and storage of carbon dioxide is applied to coal power plants, the emission can be reduced. Typically, it is assumed that 80-90% of carbon dioxide emissions can be captured. The emissions of coal-fired plants with CCS are therefore significantly lower than those of coal-fired plants without CCS.

#### 4. **Environmental impacts**

Coal-fired CCS requires ongoing development of coal mines to supply fuel to those power stations. Whilst environmental management of coal mining has improved over time there are ongoing environmental impacts. These include land clearing (followed by rehabilitation when mining ceases), managed releases of partially treated waste water from dams, dust emissions and release of mine gases (such as carbon dioxide and methane). There are various practices commonly used to minimise dust and gas emissions and to treat waste water for acidity and other contaminants. However, none of these impacts can be reduced to zero. Where the coal deposit to be mined occurs near other land uses (e.g. residential, national parks, agriculture) there can be concerns about loss or disruption to the existing land uses. There is also the potential for bi-product or accidental leakage of waste materials during the carbon dioxide capture phase. However, the industry is yet to settle on a specific capture process and so these impacts are difficult to define at this stage.

## 5. **Policy and regulatory initiatives**

Currently there are various federal and state government legislation, regulations and initiatives that manage the resources and mining sectors, including CCS, in Australia. These sectors are guided by specific industry related laws and guiding principles which focus on both onshore and offshore mining activities. Even though significant amendments have been made to existing laws and the development of new Bills to address the safe storing of greenhouse gases, there is still a need for Australia to establish a national regulatory body which would ensure that best practice regulatory principles are implemented across the country and into all CCS projects.

## 6. **Reliability of fuel supply**

Coal has the largest resource reserves in the world providing for around 23% of world's energy supply. Australia has substantial coal reserves ensuring security of supply for many centuries to come. Potential economic black and brown coal reserves are estimated to be 100 and 400 years each which makes coal the most readily available fossil fuel in Australia. Newer more modern coal-fired electricity generation processes have the ability to assist in maintaining energy reliability by complementing gas-fired and intermittent renewable energy resources, such as wind or solar, providing the flexible reserve of power supply necessary to ensure reliability of the power system as a whole. CCS enables the continued deployment of coal fired power stations while still reducing carbon dioxide emissions.

## 7. **Availability of storage sites**

Applying resource estimates used to determine Australia's projected oil reserves, the Australian east coast has been conservatively estimated to have between 70-450 years of deep saline aquifer storage capacity for CCS purposes at 200 million tonnes carbon dioxide per year, while the technical potential of storage capacity in Western Australia is estimated to be 260-1120 years at 100 million tonnes per year. Long term it is expected that CCS will be deployed in eastern Australia where most power generation is located. Australia's CCS storage capacity is substantial and has the potential to provide many years of storage in the future.

## 8. **Pipeline infrastructure**

Infrastructure requirements for CCS deployment consist of pipelines for transporting carbon dioxide from capture to storage sites where it is injected into underground reservoirs. Capture demonstration projects are likely to be located close to storage sites; however, as project numbers and locations increase the need for more extensive and larger capacity pipeline systems will be required. Where multiple large carbon dioxide capture sources exist in close proximity, more economical single large capacity pipeline systems may be required to link the sources. Placement of these pipelines may span private and public land, be visible, and impact access routes for individuals and livestock.

## 9. **Safety of carbon dioxide pipelines, wellheads and storage**

Carbon dioxide is neither flammable nor explosive but too much carbon dioxide in the air is hazardous and can even be lethal. During the transportation of carbon dioxide in pipelines, the pipeline may leak, causing the carbon dioxide to be emitted into the air. The chance of leakage is comparable to the experience with carbon dioxide pipelines in the USA where 14 incidents took place over 3100 km of pipeline between 1990 and 2004. These incidents did not result in any fatalities or injuries.

Expectations are that by placing systems for monitoring, the chance of leakage of carbon dioxide from pipelines will become very small. Carbon dioxide leakage may also occur at the drill site wellhead - the part that sits at the surface of the well that provides the structure and pressure to contain the carbon dioxide underground. In order to reduce the occurrence of wellhead failures, monitoring systems installed in the well detect leaks. The probability of blowouts from carbon dioxide wells is estimated to be one every 10 years. The secure permanent storage of carbon dioxide underground requires the careful exploration and selection of potential storage sites. Poor storage sites may result in carbon dioxide leaking out through the subsurface into the atmosphere. The long term chances of this happening are yet to be determined, however secure natural geological storage of oil and gas over millions of years would indicate the likelihood would be low. To what extent carbon dioxide leakages may affect the quality of groundwater, soil, energy and mineral sources is yet to be fully determined.

