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RISK COMMUNICATION OF UNCERTAIN AND AMBIGUOUS RISKS: COMPARISON BETWEEN THEORY AND PRACTICE AND RECOMMENDATIONS FOR CO_2 CAPTURE AND STORAGE IN THE NETHERLANDS

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A thesis submitted towards the degree of Master of Science in Sustainable Development at Utrecht University, August 2010.

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ABSTRACT

CO_2 capture and storage (CCS) has been given high significance by the Dutch government as a measure to reach emissions reduction goals in the Netherlands, due to the advantageous characteristics the Netherlands possesses such as existing transport pipelines and empty gas reservoirs. Currently, the development of onshore CCS is in the demonstration phase, which will be followed by large-scale commercial projects by 2020. Nevertheless, CCS has been met with controversy among the stakeholders and the public. This thesis framed the problem as one of risk communication. Risks related to CCS are considered uncertain and ambiguous, in that differing risk perceptions of CCS stem from conflicts in knowledge and expertise as well as in worldviews and values among different experts and laymen groups. Drawing from the evidence-based literature on risk communication of CCS-like risks, this thesis developed hypotheses on strategies in the components of sources, participants, content and channels of risk communication that could increase its effectiveness. After comparing with the practice of risk communication, it was observed that although they were found to increase the effectiveness of risk communication, three of the hypotheses were not translated into practice in general, namely the credibility of funders, upstream engagement, and differentiation of the public. In reviewing of the current Dutch CCS risk communication practices, these gaps also applied to the Netherlands. At the end of the thesis, recommendations as to how to bridge the gaps for the Netherlands were given.

PREFACE

After over half a year of hard work, the writing of my thesis has finally come to an end. This master's thesis has been a long journey for me. Except for at the beginning, when everything was unfolding exactly according to plan, I was more often faced with unexpected findings, lack of information, flaws in methodology and so on. Soon the initial excitement and ambition were replaced with frustration and even the occasional despair(!), which was simply the reality of research. Thanks to the following people who have accompanied me throughout the process, this journey has not been without its joy and inspiration.

First of all, I would like to thank my supervisor Suzanne Brunsting at the Energy research Center of the Netherlands. She has devoted so much time and effort in countless questions I had, and has given me an enormous amount of useful resources for my thesis as well as help with the interviews. Our weekly meetings were always extremely enjoyable and fruitful for me. I am also grateful to many other colleagues in the Energy Innovation and Society group, who have generously given me so many comments or simply "tips" that inspired my writing from time to time. I would particularly like to thank Sylvia Breukers, who took time to comment on my drafts and help me with the development of interviews. I feel really fortunate to have been given the opportunity to do an internship at ECN, I have enjoyed my six months there tremendously.

I would also like to thank my supervisor Hens Runhaar at Utrecht University. I received so much feedback from him that helped shape my research when the larger picture often remained fuzzy for me, as well as lots of constructive advice later on when sometimes my research was starting to confuse myself.

Furthermore, my thanks go to the interviewees, who have spared their precious time to provide me their invaluable insights on risk communication of CCS in the Netherlands. These insights were not only useful for my research, but also helped me visualize the picture of CCS in the Netherlands more clearly.

Last but by no means the least, I would like to thank my parents, for the unconditional support they have given me, not only during the thesis but on every decisions I have made in my life. Without them, nothing would have been possible. I would also like to thank Frank, who is always there to listen to my outlet of frustration and complaints, and who has helped me go through some difficult points in the past few months.

Thank you all and hope you enjoy reading this thesis!

Ting Zhang

August 2010, Utrecht

LIST OF ABBREVIATIONS AND ACRONYMS

ACA	Australian Consumers' Association
AEBC	Agriculture and Environment Biotechnology Commission
Andra	National Radioactive Waste Management Agency of France
ARGONA	Arena for Risk Governance project
BBSRC	Biotechnology and Biological Sciences Research Council
BERR	UK Department of Business, Enterprise and Regulatory Reform
CATO	CO_2 capture, transport, and storage in the Netherlands
CBS	Central Bureau for Statistics in the Netherlands
CCS	CO_2 Capture and Storage
CO_2	Carbon dioxide
CSI	Cognitive scenario information
CSIRO	Australian Commonwealth Science and Research Organization
DCMR	Environmental Protection Agency of Rijnmond
DEFRA	UK Department for the Environment, Food and Rural Affairs
EC	European Commission
EIA	Environmental Impact Assessment
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
EZ	The Dutch Ministry of Economic Affairs
GFZ	German Research Center for Geosciences
GM	Genetically-modified
HLW	High-level waste
IEA	International Energy Agency
ILW	Intermediate-level waste
IPCC	Intergovernmental Panel on Climate Change
IRGC	International Risk Governance Council
LIC	Local Information and Monitoring Commission
LLW	Low-level waste
NGO	Non-governmental organization
NIMBY	Not-in-my-backyard
OCAP	Organic Carbon dioxide for Assimilation of Plants
ONDRAF/NIRAS	Belgian Agency for Radioactive Waste and Enriched Fissile Materials
Q&A	Questions and answers
R&D	Research and development
RAWRA	Radioactive Waste Repository Authority of the Czech Republic
RCI	Rotterdam Climate Initiative
RFI	Relative frequency information
RISCOM	Risk Communication model in the ARGONA project
SARF	Social Amplification of Risk Framework
SEED	Social-Economic Environment Development Research Group
SKB	Swedish Nuclear Fuel and Waste Management Company

SKI	Swedish Nuclear Power Inspectorate
SME	Small and medium enterprise
SNM	Nature and Environment Foundation of the Netherlands
TAR	Third Assessment Report
TNO	The Netherlands Organization for Applied Scientific Research
UK CEED	UK Center for Economic and Environmental Development
UKAEA	UK Atomic Energy Agency
VME	The Dutch Association for Energy Marketing
VROM	The Dutch Ministry of Housing, Spatial Planning and the Environment

LIST OF TABLES AND FIGURES

1. INTRODUCTION

This chapter starts by introducing the two main concepts in this study, namely CO_2 capture and storage (CCS) and risk communication. It then explains what the problem is with risk communication of CCS that needs addressing and outline in what way this thesis is going to contribute to problem solutions.

1.1 INTRODUCTION TO CO_2 CAPTURE AND STORAGE

1.1.1 CO2 CAPTURE AND STORAGE

Against the backdrop of climate change, every technology option to reduce greenhouse gases emissions is being explored. The Third Assessment Report (TAR) by the Intergovernmental Panel on Climate Change (IPCC) indicates that no single technology option will provide sufficient emission reductions needed to achieve stabilization (IPCC 2001). In addition, most scenarios in the TAR predict a domination of energy supply by fossil fuels into the middle of this century. The projection leaves a role for CCS to enable fossil fuels to be used with less CO_2 emissions during the transition from fossil fuels to renewable energy.

CCS is defined by IPCC (2005, p3) as "a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere". Power plants and other large-scale industrial processes are the primary sources from which CO_2 can be captured and transformed into a concentrated stream that can readily be transported to a storage site, most commonly in a gaseous form via pipelines, but also as liquid in ships and road or rail tankers. CO_2 is then stored via geological storage, ocean storage or mineral storage. Geological storage involves injecting CO_2 into underground geological formations such as oil and gas fields, deep saline formations and un-minable coal beds. Once injected, different physical as well as geochemical trapping mechanisms would prevent the CO_2 from escaping to the surface. Ocean storage involves the injection of CO_2 into the water column of the ocean or at the sea floor at depths greater than 1000 meters. The idea is that the dissolved and dispersed CO_2 would then become part of the global carbon cycle. The last option, mineral storage, can be further divided into mineral carbonation (a conversion of CO_2 into solid inorganic carbonates using chemical reactions), industrial use (e.g. feedstock for production of carbon-containing chemicals) and direct use (e.g. in carbonated drinks).

With the potential to reduce emissions from fossil fuels power plants by as much as 90%, CCS seems to be the only technology option at present that could allow abundant and flexible fossil fuels to continue to be used for electricity generation without adding to the damaging effects of climate change (BERR 2008), and that could help the EU and the rest of the world to achieve the 50% reduction target by 2050 for CO_2 emissions (European Commission 2008).

1.1.2 RISKS AND DRAWBACKS OF CCS

The most prominent risk of CCS is the leakage of CO_2 during transport and storage. A sudden and large amount of CO_2 release could cause harm to human life and health, if exposure occurs at a concentration level higher than 7-10% by volume in air (IPCC 2005). Nevertheless, IPCC (2005) states that when risk management is conducted properly by careful siting and monitoring, regulatory systems and remediation methods to deal with leakage, the risks on human health, safety and the environment are no higher than those of natural gas storage, enhanced oil recovery, and deep underground disposal of acid gas, all of which are existing activities being carried out on a large scale. IPCC (2005, p14) estimates that "the fraction retained in appropriately selected and managed sites is very likely to exceed 99% over 100 years, and likely to exceed 99% over 1000 years", making CCS relatively safe in numbers.

IPCC (2005) also gave examples of other negative impacts of CCS, including alteration of the local chemical environment by adding CO_2 to the ocean or forming pools of liquid CO_2 on the ocean floor on an industrial scale, which will cause mortality of ocean organisms. Large-scale mineral carbonation also produces environmental impacts related to land clearing, decreased local air quality and affected water and vegetation as a result of drilling, moving of earth and the grading leaching of metals from mining residues. Furthermore, the products of mineral carbonation needs landfill and transport to dispose of.

1.1.3 CO_2 CAPTURE AND STORAGE IN THE NETHERLANDS

The Dutch government's energy strategy, as set out in the Clean and Efficient Program (VROM 2007), aims to provide the Netherlands with secure energy supplies and contribute to the climate change effort. The program positions CCS is as a third pillar in the Dutch energy and climate policy, after energy efficiency and renewable energy. The Dutch government recognizes CCS as a necessary intermediate step in the transition towards a sustainable energy system, since coal is expected to continue to be used in a significant proportion of the electricity production in the Netherlands. If CO_2 emissions are to be reduced by 50% before 2050 (an ambitious target considering the status quo of greenhouse gases emissions in the Netherlands at present, see Figure 1), then 20% of the Dutch generation capacity is anticipated to consist of power plants with CCS, or even 40% if the government fails to reach the 30% renewable energy sources target by 2050 (van Egmond et al. 2009).

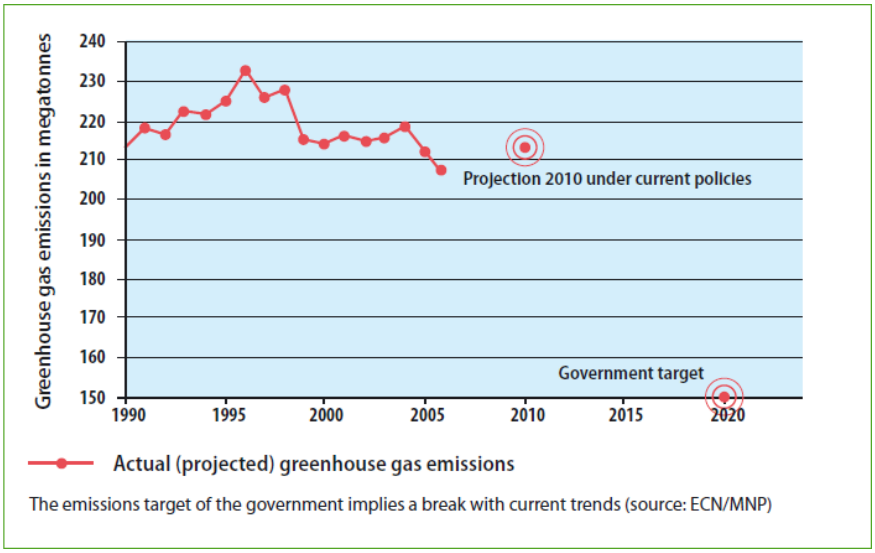

FIGURE 2 GREENHOUSE GASES EMISSIONS DEVELOPMENTS IN THE PAST AND FUTURE (SOURCE: VROM 2007).

In 2008, the Ministry of Public Housing, Spatial Planning and the Environment (VROM) and the Ministry of Economic Affairs (EZ) initiated the Dutch "CCS Project" with four phases: fundamental research, pilot projects, demonstration projects and commercial projects (van Egmond et al. 2009). Two demonstration projects to be located in Barendrecht, Zuid-Holland and Geleen, Limburg were allocated €60 million by the government in November 2008 (van Egmond et al. 2009). The Netherlands has great potential in CO_2 reduction by CCS. Van Egmond et al. (2009) show that about 60 million tonnes of CO_2 could be captured annually by 2050.

1.2 INTRODUCTION TO RISK COMMUNICATION

1.2.1 DEFINITION OF RISK COMMUNICATION

Risk communication has been taking place for as long as humans have had to contend with a variety of risks for survival and personal well-being (Plough and Krimsky 1987). However, research on risk communication has not been accorded much attention until about two decades ago, with the earliest studies dating back to the mid-1980s (Pidgeon 1992) and the term "risk communication" first appearing in the literature in 1984 (Leiss 1996). The growth of risk communication (and its literature) is partly due to governmental laws and regulations (as responses to prominent risk events such as the accident at Chernobyl), and partly because of public pressure (as resulted from a long-term movement for public participation rooted in civil rights and environmental movements in the 1960s) and stakeholder demand (Renn 2003; Kasperson 1986). Various definitions exist for risk communication in the extant literature. The definition by Covello et al. (1986, p172) is used in this study:

> *"Risk communication is defined as any purposeful exchange of information about health or environmental risks between interested parties. More specifically, risk communication is the act of conveying or transmitting*

information between parties about (a) level of health or environmental risks; (b) the significance or meaning of health or environmental risks; or (c) decisions, actions or policies aimed at managing or controlling health or environmental risks. Interested parties include government agencies, corporations and industry groups, unions, the media, scientists, professional organizations, public interest groups, and individual citizens."

This definition is comprehensive, from which the components of risk communication can be derived: **objective** (the desired end result of the sources of risk communication), **content** (the information, knowledge and opinions exchanged during risk communication), **participants** (individuals and organizations present in risk communication that are not the sources), and **flow** (direction of risk communication). In addition, the author would like to add three more elements: 1) **channels** via which risk communication is carried out; 2) **context** in which communication takes place; and 3) **source** of risk communication. Channels can act as amplification stations for risk signals in transmission according to the SARF and are likely to have an impact of the risk perceptions formed in the end. Context is arguably a even more important component because it has potential influences on all components of risk communication and therefore the effectiveness of risk communication. The source is the component where risk communication starts. Each of the components will be elaborated on in Chapter 2.

There are many types of risk communication. The type addressed here is the formal type of risk communication, with "official" sources planning the process and the participants meaning the citizens. There are also the organized grass root and more spontaneous risk communication coming from the citizens or NGOs, but they are not included here because they will not generate much meanings for the ultimate purpose of this study, i.e. to make recommendations for CCS in the Netherlands. Furthermore, there is unintentional risk communication via mass media, over which the "official" source of risk communication may have little control over the design, delivery and impact (McComas 2003). They are also excluded for the same reasons.

Gutteling and Wiegman (1996) measured the effectiveness of risk communication by detecting the differences in **knowledge**, **risk attitudes** (attitude towards the technology in general, attitudes towards the facility, assessment of risks and benefits), **feelings of insecurity**, **risk perceptions and control** (perceived threat and controllability), and **behavioral measures** (intention to seek information, intention to adopt certain behavior) before and after risk communication. This study defines effectiveness of risk communication based on Gutteling and Wiegman: risk communication is effective when it increases the knowledge on the risk issue; changes attitudes towards the technology, facility and assessment of risks and benefits; decreases the feelings of insecurity; decreases risk perceptions; increases the perceived controllability of the risk; and stimulates the adoption of behavioral measures in response to the potential risks. Depending on the objective of the risk communicators, risk communication is effective when one or several of the abovementioned factors are satisfied.

1.2.2 DIFFERING VIEWS OF RISK

There are two types of definitions of risk (Bradbury 1989). The first one sees risk as a physically-given attribute, where objective facts that can be explained, predicted and controlled by science are separated from subjective values. An example is risk as a function of probability of occurrence and consequences of an adverse event (see e.g. Brooks 2003). There are many criticisms towards this type of definition. Firstly, experts' predictions are generally obtained by assessing risks using historical data to calculate statistical estimates of risk either directly or using mathematical systems models. Where data are not readily available, e.g. in cases where the number of incidents is very small or yet to be recorded, extrapolation of results is needed (Gough 1991), meaning many uncertainties are involved. Secondly, using the multiplication of probability and consequence to denote risk assumes that society should be indifferent towards a low-consequence/high-probability risk and a high-consequence/low-probability risk with identical expected values (Kasperson et al. 1988). Finally, this definition of risk neglects equity issues in relation to time (e.g. future generations), space (e.g. not-in-my-backyard or NIMBY-ism), or social groups (e.g. vulnerable groups) (Kasperson et al. 1988).

The second type of definition emphasizes that risk is a social construct. Experts and laymen have different risk perceptions. While laymen do not ignore the experts' predictions, they take into consideration more factors when deciding the level of the risk. Depending on the factors, laymen have different risk perceptions among themselves (see below). So do experts differ, however. While the early realization of the value-laden nature of technical risk analysis was of how an analysis depends on its treatment of uncertainty and the amount of conservatism in its assumptions, the later awareness was of the importance of details such as what units are used, how results are aggregated, whose results are taken seriously and what gets studied (Fischhoff 1998). Decisions on these questions imply an expression of values.

This study adopts the second type of risk definition for the following reasons. Firstly, from a democracy and legitimacy point of view, risk should not solely be seen as a physical hazard[1]. The essence of democracy is that those who bear the consequences of decisions should have a share in making them (Harding 2000). When risk is the basis for decision-making, individuals should have the right of “shaping” the risk, their opinions should be as valid as the experts’. Secondly, modern society encounters emerging risks that present challenges beyond the capability of science to address. Funtowicz and Ravetz (1990) speak of "post-normal science" with high system uncertainty and high decision stakes, which needs extended peer communities and therefore creates space for citizen involvement. Furthermore, it may be wise to incorporate the widest range of knowledge possible, including local knowledge often possessed by laymen (Kinsella 2002). Local knowledge can complement the standardized generalizable data and trends from around the world that are often used by experts, which may not say much about local circumstances that could suggest exceptions.

[1] Hazard is “a situation that could occur during the lifetime of a product, system or plant that has the potential for human injury, damage to property, damage to the environment, or economic loss” (Warner 1992, p4). While risk is context-dependent, hazard is property-bound (Renn 2008).

Risk communication is particularly challenging when the definition of risk as a social construct is adopted, due to the different ways individuals perceive risks. Risk perception consists of "people's beliefs, attitudes, judgments and feelings, as well as the wider cultural and social dispositions they adopt towards hazards and their benefits" (Pidgeon et al. 1992, p89). Researchers have hypothesized and tested a list of factors that may influence risk perceptions using different approaches, e.g. the psychometric paradigm (Fischhoff et al. 1978), cultural theory (Douglas and Wildavsky 1982), and social amplification of risk framework (Kasperson et al. 1988). Factors influencing risk perception are summarized in Appendix 1. The factors are likely to play a bigger role in the formation of perceptions of the less straightforward risks. The next section will give an overview of a categorization of risks.

1.2.3 TYPES OF RISKS

Renn (2008) distinguishes between four types of risks according to the level of conflicts on the acceptability of risks. He differentiates between three levels of conflicts. *Knowledge and expertise* is the lowest level of conflict. It involves factual arguments about probabilities, exposure levels, dose-response relationships and predicted damage. *Experience and competence* is the middle level, which focuses on the distribution of risks and benefits and trustworthiness of risk management institutions. The highest level of conflict is on *world views and values*, which implies that social values and cultural lifestyles are involved.

Risks perceived as **linear** tend to have conflicts over matters of technical expertise. Linear risks are well-known to scientists and their consequences are well-known to the risk managers. Assurance that the risk is under control and that risk management institutions are well-prepared for the risk can usually suffice. The objective of risk communication is then to transfer knowledge and create common understanding of a problem. For efficiency reasons, risk communication is advised to include agency staff, directly affected groups and enforcement personnel, since other actors may not even try to participate because of the more or less obvious expected results. An example of linear risk is risk from drinking polluted water.

Complex risks include conflicts over knowledge and expertise as well as experience and competence. The complex web of relationships between the causes and effects of the risk imply that there are many ways of interpretation in science and subsequently in risk management. Risk communication of these risks often has the objective to resolve cognitive conflicts, first between scientists and risk managers, and then towards stakeholders and the general public. Biodiversity loss represents an example of a complex risk.

Uncertain and ambiguous risks both consist of conflicts on the level of world views and values. Uncertainty refers to a lack of clarity of the scientific or technical data (IRGC 2008). There are two types of uncertainty, namely outcome uncertainty (what may happen and with what probability) and assessment uncertainty (to what extent are the results of the analysis likely to change with additional information) (Brown and Ulvilla 1987). Uncertain risks may lead to consequences (particularly in health and the environment) that are not fully understood by risk professionals. Ambiguity results from divergent or contested perspectives on the justification, severity or wider meanings related to a hazard (IRGC 2008). Ambiguous risks may

not necessarily entail the same uncertainties. They may contain a situation in which decision-makers, stakeholders and the public characterize risks differently, e.g. when decision-makers see risks as linear and therefore of no concern, while the public perceive the risks as uncertain with possible catastrophic consequences. The objective of communicating these risks is more elaborative than that of the linear and complex risks, in which a great deal of emphasis on a "participation" component is included.

How the four types of risks relate to the three levels of risk debates is illustrated in Figure 2. The different factors influencing risk perceptions play different roles regarding the four types of risks. With linear risk (and arguably also complex risks to some extent), such factors play a small role. There is usually a well-established knowledge base for the risks. The media representation of the risk is probably more straightforward as well. Moreover, people tend to have more experiences with the risk (related to this and the established science: more certainty regarding outcome of exposure to risk) – e.g. drinking polluted water may lead to illness.

The roles played by experiences with the risk, attributes of the risk and contextual factors tend to increase when uncertain and ambiguous risks are under discussion. Not many people would have had direct experiences with the risks, the characteristics of the risks are not well-known, the media sometimes become a source of "scaremongering", the risk management authorities cannot gain public trust easily for many reasons, and so on. In this sense, the perception factors can be considered as more "constraining" for risk communication of uncertain and ambiguous risks than for linear and complex risks. As a result, more attention and effort need to be directed at the role of risk communication to address the differences in these factors between different participating groups.

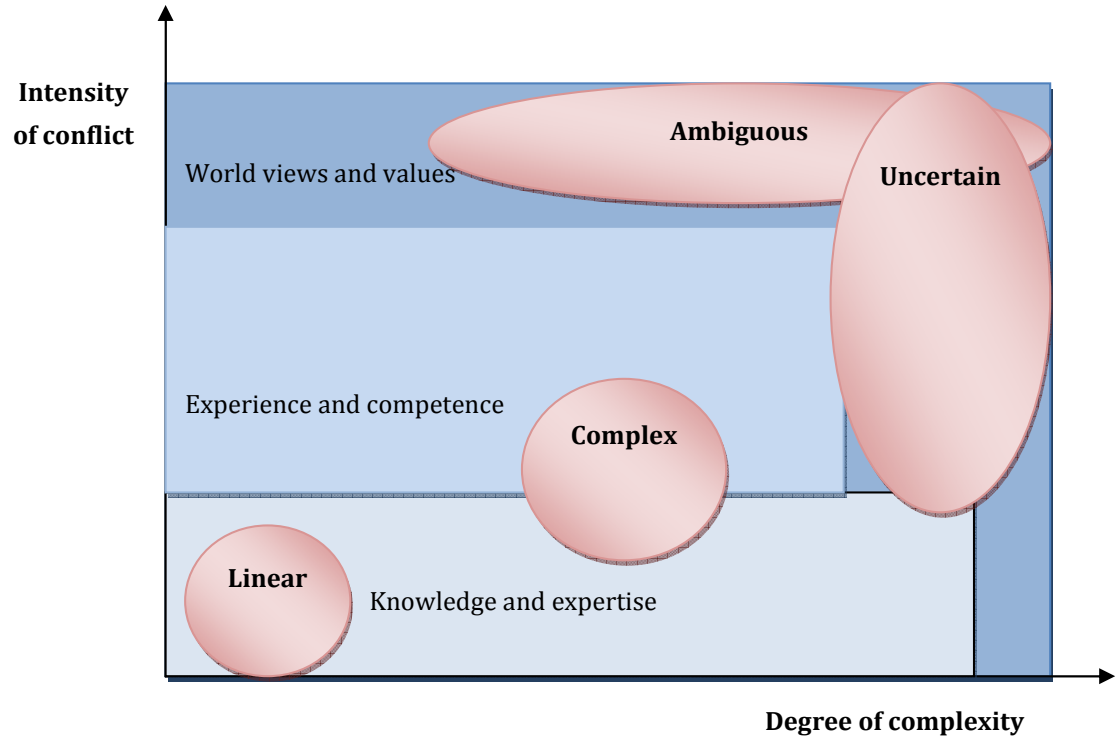

FIGURE 2 THE FOUR TYPES OF RISKS AND THEIR POSITIONS ON THE THREE LEVELS OF RISK DEBATES (MODIFIED FROM RENN 2008, P244).

1.3 RESEARCH OUTLINE

1.3.1 PROBLEM DEFINITION

This thesis frames the problem as one of risk communication, the root of which lies in an atmosphere of distrust. Covello and Sandman (2001) list a few sources of distrust: disagreements among experts; lack of coordination among risk management organizations; inadequate training of experts and spokespersons in risk communication skills; insensitivity to the requirements for effective communication, public participation, dialogue and community outreach; mismanagement and neglect; history of frequent distortion, exaggeration, and secrecy or worse on the part of many risk information providers. Two of the sources of distrust are often present with regard to uncertain and ambiguous risks. The first one is disagreement among experts. Uncertain and ambiguous risks are full of uncertainties, complexity and incompleteness of data based on which risk assessment can be made. So even on those occasions when one can place precise quantitative error bars on a risk estimate, the "lesson" of the assessment may be only that the risk in question is somewhere between serious and non-existent (Covello and Sandman 2001). Moreover, dealing with these types of risks means coping with different timescales, such as long-term effects (Renn 2008). Thus it is common for experts to disagree on many dimensions of the risks. CCS is an example of such uncertain and ambiguous risk. There are conflicts over knowledge and expertise in the form of disagreements among different parties with regard to the consequences of CCS. For example, while project developers may view CCS as an opportunity to lower CO_2 emissions, environmental NGOs may see it as an excuse to allow continuing use of fossil fuels. Therefore one consequence of CCS would be mitigation of climate change whereas the other would be exacerbation of climate change. There are also conflicts over worldviews and values. Even for the same results, there are different interpretations among experts.

The second one is the insensitivity to the requirements for effective communication, public participation, dialogue and community outreach. Risk communicators often fail to recognize the different types of risk that exist or fail to recognize that risk is in the eye of the beholder. While risk communicators may feel it is legitimate to view certain risks as linear or complex, citizens may view them as uncertain and ambiguous. Moreover, there is diversity among the citizens as well as between stakeholders in terms of risk perception (Renn 2008). Using the same approach for all types of risks would lead to those viewing the risks as uncertain and ambiguous to think that the risk communicators attempt to trivialize the risks, which then leads to distrust in the risk management authorities.

When risk communication fails, there are often two types of proceeding action. The first is that the project entailing the risks may still be implemented. This means that there is low legitimacy in the project as it does not have support. Moreover, it creates a low distrust starting point for similar future projects or different future projects implemented by the same types of organizations. The second is that the project may be forced to a halt due to the public and

stakeholder opposition. This means that some interesting possibilities may be forgone, which may have high opportunity costs, e.g. emissions reductions in the case of CCS. Some signs of risk communication failures are already evident in one of the first onshore CCS demonstration projects in Barendrecht, the Netherlands. The project has been met with significant opposition from certain stakeholder groups, e.g. local governments and local residents, despite the efforts the national government and the project developers have spent in promoting the technology. Different stakeholder groups have different perceptions of the risks of CCS and misunderstand each other's positions and motivations. For example, while the local residents may distrust the information they receive from the project developers, the latter may view the local residents as irrational and lacking education to understand and judge the risks involved. It is already known from the Dutch energy policy that CCS will be developed. Instead of having large-scale deployment of CCS projects that local residents and possibly other stakeholders such as local government and environmental NGOs are against (and thereby going down the first path as described in the proceeding action), improved risk communication may be able to make the development of CCS a more nationally-welcomed option. The questions are then what does improved risk communication look like, is it in fact realistic or possible to aim at such a standard and if so, how to improve risk communication. The next section will outline how the problem could be addressed in this thesis.

1.3.2 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

In light of the problem defined above, the main objective of the thesis is to learn from existing theory and practice of risk communication of uncertain and ambiguous risks in general and apply the lessons to risk communication of onshore CCS in the Netherlands. The research objective has been translated into a central research question:

What recommendations for risk communication of onshore CCS in the Netherlands can be inferred from the comparison of theory and practice of risk communication of uncertain and ambiguous risks?

The central research question is broken down to six research questions:

1. What have been proved to be the effective risk communication strategies for uncertain and ambiguous risks?
2. How has risk communication of uncertain and ambiguous risks been conducted in practice?
3. What are the gaps between the strategies proven effective and the strategies used in real life and why do they exist?
4. What implications do the gaps have for risk communication in general?
5. How do the gaps and their implications apply to the risk communication of CCS in the Netherlands?
6. What recommendations can be made in light of the gaps in order to increase the effectiveness of risk communication of CCS in the Netherlands in the future?

2. CONCEPTUAL FRAMEWORK FOR RISK COMMUNICATION

Chapter 2 is dedicated to a literature review of the normative literature on risk communication, which is the literature that discusses what risk communication should look like, albeit only based on intuition and is largely anecdotal. The review is structured along the seven components of risk communication as given in Section 1.2.1.

2.1 THE CONTEXT OF RISK COMMUNICATION

The context does not determine the outcome of a situation, but it does shape the problem people seek to solve and constrains the range of actions they can take to solve it (Laird 1989). Being the overarching factor in risk communication, context can be divided in three levels. The first level is interaction. It may refer to features of the physical settings in which the message is received, such as whether one is alone or with others that he can discuss the message with, whether there is distraction during the message processing period, and whether there is time pressure during message processing (Desbarats et al. 2010). It may also refer to the amount and nature of other information surrounding the message (Desbarats et al. 2010). The second level is the organization. Source credibility is the most relevant variable in this context, which is more appropriate to discuss in the section below on the source of risk communication. Source credibility may enable risk communication to have a positive outcome, with even mishaps or minor failures accepted (Renn 2008). The third and highest level is the society. This level includes laws and regulations regarding risk communication, political system, history of risk management, economic development and so on. In this thesis, the organizational context is of particular interest. The interactional context is too detailed and therefore not suitable for the methodology deployed in this study. The societal context is too broad and contains factors that cannot be (easily) influenced.

2.2 SOURCE OF RISK COMMUNICATION

Source of risk communication is the individual(s) and/or organization(s) from which risk communication is initiated. In most cases, they tend to be the organizations from which the risks are originated as well, although this needs not be the case. Concerned citizens may also take initiative by looking for information relevant to the risks affecting them and subsequently communicating such information and their concerns to the appropriate organizations (out of the scope of this study). The source can potentially exert great influence on the risk communication process through its attitudes and expertise, choice of content and mode of delivery, and choice of a medium for communication (Gutteling and Wiegman 1996).

The most important issue related to the source is credibility. McGuire (1969) identified 2 factors affecting source credibility. The first one is expertise, which is related to the source's education level, intelligence, social status, familiarity with the issue, and professional availabilities. While expert sources are generally more trusted than non-expert sources, there are exceptional cases where the opposite may be true, particularly when trustworthiness comes

into play, which is the second factor affecting source credibility. Trustworthiness relates to the source's possible intention to manipulate or to deceive the public (McGuire 1969). When the source does not attempt to manipulate the public but is honest and open, they are perceived as trustworthy. The importance of source credibility is reflected in possible response to uncertainties in information. If the information came from a credible source, revealing uncertainties may result in the source losing absolute authority but gain more credibility; if the information with uncertainties came from a non-credible source, the source may be suspected to be hiding facts (Breakwell 2000).

The saying "trust arrives on foot but leaves on horseback" is also applicable to risk communication. Slovic (1993) observed an "asymmetry principle", which shows that trust-decreasing factors are more powerful than trust-increasing factors. four possible explanations included: 1) negative events are more noticeable than positive events; 2) negative events have a greater impact on people's perceptions and attitudes than positive events; 3) people tend to perceive sources of bad news as more credible than sources of good news; and 4) existing distrust is likely to maintain or even reinforce itself. Trust requires continuous efforts to maintain and reinforce, because if a void occurs between the source and the receiver, it will immediately be filled by speculation, rumors or misinformation (Ng and Hamby 1997). Examples of factors undermining trust are *perception* (that the agencies are influenced by industry, that if they are biased in favor of certain outcome, that if the staff of the agencies are not technically or managerially competent, that if the agencies are not telling the truth fully), and *failed practices* carried out for any of the other components in risk communication (Covello 1989).

2.3 OBJECTIVE OF RISK COMMUNICATION

Objectives should be defined in clear and measurable terms (Chess 2000). Defining them in such a way assists the design of risk communication closely following the objectives, as well as assists an evaluation in the end to see whether certain objectives have been achieved. Particularly for the sake of evaluation, objectives need to be defined carefully. Since evaluation is essentially deciding whether the observed effects of risk communication are in accordance with its pre-formulated objectives, and allows any systematic improvements to be made (Gutteling and Wiegman 1996). Gough (1991) also suggests that objectives should be kept as broad as possible in order to find areas for trade-offs between parties more easily.

Several types of objectives of risk communication have been derived from literature:

- To rectify knowledge gaps between the originators of scientific information and those receiving the information, by assuming that the public is deficient in their understanding of risk (Frewer 2004);
- To convince the audience to accept the communicators' values and prescribed actions (Ng and Hamby 1997);
- To provide reassurance when unnecessary panic occurs or generate alert when the public

are apathetic in the face of serious hazards (Covello and Sandman 2001);

- To inform the public by provide easily comprehensible tools to groups and individuals that enable them to understand the nature of the risks, to process probabilistic information and to evaluate the likely impacts (Fischhoff et al. 1993);
- To empower the public by first finding what people's concerns are, then including their concerns in risk assessment, and finally helping them to interpret the results and helping them use ways to affect the decision (Fischer 1999);
- To negotiate solutions that explicitly recognize the necessity of free, informed consent to risk among stakeholders (Shrader-Frechette 1990).

The abovementioned objectives can be categorized into three types. The first three objectives are to inform, but have the elements of manipulation/persuasion. Witte (1994) summarizes these objectives as "by virtue of framing messages in a certain manner, in a certain order, with a certain amount of information, communicators manipulate receivers into certain mindsets, sometimes intentionally and sometimes unintentionally". Persuasive objectives may have backlash effects, since participants value the freedom to take a stand on an issue. By persuading them to accept a particular point of view, thereby eroding such freedom, participants may react by maintaining their existing views, or even change their views in the direction opposite the desired path of the source (Brehm and Brehm 1981). There are also objectives to inform without persuasion. In this case, the rejection of the risk is seen as a lack of understanding. Finally, the last type of objectives are to empower the participants, so that they can think about various risk issues, make their own decisions about risks, and provide informed input into community, regional or national decision-making. To inform with persuasion, to inform without persuasion, and to empower are all intermediate steps to achieve the ultimate objectives (as included in the definition of risk communication effectiveness in Section 1.2.1): desirable changes in knowledge, risk attitudes, feelings of insecurity, risk perception and controllability, and behavioral measures.

2.4 PARTICIPANTS IN RISK COMMUNICATION

2.4.1 WHO TO INVOLVE

In principle, participants include everyone involved in risk communication, who are not the sources of risk communication. For effectiveness and ethical considerations, all affected parties should be included in risk communication. In reality, it is not uncommon for a mismatch to occur between those who are affected and those who are involved. Often those at greatest risk are least likely to be well-informed about the risks they face or able to understand the complex, changing data about the hazards, whereas those who are active in campaigning against certain risks are from a more upscale, literate public group (Russell 1999). Because of these mismatches, initial scoping exercise for who to involve should be broad and include those who directly or indirectly affected and those with an interest. It is better to include people who may choose not to be involved than to ignore or neglect groups or individuals who believe they

should have been included, since bringing them into the proceedings at a later date may negatively bias their reactions to the process (Gough 1991).

Dividing the potential participants into target groups based on mutual characteristics is helpful for obtaining an overview of the most appropriate people or organizations to involve (Gutteling and Wiegman 1996). Earle (1984) suggested that target group could be formed on issue involvement, level of education, and proximity to the potential risks. Issue involvement is used by two other authors to distinguish between potential participants. Renn (2008) differentiates between *stakeholders* (socially-organized groups who are or will be either effected or have a strong interest in the outcome of the event or activity from which the risk originates and/or by the risk management options to counter the risk); *directly-affected public* (individuals and non-organized groups who will be affected by the outcome of the event or activity from which the risk originates and/or by the risk management options to counter the risk); *observing public* (e.g. media, cultural elite, and opinion leaders who may or may not comment on the risks or influence public opinions); and the *general public* (those who are not directly affected by the risk or risk management). Rohrmann (1992) makes a distinction between risk-exposed people, risk producers, administrative/regulatory authorities, media, scientists and the general public, the categorization of which is similar to that by Renn (2008). Among the various groups, this thesis will focus on citizens as participants in particular (i.e. the directly-affected public and the general public), since it is an area where problems of risk communication most frequently arise, e.g. misunderstanding and distrust.

2.4.2 HOW TO INVOLVE

Different risks imply different involvement strategies. Gough (1991) distinguishes between the type of risk situation such as siting, emergency preparedness or emergency response when timing is discussed. For example, for prospective projects, involvement should be as soon as the project is planned or as soon as any evidence of risk becomes apparent. If risk communication is postponed until late in the developmental process of the potential hazardous projects, program or facility, then major choices have already been made by that time, options are foreclosed and the developers and regulators are committed to the enterprise. Moreover, Kasperson (1986) argues that risk communication should not only occur early in risk communication, but should also continue throughout the consideration and decision processes.

Different groups should also be approached with different involvement strategies. It may be useful to make further divisions within the targeted public based on whether they are actively looking for information or whether they are passively waiting for information provision (Weinstein 1978). The two groups should be approached with different involvement strategies. For those actively looking for information, there need to be efforts to anticipate the information need and make relevant information available accordingly. Particular attention should be paid to the passive participants, as they may be informed inadequately when the information need and information provision do not coincide (Gutteling and Wiegman 1996). They may even be resistant to communication and involvement efforts (Kasperson 1986).

2.5 FLOWS WITHIN RISK COMMUNICATION

Flow of risk communication has two aspects: direction of information transfer (parallel to power exertion) and parties on both ends of the arrow. Similar to the categorization of the definitions of risk, there are two types of approaches to risk communication, namely a technical approach and a democratic approach (Rowan 1994). The former is based on the definition of risk as a physically-given attribute. In this approach, the public is seen to be in need of accurate information and scientific expertise, which should come from experts only. Therefore the flow is represented as:

Experts → Citizens

The democratic approach takes into consideration the view that risk is a social construct. The flow then becomes two- or multi-directional between a variety of parties, 3 examples include:

Experts ←→ Citizens

Citizens ←→ Citizens

Policy-makers ←→ Citizens

2.6 CONTENT OF RISK COMMUNICATION

The content here only refers to "official risk messages". There are also "unofficial risk messages", which often accompany and sometimes contradict official messages (Fessenden-Raden et al. 1987). The information should be carefully chosen. Poorly chosen information can have several negative consequences: it can waste recipients' time; it can be seen as wasting risk communicators' time; it can fill the place that might be filled with pertinent information; it can lead recipients to misunderstand the extent of their knowledge; and recipients may be judged unduly harshly if they are uninterested in information that they find irrelevant (Fischhoff 1998).

Many authors speak of briefness in information. While open disclosure of all information is more likely to gain credibility and to bring the public onside, information overload may occur. Fischhoff et al. (1993) suggest that information should attempt to convey a comprehensive picture of the processes creating and controlling a risk and provide the pieces that have the largest possible impacts on pending decisions. Being brief also means getting to the point in a straightforward manner, by stating the intention as the central part of the message, since most participants would have little time to read long essays or detailed descriptions (Breakwell 2007). Brief can also mean the information being simplified as drastically as possible without being inaccurate (Renn 2008), or the information being specific enough to aid decision-making, but not so detailed that it is obfuscated with needless (technical) information (Atman et al. 1994). Renn argues that the messages will be simplified regardless of how well-written the text may be. Rather than having the simplification happening during transmission or during reception, to a form unintended by the message constructors, simplification with an original intention may be more accurate. Although simplicity is recommended, information about the

decision processes, the values that were used to make trade-offs and the remaining uncertainty should not be omitted, since such information is crucial for building credibility and trust (Renn 2008). Breakwell (2000) also mentions the importance of presenting uncertainty voluntarily in the information, because this would enhance trust in the information and its source, as opposed to revealing uncertainties only through unexpected disclosure by other sources or under duress, which has the opposite effect.

Clarity is also mentioned. Breakwell (2007) argues that clarity is a major condition for information to pass through the attention filters of the participants, in that it is more readily noticed and captured, and in ideal situations remembered and referred to later on. Clarity means avoiding technical jargons and explaining only the elements essential for understanding the message, and not presupposing any systematic knowledge of the subject beforehand (Renn 2008).

In addition, balanced information is emphasized. Balance means a balance between different view points on the risk issue, which will make the information less biased. Balance also means taking into account not just the experts' points of view but also lay perspectives (Renn 2008). Parties other than the agency promoting the activity, including the public and other stakeholders, have information that is as important from their perspectives as the technical data provided by the risk analysts, which the agency should evaluate (Gough 1991).

Kasperson (1986) points out that there may be trade-offs between early involvement and information quality. Early on in the process the scientific risk assessment underlying the information tends to be less adequate, the early generation of information is not cost-effective because numerous candidates compete for attention, and early communication increases opportunities for opposition. The first argument, that the scientific risk assessment tends to be less adequate, often applies to uncertain and ambiguous risks. Critics of an event or project containing potential risks often attack assessments by the promoters on the grounds of uncertainties, particularly because the public may be misled by such assessments that may claim greater quantitative precision than can reasonably be justified (Covello 1989). The latter arguments by Kasperson have too narrow a focus for information. Having multiple sources is instrumental for the balance in information. Additionally, opposition needs to be seen as a legitimate viewpoint, rather than as a negative trait.

Content of risk communication is not only about the information itself, but also about the presentation of information. The presentation of information, it can be done orally, or visually, or both (Ng and Hamby 1997). Oral presentation stimulates interaction more easily. However,, it is also more easily to be misunderstood and therefore the communicators need to have strong expertise and communication skills. Visual presentation can better raise awareness of an issue, with both graphics and texts, but can be expensive and time-consuming to produce (Lundgren 1994). Written materials are also frequently used. Renn (2008) recommends that simple messages should be placed at the beginning of a text and the complex issues can be gradually added, since starting from simple can attract the attention of the peripherally-interested participants. Atman et al. (1994) note the benefits of adjunct aids, which include creating headings for text segments to help readers recall information more easily and find information

more rapidly; offering an outline beforehand; providing summaries of the information; and highlighting the most important information.

2.7 CHANNEL OF RISK COMMUNICATION

Due to the co-existence of groups that are actively seeking information and groups that consist of passive information receivers, and because content can be in different forms with varying presentation needs, risk communication should be transmitted through different channels accordingly. Russell (1999) suggested a two-pronged approach, which transmits information through both the traditional channels such as the mass media, as well as provides opportunities for concrete, highly directed, high-quality risk messages to reach targeted audience.