## **Information Package Option 5 - Deploying renewable sources**

This option aims to reduce 50 million tonnes of carbon dioxide by 2030, by increasing the use of a range of renewable energy generation technologies (e.g. solar, wind, geothermal, biomass). Currently most of Australia's energy is generated from fossil fuels (92%) with renewable sources contributing around 8%. To achieve the aim of this option, the share of renewable electricity in the total electricity production has to grow to approximately 23% in 2030.

The largest existing renewable sources are hydroelectricity (5%) and wind (2%). In the future, both solar and wind electricity generation resources have the potential to contribute over 100% of Australia's electricity needs but their supply will be less secure with their generation output being driven by the climate (such generation is called "intermittent"). Sustainably produced biomass would not be intermittent but its resource is more limited such that it could only produce 30% of power needs each year. Geothermal energy is not intermittent and is available on the scale of solar and wind resources. Consequently, while the technology is less proven, it has a strong potential to increase the share of renewable sources in electricity generation.

### **Consequences**

#### **1. Costs**

The cost of energy generation from renewable sources differs from technology to technology. The cost of renewable energy generation typically exceeds the cost of generation by traditional fossil fuel sources. Costs anticipated for renewable energy by 2030 have been estimated to range from 44% to 319% higher than traditional fossil fuel sources depending on the source. By 2030, it is estimated that the costs of electricity for solar photovoltaic systems will be around 256% higher on average than for electricity generated by traditional fossil fuel sources. The costs of geothermal energy are expected to be an average of 151% higher. Costs of electricity from medium-sized wind turbines are expected to be an average of 92% higher. The cost of renewable energy will therefore be substantially higher than that of traditional fossil fuels.

#### **2. Economic impacts**

To provide a greater balance to energy fluctuations that are likely to result from increased renewable sources, Australia will need to consider interconnecting renewable energy sources across large geographic areas with conventional forms of energy capable of responding to demand. This may have some negative economic impacts due to additional costs to achieve reliability when deploying intermittent sources. However, the installation and integration of renewable energy sources into the Australian electricity system may provide employment opportunities as well as provide alternative income streams in some regional communities given the greater geographical dispersion of renewable energy resources.

#### **3. Greenhouse gas emissions**

Renewable energy sources are low carbon dioxide emitting and once established they do not generally contribute to carbon dioxide emissions directly. However, some associated activities such as production of materials used in the renewable energy plants may emit small amounts of carbon dioxide. These emissions can be reduced through materials recycling processes.

#### **4. Environmental impacts**

There are environmental impacts for renewable energy sources. Sometimes birds fly into the wings of wind turbines located on land and most of the time they do not survive. Globally, approximately 50 000 birds die each year because of wind turbines yet every year more than 2 million birds die due to air traffic. If wind technology is implemented the location of turbines in relation to bird migration will need to be considered. It is expected that turbines located off-shore will kill less birds than wind turbines currently located on land. For geothermal energy sources impacts include the potential for induced seismicity as a result of water injection and production. Burning (woody biomass) creates more local air

pollution than natural gas but is significantly less than that produced by coal. The materials used in the manufacture and construction of solar photovoltaic systems and concentrated solar thermal power plants are also known to have some environmental impacts. As a result of using renewable technologies instead of coal and gas to generate electricity, less mining will be required and therefore the environmental impacts on land and water resources and air quality from mining will decrease.

## **5. Policy and regulatory initiatives**

A number of federal and state government policy initiatives have been implemented that support the development of renewable energy options in Australia. Current policies aim to achieve greater diversity in Australia's energy mix and a reduction of greenhouse gas emissions. There are still some issues however that policy will need to address, which mainly focus on intermittent energy supply concerns inherent in renewable energy contribution to electricity grids.

## **6. Reliability of energy supply**

Energy supply from some renewable resources can be intermittent or irregular. For example, production of solar power energy changes with sunlight availability and strength, seasonal weather patterns and changing day lengths. Similar to solar, the volume of electricity a wind turbine is capable of generating depends on wind availability, access and speed. With no capacity to store electricity the mismatch between supply and demand requires drawing down of electricity from the grid. Unlike solar and wind generated power, biomass, and geothermal technologies can be used to generate electricity when it is needed. Increasing the share of biomass and geothermal in Australia's primary fuel mix will increase diversity and provide greater potential to ensure the reliability of renewable energy generation. Storage technologies can also be applied and in particular storage technology for solar thermal energy plants is well advanced.