The mass media has the advantages of reaching a large group of audience both time- and cost-efficiently. However, the journalistic section of the mass media is often criticized as being highly selective in their reporting of risks, inclining towards stories that involve people in unusual, dramatic, confrontation, negative, or sensational situations, with substantial omission of facts and oversimplified, distorted or inaccurate information (Covello and Sandman 2001). There seems to be a divide between the scientific worldview and the journalistic approach to handling risk information, in that risk to scientists is a tool to measure and compare data, whereas for journalists it is a measurement of news value – greater risk equals bigger story (Russell 1999). Such biases are due to the characteristics of the media (Slovic 1986). Firstly, journalists operate under great constraints, e.g. tight deadlines, pressure of competition to be the first with a story, and limitation of space to report stories or time (for TV reports). Secondly, for efficiency reasons, journalists are forced to rely on sources that are easily accessible and willing to speak out. Thirdly, few journalists have the background needed to review the complexities and uncertainties in risk assessments. Media performance can be improved through setting up meetings between journalists, scientists and risk managers and training of journalists in scientific writing and in understanding of science (Slovic 1986; Russell 1999).

Using solely the journalistic mass media is insufficient to address the diverse range of participants. Other techniques with more specific targeted participants are also needed. Ng and Hamby (1997) distinguish between direct techniques and interactive techniques. Direct techniques include brochures, information packets, newsletters, videotapes or slideshows, advertisements, fact sheets and press releases. In this thesis they are categorized as the non-journalistic mass media. Interactive techniques, on the other hand, include face-to-face meetings, focus groups, interviews and so on. Depending on what it is that needs to be communicated and who the content should be communicated to, the technique(s) can be tailored accordingly.

2.8 KNOWLEDGE GAPS

The relations between the components are illustrated in Figure 3. While many prescriptive attempts have been made in the literature, evidence for the effectiveness of certain risk communication practices may still remain sparse. Such an inference is made because a large body of the literature reviewed date as far back as the 1980-90s, if not earlier. Nevertheless, risk

communication remains a weak link in risk assessment and management, as is evident in public controversy around the risks of nuclear energy, genetically-modified (GM) food, and so on. While the assessment of these risks is extensive, the public often fails to be informed adequately and adopt an ambivalent attitude towards these technologies. It could also be that the theories are too parsimonious, making assumptions about an ideal situation, in which the public (and other stakeholders) were willing to learn about the risks, where all participants could be fully-informed, where resources such as money and time were abundant, etc. Real-life obstacles are likely to result in certain recommendations being invalid. Because the normative literature is largely anecdotal and intuitive, hypotheses were developed when the evidence-based literature was reviewed, which resulted in a list of strategies risk communicators ought to use in order for risk communication to be effective.

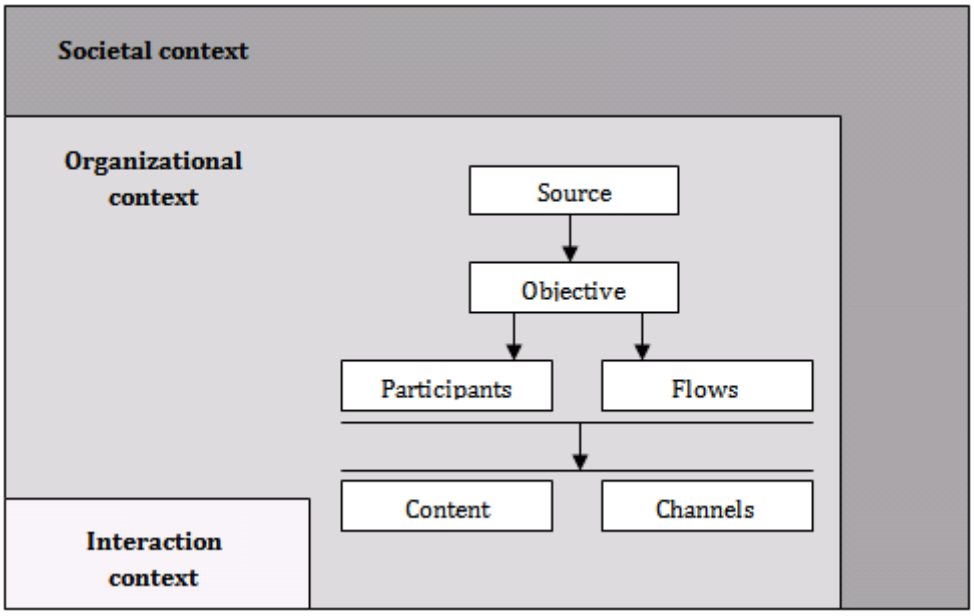

FIGURE 3 THE CONTEXT OF RISK COMMUNICATION AND THE COMPONENTS TO BE STUDIED.

The literature on public participation was included in the review alongside the risk communication literature. Public participation is defined as "…any of several mechanisms intentionally instituted to involve the lay public or their representatives in administrative decision-making" (Beierle and Crayford 2002, p6). Risk communication and public participation are closely intertwined. Public participation can be seen as a means of risk communication. It can also serve as a method of identifying areas of public concerns and subsequently to design the risk communication efforts accordingly. In addition, risk communication can also be seen as an approach to enable informed participation. Despite the overlaps, it was recognized that public participation and risk communication are not inter-changeable, since the former may have broader objectives. Taking into account public participation with awareness of differences between public participation and risk communication in mind, the following terms in Table 1 were derived from the conceptual framework to be used as key words in literature search.

Main item	Item combined with	Item further combined with
Risk communication	Source	Trust
		Credibility
	Objective	Goal
		Intention
		Purpose
	Participants	Public
		Lay
		Citizens
	Content	Information
		Message
	Flow	
	Channel	
Participation	Engagement	Consensus conferences
	Inform	Citizens jury
	Dialogue	Public hearing
	Deliberation	Referendum
	Consultation	Citizens panel
	Involvement	Focus groups
	Partnership	Opinion polls
		Citizens advisory groups
		Deliberative mapping
		Delphi method
		Planning cell
		Scenario workshop

TABLE 9 KEY ITEMS IN THE LITERATURE SEARCH.

3. HYPOTHESES ON EFFECTIVE RISK COMMUNICATION

This chapter seeks to answer the first research question from Section 1.3.2 and provides empirical basis of the normative literature reviewed in the preceding chapter. At the start of the chapter, the methodology for the literature survey is outlined. The subsequent sections presents the results of the studies surveyed for each risk communication component, as well as hypotheses derived from these results on how risk communication can be made effective.

3.1 SELECTION OF THE RISKS AND SAMPLING LITERATURE

Evidence-based literature contained studies that investigated the effectiveness of certain risk communication strategies under experimental conditions or through focus groups, interviews, or questionnaire surveys, as well as studies that independently evaluated risk communication efforts in practice. With risk communication being multidisciplinary, there are many fields in which it is studied, including: cognitive and social psychology, communication science, political science, organization theories and natural and life sciences (Gurabardhi et al. 2004, 2005). Therefore the study reviewed all these wide-ranging fields. The sampling frame included published articles in peer review journals, conference proceedings, dissertations, books and book chapters, all of which must be written in English. The literature to be reviewed were based on cases in developed countries in Europe, North America and Oceania, to ensure a proximate comparability of economic, social and cultural context. The search was carried out in Web of Science and Google Scholar, with the time frame 1980-2010. 1980 was chosen as the starting time since no significant number of publications on risk communication was found before that. The evaluation studies were only taken from independent evaluators, since minimizing interaction is essential to maintain objectivity and increase the accuracy of conclusions (Scriven 1997). Articles selected using the search strategy were supplemented by those recommended by colleagues or obtained from bibliographies.

30 studies were located that satisfied the requirements to be used in this thesis. Snowball sampling yielded the majority of the literature reviewed. A possible reason may be that “risk communication”, with “public participation” and other search terms, were limiting in themselves since many researchers did not use these words either in the title or the key words. Rather, words representing elements within risk communication were often used, such as "information" and "trust". Since it was unknown beforehand what exact words would be used on such a detailed level, relevant articles were difficult to identify. As a result, the literature search depended heavily on references of identified articles.

Some evidence-based studies were not concentrated on the uncertain and ambiguous risks, e.g. risks related to chemicals in drinking water and domestic radon. This is partly because these risks were not viewed as simple linear risks by the researchers. They were also included in order to increase the number of studies from which hypotheses could be drawn from. The nature in which the findings of the studies on these risks were used was not unique to the original risks and was also relevant for uncertain and ambiguous risks. The author failed to

identify studies in the evidence-based literature on “objective” and “flow”, therefore they are excluded from below.

3.2 HYPOTHESES ON THE SOURCES OF RISK COMMUNICATION

3.2.1 WHY IS SOURCE CREDIBILITY IMPORTANT?

The importance of source credibility is confirmed by the evidence-based literature. Source credibility is found to influence how the information provided is perceived, how the risk is perceived, and how the source itself is perceived (see Table 12). Trust in the information provided was found to increase when the source of information was perceived as credible by the participants in the study by Frewer et al. (1997) on microbiological food-borne risk as well as excessive alcohol use, and the participants in the study by Frewer et al. (1996) on food-related risks. A similar variable, confidence in results of assessment studies of food additives risks and risks from electromagnetic fields of power lines, also had a positive correlation with the reputation of the source in a questionnaire survey with university students (Siegrist and Cvetkovich 2001). Furthermore, information was perceived as having higher personal relevance when it came from the government (low credibility source) than when it was from a consumer organization (high credibility source) (Frewer et al. 1999).

However, source credibility did not impact on comprehensibility of the information as found by Frewer and Shepherd (1994), who gave the same information to four groups of participants but attributed it to four sources (government, consumer organization, quality newspaper and no source) and discovered that participants had higher comprehension when the information had no source. Not only does a credible source influence whether the information is trusted or not, it also affects how the information is subsequently dealt with. In a questionnaire survey by Trumbo and McComas (2003), it was found that when the perceived credibility for the state and industry was high, there were greater heuristic processing and less systematic processing. It means that the participants were more likely to make a quick, less effortful judgment based on their existing understanding or on the perceived opinions of experts. When there was high perceived credibility of citizens' groups, the result was the opposite, with participants spending more efforts on acquiring and comparing information.

After information is processed, risk perceptions are formed. Frewer et al. (1997) found that source credibility was positively correlated with risk perceptions. More specifically, in interviews communities members near industrial chemicals and hazardous waste sites, Peters (1996) observed that respondents' level of concern with environmental health risks were positively related to credibility of industry and the government sources. Other studies also identified a relationship between source credibility and risk perception, although there were factors involved other than source credibility. Frewer et al. (1998) found that source credibility influenced participants' acceptance of genetically modified (GM) food, albeit secondary to participants' initial attitudes and the admission of uncertainties. Frewer et al. (1999) found that a more credible source (a consumer organization) resulted in more rejection of genetic engineering than a less credible source (the government), although other factors such as

perceived personal relevance and persuasiveness of information also interacted to play a role. Trumbo and McComas (2003) also yielded the result that credibility had an effect on risk perception, but the effect depended on source characteristics. Greater credibility for the state health departments and industries resulted in lower risk perceptions, whereas greater credibility for citizens' groups was related to higher risk perceptions. Finally, one large-scale study failed to identify any relationship between source credibility and attitudes towards GM food products (Frewer et al. 2003).

Only one study investigated whether source credibility had an effect on how the source was perceived. This was a large study on food-related risks, which found that when a source was more credible, it was also perceived as having a higher level of knowledge than a source that was less credible (Frewer et al. 1996).

Observations:

- There is higher trust, confidence and perceived personal relevance in the information when it comes from a credible source.
- Even when a source is credible, there are differences between credible sources in activating systematic processing of information, with citizens' groups inducing more systematic processing than governmental or industrial organizations.
- A credible source may both heighten or lower risk perception, thereby resulting in acceptance or rejection of risk. However, the effects may not always be attributed to source credibility alone.
- A credible source could be seen as more knowledgeable on the risk by the public.

3.2.2 BUILDING SOURCE CREDIBILITY

Government sources were often seen as least credible (Frewer et al. 1996). Scientists, medical sources, radio and consumer organizations are more trusted, but tended not to be frequently used (Frewer et al. 1996). Frewer et al. (1997) also found that medical sources are rated more credible. Frewer et al. (2003) did not identify any particular source being seen as more credible than others, but instead found that participants tended rate sources as more credible when their views coincide with those of the participants'. Siegrist and Cvetkovich found that university researchers as a source tended to make participants have more confidence in the results than manufacturer as a source, although the effect was only marginally significant.

For the sources generally not considered credible, a few factors have been found to influence source credibility (see Table 3), one of them being collaboration between sources. For example, Dean and Shepherd (2007) found that when the government teamed up with other sources, regardless whether they were in agreement or disagreement with one another, credibility of the government increased. However, the opposite effect was noted for consumer organizations, which declined in credibility when working with the government. Ter Mors et al. (2009) did not observe any effect of collaboration between information sources on how the sources are viewed, although they did see an increase in the perceived value of information when there was

collaboration.

Peters (1996) examined a list of variables that may potentially affect credibility of industry, government and citizen groups, namely: perceptions of knowledge and expertise; perceptions of openness and honesty; perceptions of concern and care; amount of information received from the source; sensitization to the risks; and time and money invested in risk communication by each organization. The first three variables were positively related to source credibility. Sensitization to the risks lowered the credibility of industry and the government, while raising the credibility of citizen groups. Finally, when industry and government invested more time and money in risk communication, it had a negative impact on their credibility, whereas the opposite was observed for citizens' groups. Another factor, source independence, which may be related to source credibility (in that more independent sources may be seen as more credible), did not have a positive impact on participants' trust in information on food-related risks, as discovered by Frewer et al. (1996). Rather, Frewer et al. (1996) found that a "middle point" in source independence in most appropriate in increasing trust, as too much independence is perceived as apathy, whereas too little independence is viewed as bias.

Observations:

- When different sources collaborate, there may be positive or negative effects on the sources' credibility depending on their characteristics.
- When the source has a high level of knowledge and expertise, is open and honest, and shows concern and care, it is seen as more credible.
- Governmental and industrial sources are often seen as less credible than NGOs, independent scientists and medical sources.

Hypotheses:

- Risk communication is more effective when credible organizations are involved and collaborated with as sources.
- Risk communication is more effective when the sources have a high level of knowledge and expertise.

Authors	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[2]
Frewer & Shepherd 1994	Case control	Participants	150	Genetic engineering in food production	Unknown source instead of governmental, consumer organization, or quality newspaper sources	Comprehensibility	+
Frewer et al. 1996	Questionnaires	Quota sampled participants	920	Food-related risks	Trust in information source	Perceived level of knowledge of source	+
					Source independence	Trust in information	0
	Interview; questionnaires	Participants	35	Food-related risks	Information sources	Trust in information	+
Frewer et al. 1997	Questionnaires, intervention	Participants	210	Excessive alcohol use; microbiological food-borne risk	Source credibility	Trust in information	+
					Source credibility	Risk perception	+
Frewer et al. 1998	Questionnaires, intervention	Volunteers	260	Genetic engineering in food production	Trust in source	Acceptance of risk	0/+
Frewer et al. 1999	Questionnaires, intervention	Participants	186	Genetic engineering	Information source	Rejection of technology	+/-
						Perceived personal relevance	+/-
Frewer et al. 2003	Questionnaires, intervention	Beer and yoghurt consumers	1405	Genetically-modified food	Trust in organizations	Attitudes towards GM food products	0
Peters 1996	Interview	Adults from communities studied	1181	Industrial chemicals and hazardous waste sites	Trust and credibility	Respondent's level of concern with the risks	+

[2]0 No correlation between dependent and independent variables

-Negative correlation between dependent and independent variables

+Positive correlation between dependent and independent variables

+/-Mixed evidence in correlation

Authors	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[2]
Siegrist & Cvetkovich 2001	Questionnaire	University students	260	Food additives; electromagnetic fields of power lines	Reputation of information source	Confidence in results	+
Trettin & Musham 2000	Focus groups	Residents near nuclear power & hazardous waste	N/A	Nuclear power and hazardous waste storage	Trust (uncritical emotional acceptance)	Adequate risk communication	0
Trumbo & McComas 2003	Questionnaires	Adult volunteers	696	Aircraft exhaust; landfill; industrial dumping; industrial emissions; golf course chemicals	Perceived credibility	Risk perception Heuristic processing Systematic processing	+/- + -

TABLE 10 AN OVERVIEW OF HOW SOURCE CREDIBILITY INFLUENCES RISK COMMUNICATION.

Authors	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[3]
Dean & Shepherd 2007	Intervention, questionnaire	Participants	159	GM food	Government-sourced information in conflict or consensus with other sources	Credibility of source	+
					Consumer organization in collaboration with government	Credibility of source	-
Frewer et al. 1996	Questionnaires	Participants with a range of jobs	35	Food-related risks	Familiarity with hazard	Trust in information	+
Peters 1996	Interview	Adults from communities studied	1181	Industrial chemicals and hazardous waste sites	Perceptions of knowledge and expertise	Trust and credibility	+
					Perceptions of openness and honesty	Trust and credibility	+
					Perceptions of concern and care	Trust and credibility	+
					Amount of information from the source	Trust and credibility	+
ter Mors et al. 2009	Intervention; questionnaire	Students	N/A	CCS	Collaboration between information sources	Perceived value of information	+
					Collaboration between information sources	Perceptions of information sources	0

TABLE 11 OVERVIEW OF STUDIES ON THE FACTORS AFFECTING SOURCE CREDIBILITY.

[3]0 No correlation between dependent and independent variables

-Negative correlation between dependent and independent variables

+Positive correlation between dependent and independent variables

+/-Mixed evidence in correlation

3.3 HYPOTHESES ON THE PARTICIPANTS OF RISK COMMUNICATION

Table 4 presents the studies on the participants of risk communication. Ashworth et al. (2009) investigated the effects of individual's strength of existing attitudes on their shifts in knowledge and attitudes after risk communication. The results showed that when an individual had strong attitudes, risk communication resulted in less of a shift in their knowledge and attitudes on the risk. Similarly, Scholderer and Frewer (2003) found that exposure to benefits in the information did not change consumers' attitudes towards GM food, due to their strong upfront negative attitudes.

Frewer et al. (1998) showed that the nature of attitudes also matters: respondents with more positive prior attitudes tended to rate information provided during risk communication as more accurate, factual, informative, and less biased, and tended to develop more positive attitudes towards the information source as well. Further, Ashworth et al. (2009) found that information also interacts with attitudes *ex ante* to influence attitudes *ex post*. When participants were exposed to information that created dissonance with their prior attitudes, there were more changes in attitudes.

Kahlor et al. (2003) examined if and how perceived information need was related to style of information processing. They defined perceived information need as the gap between one's understanding of a risk and the level of understanding that one needs to make a decision about that risk. It was found that the larger the gap of information need, the more likely participants were to process the information systematically.

Observations:

- The strength and positivity of people's attitudes could interact with information characteristics to directly or indirectly influence their attitudes towards a risk after risk communication.
- When people perceive that they need more information to make a decision on the risk issue, they tend to spend more efforts on acquiring and comparing information carefully.

Hypotheses:

- Risk communication is more effective when participants have not yet formed strong attitudes about the risk issue.
- Risk communication is more effective when target groups are differentiated and information is designed for each target group.
- The non-participating public should be informed about the outcome of risk communication.

Authors and Year	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[4]
Arvai 2003	Case control	Adult volunteers	378	Space exploration	Informing non-participants whether public involved in decision-making	Support for the decision-making process and its resulting decisions	+
Ashworth et al. 2009	Focus groups	Volunteers	107	CCS	Strength of existing attitudes	Shifts in knowledge and attitudes	-
					Information dissonance with attitudes	Changes in attitudes	+
Frewer et al. 1998	Questionnaires	Volunteers recruited from newspaper	260	Genetic engineering in food production	Attitude before information provision	Attitude after information provision	+
						Attitude towards source	+/-
Kahlor et al. 2003	Questionnaires	Participants	144	PCBs in fish	Perceived information need	Systematic information processing	+
						Heuristic information processing	0
Scholderer & Frewer 2003	Questionnaire	Randomly selected participants	1655	GM foods	Information about benefits	Attitudes towards GM food products	0

TABLE 12 OVERVIEW OF STUDIES ABOUT HOW THE COMPONENT OF PARTICIPANTS CAN CONTRIBUTE TO EFFECTIVE RISK COMMUNICATION.

[4] 0 No correlation between dependent and independent variables

-Negative correlation between dependent and independent variables

+Positive correlation between dependent and independent variables

+/-Mixed evidence in correlation

3.4 HYPOTHESES ON THE CONTENT OF RISK COMMUNICATION

Table 5 presents the studies on the content of risk communication. For the actual content, Scholderer and Frewer (2003) exposed the participants to information about benefits of GM food and discovered that participants were less likely to choose GM food products afterwards. Similarly, Siegrist and Cvetkovich (2001) found that regardless of the source, participants had more confidence in negative results. Moreover, negative results increased risk perceptions more than positive results decreased risk perceptions.

Frewer et al. (1998) found that although admission of uncertainty had no effect on participants with positive initial attitudes regarding GM food, it increased the rating of the quality of information by those with negative initial attitudes. The desirability of uncertainty was further investigated in the impact on attitudes. When uncertainty was combined with positive and negative initial attitudes, there was more acceptance of the technology. In addition, uncertainty resulted in more elaborative processing of the information. Finally, uncertainty had an effect on the attitudes towards information sources. For participants with prior positive attitudes, uncertainty reduced their rejection of information from consumer organizations and sources in consensus. However, Frewer et al. (2002) showed that not all types of uncertainties were equally acceptable. Uncertainty related to government inactivity was less acceptable in general than uncertainty related to scientific processes and assessments, due to people's preference to be able to make an informed choice (instead of taking no action).

As for the presentation of information, Connelly and Knuth (1998) provided printed materials with 5th grade and 11th grade reading level, based on clarity and understandability, to 8000 licensed anglers from Great Lake states about eating non-commercial Great Lakes fish affected by chemical contaminants. While the reading level did have an effect, it was varied according to participants' education background. Those with lower education found the 5th grade reading level materials clearer and easier to understand. Connelly and Knuth (1998) also investigate the effects of certain adjunct aids. Participants thought providing a diagram together with a text was clearest and easiest to understand compare to a text-only format.

Keller et al. (2006) investigated the effects of evoking negative emotions on perceived risks. Affect-laden imagery depicting houses during floods was used to evoke such negative emotions. The results showed a positive relationship between negative emotions and risk perceptions. Meijnders et al. (2001) also explored the effect of negative emotion about climate change. While exposure to strong arguments resulted in more positive attitudes towards energy-efficient light bulbs, exposure to weak arguments only achieved the same result when participants were exposed to moderate negative emotion or control conditions. Moreover, exposure to strong arguments only resulted in stronger intentions to purchase the bulb than exposure to weak arguments if moderate negative emotion was induced.