## **7. Land mass requirements**

The amount of land required for the different renewable energy options vary according to the renewable energy source. Wind, solar and biomass generally require greater land mass for their operation and connection to the grid whereas geothermal energy requires only limited land upon which to operate. For biomass substantial land is required to cultivate organic biomass material which, if managed sustainably, results in minimal ecological impacts. However, much of Australia's biomass is expected to come from waste streams sourced from agricultural activity. On the whole therefore, increased reliance on renewable energy sources would require increased access to land and as a consequence increased conflict with other land uses and the perceived visual amenity of the landscape.

## **Information Package Option 6 - Participating in an international emissions trading scheme**

This option aims to reduce 50 million tonnes of carbon dioxide by 2030 by buying international emission permits. This would typically be introduced as part of a national emissions trading scheme that would induce abatement in many sectors across the economy and such is the case in Australia from July 2015 (following on from a fixed price scheme starting in July 2012). A domestic carbon price scheme is one of many policy initiatives that could be used to encourage people to take up abatement options and can be targeted to achieve any level of abatement (the Australian Government's target is 80% below 2000 levels by 2050). However in this abatement option we are strictly only interested in the part of the emissions trading scheme that allows the purchasing of emissions permits from overseas which can substitute for taking domestic abatement action.

When Australia introduces emissions trading there will be a limited number of permits available in Australia and the scheme will allow the option to buy permits internationally to cover emission liabilities. The purchasing of international permits will be limited to only 50% of a business's annual emissions under Australian emissions trading scheme rules. In order for Australian businesses to participate in purchasing international permits, the Government would need to agree to link its carbon trading scheme with other countries trading schemes. Presently no such agreements exist but the Australian Government foresees international linking at the start of its flexible price cap-and-trade scheme from 1 July 2015 onward.

### **Consequences**

#### **1. Costs**

If businesses must purchase permits equal to their emission levels as required by the government's carbon pricing scheme then having the option to trade with other countries potentially reduces the cost of meeting that requirement. Businesses can choose between investing in technology and processes to reduce their own emissions, purchasing domestic emission permits that have become available because of emissions saved by others or purchasing international emission permits that have become available because of international success in reducing emission below their targeted level. If international emission permits are the lowest cost option then this option to trade internationally has reduced business costs. The effect of international emission trading is to equalise emission permit prices across the globe as high abatement cost countries seek lower cost abatement and low abatement cost countries seek a better price for their abatement efforts. Given Australia is a relatively high emission intensive economy, it is generally regarded that we will benefit from international emission trading by gaining access to lower cost abatement than is available domestically in some sectors.

There will be some reporting and administrative costs associated with being in the scheme. It is expected that businesses that produce emission intensive products and services will incorporate these costs into prices to consumers. However, the overall impact on households will be minimal. Nine in 10 households will receive income tax cuts, increased payments and other assistance to help them with the cost of living.

#### **2. Economic impacts**

Adding the option to trade permits internationally to an existing domestic emission trading scheme should reduce the cost of that scheme to the economy if it gives Australia access to lower cost abatement overseas. It means that Australia could continue to emit more for longer while other countries reduce their emission more rapidly to balance out the targeted level of emissions globally. Modelling conducted by the Australian Department of Treasury assumed that Australia would have access to international emission trading if a carbon price is introduced. Treasury anticipate that the carbon emission scheme will work in line with other clean energy initiatives, such as the Jobs and Competitiveness Program and low emission technology research and development, to improve economic growth in Australia. Government investment in these initiatives will be \$9.2 billion over the first three years into the Jobs and Competitiveness Program and \$1.2 billion towards clean energy technology research and development. It is predicted that the carbon trading scheme will only effect job creation by approximately 1% by 2020 and is expected to remain a low impact factor on employment into the future.

### **3. Greenhouse gas emissions**

One third of Australia's greenhouse gas emissions are from electricity generation. Emissions from electricity generation are projected to increase by more than approximately 30% by 2030 without a carbon emissions trading scheme. Participating in an international emission trading scheme would mean that as these emissions rise, Australia would be able to offset the increase by purchasing another country's unused permits. Note that, from a climate change impact point of view, it does not matter where emissions on the planet are reduced, so long as the globally agreed target summed over all countries is met.

### **4. Environmental impact**

A central part of international emission trading is that funds must flow overseas from Australia to other countries to buy the emission permits. This could involve funding land owners in other countries to plant or retain forests which act as a sink for carbon dioxide emissions. More specifically, the scheme could require them to invest effort into reforestation, revegetation, soil carbon, fire management, reductions in emissions from livestock, crops and fertiliser use and enhance sustainable agriculture practices. However, the international rules for what types of carbon sinks will be eligible to be counted and included as abatement is yet to be agreed between countries.