Arvai et al. (2001) found that compared to an alternative-focused approach, participating in a value-focused risk approach (where decision-making is structured by drawing participants'

attention to their values, objectives, and trade-offs in the decision context) helped participants feel more comfortable with their decisions and more satisfied that their choices reflected their values and concerns. Moreover, it led participants to consider and discuss a wider array of decision-relevant issues. Finally, participants felt more knowledgeable about issues relevant to the decision context, due to the value-focused approach.

Connelly and Knuth (1998) found that between a cajoling and a commanding tone of information, participants preferred the former because they felt that they were provided with necessary information to make their own decision, wanted to keep their consumption within the recommended limits, and prompted to continue their fishing involvement. They also compared the effect of a quantitative and a qualitative risk ladder used to present information. The former was preferred by participants as it increased understanding of the risks.

Golding et al. (1992) found that narrative information was better at retaining readers' attention and reducing their concern than technical information. Another finding was that both formats enhanced the level of knowledge but neither encouraged behavioral change. Chipman et al. (1996) compared four approaches to communicate risks of agricultural chemicals: video news release, video public service announcement, print news release, and newsprint column. Video news releases and newsprint column were preferred because of their dialectical style with feature stories, compare to the more simplified and one-sided information the others were perceived to provide. The benefits of using dialectical messages were also found by Scherer et al. (1999). In two sub-studies that compared dialectical messages with narrative, balanced, and persuasive messages, dialectical messages showed advantages by increasing critical thinking among participants without increasing their level of concern about the risks.

Hendrickx et al. (1989) provided information to participants with: no specific risk information added (control), relative frequency information (RFI) (quantitative) only, cognitive scenario information (CSI) (qualitative) only, and both RFI and CSI. They found that both RFI and CSI affected participants' judgments. With RFI, participants tended to base their assessments on accident frequencies, but ignored the information quality. With CSI, the number of suggested accident scenarios, their concreteness and the implied personal control all influenced assessments. When both information were available, RFI was only used when little or no CSI was available.

A study by Qin and Brown (2007) provided information about GM salmon in two ways: perspectives on the introduction of the salmon (identifiable stakeholder perspectives given) and possible consequences (stakeholders not identifiable). Results showed that participants that read the consequence information learnt more, expressed more interest in learning, felt the information was more important to them, and indicated a higher level of actual confidence in understanding the effects on consumer choice and on consumer health than participants that read the perspectives information. Both information managed to reduce the negative attitudes.

Observations:

- People believe in bad news more than they believe in good news.
- Admission of scientific uncertainty in information is desirable in risk communication.
- Information is easier to understand when reading level is low and graphics are used.
- Appealing to negative emotions heightens risk perceptions and results in more attitude changes.
- Focusing on values leads to more informed participants.
- Cajole is preferred over command when it comes to information provision.
- Qualitative information is preferred than quantitative information.
- Dialectical and narrative information are preferred over monotonous factual information.
- Overall, providing information in the form of consequence of the risk is more effective than in the form of perspectives on the risk

Hypotheses:

- Risk communication is more effective when the information is balanced.
- Risk communication is more effective when scientific uncertainties are displayed in the information.
- Risk communication is more effective when simple lay language is used for the information.
- Risk communication is more effective when graphics are used to illustrate the information.
- Risk communication is more effective when the information focuses on not only relevant facts to the risk but also values.
- Risk communication is more effective when the information does not use a commanding tone.
- Risk communication is more effective when the information is (mostly) qualitative in nature.
- Risk communication is more effective when the information adopts a dialectical or narrative style.

Authors	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[5]
Frewer et al. 1998	Questionnaires, intervention	Volunteers	260	Genetic engineering in food production	Admission of uncertainty	Perceived quality of information	+/-
						Elaborative information processing	+
Frewer et al. 2002	Focus groups	Participants	1092	Food risk	Type of uncertainty	Acceptance of uncertainty	+
Frewer et al. 1997	Questionnaires, intervention	Participants	210	Excessive alcohol use; microbiological food-borne risk	Persuasiveness of content	Perceived information quality	+
						Elaborative processing	+
Frewer et al. 1999	Questionnaires, intervention	Participants	186	Genetic engineering	Persuasiveness of information	Rejection of application	+/-
Meijnders et al. 2001	Intervention, questionnaire	Members of social clubs	162	Climate change	Strength of arguments	Attitudes towards mitigation measures	+
Scholderer & Frewer 2003	Questionnaire	Randomly selected subjects	1655	GM foods	Information about benefits	Probability of choosing GM food products	-
Siegrist & Cvetkovich 2001	Questionnaire	University students	260	Food additives	Negative results	Confidence in results	+
		High school students	150	Electromagnetic fields of power lines	Severity of reported risks	Effect on judgment of danger	+
Connelly & Knuth 1998	Intervention, questionnaire	Licensed angler	3536	Chemical contaminants in fish	Quantitative	Ease to understand information	+
Golding et al. 1992	Focus groups, interviews	Randomly selected homeowners	729	Radon	Narrative instead of technical presentation of information	Readership	+
						Concern	-
						Knowledge	+/-

[5]0 No correlation between dependent and independent variables

-Negative correlation between dependent and independent variables

+Positive correlation between dependent and independent variables

+/-Mixed evidence in correlation

Authors	Design	Subjects	N	Hazards	Independent variables	Dependent variables	Results[5]
						Mitigation behavior	0
Scherer et al. 1999	Intervention, questionnaire	Selected individuals interested in related risks	108	Pesticide residues, bovine growth hormones, food irradiation	Dialectical instead of persuasive or balanced messages	Critical thinking	+
						Level of concern about the risk	0
			74	Pesticide residues, compost facility siting, Lyme disease	Dialectical instead of narrative or balanced messages	Critical thinking	+
						Level of concern about the risk	0
Hendrickx et al. 1989	Case control	Mainly university students	128	16 risky activities	RFI or CSI	Probability assessment of accident	0
					RFI or CSI	Use of information to assess probability	+/-
					RFI or CSI	Attention paid to the information quality	+/-
Chipman et al. 1996	Questionnaires, focus groups	Women in community organizations	86	Agricultural chemicals in food production	Communication channels	Audience assessment of a risks/benefits/option message	+
Keller et al. 2006	Questionnaire, case control	Residents in risky area	1598	Flooding	Affect-laden images	Risk perception	+
		Students	92				+
Arvai et al. 2001	Intervention	Participants	101	Conflict between salmon habitat and hydroelectricity facilities	Focus on values, objectives, and trade-offs in the decision context	Comfort with decisions and satisfaction that choices reflected values and concerns	+
						Range of decision-relevant issues discussed	+
						Knowledge about issues relevant to the decision	+
Qin & Brown 2007	Questionnaire	Attendees of art festival	205	Genetically-engineered salmon	Perspective instead of consequence information	Knowledge	+/-
						Motivation to learn	-
						Confidence about understanding	-
						Negativity of attitude	+/-
Connelly & Knuth 1998	Intervention, questionnaire	Licensed angler	3536	Chemical contaminants in fish	Reading level	Ease to understand	-
					Graphic	information	+
					Cajoling tone	Behavioral change	+

TABLE 13 OVERVIEW OF STUDIES ABOUT HOW THE COMPONENT OF CONTENT CAN CONTRIBUTE TO EFFECTIVE RISK COMMUNICATION.

3.5 HYPOTHESES ON THE CHANNELS OF RISK COMMUNICATION

Only the mass media has been examined as a channel for risk communication in evidence-based literature (see Table 6). Quality of the mass media was researched in 4 studies with content analysis. McCarthy et al. (2008) examined how newspapers and TV reported risks of salmonella and GM potatoes. By comparing them with the content of press releases, it was found that newspapers and TV did make use of press releases accurately. Moreover, journalists had limited use of sensational terminology in headlines. However, such findings were not replicated in the results of the content analysis by Roche and Muskavitch (2003) of major newspapers in the US on the West Nile virus. They identified low precision of risk information printed. In addition, although McCarthy et al. (2008) found limited dramatization of risk by journalists, other researchers found some "stereotypical" traits of the mass media on risk reporting. For example, McInerney et al. (2004) found that while scientific literature remained rather static, the popular press changed with risk perceptions of the public and of scientific journalists, and that stories about the risk were not always "on topic", e.g. the title may claim to be about GM food but the article was barely connected to GM food. Similarly, Wakefield and Elliot (2003) found increasing coverage in local newspapers about non-hazardous industrial waste landfill during key decision periods and that the change in coverage was un-related to the changing scientific knowledge.

Observations:

- The mass media is of varying quality, while some report risks "accurately", others focus on other issues around a risk to gain readership.

Hypothesis:

- Risk communication is more effective when a variety of channels are used, including (quality) journalistic and non-journalistic mass media and interactive channels.

Authors	Design	Subjects	N	Hazards	Results
McCarthy et al. 2008	Content analysis	Press releases, newspapers, TV broadcasters	N/A	Salmonella, GM potatoes	• Press releases utilized and represented fairly in media; • Journalists perspectives differed greatly; • Limited use of sensational terminology in headlines.
McInerney et al. 2004	Content analysis	Scientific journals, press releases, lay press	N/A	GM food	• Scientific literature relatively static. Popular press changes with risk perception of the public and scientific journalists. • Stories about GM food were not always “on topic”.
Roche & Muskavitch 2003	Content analysis	Major newspapers	N/A	West Nile virus	• Low degree of precision of information
Wakefield & Elliot	Content analysis	Local newspapers	N/A	Non-hazardous	• Coverage increased around key decision periods.

Authors	Design	Subjects	N	Hazards	Results
	Interviews	Journalists, stakeholders	23		• Journalists use same sources as residents • Journalists do not address accuracy • Residents see newspapers as important but untrustworthy.

TABLE 14 OVERVIEW OF STUDIES ABOUT HOW THE COMPONENT OF CHANNELS CAN CONTRIBUTE TO EFFECTIVE RISK COMMUNICATION.

3.6 ADDITIONAL HYPOTHESES FROM INDEPENDENT EVALUATION STUDIES

As additional evidence, four cases of risk communication that were given positive verdicts by independent evaluators were included, since they are also an alternative way of proving the effectiveness of certain strategies. Only a brief description will be given of each case (see Table 7), for details see Appendix 1 and 2.

Some of the studies converged with the other evidence-based studies in what was observed to be effective, while others had contradictory observations. Firstly, for the source of risk communication, citizens' groups were always (attempted to be) included. In the public dialogue on industrial biotechnology, NGOs were not involved, but only due to themselves declining the invitation to participate. Scientists from universities, which were often seen as relatively independent compared to other scientists, were also involved. Three cases had collaboration among sources, between funders and conductors (Nanodialogues, public dialogue on industrial biotechnology) and within funders and conductors themselves (NanoJury). However, the source independence was questionable. While NanoJury had a combination of sources with differing interests in nanotechnology, the others were funded by the government, with vested interest in the development of genetic engineering and nanotechnology. To compensate for the lack of independence, relatively interest-free organizations were invited to conduct these cases.

Secondly, for the participants in risk communication, the cases achieved effectiveness both with or without conducting prior to the formation of strong attitudes. However, this statement is speculative at best. It was unknown whether GM food had any momentum in Norway before the consensus conference was conducted. In the UK, nevertheless, genetic engineering had been a debated topic for years before the public dialogue was carried out (Barbagallo and Nelson 2005). It was likely that some participants would have formed strong attitudes beforehand. Nanotechnology was in its early stages in the UK during the period when NanoJury and Nanodialogues took place, thus the public did not have much of an opinion on the issue.

Thirdly, for the content of risk communication, all cases used perspectives of different stakeholders as the main content. This is the opposite of what the other evidence-based studies found, i.e. providing information on risk consequences was more effective than only stakeholders' perspectives. None of the cases used a commanding tone. Both Nanodialogues and the public dialogue on industrial biotechnology acknowledged uncertainty about the two technologies in the information, as well as provided qualitative (on top of quantitative) information. Nanodialogues, being the only case with details on the information, also used

jargon-free language to explain nanotechnology in a story-telling manner, illustrated with graphics. It was unknown across all cases whether the information focused on values or facts.

Finally, the channels used in the case were wider than those discussed in the other evidence-based studies. While the latter focused on journalistic mass media, the former also used non-journalistic mass media and non-mass media channels. In NanoJury and the consensus conference on GM food, journalistic mass media were used to disseminate the output to the wider public. Other mass media channels, such as documentaries and briefings were also used in three cases. Apart from the non-interactive channels, interactive channels such as through presentations, question and answers sessions, debates and discussion were used in all cases.

Observations *(only showing the ones additional to observations in Section 3.2-3.5):*

- The funding sources were not always independent, but the organizers/conductors of risk communication were often independent.
- Perspectives of stakeholders were used in information provision.
- Both journalistic and non-journalistic mass media, as well as interactions, were used as channels in risk communication.
- The non-participating public was informed about the process and/or outcome of the risk communication.

	Nanodialogues	NanoJury	Biotechnology public dialogue	GM consensus conference
Evaluator(s)	Chilvers 2006	Rogers-Hayden and Pidgeon 2006	Rathouse 2009	Møkrid 2001
Process	1/4 Nanodialogues to engage the public upstream in issues surrounding nanotechnology. The experiment was funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC), and was conducted by Demos (an independent think tank) and researchers from Lancaster University. Citizens, scientists and research council staff were involved to discuss public values, concerns and aspirations about nanotechnology, and the role of public engagement in shaping research agendas.	Organized and funded by the Cambridge Nanoscience Center, Greenpeace UK, and the Policy Ethics and Life Sciences (PEALS) Research Center. It also involved the Guardian as a media partner. The three sources formed an oversight panel together with representatives from the government, which was responsible for planning, publicity and decision-making for the project. A science panel was also formed to provide guidance to both the oversight panel and the jury. The jury was facilitated by PEALS. Experts informed the jury about nanotechnology and the jury was given opportunities to ask questions. At the end, recommendations were constructed.	Commissioned by the UK Department of Business, Enterprise and Regulatory Reform (BERR) and the Sciencewise Expert Resource Center for Public Dialogue in Science and Innovation. It was conducted by Opinion Leader (a research-based consultancy) and 3KQ (independent facilitator in stakeholder engagement). The process started with a citizens meeting introducing industrial biotechnology and related scientific concepts. A second meeting was conducted so that experts could provide more detailed insights to citizens. A project advisory group was created to inform the two meetings.	Conducted by the Biotechnology Advisory Board (an official independent body appointed by the government) and the National Committees for Research Ethics, and were funded by several ministries and public institutions apart from the conductors (the Research Council of Norway, the Ministry of Fisheries, the Ministry of Agriculture, the Ministry of the Environment, the Ministry of Trade and Industry, and the Ministry of Health and Social Affairs). A laymen's panel was constructed with participants from various parts of the country with different backgrounds, who did not have close links with occupations or organizations with established policies in biotechnology. The lay panel were first involved in seminars where they prepared questions for experts, with guidance from the facilitator. After reading and preparing answers to questions posed by the panel, experts gave lectures. The panel could then ask additional questions. At the end, the panel presented a report at media conferences and on TV to the wider public and other stakeholders

	Nanodialogues	NanoJury	Biotechnology public dialogue	GM consensus conference
Evaluation data and methodology	Observation, interviews with participants during the process and via follow-up emails, interviews with scientists, interviews with BBSRC and EPSRC representatives, and interviews with facilitators during and after the process	Observations, interviews with the jurors before the process about their expectations, and focus groups with the jurors after the process to discuss insights	Observation of the meetings, as well as hearing from participants, experts and policy makers.	Having participants filling in questionnaires
Evaluation criteria	Context and framing, deliberation and competence, learning and influence.	None (reflection rather than evaluation)	1) How well did the process work to enable effective dialogue? 2) What impacts did the process have? 3) To what extent were the dialogue objectives met?	To what extent the conference contributed to the recommendations based on consensus in the group; dialogues between experts and non-experts; and a broad and informed public debate.

TABLE 15 BRIEF DESCRIPTION OF EACH OF THE CASES EVALUATED AND THE EVALUATION METHODOLOGY AND CRITERIA USED.

4. HYPOTHESES VERIFICATION WITH RISK COMMUNICATION IN PRACTICE

This chapter first outlines the methodology for the literature survey. It then verifies whether or not and how much evidence can be found for each hypotheses in the general practice of risk communication of uncertain and ambiguous risks. Appendix 6 provides an overview of the evidence. The verification is followed by a discussion of the existence or absence of evidence and what implications it has.

4.1 SELECTION OF THE RISKS AND SAMPLING LITERATURE

CCS is the main focus of this study. Nevertheless, there is not yet a large body of literature on risk communication of CCS. Thus by analyzing the theory and practice of similar risks, insights could be generalized to CCS. In risk governance, Renn's (2008) classification discussed in Chapter 2 differentiates among linear, complex, uncertain and ambiguous risks. The risks to be studied are those characterized with "uncertainty" and "ambiguity".

The International Risk Governance Council (IRGC) (2005) used the following to characterize uncertainty and ambiguity: *degree of novelty* (emerging or re-emerging; increasing in importance, current or institutionalized); *scope* (local, dispersed, transboundary or global); *range* (impact on human health and safety, the environment, capital assets, trades, etc.); *time horizon*; *type* (ubiquitous, persistent and/or irreversible); *latency*; *type of change* (incremental or breakthrough). The categorization could be said to operationalize Renn's uncertain and ambiguous risks (Table 8).

Characteristic	Uncertain and ambiguous risks
Degree of novelty	High
Scope	Dispersed/transboundary/global
Range	Wide
Time horizon	Short
Type	Ubiquitous/persistent/irreversible
Latency	Long latency period
Type of change	Breakthrough

TABLE 16 CRITERIA FOR SELECTING UNCERTAIN AND AMBIGUOUS RISKS.

Based on the criteria, 26 cases of 4 hazards were selected: CCS, nanotechnology, genetic engineering, and radioactive waste. These four hazards do not each satisfy all criteria outlined above but most of the criteria (see Table 9). An overview of each case can be seen in Appendix 2-5. These hazards were also of interest since they tend to generate risks that may be neglected or discarded out of ignorance, high technology enthusiasm, or private interests (de Marchi 2003). Moreover, these hazards have similar levels of catastrophe, comparability and data availability.

Criteria	CCS	Nanotechnology	Genetic engineering	Radioactive waste
High novelty	✓	✓	✓	
Dispersed impacts	✓	✓	✓	✓
Wide-ranging impacts	✓	✓	✓	✓
Persistent and irreversible	✓	✓	✓	✓
Long latency period		✓	✓	✓
Breakthrough technology		✓	✓	

TABLE 17 THE CHARACTERISTICS OF CCS, NANOTECHNOLOGY, GENETIC ENGINEERING, AND RADIOACTIVE WASTE THAT MAKE THEM UNCERTAIN AND AMBIGUOUS RISKS.

The literature review of practice-based literature had a sampling wider than that of the evidence-based literature. In order to examine risk communication practices, materials such reports, other output (e.g. meeting minutes or summaries), and websites were helpful in establishing each case. The literature review were structured in the same way as the review of evidence-based literature. Both reviews were drawn from the same period to ensure comparability. It was examined whether the observations found in evidence-based literature also applied to practice.

A case is defined in this study as *planned* efforts with *designated content, flows and channels*, with the intention to *communicate and/or deliberate around a risk issue* involving *a (potential) hazard*. Distinct *funders, organizers and conductors* of the risk communication can be identified, and the communication can either be on a *local or national scope* as measured by the target populations. Risk communication on an international scale was not examined because of the high complexity, involving issues of jurisdiction, sharing of potentially sensitive information between nations, and the difficulties of expanding well-established risk communication networks across national borders (Löfsedt 1996).

There were several sources for the discovery of real-life cases: references of published peer review papers; references of reports of real-life cases; governmental websites; research project websites; and public participation websites (e.g. http://www.nanoceo.net). Overall, 27 articles were found, depicting 26 cases of nanotechnology (12 cases), genetic engineering (5 cases), radioactive waste (6 cases), and CCS (3 cases). Of these cases, the risk communication of nanotechnology and genetic engineering tended to be on a societal level, with no specific project/product mentioned and no "local residents" could be identified. However, while the risk was on a national level, the risk communication was often on a local level, involving only a small number of participants. On the contrary, the risk communication of radioactive waste and CCS were all project-based, with clearly identifiable directly-affected public (mostly local residents). Again, most risk communication for these two technologies was conducted on a local level. The actual articles/reports used to describe the cases mostly came from the specific project websites, although some were also obtained from peer review journals. The majority of the articles/reports were written by the organizers of risk communication, the remaining few were complied by researchers.

4.2 SOURCES OF RISK COMMUNICATION

4.2.1 VERIFICATION OF HYPOTHESES IN PRACTICE

Three types of sources were recognized: the funders, the organizers, and the conductors. Funders are those providing financial support for the risk communication process. Organizers were the ones arranging practical matters, designing the process, and deciding on whom (experts and laymen) to participate. The conductors are the people present during the process to facilitate risk communication. However, some cases did not give a distinction between the three groups. The government (15 cases) were the most common funders, followed by research institutes/universities (8 cases), and industry (7 cases). 3 cases had an NGO as a funder. The total number did not add up to 26 because some cases had more than one type of organization as the funders. In just under 2/3 of the cases, the sources were single organizations, or were similar organizations in collaboration, e.g. different Ministries collaborating at the Norwegian consensus conference on GM food. In the remaining 1/3 of the cases, the sources had some collaboration, 5 cases had collaboration among funders, 4 cases had collaboration among organizers and conductors. Within these 9 cases, only 3 had collaboration between the funders, organizers, and conductors.

Similar to the funders, research institutes/universities, government and industry were again the most common bodies in organizers. However, research institutes/universities were most common as organizers (15 cases), followed by the government (13 cases) and industry (11 cases). An additional type of organization, independent facilitators, was often used as organizers (4 cases) and/or conductors (9 cases). Independent facilitators were the mostly used conductors, with the other organizations having far less presence in conducting (government in 3 cases, research institutes/universities in 2 cases, NGOs and industry each in 1 case). Sometimes, an organization that may not be seen as credible by the public (such as the government and industry) restricted its involvement as a funder only, while independent facilitators or research institutes/universities were the organizers/conductors.

The first area of match is the high credibility of organizers and conductors of risk communication, the majority of whom were represented by research institutes, universities and independent facilitators. Due to the distinction made in the practice-based literature, this hypothesis was applied to three types of sources in risk communication: funders, organizers, and conductors. The second area of match is the high knowledge and expertise of the sources. Only the knowledge and expertise of organizers and conductors were considered, since the funders were often not directly involved in the process. Considering the large proportion of organizers and conductors being made up of research institutes, universities, advisory bodies, and professional facilitators, high knowledge and expertise were not unexpected. The third area of match is that balanced information was provided to participants. As mentioned in Section 4.3.3, the balance of information was sometimes deduced from the variety of information sources used. A weakness of this assumption is that simply presenting different views is still different from a joint effort to produce truly balanced information. When different views are simply provided separately, the receiver may be left wondering which ones to listen to (confusion) and have doubts on the expertise since the experts who are supposed to know the facts, give conflicting or contradictory information about the risk (Fessenden-Raden et al. 1987). If balance of information is viewed in this more "stringent standard", a gap is implied. However,

the gap is more suited to the discussion of source collaboration in Section 5.1.

4.2.2 DISCUSSION OF RESULTS

In practice, while organizers and conductors of risk communication were generally credible, the funders were sometimes not. Credible organizations included research institutes, universities and NGOs, whereas non-credible organizations included the government and industry. Moreover, in most cases, the collaboration effort was limited to having each source provide information separately rather than produce joint information.

There are three plausible reasons for why the funders are not credible while the organizers and conductors generally were. The first is that the government or the industry intended to conduct risk communication, but out of realizing the shortcomings of having non-credible sources, restricted their involvement to funding only and invited credible organizations to organize and conduct the process. The other reason could be the lack of financial resources of some credible organizations that wanted to start risk communication, who then turned to the government or industry for funding. In this case, the funding bodies sometimes demanded to be involved in organization and conduct of the process as a condition of the financial support. Out of these two, the former applied more frequently to the cases reviewed. Finally, knowledge and expertise are more universally recognized than credibility, being a more objective and less subjective characteristic than credibility. For example, there is less doubt among the stakeholders about universities being knowledge clusters than about whether an organization is credible or not. As a result, in terms of collaboration, it was easier to identify those with high levels of knowledge and expertise to work with as the sources of risk communication than to find organizations with less debatable credibility.

As for the lack of "true" collaboration between non-credible and credible sources, the reasons could be two-fold. Firstly, credible organizations may have refused to collaborate with non-credible organizations when they are asked, because of the possibility of losing their own credibility (Dean and Shepherd 2007). For example, in the public dialogue on industrial biotechnology in the UK, invitations were sent to NGOs, who then declined to participate (Rathouse 2009). Secondly, credible organizations may not have been asked to collaborate by the non-credible organizations, due to many possible reasons. For example, the latter may have a narrow view of risk communication, in that risk communication should be the sole task of, e.g. the project developer, and that it is sufficient to simply provide some information. In addition, they may be concerned about the impact of the different and perceived more radical opinions held by certain credible organizations on the public's attitudes towards the risk. For instance, in the risk communication of radioactive waste siting in Sweden, the sources turned down NGOs' requests to participate in the process for "efficiency reasons", implying that NGOs' involvement (because of their opposing views) would slow down the risk communication process (Elam et al. 2008).

The importance of having a credible funder is undetermined. On the one hand, it seems

reasonable that those with a direct interest or stake in the risk issue, e.g. industry and government, are willing to contribute financially to risk communication and have the responsibility and ability to do so (personal communication with a CCS Taskforce representative). This is particularly the case where the risk is project-based. On the other hand, the funders could determine the objective of risk communication. The government or industry usually carry out risk communication out of legal requirements and/or public pressure, with high private interest (e.g. in the form of national investment, company profits). Most cases with partly credible funders or no credible funders only went as far as "to inform the citizens", whereas those with credible funders tended to have "to empower the citizens" as their objectives, which is one step further because citizens are enabled to influence decision-making. The objectives of the non-credible funders reflects the deficit model, namely to rectify the knowledge gap between the originators of scientific information and those receiving the information (Frewer 2004). Except for a few cases, where the participants could order independent research to be done (financed by the source of risk communication), participants generally did not have a say in the information sources or what they wanted to see in the information. This arbitrary choice of information reflects the top-down notion of "what people ought to know" (Fischhoff et al. 1993), instead of finding out "what people want to know". When the lack of credible funders becomes a problem, the fact that there were infrequent cross-boundary (e.g. an NGO collaborating with the industry) collaboration may exacerbate this problem. It was not uncommon for different organizations of the same type collaborating, e.g. between governmental ministries. This may have positive or negative impacts depending on the credibility of the sources. For example, if participants did not perceive governmental ministries as credible, then having them collaborating may be worse than only having one of them. Whereas if universities were considered credible by the participants, having universities collaborating with one another may reinforce the source credibility overall.

4.3 PARTICIPANTS OF RISK COMMUNICATION

4.3.1 VERIFICATION OF HYPOTHESES IN PRACTICE

Six types of participants can be derived from the practice-based literature: the government, industry, scientists, NGOs, the media, and citizens. For citizens, three categories can further be distinguished: 1) self-selected citizens; 2) citizens that were selected by the source of risk communication according to socio-demographic characteristics; and 3) citizens that were selected to be representative of the population in the geographic area of risk communication. Selecting non-representative citizens to participate in risk communication was most common, with 13 cases having done so. Self-selected citizens were the second most common type of citizen participants (11 cases). Only 2 cases recruited representative citizens.

The target groups and the non-participating public are different for the four risks reviewed. Nanotechnology and genetic engineering are risks on a societal scale, which could potentially affect the population of a whole nation, should they be introduced and developed. CCS and radioactive waste, however, would only exert influence on a project level. An interesting

observation is that wherever the risk was on a societal level, the participants tended to be selected by the organizers; whereas when the risk was on a project level, participants were normally self-selected. However, the difference was not significant.

Evidence of informing the wider public was also rare, with 5 cases having done so. All of them were done through the mass media, by either inviting journalists to observe the process or hosting press conferences after the process. Of the cases reviewed, risk communication of nanotechnology and radioactive waste tended to be carried out before strong attitudes were formed among the (citizen) participants. Mixed evidence was seen for CCS cases. Risk communication for genetic engineering was generally extemporaneous in nature and conducted in response to past failures or public protests.

Some evidence has been found for engaging the public before strong attitudes have been formed. The evidence clustered around nanotechnology (7 out of 12 cases) and radioactive waste (5 out of 6 cases). 1 of the CCS cases also had upstream engagement. However, no evidence was found for genetic engineering cases.

4.3.2 DISCUSSION OF RESULTS

Rogers-Hayden and Pidgeon (2006) characterize upstream engagement as occurring very early, before significant R&D, and consequently before many examples of the technology exists for people to access in everyday lives, before media representations are firmly established, and before there is widespread public knowledge of the technology. It is the opposite of downstream engagement, which occurs as a response to controversy arising at the point of market entry of a product or process, when decisions cannot be influenced anymore. Upstream engagement is used here to indicate the hypothesis which states risk communication is more effective when it is conducted before strong attitudes are formed. Some evidence have been found for this hypothesis in practice, which clustered around nanotechnology and radioactive waste. While genetic engineering generally had downstream engagement, evidence for the few cases of CCS was mixed.

Risk communication of radioactive waste being upstream was unexpected, since "waste" implies the end of a pipe. In fact, the radioactive waste risk communication could only be considered pseudo-upstream at best, because in all cases it was conducted to communicate risks related to the siting of radioactive waste, meaning that a decision had already been made more upstream to store the waste. However, it can still be considered more upstream than the siting of CCS projects, where risk communication was only carried out after sites had already been chosen. Pidgeon and Rogers-Hayden (2007) explained why nanotechnology engagement could be upstream. They note that: 1) decisions that will affect the future trajectory of nanotechnology, i.e. related to research funding and R&D infrastructure, are not made yet; 2) many impacts of nanotechnology are still not envisioned, hypothetical, or will depend on its convergence with other technologies; and 3) nanotechnology does not have a prominent place in the public discourse yet, and awareness of nanotechnology among the general public is low. Another plausible explanation for nanotechnology risk communication being upstream may be

the "past failure" of genetic engineering risk communication, from which lessons could be learnt. Both being relevant as consumer products, many similarities exist that could prevent the risk communication of nanotechnology from going onto the same path as genetic engineering, where risk communication only occurred as a response to controversy and/or accidents.

Conversely, Reiner (2008) suggests some possible reasons for not carrying out risk communication upstream from the perspectives of the sources of risk communication. The sources may fear that risk communication would raise concerns that the technology is hazardous. Furthermore, when development is upstream, investment of efforts and money in risk communication is seen as diverting resources needed to develop the technology itself. Risk communication is viewed as necessary only when the development of the technology has advanced into a more mature stage. A representative of the CCS Taskforce recognizes the fault of the risk communication sources of starting too late, but also points out that the public often become interested only when something has happened (personal communication).

Not involving the public upstream has three implications. Firstly, it means that risk communication is a one-way process, in which influence is exerted by the sources of risk communication onto the public and not the other way around. Secondly, those involved may develop distrust in the motives of the sources, since they may be given the impression that the sources are only conducting risk communication out of routine instead of out of real concern and care. Finally, downstream means that a higher proportion of the public have already developed some form of an opinion on the risk. Whatever the objective of risk communication is (and particularly when the objective is to influence risk perceptions), firmly established opinions mean that effectiveness of risk communication is reduced, unless the information provided is in line with the established opinions. Such coincidence is not likely since a variety of opinions are likely to be present and the information cannot be in accordance with every strand of opinions.

This is the most striking mismatch between theory and practice. When a case had self-selected citizens as the participants, target groups were not differentiated. However, even when participants were selected by organizers, it was still the same. It could be argued that, implicitly, more cases have made a distinction between societal groups. For example, by providing information materials at an information center with different reading levels and technical details, different societal groups could choose how they would like to be targeted. A reason why this kind of efforts did not go further into explicitly separating target groups may be for ethical considerations, as it would only be fair that every individual were exposed to the same type and amount of information and had a free choice. However, this argument is only restricted to the information provided and would not be valid for channels of risk communication, since for the same information, communicating through different channels (e.g. lectures and interactive games) would be better suited for different needs. As for informing the wider public, the necessity was possibly overlooked wherever risk communication is open to the public, e.g. through the establishment of an information center or a website. The wider public is assumed to be automatically reached. However, sometimes risk communication is more than establishing

information structures, e.g. if a public meeting is held. In these cases, the wider public may be excluded because they were not seen as relevant to the risk, because they may not be interested (since they chose not to attend the events), or because it is not cost-efficient to involve them.

Having open participation may seem the fairest, and possibly the most straightforward and least costly way of involving participants. However, this is likely to exclude the marginalized groups, which may be most affected by the risk but are at the same time least likely to participate in risk communication (Russell 1999). Differentiating between target groups is important because risk perceptions differ across groups according to risk perception studies (see Appendix 1). All individuals are characterized with their own personalities and risk perceptions, and bring with them a background of prior and contemporaneous experience and knowledge to the risk communication process (Fessenden-Raden et al. 1987). Individuals also differ in terms of risk susceptibility, exposure and risk literacy (Russell 1999). Finally, the fact that risks are not uniformly distributed across society provides an additional reason to examine the implications of different groups (Vaughan 1995). By grouping these individuals on similarities, risk communication approaches could be more precise and efficient in addressing group needs. Opportunities could be lost if everyone receives the same information, even if they might not want to. For example, those with high interest and education may want more detailed information and have the ability to understand such information, whereas those with low education and not as interested would not want to read or cannot read the information disseminated.

Particularly for the cases where participation was not open to all, there were likely to be people who were not directly involved but were still interested in learning about either the process (e.g. Who were the participants? What were their objectives? What was the information like?) or the outcome (e.g. What trade-offs were made? What decisions were made?), or both. The problem of reaching only a small section of the public is not so significant when that section is representative of the population and trusted by the rest of the population, but this is often not the case (personal communication with a CCS Taskforce representative). Even when risk communication was open to all, there may be certain section of the public who did not participate (if risk communication was a single event) due to lack of time, distance, etc. or who did not know how to access the information available. Often, the most vulnerable or disadvantaged groups also tend to be the groups least likely to participate in risk communication (see Section 2.6.3). Without a plan to inform these non-participating people, they would be "forced" to turn to other sources for information, for example, the mass media or social channels (e.g. friends and neighbors) (Arvai 2003). Because these types of "unofficial" sources may not have participated directly in the process either, the non-participants are likely to obtain inaccurate reflection of the risk communication, which may lead to mistrust and discouragement for future participation (see SARF in Section 2.3.3). If the process included public participation, by showing the non-participants that the process was participatory could increase their acceptance of decisions (Arvai 2003).

4.4 CONTENT OF RISK COMMUNICATION

4.4.1 VERIFICATION OF HYPOTHESES IN PRACTICE

There were two main types of content. The first one was paper-based. "Paper-based" content was not necessarily written on paper. Rather, it was used to make a wider reference to the content with objects of information that can be given to participants without much or any human interference. Examples included information brochures, postcards, display boards, newsletters, comic strips, advertisements, official reports, e-alerts, websites, exhibition, workbook, CD-ROM, and documentary. The second type of content had more people-involvement. Involvement could be one-sided (e.g. presentations and laboratory experiments) or two- or more sided (e.g. questions and answers (Q&A), narrative-imaginaries, software, guided tours, interactive exhibits, and interactive games).

Unfortunately, the reporting of most cases did not go so far in details in their cases, except with respect to the balance of information. Some cases did not provide explicit detailed information on the content, but information was either derived by the author from the description/evaluation wherever possible or was obtained from the content itself (e.g. brochures, leaflets, etc.). Half of the cases used balanced information, while the other half either did not use balanced information (5 cases) or information could not be obtained on them (8 cases). Whether the information was balanced or not was not always explicitly stated. However, whenever a case included a variety of experts as information sources, that may incorporate both positive and negative viewpoints, it was taken to provide balanced information. The remaining of the characteristics only had few cases with available information: admission of uncertainty (4 cases with strong evidence, 1 with some evidence and 1 with none); simplicity (5 cases with strong evidence, 1 with some, and 2 with none); illustration with graphics (6 cases with strong evidence); value-based (5 cases with strong evidence, 1 with some and 2 with none); no commanding tone (2 cases with strong evidence); qualitative information (4 cases with strong evidence); narrative or conversation-style (4 cases with strong evidence, 1 with none). It can be seen that, of the cases with available information, there was more matching than mismatching areas between theory and practice.

4.4.2 DISCUSSION OF RESULTS

Although there were some evidence for content-related characteristics, they will not be elaborated on. The lack of information may be because the authors of the reports would only write about certain traits of the content when they are positive, as opposed to independent evaluators (in a small number of the cases), who would point out the weaknesses as well.

4.5 CHANNELS OF RISK COMMUNICATION

4.5.1 VERIFICATION OF HYPOTHESES IN PRACTICE

There were three main types of channels. The first one being an **information structure**. This

kind of channels included library, information centers, and telephone hotlines. Sometimes, local facilities are used as an information structure, e.g. local school and the local council. Using local facilities may be able to increase the "at-home" feeling of participants, in the hope to increase their trust in both the source and content of risk communication during the participating process. In an information structure, information is provided, participants could pay the structure a visit or give it a call, voluntarily, to read or hear the information. Sometimes, interaction was present within the information structure, e.g. when citizens were able to ask questions and discuss with experts in the information structure.

The second was the **mass media**. There were *journalistic* (e.g. local newspaper, TV programs) and *non-journalistic* mass media used (e.g. newsletters, official reports). This channel is similar to information structures in that they both have an information provider and a potentially very large section of the public. The difference is that with the mass media, information is provided to the public whether they requested it or not, but it is up to those exposed to such information if they want receive and accept the information. The participants play a more passive role than in the case of information structure. The mass media was not only used as a channel before or during risk communication for the participants, but was also used to disseminate the output of risk communication to the wider non-participating public. For the former, paper-based information, documentary films, and the internet were included. For the latter, newspapers and TV were commonly used. Additionally, newsletters and official reports were used. Some cases were open to the nation and thus used the mass media for both purposes.

Another channel is **interaction**. Face-to-face meetings/discussions were most representative of this type of channel. Other examples also included role-play, training, guided tours and multimedia (such as interactive software). Interaction was used in all the cases reviewed. Nevertheless, the extent of interaction differed among cases. A lower level was in the form of information meetings, where experts delivered presentations, after which citizens could ask questions. Examples of higher levels of interaction included role-playing, discussions via interactive software, and roundtable discussions.

Non-journalistic mass media was second mostly used as a channel, with 18 cases having used it. Journalistic mass media and information structures were less common, with 8 and 7 cases having used them, respectively. When risk communication was based around a project (e.g. a CCS project or a radioactive waste siting project), information structures (particularly local facilities) were often used, whereas they were not used in the risk communication of nanotechnology and genetic engineering, the risks of which are not confined to a project. Only 1/5 of the cases have used all channels. Most of the cases (11) used 2 channels, only 3 cases used 3 channels. Using only one channel was not uncommon, which was done in 7 cases.

4.5.2 DISCUSSION OF RESULTS

There was generally more than one type of channel used for each case. Interaction being used as a channel in every case may be partly because the cases were located with "public participation" (or similar phrases) as part of the search key. However, there are a number of cases that did not use journalistic mass media as a channel. It means that unless happened to be reported by the

journalistic mass media (unintentionally of the sources of risk communication), the risk communication carried out was never communicated to the non-participating public. Thus although the channels used were generally diverse, little use of the journalistic mass media is acknowledged as a gap, which was elaborated on in Section 4.3.2 about informing the wider public.

4.6 SUMMARY OF COMPARISON BETWEEN THEORY AND GENERAL PRACTICE OF RISK COMMUNICATION

Table 10 presents a summary of the comparison between evidence-based literature and practice-based literature.

Component	**Risk communication is more effective when…**	**Evidence found in practice-based literature**	
Source	H1: Credible organizations are involved and collaborated with as sources (refined as funders, organizers, and conductors).	Funder Organizer Conductor	Sometimes Often Often
	H2: The sources should have a high level of knowledge and expertise.	Often	
Participants	H3: Participants have not yet formed strong attitudes about the risk issue.	Sometimes	
	H4: Target groups are differentiated and information is designed for each target group.	Rarely	
	H5: The non-participating public should be informed about the outcome of risk communication.	Rarely	
Content	H6: The information is balanced.	Often	
	H7: Scientific uncertainties are displayed in the information.	Mostly did not have information available	
	H8: Simple lay language is used for the information.		
	H9: Graphics are used to illustrate the information.		
	H10: The information focuses on not only relevant facts to the risk but also values.		
	H11: The information does not use a commanding tone.		
	H12: The information is (mostly) qualitative in nature.		
	H13: The information adopts a dialectical or narrative style.		
Channels	H14: A variety of channels are used, including (quality) journalistic and non-journalistic mass media, and interactive channels.	Often	

TABLE 18 SUMMARY OF THE THEORY-PRACTICE COMPARISON.

5. RECOMMENDATIONS FOR THE NETHERLANDS

After obtaining insights on the gaps between the evidence-based literature and practice-based literature, as well as appraising possible reasons for these gaps in the last chapter, the current chapter discusses whether or not these gaps also apply to the Netherlands, given the past and present practices of risk communication of CCS. For each gap, possible recommendations to improve risk communication in the Netherlands against the "best-practice" of effective risk communication are made.

5.1 METHODOLOGY

This part drew on secondary data compiled by other researchers such as interview records, databases, scientific publications and reports available. It also obtained information from key informants that are involved in CCS and/or risk communication in the Netherlands through interviews. Key results of theory-practice comparison were presented to the informants during the interviews and the informants were asked whether they recognized such findings in practice. Questions were also asked on their views about CCS risk communication in the Netherlands, based on their work experiences. Overall, 6 interviews (or semi-structured questionnaires with the same content as in the interviews when interviews were not possible) were conducted in July and August 2010 with a wide array of actors that are relevant to CCS risk communication in the Netherlands, including representatives from: project developers, environmental NGOs, scientific researchers, scientific journalists, CCS Taskforce, and an environmental agency in a region with CCS projects. The aim of the interviews was to 1) detect differences in recognition of theory-practice gaps that may potentially apply to risk communication of CCS in the Netherlands; and 2) gain insights on how actors with different types of relevance to CCS projects (and potentially its risk communication) view risk communication in the Dutch context. The insights from the interviews/questionnaires were used to validate the application of the findings to the Netherlands, as well as to draw recommendations for future risk communication practices. The names of individuals and organizations were omitted from the reference since anonymity was guaranteed to the interviewees in order to obtain the opportunities for interviews.

5.2 CREDIBILITY OF FUNDERS

In the Netherlands, the national government and project developers are the two sources currently funding risk communication for CCS, as well as the main actors organizing and conducting risk communication at present. These two organizations tend to be the ones perceived as the least credible by the public (see Section 3.2.2). Interestingly, when asked about who should be responsible for risk communication in the Netherlands, different actors held rather different views. A project developer sees risk communication as the responsibility of the national government, for they are ones advocating for CCS in their policy (personal communication). A representative of an environmental NGO, however, points out that a CCS

project is solely the responsibility of the project developer, which includes communicating the risks (personal communication). A scientific journalist disagrees with both views by stating that an independent body should be the source, an example of which is the local government, who does not necessarily hold strong opinions about CCS but somehow still has the responsibility in the issue (personal communication). Finally, a representative of an environmental assessment agency thinks that at the demonstration phase, it should be the national government (who is putting forward CCS) who should be mainly responsible for risk communication; whereas in a later phase, the project developers should be the main actor responsible (personal communication).

Judging from both the physical (at information center) and virtual (on the CCS websites) information provided to the public, there seems to be no sign of imbalance or any deliberative attempt to "hide" information about certain aspects of CCS, despite the government and project developers (pro-CCS organizations) being the funders. Various sources of information were present both at the information center and on general CCS websites, including the government, project-developers and other industrial organizations, as well as research organizations. However, on project-specific websites and at public meetings, information was one-sided in that it only came from sources related to the proponents of the project, e.g. TNO, project developers, and the government. Problems also existed in the presentation of information. The omnipresence of the project-developers across different types of information and channels was not instrumental to the establishment of information credibility. True collaboration occurred on national level in the form of a website with general information on CCS, which was a joint effort by the government, industry, NGOs and academia. There is also a research project (CATO2, follow-up on CATO), with a consortium of wide-ranging organizations from energy companies, other industries, universities, other research institutions, Ministries, NGOs, and environmental agencies. As pointed out by most interviewees, this collaboration is an advantage unique to the Netherlands. No such efforts were identified for project-specific risk communication.