### **5. Limiting the number of international permits able to be purchased**

The Australian Government's carbon emissions trading scheme limits businesses purchasing international permits to 50% of the total number of permits needed to cover their emissions. Regardless of this limitation, should the Government's trading scheme achieve a projected overall emission reduction of 21% by 2030 (on the way to achieving the 80% reduction target by 2050), high level Australian carbon emitters would be able to purchase international permits to the value of 204 million tonnes of carbon dioxide emissions over that period of time – substantially more than the 50 million tonne aim of this option. The 50% limit therefore has little impact on achieving the 50 million tonne reduction of carbon emissions required for this option.

### **6. Safeguards when linking with other international schemes**

In order to protect Australian businesses when they do buy international permits, safeguards will be put in place in the event that there is extreme international price instability and to protect against a flood of non-credible permits during the first three years (until 2018) of the scheme. The safeguards will include: 1) a price ceiling and price floor to the international carbon price; 2) only make available international permits that are proven to be credible and have environmental integrity; and 3) monitor the number of permits available in other trading schemes. Along with agencies such as the United Nations, the establishment of an Australian Climate Change Authority from 1st July 2012 to act as a gatekeeper in relation to monitoring and enforcing credibility and integrity of international permits will be essential. All these safety measures should ensure a secure carbon emission trading scheme for Australia's high emitting businesses when linked to other international schemes.

## **Information Package Option 7 - Nuclear power**

This package aims to reduce 50 million tonnes of carbon dioxide by 2030 through the introduction of nuclear powered electricity. In order to achieve this Australia would need to install five new nuclear power plants. The next generation of nuclear power plants would have a 60 year lifespan and use automated safety systems which are a significant improvement on some existing nuclear power plants. Currently Australia has no working nuclear power facilities; however, there is a research nuclear reactor in Sydney for research and medical purposes.

### **Consequences**

#### **1. Costs**

To build nuclear power stations requires reasonably high upfront investments. Costs associated with operating the power stations are relatively low, due to the lower cost of nuclear energy fuel (uranium). It is anticipated that nuclear power plant generated electricity could range on average between 14% and 59% more than electricity generated by traditional fossil fuel energy production.

#### **2. Economic impacts**

The inclusion of nuclear energy to Australia's energy mix would require a 10 to 15 year start up period in order to develop and deploy a nuclear reactor. This timeframe would impose many economic implications at the state and federal level. Significant investment from the government would be needed to support the necessary infrastructure required for the implementation and long term success of a nuclear energy industry in Australia.

#### **3. Greenhouse gas emissions**

The emission of carbon dioxide with nuclear electricity generation is relatively low. Nuclear power stations do not produce greenhouse gas emissions during electricity generation. However, some steps of the nuclear energy chain do, such as mining of uranium from the Earth's surface, processing the uranium, and decommissioning processes associated with the closing of a nuclear energy reactor.

#### **4. Environmental impacts**

Nuclear power's long term viability depends on the safe, cost-effective management of high-level waste and spent fuel. Though not presently in use, some countries are considering underground geological storage management options. Long term security offered by underground storage is however of continuing concern. Risks associated with this option include possible leaking of storage canisters due to corrosion and loss of underground storage integrity. The environmental impact of these issues being possible groundwater contamination; therefore, continual monitoring and the ability to retrieve waste may assist in identifying and alleviating such possibilities.

#### **5. Policy and regulatory initiatives**

There is presently no regulatory system in Australia to support nuclear energy generation. Before nuclear energy could be considered, an appropriate national regulatory system would need to be established. Such a system would need to enhance existing strict laws and regulations already established by both state and federal governments for Australia's uranium mining and potential enrichment industry. As several state governments have banned uranium mining and enrichment in their borders, in order to establish a national regulatory system, the Australian Government would need to override existing state government legislation. For this to occur, the Australian Government would need to call upon certain Constitutional corporate powers to establish federal law, which would prevent state governments from legislating in direct conflict with the federal legislation.

#### **6. Skills and qualifications**

Australia currently does not offer university courses with a nuclear engineering focus. As a result there is presently little nuclear engineering experience available to call upon to support the establishment of nuclear energy in Australia. The Australian education system would need to introduce and fast track

nuclear engineering education and establish research and development programs that focus on nuclear activities. The introduction of such would need to be a priority for nuclear energy to be seriously considered as part of Australia's energy future.

#### **7. Reliability of fuel supply**

Uranium is a plentiful resource with no known resource limitations for the supply into the next century in Australia. Approximately 38% of the world's uranium resources can be found within Australia's borders. Mining research and development is likely to discover new exploitable geological reserves into the future while uranium can also be found in the World's oceans. As a result, nuclear energy experiences minimal supply disruptions or price volatility.