It may not be possible to have project-developers retreat from information provision, with them being one of the organizations responsible for the operation and monitoring of CCS. Nonetheless, two strategies may be attempted. The first is that risk communication should be a joint effort with equal contribution from all parties, instead of each party pushing forward its own agenda without the consideration of others'. Secondly, considering the positive role of trustworthiness of information sources and collaboration between information sources may play, project-developers and the government could cooperate with, e.g. environmental NGOs, in producing information together. The possibility to work with Dutch NGOs is also acknowledged by a representative of a CCS project developer (personal communication). Moreover, a representative from an NGO indicated the general willingness of NGOs to participate in risk communication (personal communication with representative of an NGO). While there are a number of NGOs that strongly oppose CCS development, several other NGOs give support for CCS under certain conditions (e.g. the development of CCS cannot impair the development of renewable energy). Working with the latter NGOs is therefore possible. However, the project developer pointed out the difficulty of putting the collaboration idea into practice as the project

developers do not have the sole decision power. They are dependent on other actors such as the government in the making of these decisions, who may not necessarily hold the same views about involving NGOs. The validity of this statement, however, was not checked with the government. No recommendation for practice was made for involving credible organizations as funders, since its impact is unknown. Rather, the recommendation for further research is to investigate the effect of having credible funders on the risk communication process and outcome.

5.3 UPSTREAM ENGAGEMENT

Some "upstream" characteristics are possessed by CCS in the Netherlands. The Dutch government has given CCS a favorable position in the national policy, and as mentioned in Chapter 1 is taking a 4-step approach to CCS, namely: fundamental research, pilot projects, demonstration projects, and commercial projects. CCS development is already at the demonstration projects phase, two of which are supported by a governmental grant of €60 million. There is a well-developed and well-connected R&D infrastructure, e.g. the CATO-2 research program, which is a joint effort by governmental organizations, NGOs, universities, other research institutes and the industry. While the future trajectory of CCS may not be easily modified, considering how far down the line CCS development has evolved, there are still uncertainties surrounding the technology. Experts tend to disagree on the severity and probability of an accident in the transport and storage of CO_2, and it remains unclear how much CO_2 can be cost-effectively reduced and what are the impacts on the pricing of CO_2, as well as the impacts on the development of renewable energy in combination of CCS. Finally, except for in Barendrecht, there is not yet significant public discourse on CCS in the Netherlands. Because of the lack of awareness and knowledge, these attitudes and risk perceptions could only be said to represent the views of the respondents at the time of the survey or interview. A study by de Best-Waldhober and Daamen (2006) showed that uninformed opinions are unstable and cannot be used to predict future opinions. Other authors have also confirmed that uninformed attitudes and risk perceptions are not firmly anchored, and subject to change upon information provision. Depending on the type and content of the information, the change could be from more negative to positive (e.g. Itaoka et al. 2004, Tokushige et al. 2007, Shackley et al. 2005, Huijts et al. 2007) or the other way around (e.g. Palmgren et al. 2004, Ha-Duong et al. 2009). The potential role information can play is great, leaving a large gap for risk communication to fill. On the other hand, the controversy around Barendrecht has already created its own dynamics (personal communication with an NGO representative). Nevertheless, the controversy may still be confined to the project area itself. Upstream is also important in order to address any concerns early. Instead of ignoring the concerns and downplaying the risks, every concern should be seen as valid and addressed in a serious manner. Otherwise the opponents of CCS may catch the opportunity to develop their own momentum first, which may in time turns into organized protesting and distrust against the sources. When this happens, a remediation measure may be to start an institutionalized debate that is transparent to citizens so they can gauge the extent of disagreement, tell the center of opinions away from the fringe, and to discern the most

important bases of disagreements (Stern 1991). The action of "sitting around the same table with opponent and negotiate" is seen as typical of the long-established Dutch culture of "polderen" (personal communication with representative from the CCS Taskforce, with representative from regional environmental assessment agency).

5.4 DIFFERENTIATING AMONG THE PUBLIC

Risks associated with CCS are project-based. Although only residents living near a project site are the main ones affected, they should not be the only ones to whom risks are communicated. Due to the importance the Dutch government has attached to CCS, CCS will soon spread to other parts to the Netherlands. At present, there are onshore small-scale demonstration projects in Eemshaven, Geleen, Buggenum, Maasvlakte, Barendrecht, and Ijmond (Source: CATO-2 website http://www.co2-cato.nl/cato-2/locations). They represent locations in the west, north and south of the Netherlands. In addition, the government may extend their support for demonstration projects further by supporting several large-scale projects in 2015, in order to gain more experience before the broader deployment of CCS around 2020 (VROM 2007). The (potential) wide geographical spread provides rationale for risk communication to not simply be carried out on a project level but to the national population, many of whom would be affected by different projects. This is especially the case since the Netherlands has high population density (personal communication with scientific journalist and with project developer). Even for those not directly affected by the projects, because of the widespread use of CCS, risk communication is the way to realize citizens' right-to-know about a significant energy option in the country. Currently, risk communication of CCS in the Netherlands is confined to the project area (personal communication with a project developer) despite the (potential) broader political and public interest. Moreover, in the Netherlands there are different dimensions to the CCS debate. On a higher level, there is the debate of whether CCS should be developed or not. On a lower level, there is the debate, among those who think CCS should be developed, about the siting of CCS projects. These dimensions of debates are present irrespective of the size or location of an area, implying the necessity to differentiate between different groups with different opinions in risk communication.

In light of the gap, the public could be divided into different groups. Miller and Pardo (1999) distinguish between *attentive* public (with high interest in the issue and feel well-informed); *interested* public (claim to have an interest but not feel well-informed); and *residual* public (neither interested or feel well-informed). No study has yet been carried out on the classification of the Dutch public on the CCS issue. The attentive public could be a small section of the residents near a planned or implemented project site as well as an even smaller section of the public elsewhere in the country, whereas the interested public could be the majority of the remaining residents near the project site as well as a small part of the national population. Most of the population in the Netherlands (that do not live close to a project area) are not expected to take much interest (the residual public). The attentive public will seek to be involved whether or not a proactive approach is taken by the sources of risk communication to involve them. Instead of excluding them (and risk the development of antagonistic stands and mistrust), risk

communication should be designed according to the characteristics of such a group, i.e. What drives their interest? What is their educational background? How much do they know already about CCS? It is unlikely that such individuals would be interested in non-interactive risk communication due to their strong interest and possibly opinions, hence straightforward information provision is not recommended. The interested public do not feel well-informed and so information is key. An investigation of the cross-section of this type of public would reveal clusters of individuals that could be targeted with different strategies, ranging from interactive exchanges, information meetings, or more passive ways such as information centers, newsletters, and the internet. Finally, risk communication to the residual public is tricky. On the one hand, journalistic mass media seems the most efficient way to reach the residual public. On the other hand, this channel provides messages that are easy to ignore (Scherer et al. 1999). Moreover, some of the journalistic mass media could be biased. Although not able to solve the former problem, the bias problem can be reduced by setting up meetings between journalists, scientists and risk managers and training of journalists both in scientific writing and in understanding of science (Slovic 1986; Russell 1999). Such media improvement may be costly at the start but the establishment of a long-term communication channel for not only a single CCS project but all future CCS (and possibly similar non-CCS) projects may be worth the investment. The dynamics of the different public(s) should be reviewed from time to time as the boundary between them is permeable. For instance, as an issue moves closer to community concern, more of the non-attentive public will become engaged (Reiner 2010).

6. SUMMARY

Many risk problems today can be classified as risk communication problems, particularly for uncertain and ambiguous risks. In the past, when our society was faced with more straightforward risks, expertise automatically granted legitimacy. When the risks are uncertain and ambiguous, no single (or sometimes even combined entity) can be said to possess absolute expertise on a risk issue. Consequently, legitimacy needs to be gained from risk communication.

Although the literature on risk communication have started forming in as early as the 1980s, they remained largely conjectural and intuitive, which is of limited use for practice. Meanwhile, public controversies around technological risks do not cease to be seen, which could (at least partly) be due to failures in risk communication. The objective of this thesis was to investigate whether or not there were gaps between "what has been proved to be effective" and "what has actually been used in practice", and to examine whether the gaps apply to CCS risk communication in the Netherlands and infer recommendations.

From the 1990s onwards, field studies have been conducted to test the effectiveness of certain risk communication strategies. At the same time, some risk communication processes that have been carried out since the 1990s have been assessed by independent evaluators in order to find out whether certain strategies were effective or not. Although proven effective in evidence-based literature, the recent proliferation of promising and empirically-tested risk communication strategies has not always been matched by widespread and effective implementation in real-life settings. The first and most prominent gap lies in the way public are involved. While it has been shown that risk communication is more effective when the public are divided into target groups (including a target group of non-participating public) that can be approached with different strategies, very few real-life risk communication projects have actually done so. A second gap is the sometimes lack of upstream risk communication in the course of technological development. The final gap was that the funders were sometimes not credible organizations despite credible sources tend to be beneficial for the effectiveness. Contrary to a presumption earlier on in the thesis, none of the gaps occurred because the theory was too parsimonious in that it missed important variables and needed extension. Across the real-life cases reviewed, there were always at least some (although very few) cases in which the gap was not observed for the above three descriptions. Moreover, there were many ways to bridge these theory-practice gaps that are not impossible to actualize for the sources of risk communication. The main contribution of this study to the field of risk communication research is the linking of two fields in risk communication that ought to be well-connected but is rather separated at present: the field that conduct primary research to produce knowledge and the field that puts knowledge into practice to produce results. This exploratory study attempted to find explanation for the missing link of the “knowledge” part, which had hardly been addressed in previous studies. As mentioned by one of the interviewees, realizing the gaps early enough can be a challenge in itself (personal communication with a CCS Taskforce representative).

7. LIMITATION OF STUDY AND FUTURE DIRECTIONS

One of the biggest limitations of this study was the assumption that risk communication remains within a closed system with no influences from a bigger context such as legislation and history of the risk issue and risk communication in general. Vaughan (1995) argues that studies that isolate a risk from the surrounding social and cultural dynamics may provide only a limited understanding of risk responses. At the start of the study, however, this limitation was already acknowledged when the scope of study was defined, because the societal context is too broad for the aim of this study. Care was taken to minimize the effect of societal context by selecting cases from countries with similar stage of economic development and similar culture (to some extent). Nonetheless, because the Netherlands has its own dynamics that were also not taken into account when the recommendations were made, the recommendations remain on a general level. An example of the contextual factor is the legislation regarding public participation in decision-making. Because the requirements of EIA only went as far as "to inform", the risk communication efforts did not go one step further "to empower" (personal communication with scientific researcher). Future studies could consider the Dutch societal context and translate the recommendations into more detailed levels of action as well as more detailed level of the project (according to project-level context).

A second limitation was the comparability of the technological risks reviewed. While nanotechnology and genetic engineering are on a societal level, radioactive waste and CCS are on a project level. An implication of the difference in level is that the participants in risk communication may be different, since the NIMBY syndrome may be acute in project-level risks, whereas in society-level risks all consumers are affected. In addition, the content may be different in that project-level risks would provide project-specific information on top of general risk information. However, this limitation was inherent in the design of the study in order for a sufficient number of cases to be obtained for aggregation and comparison. Future studies could include only technologies with project-level risks to see if the gaps could be confirmed. Some good examples of such technologies are renewable energy projects, which were excluded from this study because they were not considered uncertain and ambiguous risks.

The third limitation was the lack of information available about most content-related characteristics (except for the balance of information) across most of the cases reviewed. This limitation stems from the reliance on often limited number of descriptive materials on each risk communication case (in most cases, only 1 report was available), most of which tended not to present sufficient details on the established content-related characteristics.

There are several other suggestions for future research. Firstly, there are several components of risk communication that are often mentioned in the practice-based literature (and sometimes in the theories of risk communication as well) but not addressed in evidence-based studies, i.e. objective and flow of risk communication. These could become the topics for future experimental studies to examine what strategies related to these two components could make

risk communication more effective. For example, "to inform" and "to empower" are the two main forms of objectives in risk communication, with the latter being one step further on the part of the risk communication sources to enable citizens to have a voice. Studies could be conducted to examine whether risk communication with the objective to empower, with other components being the same, is more effective than risk communication with the objective to inform. Another example is the presence of one-way flow and two-way flow in risk communication in different cases. Studies could investigate whether risk communication with two-way flows is more effective than risk communication with one-way flows.

Secondly, at the moment, the objective of the risk communication strategy for CCS in the Netherlands is to inform (and to convince, to a certain extent) the public living around a project site, by giving them information on climate change, the CCS technology, and the CCS project. As mentioned by a representative from a prospective project, the project developers do not expect citizens to do more than being educated (personal communication with project developer). The objective should be designed according to the actual situation. Do people truly not understand CCS, which is why they oppose to the project? Or do people actually have considerable knowledge about CCS, but still choose to oppose to the project anyway? Or, rather, is it only a small group of the public that is actively protesting against CCS, which does not actually represent the prevalent views? So far, no information has been found on the rationale behind the need for risk communication, leaving knowledge gaps for research to fill.

Thirdly, project developers often feel lost about developing risk communication plans because they do not have an idea about how much the citizens actually know (personal communication with project developer). To complement risk communication studies in the future, surveys of the state of public knowledge of CCS could be carried out so that the information provided is at an appropriate level (i.e. not so detailed that the public feel that they are treated as ignorant persons, and not so abstract that the public still would not be able to grasp the concept). This should also be combined with the cross-section analysis of the public, in order to assist the differentiation of target groups.

Fourthly, there is a prevalent assumption in risk communication that informing the public would lead to awareness, which would then lead to changing attitudes/behavior (Gough 1991). However, it is only under highly specified conditions, when properly executed, with certain target publics, would such informing have the desired results (Sims and Bauman 1983). Risk communication of CCS has so far only been seen for the Barendrecht project. With the advent of more CCS projects being under planning and possibly implementation in the near future, now would be a good opportunity to review whether the risk communication efforts at Barendrecht has led to desirable effects. If not, the possible adaptation to be made could be communicated to future project developers. If so, knowledge-sharing is equally as important.

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APPENDIX 1. FACTORS INFLUENCING RISK PERCEPTIONS

Category	Factor	Effects on risk perception
Individual characteristics	Gender	Men perceive risks as lower than women do. Slovic (1999) focused on women's vulnerability to violence, and their life nurturer responsibility that results in more concern about human health.
	Family structure	Family with young kids in particular might perceive the risk to be high because they feel more protective of their family members (somewhat similar to women in the gender factor) and having young kids make them feel more vulnerable to such risks.
	Income	People with higher income often have more choices in life, e.g. regarding where to live. They are also more powerful in influencing decisions. Thus they may feel that they have more control over their risk exposure and perceive risks to be lower.
	Education	People with higher education may have more knowledge regarding hazards, therefore they may perceive the risk to be lower based on the statistics. They may also think the opposite exactly because of what they know about certain hazards.
(Perceived) Attributes of risk	Voluntariness of exposure	A higher level of risk becomes acceptable if people take it voluntarily (Fischhoff et al. 1978). For example for nuclear energy, nuclear power plant employees rated the risks lower than the general public or workers in other industries such as coal fired power plants, partly because they voluntarily undertook the risks (Sjöberg 1999).
	Personal control over outcome	If there is higher personal control over the outcome of the risk, i.e. with one's own skills and action instead of being at mercy of chance or the skills of others, the perceived risks tend to be lower (Otway and Von Winterfeldt 1982).
	Certainty about risk of exposure	When people know what to expect when exposure to the hazard occurs, particularly when the experts share a consensus among themselves, they tend to perceive the risk as lower (Otway and Von Winterfeldt 1982).
	Immediacy of effects	Delayed somatic impacts of the risk, e.g. in the form of carcinogens and radiation, increase people's risk perceptions of a hazard(Otway and Von Winterfeldt 1982).
Contextual factors	Trust	People perceive smaller risks when they trust the risk management authorities (Siegrist and Cvetkovich 2000). The disagreements between experts themselves can diminish public trust (Slovic 1999).
	Mass media	It is usually understood that the media is biased when reporting risks. However, it should be recognized that although differences in coverage of risks from experts' viewpoint exist, they are smaller than assumed (Hinman et al. 1992). The extreme opinions are often removed, and the media does not necessarily impose negative views on the general public. On the other hand, people are more convinced by the sources of bad news than those of good news (Slovic 1999). Therefore any negative information about nuclear power in the mass media can contribute to fortification of people's distrust on this technology, and leave a greater impact than the benefits it brings. Because individuals pay more attention to the negative events, the media also follows their preference by reporting more of those, thereby further increase people's perceived risks (Slovic 1999).
Personal experiences with	Perceived benefits	When the benefits of a potential hazard are considered to be high, it is viewed as having low risks, and vice versa (Alhakami and Slovic 1994; Starr 1969).

Category	Factor	Effects on risk perception
	Familiarity with the hazard	More familiarity with the hazard tends to reduce risk perception. Nuclear power plant personnel are more familiar with nuclear technology than the average lay people, which is why some studies have found they also tend to view nuclear energy more positively than the average lay people (Kivimäki and Kalimo 1992; Sjöberg and Drottz-Sjöberg 1991).
	Availability of comparisons	In a study of risk perceptions of nuclear plant employees (Sjöberg 2000), the results showed a relationship between the perceived nuclear risk and other risks they were exposed to. If risks from other activities were perceived low, they rated nuclear risk as low since they were not alerted to danger signals. On the other hand, when other risks were high, nuclear risk was still considered low due to contrast effect.
	Previous experiences with the technology	The role of experiences varies widely according to Johnson (1993): a factory smoke could symbolize pollution to some people, who fear such signs; or the smoke could symbolize jobs to other people, who are then reassured. Similarly, the invisibility of radiation in nuclear energy might provoke fear to some people because such 'invisible objects' could be ubiquitous and potentially cause cancer. On the other hand, other people might find comfort in not being able to see the radiation. As for probability of the risk, people tend to use experiences to judge an event as more likely if it is easier to recall or imagine. For a nuclear accident, because the average lay people are inexperienced, they are likely to overestimate the frequency of such events. However, those with experiences do not necessarily accurately estimate the risk. They might be biased and judge the risk as smaller because they survived it or because they do not imagine another occurrence.
	Distance from risk	The shorter the distance to a hazard, the lower the risk is perceived. People living closer to a nuclear power plant tend to perceive the risks to be lower than people living further away (Wiegman et al. 1994). They either had a preference for such a site, or because they were dependent on nuclear energy due to jobs, they were unlikely to move away from the risk area and had therefore learnt to accept the risk at a higher level. Another reason is that they discovered that it would be possible to live with the potential hazard (Maderthaner et al. 1978).
	Perceived causes	When the source of accidental risk comes from human failures rather than natural forces, people tend to view the risks as higher (Otway and Von Winterfeldt 1982).

APPENDIX 2. NANOTECHNOLOGY RISK COMMUNICATION

NANOTECHNOLOGY FOCUS GROUPS IN NEW ZEALAND (COOK AND FAIRWEATHER 2005)

The nanotechnology focus groups in New Zealand had the goal to inform the development and implementation of nanotechnology applications through developing an understanding of relevant public reactions. Several objectives were defined: to investigate and identify salient attitudes, beliefs, views and values arising from possible developments of nanotechnology; to identify and compare reactions to particular applications as well as overall attitudes towards nanotechnology; to understand ethical and social reactions to, and implications arising from, a range of nanotechnologies; and to provide guidance for processes of interaction between scientists, policy-makers and the public. The focus groups were funded by the MacDiarmid Institute for Advanced Materials and Nanotechnology.

Participants were solicited using local primary schools, representing a range of levels of income. In the first session, participants were given a booklet with information about the aims of the meeting, as well as a brief introduction of nanotechnology. In the second session, participants were shown a documentary made by the European Commission (EC), called "Nano: the next dimension".

Component	Nanotechnology focus groups
Source (funder)	MacDiarmid Institute for Advanced materials and Nanotechnology
Source (organizer)	MacDiarmid Institute for Advanced materials and Nanotechnology, local schools, fund-raising committees
Objective	To inform the development and implementation of nanotechnology applications through developing an understanding of relevant public reactions
Participants	40 participants with different levels of personal income from within the school zone.
Flows	Experts <-> public, public <-> public
Content	Booklet introducing nanotechnology, documentary made by the EC
Channels	Mass media, paper-based information

CITIZENS' PANEL ON NANOTECHNOLOGY IN AUSTRALIA (KATZ ET AL. 2004)

The citizens' panel on nanotechnology was initiated by the Australian Commonwealth Science and Research Organization (CSIRO) as their second attempt to contribute to informed public discussion on nanotechnology. The issues chosen for discussion emerged from the previous workshop, including commercialization, ethics, environmental impact, social impact, and regulation.

Participants were self-selected by responding to advertisements on the internet, in the newspapers and on notice boards. 6 speakers were invited to give presentations and answer any questions from participants. The speakers came from various institutions with different backgrounds, including CSIRO, NanoVic (a nanotechnology business), Melbourne University, Royal Melbourne Institute of Technology, and Charles Sturt University. The presentations were

based on experts' knowledge and organization's perspective. Information was balanced, recognized uncertainties, and discussed nanotechnology in many aspects. In the second part, participants took part in role-playing of government, industry and civil society organization members while exploring nanotechnology and gave recommendations based on their roles.

Component	Citizens' panel on nanotechnology
Source (funder and organizer)	CSIRO
Objective	To inform public discussion about nanotechnology
Participants	Self-selected participants
Flows	Experts <-> public
Content	Lectures from various speakers, balanced, admission of uncertainties
Channels	Presentations, Q&A, role-playing

CITIZENS' PANEL ON NANOTECHNOLOGIES IN BELGIUM(GOORDEN ET AL. 2008)

The Flemish governmental innovation policy went through a top-down approach in the 1980s and a bottom-up approach in the 1990s. It then realized that while the former had the immature assumption that governmental officials were better at recognizing growth opportunities in the market than entrepreneurs, the latter resulted in a laissez-faire policy with ad hoc approaches to investments in research and development (R&D). As a result, the Flemish Institute for Advancement of Innovation through Science and Technology was established to incorporate more participation in technological assessment, which gives advice to the Flemish parliament.