#### **8. Safety and risks**

The likelihood of a nuclear accident, though possible, is considered small – the impact should one occur however can be large. Radioactive contamination of areas surrounding a reactor may result in loss of land and land use, and cause substantive impacts upon populations and ecosystems. The most recent generations of nuclear reactors are specifically designed to reduce such impacts. They are designed such that in case of malfunction they do not require operator intervention to attain a safe state and that in case of an accident the consequences are limited to the reactor site. Therefore, they are expected to have lower operational risk levels to the public than present day reactors.

#### **9. Nuclear weapons production**

There is a belief that increasing nuclear power capacity for the general population may result in greater production of nuclear weapons which could be viewed as reducing or increasing security depending on a wide variety of factors and perspectives. The potential concerns about increased nuclear weapons production are primarily based on the risks associated with inadequate controls around gaining knowledge on how to develop such weapons, and the availability and access of weapon components such as separated plutonium and spent fuel. It is possible to produce a nuclear weapon from materials separated from spent fuel from a power reactor or uranium enrichment facility. Concern also exists regarding the possibility of terrorist attacks on nuclear power station facilities. Elimination of nuclear power for electricity generation does not eliminate the possibility of a country embarking upon a nuclear weapons program.

## Dutch Options and Consequences

### Climate Change

We will now ask you to evaluate a number of consequences of the temperature rise that results from the greenhouse effect.

#### Consequences

##### 1. 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.

##### 2. Heat

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

##### 3. 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 and cause more damage. The risk of floods will increase in many areas due to heavy rainfall, snowfall and storms.

##### 4. 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 centimetres on average between 2007 and 2099. In some areas local sea currents can cause a higher sea level at the coastline. Around the Netherlands the rise in sea level may accumulate to 85 centimetres between 2007 and 2099. Areas 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 consequence, 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 areas may be affected or may disappear.

##### 5. 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 designate areas as flood meadows to cope with temporary excesses of river water. The establishment of these areas 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.

##### 6. 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.

**7. 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 very old) will more often fall 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.

**8. 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.

## **Option 1 - Improvement of energy efficiency**

This package aims to reduce carbon dioxide emissions with 40 million tonnes 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 needed to heat a medium-sized house, or, the energy needed to produce a tonne of steel; or the energy needed to drive one kilometre with a car. For instance, by developing more efficient technologies or better isolated houses or more efficient cars, less energy will be needed to get the same result. Without extra measures the energy saving improves every year. To save 40 million tonnes of carbon dioxide emission, an additional energy efficiency increase of 1% per year needs to be realised for appliances, cars, houses and factories. To achieve this additional 1% of energy saving per year, the government has to take mandatory measures. These measures are needed to ensure that companies and civilians make an effort to increase the energy efficiency of their appliances, cars and houses and to optimise the production of goods. Because this package requires less energy to get the same result, less fuel is needed to generate energy.

### **Consequence**

#### **1. 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.

#### **2. 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 will need 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 will be discarded less quickly than before.

#### **3. Reliability of the energy supply**

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

#### **4. Economic consequences**

Because of the decreasing demand for energy, less money will need 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 may possibly create hundreds of thousands of additional jobs within the European Union, especially in construction.

#### **5. Measures to reduce fuel use for transportation**

This package will lead to European legislation requiring that cars can drive 18 kilometres on 1 litre of fuel by the year 2035. In 2005 cars could drive approximately 10 kilometres on 1 litre 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. Toll roads and additional taxes for polluting cars are other examples of government policy measures which can be taken to reduce fuel use. All in all, the costs for car use will probably increase for people who use a lot of fuel.

#### **6. 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, they will be equally expensive as less efficient

technologies and equipment.

**7. Consequences for houses and buildings**

This package will result in strict policies which will force new houses and buildings to be built more energy efficiently. By providing allowances for insulation or by tax measures the improvement of existing, badly isolated houses and buildings will be stimulated.

**8. Price**

This package will result in additional taxes being raised in order to stimulate people to reduce their energy consumption. This will result in higher energy prices, but to what extent they will rise is not known. The government may decide to 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 the energy bill might also increase.

**9. Contribution to the greenhouse effect**

The contribution of carbon dioxide emissions to the greenhouse effect will be greatly reduced by this package. The emission of carbon dioxide into the air will be 17% lower than the amount that is currently being emitted.

## **Option 2 - Improvement of energy efficiency and decreased use of materials and energy**

This package aims to reduce the emission of carbon dioxide by 40 million tonnes in 2030. This package is an addition to the first package “Improved energy efficiency”. This first package aims to reduce the emission of carbon dioxide with 40 million tonnes, by improving the efficiency of appliances, cars and houses with 1% per year. This second package is an addition to the first package and aims to reduce another 40 million tonnes of carbon dioxide by improving the efficiency with another 1% per year. The first and second packages together lead to a reduction of carbon dioxide emission by 80 million tonnes by 2030. To implement this package the government has to take extremely tough and compulsory measures, even tougher measures than in 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, very strict government policies such as deposits, taxes and fines will have to force people to reduce the use of energy and materials.

### **Consequence**

#### **1. Contribution to air quality**

As this package lowers the energy that that is needed for the same kind of use, less fuel is needed to generate energy. When this package of efficiency measures is implemented, the air quality will be improved because less car fuel will be used. Around five thousand people die early in the Netherlands every year due to the consequences of poor air quality caused by traffic exhaust gasses, implementing this package will improve people’s health, even more than the first efficiency package.

#### **2. Economic consequences**

Because of the decreasing energy demand, less money needs to be spent on new power plants and power cables. The use of coal, gas and oil will decrease. It is uncertain whether these cost reductions will have a positive effect because of the need for large investments in houses, the industrial sector, appliances and cars.

#### **3. Consequences for transportation**

In 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 they will consume less fuel. Toll roads will be instated so that the cost of public transportation will much lower than the cost of travelling by car. Moreover, the freight traffic will have to deal increasing road 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, the costs of which will be passed on to the ticket prices. Depending on the travel distance a flight could become 8 to 40 Euros more expensive if carbon dioxide emissions are taxed. All in all, most ways of transportation will become more expensive.

#### **4. Consequences for manufacturers/industry**

This package will require very innovative technologies. These will cost more money and will therefore be more expensive for the manufacturing industry. Possibly, because of the extra costs involved for production, some products will also become more expensive for the consumers.

In this package the manufacturers are held responsible for disposing and recycling of packing materials and end products. For example, by introducing a deposit, not only for soda bottles, but for all sorts of packaging materials. Measures will also need to be taken that make people recycling more, for instance by informing the people or implementing fines when people don’t recycle their waste.

To make sure that this package is fully realised, strict rules have to be imposed on manufacturers.

#### **5. Consequences for consumers**

Because consumer products have to be much more energy efficient for this package, certain products may be difficult to bring to market or may 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 obtain or be very expensive.

#### **6. Consequences for houses and buildings**

By implementing this package, strict measures have to be taken to enforce 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 needs 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 behaviour (for instance by lowering the temperature in their houses).

#### **7. 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 exceed 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 price level 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.

#### **8. Contribution to the greenhouse effect**

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

### **Option 3 - Electricity from wind turbines at sea**

This package aims to reduce the emission of carbon dioxide with forty million tonnes 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 kilometres from the coast.

#### **Consequences**

##### **1. 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 blades. A few days per year that are very clear, some of the wind turbines may be visible from the coast.

##### **2. 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. For the sake of comparison: every year more than 2 million birds die in traffic. By implementing this package the number of wind turbines will increase, but because of their location far from the coast, expectations are that these wind turbines will kill fewer birds than the wind turbines currently located on land.

##### **3. 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.

##### **4. Consequences for the fishery**

By placing farms of wind turbines at sea, the amount of Dutch fishing grounds decreases. The wind turbine farms will take up approximately 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 fishing 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.

##### **5. Dealing with fluctuations in electricity production**

Because of the wind dependency of wind turbines, they sometimes don't produce enough electricity, while too much at other times. It is 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 number of additional power cables will be necessary.

##### **6. 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 of additional full-time jobs, mainly in the Netherlands.

##### **7. 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.

##### **8. Contribution to the greenhouse effect**

The contribution to the greenhouse effect will be greatly reduced by this package. The emission of

carbon dioxide into the air in the Netherlands will be 17% less than the amount that is currently being emitted.

## **Option 4 - Conversion of biomass to car fuel and electricity**

This package aims to reduce the emission of carbon dioxide by forty million tonnes by powering a share of the cars using fuel converted from biomass and by making power plant use biomass as a fuel for the generation of electricity. Biomass is a term used for a variety of organic materials such as wood, grass, organic waste, etc. Biomass can be used to generate electricity, but also to create fuel for cars. When plants grow they withdraw carbon dioxide from the air. This carbon dioxide is released again when biomass is being burned. By burning plants, the amount of carbon dioxide that is released is not lower than the amount of carbon dioxide that has been withdrawn by the plants during growth. Therefore biomass is carbon dioxide neutral. This package is not completely carbon dioxide neutral because of the need for transportation and handling of the biomass. To reduce forty million tonnes of carbon dioxide by the year 2030 by using biomass, approximately 80 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. Biofuel factories will have to be built where biomass can be converted into fuel. A share of the currently used oil refineries, where crude oil is converted to petrol and diesel oil, may gradually be converted into or replaced by biofuel factories.