NanoSoc is short for Nanotechnologies for Tomorrow Society, a project funded by the Flemish Institute for Advancement of Innovation through Science and Technology. The objective was to make "enactors" aware of underlying assumptions, visions, expectations and concerns that guide nanotechnology research. Bio-on-chip citizens' panel is an initiative within NanoSoc, with the aim to involve citizens in fictive worlds to make explicit the values depicted therein and to have participants reflect on the changing nature of values over time.

15 participants were selected in the Flanders region to achieve a mix of gender, age, socio-economic status, work and education background. The previous activities in NanoSoc constructed future visions or imaginaries of nanotechnology situated around 2025. Participants were asked to reflect on these nano-imaginaries. The information was narrative in nature and focused on values. The research team, which includes technological assessment researchers, ethicists, nano-scientists and 2 facilitators selected the imaginaries. A professional actor and role playing were carried out within the panel to make the imaginaries more concrete. When citizens had specified the values most significant to them in the future worlds, 3 were chosen in the end as the topics of discussion among citizens during the workshops.

Component	Bio-on-chip citizens' panel
Source (funder)	Flemish Institute for Advancement of Innovation through Science and Technology
Source (organizer)	Technological assessment researchers, ethicists, nano scientists, facilitators
Source (conductor)	Facilitators
Objective	To make explicit the values in fictive worlds and have citizens reflect on the changing nature of values over time.

Participants	15 citizens from the Flanders region with different characteristics.
Flows	Public <-> public
Content	Nano-imaginaries consisting of a simple plot and a main characters
Channels	Role-playing

NANOTRUCK IN GERMANY(FEDERAL MINISTRY OF EDUCATION AND RESEARCH 2008)

Germany is a leader in nanotechnology both in research and business in Europe, thanks to the consistent promotion policy of the government since the early 1990s. Project subsidies quadrupled to €290 million from 1998 to 2007, which is high compared to the EU total of €740 million in 2007. "nanoTruck" is part of the "Nano Initiative – Action Plan 2010" initiated by the Federal Ministry of Education and Research in Germany, which is also supported by seven other Federal Ministries. The initiative has the goal of taking nanotechnology out of the laboratory and bringing it directly to the public. "nanoTruck" itself has the objectives to provide the public with more information about the benefits and potential risks of nanotechnology at an early stage, promote the ideas of nanotechnology, and show new perspectives for a successful career in nanotechnology.

"nanoTruck" is a truck touring around Germany over three months in 2010 as an exhibition and communication center. It is also available by request, e.g. for a visit to a school, with which the events can be adjusted to tailor the information need of the target audience. A large variety of content and channels are deployed in "nanoTruck", of which the final format will depend on the target audience. For the general public, there are guided tours by scientists to explain innovation product development, procedures and therapy approaches related to nanotechnology with the help of interactive exhibits. There are also discussions and roundtables in which questions can be asked about the future technology and possible risks for human health and the environment. In addition, workshops and work placements are held to allow the public experience nanotechnology live, with flexible laboratory module experiments that can be carried out on the spot. Moreover, small and medium enterprises (SMEs) can participate in sector-specific seminars and training days for operational further training regarding nanotechnology. Finally, the information and discussion results are disseminated to a wider public through the media.

Component	**"nanoTruck" campaign**
Source[6]	Federal Ministry of Education and Research
Objective	Mainly information provision
Participants	National population, SMEs
Flows	Scientists <-> public, public <-> public, organizers -> industry, organizers -> media
Content	Interactive exhibits, laboratory experiments
Channels	Guided tours, discussions, roundtables, workshops, work placements, seminars, training days, press conferences, background meetings

[6] Where a distinction is not made between funders, conductors and organizers, it was either not mentioned in the literature in such details, or that a distinction was not made between the three.

PUBLIFOCUS ON NANOTECHNOLOGY IN SWITZERLAND

Publifocus was one of the three instruments initiated by TA-Swiss (a government-funded advisory body for Parliament and the Federal Council) to facilitate public discussion on nanotechnology (Burri 2007). Apart TA-Swiss, Publifocus was also financed by the Federal Office of Public Health, the Federal Office for the Environment, and the Zurich University of Applied Sciences Winterthur (Burri 2009). Funders, other scientists and experts made up the advisory group (Burri 2009). The advisory group determined the content, setting, and questions of the publifocus, instructed the people involved, and made sure the project ran smoothly (Rey 2006).

Publifocus consisted of focus groups with 10-15 randomly selected lay participants in each group, and a group with representatives from interest groups (Burri 2007). Lay participants represented different age, gender, profession, political activities and place of residence. Participants in the non-laymen group came from science groups, industry, farmers' associations, consumer organizations, and other NGOs. Focus groups met in four cities in the German-speaking region, French-speaking region and Italian-speaking region of Switzerland (Burri 2007)

Participants were given an information brochure on nanotechnology prior to the meetings. The brochure provided balanced information on the state of the art research on nanotechnology, current and future applications of nanotechnology and the potential risks and benefits associated with it. The brochure contained numerous graphics to illustrate concepts written in lay language, and did not fail to include uncertainties regarding nanotechnology. After an initial discussion about participants' experiences with nano products in daily life, they were informed by two expert presentations, on the science of nanotechnology and on the ethical and social aspects (Burri 2007). Participants did not have to give recommendations on nanotechnology or come to a consensus, as the output was to record the process.

Component	Publifocus
Source (funder)	TA-Swiss
Source (organizer)	Scientists and experts from industry
Source (conductor)	Journalist
Objective	Find out about public views, demonstrate how nanotechnology is assessed by laymen
Participants	Randomly chosen lay public; representatives of interest groups
Flows	Scientists <-> public; public <-> public
Content	Balanced information, illustrated with graphics, lay language, admission of uncertainties
Channels	Face-to-face meetings, information brochure, experts presentation, Q&A

CONSENSUS CONFERENCE ON NANOTECHNOLOGY IN THE US (KLEINMAN AND POWELL 2005)

The consensus conference on nanotechnology had the aim to allow citizens to consider the promises and perils of the many possible future nanotechnology before they reach the market. It was sponsored by the Nanoscale Science and Engineering Center at the University of

Wisconsin-Madison and the University of Wisconsin Integrated Liberal Studies Program. The conference was organized by researchers from the University of Wisconsin

13 citizens with various backgrounds were selected from Wisconsin. All experts invited to the conference were from the University of Wisconsin-Madison, including a research compliance specialist, professors from materials science and engineering and chemistry, rural sociology, public affairs, pharmacy, and journalism and mass communication. Two co-directors of the Center for Democratic Action were used as the facilitators. Citizens received background reading to stimulate discussion and enable them to develop questions about nanotechnology.

Component	Consensus conference on nanotechnology
Source (funder and organizer)	University of Wisconsin-Madison
Source (conductor)	Center for Democratic Action
Objective	To allow citizens to consider the promises and perils of the many possible future nanotechnology before they reach the market
Participants	13 citizens from a variety of backgrounds in Madison area, Wisconsin
Flows	Public <-> public, experts <-> public
Content	Various perspectives
Channels	Packet of background reading, face-to-face discussion of readings

NATIONAL CITIZENS' TECHNOLOGY FORUM IN THE US (HAMLETT ET AL. 2008)

The federal legislation that authorizes much of the US National Nanotechnology Initiative (Public Law 108-93) speaks to importance of public input in decision making about nanotechnology research and development. The National Citizens' Technology Forum was to allow the public to examine four areas of scientific and technological growth, namely nanotechnology, biotechnology, information technology and cognitive science. It was funded by the US National Science Foundation and organized by the Center for Nanotechnologies in Society at Arizona State University. The goal was to generate informed and deliberative opinion about the management of these technologies for decision-makers, demonstrate that lay citizens can make sensible informed judgments about complex technologies, and provide information for other concerned citizens about such participatory techniques.

74 lay citizens from 6 states were selected to participate, who were representative of the communities. Participants were given a 61-page background document before the meetings, which described the emergence of the technologies and the debates around their social impacts. The document was written by researchers from the Center for Nanotechnology in Society and was reviewed by an Oversight Committee (project manager for the Danish Board of Technology in Copenhagen and the director of the Project on Emerging Nanotechnologies in Washington, D.C.) to ensure the accuracy, balance and accessibility of the document. The deliberation was also assisted by experts, who responded to questions developed by citizens. The experts consisted of technical specialists, a philosopher and a specialist in regulatory processes, from different universities. The channels deployed were both face-to-face meetings and internet communication. Recommendations were formulated by the citizens about how to manage the technologies for relevant policy-makers.

Component	National Citizens' Technology Forum
Source (funder)	US National Science Foundation
Source (organizer)	Center for Nanotechnology in Society at Arizona State University
Objective	Present informed and deliberative opinions of laymen for decision-makers; demonstrate that laymen can make sensible, informed judgments; provide information to concerned citizens
Participants	74 participants from 6 states across the country, representative of the communities
Flows	Public <-> public, public <-> experts
Content	Independently reviewed background materials explaining the technologies and their social impacts
Channels	Internet, face-to-face meetings, background materials

NANODIALOGUES – A PEOPLE'S INQUIRY ON NANOTECHNOLOGY AND THE ENVIRONMENT (IRVING ET AL. 2006)

The people's inquiry on nanotechnology and the environment was set against the backdrop of the report by the Royal Society/Royal Academy of Engineering (2004, p85), particularly two recommendations from the report:

- "Until more is known about the environmental impacts of nanoparticles, we recommend that the release of manufactured nanoparticles into the environment to be avoided as far as possible;
- We recommend that the use of free manufactured nanoparticles in the environmental applications such as remediation be prohibited until appropriate research has been undertaken and it can be demonstrated that the potential benefits outweigh potential risks."

The inquiry was initiated by the Environmental Agency, and conducted by Demos. The inquiry aimed to ask the public about nanoparticles, their environmental applications and the role of regulations. 13 people from East London were selected that had prior experiences in community participation. The expert panel consisted of experts from nanotoxicology, ecotoxicology, land contamination, land remediation, urban regeneration, law, and politics and regulation. The experts did not only represent vast fields of expertise, but also came from different types of organizations, including universities, NGOs and governmental agencies.

Drawing on the research, reflections and conversations with others, participants started with a discussion and came up with question for the experts, who were not selected by the participants. During the discussion, facilitators provided information boards that stimulated the questions and discussions. Scientific uncertainty was often explored. The information provided took the form of conversational style use of expert advice. Some participants carried out their own research via the internet and informal contacts. After the public meetings, representatives of the participants went to the Department for Environment, Food and Rural Affairs (DEFRA) to meet members of the nanotechnology policy team to reflect on their experiment and hear about the government's approach to nanotechnology and the environment. In the end, the Environmental Agency and DEFRA produced response to the citizens' panel's

recommendations.

Component	Nanodialogues – people's inquiry on nanotechnology and the environment
Source (funder)	Environmental Agency
Source (conductor)	Demos
Objective	Ask the public about nanoparticles, their environmental applications and the role of regulation
Participants	Randomly selected citizens with prior experience in community participation
Flows	Citizens <-> citizens, citizens <-> experts, citizens <-> policy-makers
Content	Perspectives from wide ranging experts from different types of organization (not selected by participants), admission of uncertainties, conversational style
Channels	Face-to-face meetings, expert presentations, stimulus information boards, informal self-research by the public

NANODIALOGUES – ENGAGING RESEARCH COUNCILS (CHILVERS 2006)

"Engaging research councils" was one of the four Nanodialogues experiments to engage the public "upstream". It was funded by two research councils related to nanotechnology and conducted by an independent think tank (Demos) and university researchers from Lancaster. The goal was to hold a discussion among the general public, scientists and research staffs about public values, concerns and aspirations about nanotechnology, and the role of public engagement in shaping research agendas

Participants were randomly recruited. Stimulus materials were provided to inform the public and enable discussions, which were produced by the research councils and had a narrow science focus. Certain views, e.g. from the industry, were not present in the materials. Participants had no say over which scientists should be involved. Interaction occurred between citizens and scientists, as well as between scientists themselves.

Component	Nanodialogues – engaging research councils
Source (funder)	BBSRC, EPSRC
Source (conductor)	Demos, Lancaster University researchers
Objective	To discuss public values, concerns and aspirations about nanotechnology, and the role of public engagement in shaping research agendas.
Participants	Randomly recruited citizens: full-time mothers with children of school age, young professionals with a declared interest in technology
Flows	Citizens <-> scientists, scientists <-> scientists
Content	Narrow, unbalanced and science-focused materials, no view from industry
Channels	Face-to-face discussions, media, information boards, written materials, internet

NANOJURY IN THE UK (ROGERS-HAYDEN AND PIDGEON 2006)

NanoJury was organized and funded by the Cambridge Nanoscience Center, Greenpeace UK, and PEALS, with the aim to present a non-specialist perspective on nanotechnology dilemmas and enable citizens to have a voice. Participants were selected from a group of volunteers. PEALS facilitated the jury and a wide range of experts informed the citizens jurors about nanotechnology. Local organizations were used to take care of the practical matters. Further, researchers were involved as observers. Jurors were able to ask questions during the process,

who then constructed recommendations in the end. The mass media, such as the Guardian newspaper, was used as a channel to publicize the jury and its findings.

Component	NanoJury
Source (funder)	Cambridge Nanoscience Center, Greenpeace UK, and PEALS
Source (organizer)	Funders, representatives from government, civil society, nanoscience, academia
Objective	Present non-expert's perspective, enable citizens to have a voice
Participants	Non-representative citizens from marginalized groups
Flows	Citizens <–> citizens, experts <-> citizens, media -> non-participating public
Content	Unknown
Channels	Newspaper, magazine, television, face-to-face discussion, introductory session with briefing about nanotechnology, expert presentations with Q&A

CITIZENS' PANEL ON NANOTECHNOLOGY IN THE UK (OPINION LEADER 2007)

The citizens' panel on nanotechnology was commissioned by "Which?", an independent consumer organization, and conducted by Opinion Leader, a research consultancy. The aim was to identify the key issues of importance for consumers as nanotechnologies were taken forward and came to the market. Participants were selected using quota sampling to resemble the general public, using the criteria of gender, age, life stage, ethnicity, socio-economic group and/or education, and work status. It was ensured that none of them were working in the scientific field to allow a roughly equal starting point for all.

Witnesses were selected not only based on knowledge and ability to answer questions, but also based on being effective communicators. The areas witnesses covered included introduction to nanotechnologies, the general potential applications and benefits of nanotechnologies, the UK's policy, and position compared to other countries on developing nanotechnologies, and the potential issues with regard to nanotechnologies and any concerns raised, applications in the field of medicine, food, consumer products, and the ways in which nanotechnologies are being controlled. Each witness delivered a presentation, after which the panel discussed the presentation in small groups and developed questions.

The project was overseen by a Steering Group with representatives from, "Which?", the British Retail Consortium, Demos, Nanotechnology Industries Association, Royal Society, Sheffield University to advise on the overall approach, witness selection, and the agenda.

Component	Citizens' panel on nanotechnology
Source (funder)	Which?
Source (organizer)	Which?, British Retail Consortium, Demos, Nano Industries Association, Royal Society, Sheffield University
Source (conductor)	Opinion Leader
Objective	Identify the key issues of importance for consumers as nanotechnologies are taken forward and come onto the market
Participants	Lay participants broadly reflecting the general public, not working in the scientific field
Flows	Experts <-> public, public <-> public
Content	Balanced information

Channels	Face-to-face meetings; presentations by experts

SMALL TALK ON NANOTECHNOLOGY IN THE UK (SMALLMAN AND NIEMAN 2006)

Small Talk was an initiative consisting of events to discuss nanotechnology. It was managed by Think-Lab (a communications practice) in collaboration with the British Association for the Advancement of Science, Ecsite-UK (now known as the UK Association for Science and Discovery Center), the Royal Institution (an independent research body), and the Cheltenham Science Festival. The program itself was funded by a COPUS grant and the individual events were funded by the organizations that ran the events.

The objectives were to explore the benefits of working together, run a variety of different events with different formats with a common topic nanotechnology, help organizations prepare for events, learn about and improve methods for engaging the public in science, learn more about the public's views, explore whether this kind of approach can be fed into decision-making processes, and share findings with the science engagement community, science community, policy-makers and the public. Overall, the project involved 20 events, which were attended by over 2000 participants. At the events, view points were provided surrounding the developments and use of nanotechnology, discussion of state-of-the-art of research, and risks and benefits of nanotechnology. Experts providing information included social scientists, physicists, material scientists, and health care professionals, with the affiliation with universities, Demos, industry and NGOs. Uncertainties regarding nanotechnology were constantly explored. It also involved a website, and other resources to support science communicators on nanotechnology.

Component	**Small Talk on nanotechnology**
Source (funder)	Think-Lab, the British Association for the Advancement of Science, Ecsite-UK, the Royal Institution, and the Cheltenham Science Festival
Source (organizer)	Young People's Parliament, Ecsite-UK, the British Association for the Advancement of Science, Center for Research on Adoptive Nanostructures and Nanodevices, Cheltenham Festival of Science, British Embassies in Sweden and Denmark, the Royal Institution, RSA, the Royal Society
Objective	Provide coherence to a range of activities around the UK focused on discussing nanotechnology with the public and scientists
Participants	Self-selected public, non-representative public selected by organizers
Flows	Public <-> public, experts <-> public
Content	Perspectives from wide-ranging experts, admission of uncertainty, balanced
Channels	Face-to-face meetings, presentations, websites and resources, e-alerts, interactive events, "basket of questions" based on RS/RAEng report, speech-bubble postcards

APPENDIX 3. BIOTECHNOLOGY RISK COMMUNICATION

CONSENSUS CONFERENCE ON GENE TECHNOLOGY IN THE FOOD CHAIN IN AUSTRALIA (MOHR 2002)

The consensus conference was initiated by the Australian Consumers' Association (ACA), with the objective to empower the public to gain an understanding of the issues of gene technology in the food chain. ACA was also part of the funding bodies, of which there were 28, but only ACA and the Myer Foundation were not affiliated with the government or industry in gene technology R&D. There were several contextual factors unique to Australia. The multiculturalism gave participatory risk communication a new challenge in that there should be a valid representation of the Australian community. Moreover, the reliance of the Australian economy on agriculture implies that gene technology would be a sensitive topic.

ACA was both the project manager and a member of the Steering Committee due to financial constraints. The Steering Committee included academics, journalists, public servants, representatives from science, industry and NGOs, and representatives from two sponsors who insisted on participating, and is chaired by a former Chief of Justice. No governmental representatives were present. The Steering Committee was responsible for selecting experts for the panel. Although the aim was to select a mix of experts to ensure balanced views, there were a limited number of "bio-opponents". Lay participants were selected according to geographic location, gender, age, ethnicity, and aboriginality. A further list of criteria was used to ensure that participants represented different values and attitudes towards gene technology. In the end, 13 citizens participated.

Component	Consensus conference on gene technology in the food chain
Source (funder)	28 funding bodies (mostly government- and industry-related)
Source (organizer)	Academics, journalists, public servants, representatives from science, industry, and NGOs, some of the funders
Source (conductor)	ACA
Objective	To empower members of the public to gain an informed understanding of gene technology in the food chain
Participants	Experts from various fields (chosen by the Steering Committee, not by the citizens), lay citizens with a mix of backgrounds
Flows	Experts <-> public, public <-> public
Content	Experts' views were not balanced (more proponents than opponents)
Channels	Face-to-face meetings, presentations

GM JURY IN THE UK (PEALS 2003)

GM Jury is a citizens' jury funded by the Consumers' Association, Greenpeace, the Co-operative Group and Unilever, with the aim to provide deliberative public input into GM public debate by co-sponsoring an agenda-setting citizens' jury on GM food and crops. An Oversight Panel was set up to monitor and evaluate the process, to select witnesses, to recruit citizen jurors, and to

facilitate the hearing. Members of the Oversight Panel came from the British Association for the Advancement of Science, University College London, Syngenta, Parliamentary Office of Science and Technology, International Institute for Environment and Development, University of Lancaster, representatives of the Do-It-Yourself Jury Steering Group, representatives of the funding partners, and representatives of the facilitation team.

Participants were randomly chosen from two counties in the UK. The selection did not aim to be representative of the general population. Gender and age were the only two criteria used to ensure some social mix. The witnesses were aimed to represent different perspectives so that the jurors could be exposed to balanced information. As a result, they represented the Royal Society for the Protection of Birds, National Consumer Council, Small and Family Farm Alliance, Exeter University, City University, Rothamstead Research, GeneWatch UK, University of Buenas Aires, Sekona consulting, Bayer CropScience UK.

The facilitator's approach was to strike a balance between encouraging jurors to provide policy-maker-relevant perspectives and to have control in framing issues in their own way. Formal hearing, plenary sessions, small group sessions, questions for witnesses and debate the answers with fellow jurors were the formats used. A system was used to avoid jargon by witnesses: a yellow card is shown to the witness when a jargon is used, and the witness is then given the opportunity to both explain each term as they went along and to reduce the overall amount of jargon. Final recommendations were voted on to achieve unanimity.

Component	GM Jury
Source (funder)	Consumers' Association, Greenpeace, the Co-operative Group and Unilever
Source (organizer and conductor)	British Association for the Advancement of Science, University College London, Syngenta, Parliamentary Office of Science and Technology, International Institute for Environment and Development, University of Lancaster, Do-it-Yourself Steering Group, funding partners, facilitation team
Objective	Provide deliberative public input into GM public debate
Participants	Non-representative citizens randomly chosen from Tyne and Wear and Hertfordshire
Flows	Experts <-> public, public <-> public, public -> policy-makers
Content	Limited jargons used, balanced information from various perspectives
Channels	Face-to-face discussions, witnesses presentations

GM NATION? IN THE UK (HORLICK-JONES ET AL. 2004)

"GM Nation?" was funded by the government and conducted by the Agriculture and Environment Biotechnology Commission (AEBC). The goal was to promote public debate on GM in agriculture and the environment. The program included public meetings, foundation discussion workshops, and "narrow-but-deep" meetings. The largest part of the program, public meetings, were open to the whole British public. Participants were given stimulus materials before and during the meetings. The information was balanced, but had no attributed source. It was rated as confusing and boring by some participants. Moreover, experts gave presentations on the issues around GM, to whom the public could also ask questions.