In that case a small portion of this biomass in the Netherlands will be converted into electricity by three or four large power plants in seaports like Rijnmond, Eemshaven or Terneuzen.

### **Consequences**

#### **1. 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 per year die early from the consequences of poor air quality caused by traffic exhaust gasses. When this package is realised 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.

#### **2. Use of land for biomass with certificate**

Land is needed to obtain biomass. 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 kinds of crops can result in an improvement of the cultivating ground which in turn can result in a more sustainable form of agriculture.

#### **3. 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 is not 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.

#### **4. Influence on food production**

When a large number of countries start using biomass, there is a possibility that the need for cultivated land increases to such proportions that the amount of cultivated land available for food production will become smaller. 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 grown on grounds which are unusable for other crops. 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 waste 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.

#### **5. Reliability of the energy supply**

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

#### **6. Expansion of seaports**

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

#### **7. Necessity of new vehicles**

Most of the current cars are equipped to handle fuel which is partly made of biofuel (for these cars the biofuel is mixed with petrol or diesel). Until 2030, approximately two thirds of all cars gradually have to be replaced 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 they use.

#### **8. 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 a positive effect on the Dutch economy.

#### **9. Price**

The price of electricity produced from biomass is expected to remain the same. The price of car fuel based on biofuel is expected to be a little lower. When the level of taxes is the same as for petrol, biofuel will be priced the same or possible 20% lower per litre than the; current price of petrol in 2030.

#### **10. Contribution to the greenhouse effect**

The contribution to the greenhouse effect of carbon dioxide emissions will be significantly reduced by this package. The total emission of carbon dioxide into the air in the Netherlands will be 17% less than the amount that is currently emitted.

## **Option 5 - Large plants where coal or gas is converted into electricity with capture and storage of carbon dioxide**

This option aims to decrease carbon dioxide emissions with 40 million tonnes by capturing carbon dioxide that is produced by coal-fired and gas-fired power plants and storing it underground in the Netherlands or under the Dutch part of the North Sea. Carbon dioxide capture can take place at existing power plants or be integrated into new plants. It is expected that, by 2030, about half of the power plants with carbon dioxide 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 carbon dioxide 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 on safety and availability will be needed to determine if all this storage space can be used. Research may, however, show that more space is available than currently expected.

### **Consequences**

#### **1. 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 and less in others. The degree of pollution of the land, water and air will vary from low to very high in the area surrounding the mines, depending on the countries from which the Netherlands imports the coal needed for this package.

#### **2. Safety of carbon dioxide transport in pipelines**

Too much carbon dioxide in the air is hazardous and can even be lethal. During the transportation of carbon dioxide in pipelines, the pipeline may spring a leak, causing the carbon dioxide to be emitted into the air. There is a small risk that a cloud of carbon dioxide, which is dangerous for people, animals and plants, will stay in the air without dispersing. The risk of leakage is comparable to the risk 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 carbon dioxide. Expectations are that placing good systems for monitoring will render the risk of carbon dioxide leakage from pipelines very small.

#### **3. Safety of underground carbon dioxide storage**

Subsoil storage of carbon dioxide can cause minor earthquakes similar to those caused by natural gas mining. This may cause small cracks in buildings in the area. Once carbon dioxide is stored in the underground storage space, it could leak 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 undo part of the emission reduction effect of this package. Although experts are not sure how much carbon dioxide would be released into the air, quantities are likely to be extremely small. In addition, there is a very small risk that the leaked carbon dioxide 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 risk that carbon dioxide 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 carbon dioxide leakage from underground storage space very small.

#### **4. Reliability of the energy supply**

Experts place a great deal of importance on the reliability of the energy supply, meaning that it is important to always have enough energy. Part of the fuels needed for this needs to be imported from other countries. We do not wish to be dependent on the policies of only a few countries, such as our current dependence on the Middle East for oil. Coal can be imported from many countries in various parts of the world. The risk 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 needs to be imported from other countries.

**5. Price**

If electricity is generated in power plants with carbon dioxide 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.

**6. Contribution to the greenhouse effect**

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

## **Option 6 - Conversion of natural gas into hydrogen in large plants with carbon dioxide capture and storage**

This package aims to reduce carbon dioxide emissions with 40 million tonnes by producing hydrogen and capturing and storing the carbon dioxide 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, or to replace natural gas in households. About 20 to 25 large hydrogen factories will be built for this package. The carbon dioxide that is produced during the conversion of natural gas into hydrogen will be captured and stored underground in the Netherlands and under 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 adjusted 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 heat 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 carbon dioxide 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 on the safety and availability will be needed to determine if all this storage space can be used. However, research could also show that there is more space available than currently expected. It is likely that alternative uses can be found for the infrastructure (such as installations, fuel stations and the pipeline grid) after this time, because by then other ways will have been developed to produce hydrogen without natural gas.

### **Consequences**

#### **1. New pipelines needed**

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

#### **2. New vehicles needed**

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

#### **3. Contribution to air quality**

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

#### **4. Contribution to noise**

Engines of 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 decibel or lower. (For example: 85 decibel is about the level of noise of a crowded intersection in the city; 70 decibel is about the level of noise of a calm intersection).

#### **5. Safety of hydrogen plants**

In the last decades the industry has gained much experience 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.

#### **6. 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 will most likely make the use of hydrogen in fuel stations, buses and trucks just as safe as the current use of petrol.

#### **7. Safety of carbon dioxide transport in pipelines**

Too much carbon dioxide in the air is hazardous and can even be lethal. During the transportation of carbon dioxide in pipelines, the pipeline may spring a leak, causing the carbon dioxide to be emitting in the air. There is a small risk that a cloud of carbon dioxide, which is dangerous for people, animals and plants, will stay in the air without dispersing. The risk of leakage is comparable to the risk 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 carbon dioxide. Expectations are that placing good systems for monitoring will render the risk of leakage of carbon dioxide from pipelines very small.

#### **8. Safety underground carbon dioxide storage**

Subsoil storage of carbon dioxide can cause minor earthquakes similar to those caused by natural gas mining. This might cause small cracks in buildings in the area. Once carbon dioxide 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 partly undo the emission reduction effect of this package. Although experts are not sure how much carbon dioxide would be released into the air, quantities are likely to be extremely small. In addition, there is a very small risk that the leaked carbon dioxide will 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 risk that carbon dioxide 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 carbon dioxide leakage from underground storage spaces very small.

#### **9. 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 policy of only a few countries, such as our dependency on the Middle East for oil. 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.

#### **10. Economic consequences**

The Netherlands will 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 carbon dioxide pipelines. It is unknown what the effect of these investments will be on the economy.

#### **11. 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 today. 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.

#### **12. Contribution to the greenhouse effect**

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

## **Option 7 - Electricity from nuclear plants**

This package aims to reduce the emission of forty million tons of carbon dioxide by generating electricity in five large nuclear power plant by the year 2030. Nuclear power plants use uranium as fuel. Uranium is extracted from uranium mines. Generating electricity with uranium does not produce carbon dioxide. 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 thus increase global use. It is very likely that new uranium sources will be discovered, in which case the nuclear power plants can be supplied for a long time.

### **Consequence**

#### **1. Background radiation during normal operation**

Under normal operating conditions, a nuclear power plant releases very small particles which emit very small amounts of radioactive radiation. The amount of radiation is even less than the level that is normally present in the area. This amount of radiation will not cause any health problems in the short term. Some experts think that in 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. Nuclear waste**

Nuclear waste is produced in the process of preparing uranium for use in nuclear power plants, but especially when using uranium in the power plants. A portion of this nuclear waste will have a high level of radioactivity for thousands of years, meaning that it will emit 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 is 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 cause health problems for 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 is not placed in the vicinity of ground water, but there is 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.

#### **3. Safety of nuclear power plants**

The nuclear power plants mentioned in this package are built in such a way that human interference is unnecessary for checking the system for failures or for resolving these failures. Protective domes will be constructed around the nuclear power plants. 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 risk 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 kilometre of the power plant have to be evacuated. An area with a radius of 20 by 40 kilometres around the power plant will be completely unusable for at least one year, but possibly a lot longer. The risk of an accident like this happening is less than once in two hundred thousand years. The risk of accidents with even more serious consequences taking place is even lower.

#### **4. 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.

**5. Nuclear power plants and nuclear weapons**

Spreading of nuclear weapons means that 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 say that there is no connection between the development and deployment of nuclear power plants and the spreading of nuclear weapons.

**6. Reliability of the energy supply**

Experts place a great deal of importance on the reliability of the energy supply. This means that, at any given time, there should be enough energy available. The fuels needed for energy production has to be imported, but without being dependent on a small number of supplying countries (such as our current dependency of the Middle-East for to crude oil). Uranium can be imported from many countries on different continents. Therefore the risk 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.

**7. 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 coal-fired 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 radioactivity. 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 to what extent this has an effect on the price of electricity is unknown.

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

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