Component	GM Nation?
Source (funder)	Government

Source (organizer)	Central Office of Information, Agriculture and Environment Biotechnology Commission
Source (conductor)	Agriculture and Environment Biotechnology Commission
Objective	To promote public debate around GM, to allow the public frame the issues, to allow public's views to be provided to the government.
Participants	Open to the whole nation, but only non-representative small set of citizens participated
Flows	Citizens <-> citizens (mainly), experts -> citizens (rarely)
Content	Balanced information taken out of its context, confusing and boring, difference in experts' competence as advocates for their positions
Channels	Face-to-face meetings, videos, workbook, CD-ROM, websites

PUBLIC DIALOGUE ON INDUSTRIAL BIOTECHNOLOGY IN THE UK (RATHOUSE 2009)

The public dialogue on industrial biotechnology was commissioned by the UK Department of Business, Enterprise, and Regulatory Reform (BERR) (funder) and Sceincewise. It was conducted by Opinion Leader (a research-based consultancy) and 3KQ (independent facilitator). The goal was to explore public perceptions of industrial biotechnology. The first event was a citizens meeting that introduced industrial biotechnology and related scientific concepts. Participants were given information on both the potential benefits and problems of industrial biotechnology. Games were also used to stimulate interaction. The second meeting was for experts from the government, industry and research to provide detailed insights to citizens. Break-out discussion followed the presentations. Participants were chosen to represent a mix of citizens, excluding people with extensive experiences with industrial biotechnology. Overall, information was easy to understand, even for low-educated participants, and was attention keeping and engaging. However, some participants questioned the independence of the information, with most of it being from organizations with vested interests, and sometimes the accuracy of the information, particularly regarding the use of certain concepts and terms.

Component	**Public dialogue on industrial biotechnology**
Source (funder)	UK Department of Business, Enterprise and Regulatory Reform, Sciencewise
Source (organizer)	Representatives from government, industry, NGOs, academia
Source (conductor)	Opinion Leader, 3KQ
Objective	To explore public perceptions of industrial biotechnology
Participants	Citizens selected based on different age, sex, socio-economic group, ethnicity, education, interest in science and knowledge, excluding those with good knowledge of industrial biotechnology
Flows	Stakeholders <-> stakeholders, experts <-> public, public <-> public
Content	Easy to understand, engaging, not always independent information
Channels	Face-to-face meetings, expert presentations, pub-quiz, true or false game

CONSENSUS CONFERENCE ON GM FOOD IN NORWAY (MØKRID 2001)

The consensus conference on GM food was funded by several governmental Ministries in Norway and public institutions, and was conducted by the Biotechnology Advisory Board (independent body appointed by the government). The aims were to give coordinated advice on

GM to politicians, authorities and the food industry, to establish a forum for dialogue between experts and non-experts, and to contribute to an all-embracing and well-informed public discussion. Citizen participants were chosen from different parts of the country representing people with a wide range of characteristics without any prior GM experience or knowledge. Experts were also involved to present information to the citizens, who then had to come to a consensus on the issues.

Component	**Consensus conference on GM food**
Source (funder)	Biotechnology Advisory Board, National Committee for Research Ethics, Research Council of Norway, the Ministry of Fisheries, the Ministry of Agriculture, the Ministry of the Environment, the Ministry of Trade and Industry, and the Ministry of Health and Social Affairs
Source (organizer)	Biotechnology Advisory Board, National Committee for Research Ethics
Source (conductor)	Professor
Objective	To give advice to politicians, authorities and the food industry, to establish forum for dialogue between experts and non-experts, to contribute to informed public discussion
Participants	Non-representative citizens chosen from different part of the country with different backgrounds, and no prior involvement in GM food.
Flows	Expert <-> citizens, citizens <-> citizens, citizens -> non-participating citizens, citizens -> stakeholders
Content	Unknown
Channels	Expert presentations, Q&A, face-to-face meetings, media conference, television

APPENDIX 4. RADIOACTIVE WASTE RISK COMMUNICATION

CONSENSUS CONFERENCE ON RADIOACTIVE WASTE IN THE UK (UK CEED YEAR UNKNOWN)

The consensus conference on radioactive waste was initiated and organized by the UK Center for Economic and Environmental Development (UK CEED), and funded by the Office of Science and Technology, the Natural Environment Research Council, and NIREX (responsible for implementing national policy on the disposal of intermediate level radioactive waste (ILW)). The objectives were to enable informed citizens to contribute their views to policy-making, to gain appreciation of public framing and prioritizing of issues, to identify, examine and resolve public concerns, to provide better information, and to stimulate informed public debate.

An Advisory Committee was formed to ensure the independence, integrity and credibility of the conference, members of which include representatives from Demos, Parliamentary Office of Science and Technology, Manchester University, Science Museum, Center for the Study of Democracy, Imperial College, UK CEED, and SPRU. Participants were 15 people from across the country with different backgrounds. They were not intended to represent the British population. None of them had significant prior involvement in radioactive waste management.

Members formulated questions and could choose which experts they would like to answer them. Expert witnesses included people from NIREX, Royal Institute for International Affairs, freelance research consultant, British Geological Survey, Friends of the Earth, Swedish Nuclear Fuel and Waste Management Company (SKB), Department of the Environment, Transport and the Regions, UK Atomic Energy Agency (UKAEA), Environmental Agency, Nuclear Installation Inspectorate, British Nuclear Fuels, Imperial College, Engineers and Managers Association, Gosforth Paris Action Group, Nuffield Radio Astronomy Laboratory, Institute for Research and Security Studies, Department of Trade and Industry, Manchester University, Alan Martin Associates, British Energy, Ministry of Defense, Naval Nuclear Regulatory Panel, and Greenpeace. The information ranged among different technological options, policy of monitoring, R&D, safety, and policy of informing the public. The information was balanced.

Component	Consensus conference on radioactive waste
Source (funder)	Public Understanding Grant from the Office of Science and Technology, the Natural Environment Research Council, and NIREX
Source (organizer)	Demos, Parliamentary Office of Science and Technology, Manchester University, Science Museum, Center for the Study of Democracy, Imperial College, UKCEED, SPRU.
Source (conductor)	UK CEED
Objective	To enable informed citizens to contribute their views to ILW policy-making, to gain appreciation of public framing and prioritizing of issues, to identify, examine and resolve public concerns, to provide better information to the public, and to stimulate informed public debate
Participants	15 people from all across Britain with different backgrounds, but non-representative
Flows	Public <-> public, experts <-> public
Content	Perspectives from wide-ranging experts with different affiliation, balanced

Channels	Face-to-face discussion

STAKEHOLDER ENGAGEMENT ON LLW DISPOSAL IN THE UK (RICHARDSON ET AL. 2009)

UKAEA (a company for decommissioning and waste management of radioactive facilities) initiated stakeholder engagement on LLW disposal. Participants were involved before a formal proposal was developed, so that their views could be considered. The following groups were included: internal (to UKAEA) and external decision-makers; people who are affected by the decision, e.g. residents living near a potential waste storage or disposal facility, or employees and contractors at the site; special interest groups such as environmental NGOs.

Three stakeholder panels were held. An internal stakeholder panel with 10 representative staff members selected and filtered by the Dounreay Personnel Department, to discuss the preliminary work carried out on options and technical issues. There was also an external stakeholder panel, with volunteers from local interest groups, local councilors, representatives from higher level councils and representatives from Drigg and Carleton Paris Council (the site of the UK national LLW repository). Finally, there was an external youth panel, which selected high school students and young people from other organizations such as Young Farmer's Club could participate.

Participants were given background information one week before the meetings. The information contained a brief history of the issues under discussion, a brief background to the options under consideration, the technical aspects in a reader-friendly style and supported with illustrative materials to aid understanding. The information were pre-tested with an internal focus group with UKAEA employees to assess the accessibility and attractiveness, clarity, fitness for purpose, errors and omissions of the information and any other advice. The focus group suggested three tiers of information, with varying formats, comprehensiveness, technical details, tones and so on. Moreover, supporting materials were suggested for any additional questions the stakeholders may have.

Apart from the background information, interactive techniques were used in information provision. Display boards were available before, during and after the panel workshops to show information about key elements of the proposal with great level of graphical detail. Display boards were aimed to provide information that participants could read at their own pace. Participants could also provide input via "post-it" notes, so that those who could not or did not want to express their thoughts at the discussion could still participate. A software tool was used to enable participants to see how their value judgments might influence the outcome.

Component	**Stakeholder engagement on LLW disposal**
Source (funder)	UKAEA
Source (organizer)	UKAEA, Galson Science Ltd.
Source (conductor)	Galson Science Ltd.
Objective	Unknown
Participants	Internal stakeholders, external stakeholders, external youth
Flows	Experts <-> experts, public <-> public

Content	Reader-friendly, illustrated with graphics, different types of information suited to different needs, value-focused
Channels	Face-to-face discussion, briefing packs with different purposes, display boards, post-it notes, software

PUBLIC CONSULTATION ON NUCLEAR WASTE IN SWEDEN (ELAM ET AL. 2008)

Public consultation was carried out in different formats by SKB, to obtain a permit through environmental impact assessment (EIA) as required by law. For regional consultation meetings, the county administration had the chairmanship and the agenda was set by a group with representatives of all the participating organizations. Environmental NGOs were denied access to the meetings, because SKB and Swedish Nuclear Power Inspectorate (SKI) wanted to maintain an efficient meeting format. The public were observers at the meetings. Although the regional consultation meetings officially started when the site investigation began, the working format started as soon as the facility was proposed.

Public consultation meetings were open to local residents. SKB set the theme and agenda for the meetings and provided participants with relevant information. SKB's presentations at the meetings formed a large part of how issues were framed, and therefore what type of questions and comments could be expected from the public. SKB communicated results and ready-made facts, and did not give any background behind such results and facts. SKB also included texts and pictures in their presentations to convey and argue that SKB could control the safety. Moreover, it was the public asking questions to SKB, and never the other way around. Local information activities included seminars, meetings with school children and people in the neighboring areas, study visits and Christmas fairs. Tours and exhibition also a central information activity, with trips onboard SKB's ship m/s Sigyn, the ship that transports the spent fuel to Oskarshamn for interim storage. The whole process could be seen as downstream engagement, since SKB presented already-defined problems and results from studies already completed.

Component	Risk communication on nuclear waste
Source (funder)	SKB
Source (organizer)	Representatives from SKB, SKI, SSI, county administrators, municipalities
Source (conductor)	SKB
Objective	To obey the law and get a permit through EIA
Participants	Citizens, environmental NGOs
Flows	Expert -> public, stakeholders <-> stakeholders
Content	SKB sole source, no context of information, positive aspects dominated
Channels	Seminars, meetings, study visits, tour and exhibitions, expert presentations

LOCAL PARTNERSHIP ON LLW DISPOSAL IN BELGIUM (HOOFT ET AL. 2002)

The local partnership on LLW disposal in Belgium was developed by researchers from the Department of Social and Political Sciences of the University of Antwerp and the research group SEED (Socio-Economic Environment Development) of the University of Luxembourg, on the basis of dialogue with the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS). The communication activities started as soon as the feasibility of disposal

was demonstrated.

The local partnership had a General Assembly to decide on the approaches and set the discussions, which included representatives from ONDRAF/NIRAS, local politicians and administrators, social and cultural organizations, environmental organizations, and economic organizations. The General Assembly appointed an Executive Committee for the daily operations of the organization, which also included representatives of ONDRAF/NIRAS and local partners. Moreover, four Working Groups were established to discuss the different aspects of the implantation of a LLW repository, i.e. implantation and design, environment and health, safety, and local development. The Working Groups consisted of partnership initiators and volunteering lay citizens. Finally, two project coordinators were appointed to support the Working Groups. The partnership was informed by ongoing research, paid for by ONDRAF/NIRAS. However, if participants did not trust the results of such research, they could order another research by an independent expert, paid for by the partnership.

Only a number of citizens participated, and the organizers attempted to make the partnerships more well-known to the wider public. Every four months a newsletter was distributed to local residents, local councils of neighboring towns, nuclear companies and the local press. The newsletter gave information on the purpose and current status of the partnerships. Websites were also constructed to enable visitors to find information on the purpose, structure, and activities of the partnership, and general information on the municipality and radioactive waste. They also provided the possibility to check relevant books available in the library and to comment. Finally, the offices for the partnerships were open at regular hours.

Component	Local partnership on LLW disposal
Source (funder)	Department of Social and Political Sciences of the University of Antwerp and SEED of the University of Luxembourg, ONDRAF/NIRAS
Source (organizer)	ONDRAF/NIRAS, local politicians and administrators, social and cultural organizations, environmental organizations, economic organizations.
Source (conductor)	Local organization members, ONDRAF/NIRAS
Objective	Unknown
Participants	Lay citizens, representatives of organizations that founded the partnership
Flows	Partnership initiators <-> participating public, partnership initiators -> wider public, local councils, nuclear companies, local press, experts -> participating public
Content	Participants informed by ongoing research funded by ONDRAF/NIRAS, and independent research selected by participants; wider public informed by newsletter and websites, and books
Channels	Internet, library, information centers, face-to-face meetings, newsletters, books

RISK COMMUNICATION ON HLW DISPOSAL IN FRANCE (BARTHE AND MAYS 2001)

The National Radioactive Waste Management Agency of France (Andra) created local agencies as soon as feasibility studies of the laboratory siting had started. The aim of the local agencies was to "blend in with the locals". Visitor centers were established to present experiments to be carried out in the projected laboratories, major research directions, and administrative procedures set up by the Waste Act. The exhibits were a joint effort between communication

personnel and geologists. Guided tours were available to visit the drill works. Additionally, brochures, comic strips, and documentary films were distributed at the visitor centers or during events, and advertisement were made in local newspapers. Finally, monthly newsletters were sent to residents' homes. The newsletters recounted events on both the scientific and communication fronts at the site, with adaptation to the local context. Overall, the main focus of the information was not on the scientific research itself but on the process of research. The experimental approach, uncertainty surrounding future decisions, importance of data gathering were stressed.

A local information and monitoring commission (LIC) was established at potential laboratory sites, incorporating representatives from local elected officials, environmental protection groups, spokesmen for union and trade association, state representatives, and local scientific experts. The objectives were to inform itself on the basis of serious, objective and scientific data, to transmit the information to local residents, to analyze and forge an opinion on the nature of project, deadlines, procedures, issues, risks, safety measures and possible impacts on human and the natural environment. The LICs met occasionally to discuss around specific themes, such as radiation risks. Andra representatives and independent experts came before the LICs to testify regularly on the advancement of the geological evaluation. The outcome were distributed to the public through reports by elected officials to municipal councils, commission newsletters, and newspaper articles by local journalists that were invited to sit in on the meetings. Andra also organized public information sessions, separately from and outside the LICs. In these sessions, Andra representatives attempted to answer questions raised by public. A brief was produced after each meeting, which was fed back to Andra scientists that then developed responses to the questions.

Component	**HLW underground laboratory siting**
Source	Andra
Objective	To inform itself with science, to transmit information to local residents, to forge an opinion.
Participants	Public, local journalists
Flows	Public <-> scientists, initiators -> public, other stakeholders <-> other stakeholders, initiators <-> other stakeholders, experts <-> other stakeholders
Content	Covered a variety of issues, included independent sources
Channels	Visitor centers (exhibitions, guided tours, brochures, comic strips, documentary films), local councils (official reports, brief), local newspapers (advertisement)

RISK COMMUNICATION OF NUCLEAR WASTE MANAGEMENT IN CZECH REPUBLIC (VOJTECHOVA 2009)

The Radioactive Waste Repository Authority (RAWRA) was established in 1997 to handle safe disposal of radioactive waste. RAWRA was often seen as a distrusted bureaucrat. RAWRA's activities focused on dialogue with local representatives and on information provision to local people through public meetings, information leaflets, study trips to nuclear facilities, and so forth. During visits to nuclear facilities, participants could speak to local representatives and directly discuss issues of interest. Information was also given by assisting communities with reconstruction of local libraries and establishing information centers. RAWRA proposed further dialogues with representatives at potential sites, and offered to cover the costs of independent

experts nominated by the communities to review works to be carried out by RAWRA and review them from the perspectives of local interests.

Risk communication by RAWRA had two phases. In the first phase, a reference group was established, consisting of representatives from the nuclear industry, governmental bodies, potential siting communities, NGOs, sociology scientists, and foreign experts from Sweden. The reference group was responsible for searching for methods for inciting an interest from the public and responsible organizations, identifying possibilities and methods for the RISCOM model in the context of Czech Republic, establishing communication means for mutual open communication between all stakeholders, establishing information channels for mediating dialogue with the general public, elaborating on topics for future discussion, defining possible solutions of controversial issues and their clarification, finding ways of increasing transparency and participation of the general public in the decision-making processes. A working group was also developed, including representatives of NRI, RAWRA and foreign experts from Sweden, with the aim to provide analysis and proposals to the reference group. The reference group then provides guidelines for further work after discussions, so that the working group could design and set up arenas for increasing transparency and public participation in decision-making.

In the second phase, a public hearing was held with the aim to start an open and meaningful discussion of questions concerning the selection of a location for the repository with representatives of all stakeholder groups. The topics included the need for a repository, how the selection process could protect the rights of affected communities, what the siting situation was, timeline of activities and their effects, and what the apprehensions and expectations of the representatives would be. Over 70 representatives participated, from the Ministry of Industry and Trade, the Ministry of Environment, RAWRA, independent geologist, NGOs, and mayors of the municipalities. The moderator was a well-known media personality, to maintain neutrality and to attract a high turnout. The moderator formulated problem, then experts' presentations were given. Participants could then interact with the expert. The hearing was presented to a wider public via press and television.

Component	RISCOM model application in radioactive waste management
Source (funder)	RAWRA, ARGONA project, NRI, REZ plc.
Source (organizer)	Reference group: representatives from the nuclear industry, governmental bodies, potential siting communities, NGOs, sociology scientists, Swedish experts Working group: representatives of NRI, RAWRA, Swedish experts
Source (conductor)	Well-known media personality
Objective	To start a dialogue with the public and to provide information to the public
Participants	Representatives from the Ministry of Industry and Trade, the Ministry of Environment, RAWRA, independent geologist, NGOs, mayors of the municipalities, wider public (indirectly)
Flows	RAWRA <-> local residents (and possibly also NGOs), local resident <-> local representatives, reference group (industry, government, communities, NGOs, scientists, foreign experts) <-> working group (NRI, RAWRA, foreign experts), experts <-> public, experts -> wider public
Content	Unknown
Channels	Local libraries and information centers, mass media, information leaflets, visits to facilities, expert presentations

APPENDIX 5. CCS RISK COMMUNICATION

CCS RISK COMMUNICATION IN KETZIN, GERMANY (DÜTSCHKE 2010)

In Ketzin, a scientific research project aimed at observing and analyzing CO_2 injection into a gas reservoir was to be carried out. From the planning stages of the CCS project, officials from the local community were informed by the German Research Center for Geosciences (GFZ), who presented the project to the town council and the public as soon as funding was obtained. Risk communication started with an information event, followed by several presentations to the public (local associations were involved in many ways).

A website was maintained by GFZ as an information channel for the public. The site was not regularly updated, however, and used mainly technical jargon and was only available in English. Communication was also done by offering site visits, led by GFZ engineers. Participants including international scientists, employees from related industries, politicians, NGOs, and local citizens often ensured that the visits were fully booked weeks in advance. Information about the project was further disseminated through regularly held press conferences to the local and national press, which then distributed the information to the wider public. The media coverage was seen as neutral and factual, with a focus on project descriptions. Overall, GFZ was seen as a trustworthy research institute that was accessible to the public.

Component	Risk communication of CCS in Ketzin
Source (funder)	The CCS project itself is funded by the European Commission, Federal Ministry of Economics and Technology, Federal Ministry of Education and Research, and industry
Source (organizer)	Research institutions, universities, International Energy Agency (IEA), representatives from industry
Source (conductor)	GFZ
Objective	Unknown
Participants	Scientists, industry, politicians, NGOs, local citizens, (wider public)
Flows	Organizers -> other stakeholders, organizers -> media -> wider public
Content	Website with jargons (in English) and infrequent updates, actual information neutral and factual
Channels	Internet, mass media, site visits

CCS RISK COMMUNICATION IN BEESKOW, GERMANY (DÜTSCHKE 2010)

The project coordinator in Beeskow, Vattenfall, was not as trusted to the stakeholders at Beeskow as GFZ was trusted by stakeholders at Ketzin. Certain groups expressed the fear that Vattenfall would hide information, and not provide neutral information. The public at Beeskow were informed about the CCS project a few days before Vattenfall applied for an exploration permit. A press conference was used to inform the media, which then widely covered the issue. Local households were sent a letter and flyer with basic information about the project. Vattenfall also informed the local government, before informing the general public, who then started working on a communication campaign together with Vattenfall. Politicians, the church

and NGOs also received a letter and brochures with project information.

After the official announcement, Vattenfall began more communication with the public. Public events were held during which further information on the project was presented and questions were asked. Vattenfall also made clear their willingness to provide further information upon request and to participate in meetings. An information office was established to provide information about climate change, CCS, geology and so on. Channel of information provision was broadened to a website with information on CCS, films and animations, and local project information. Questions raised by the public were answered and frequently placed on the website. The public were also given a telephone hotline to call for more information and ask questions. Generally, being the main source of information, arguments raised by Vattenfall about CCS were seen as too positive, excluding any knowledge gaps and downplaying safety issues. Moreover, risk comparison was often used in the information (e.g. comparing CCS with other use of carbon) as a strategy to trivialize the risks. Finally, Vattenfall was omnipresent in the area during risk communication by funding local facilities and clubs, which was seen as negative.

Component	Risk communication of CCS in Beeskow
Source (funder and organizer)	Vattenfall
Objective	Unknown
Participants	Local government, general public, politicians, church, NGOs
Flows	Organizer <-> public and other stakeholders
Content	Not balanced (positive dominating), no admission of uncertainty, use of risk comparison
Channels	Mass media, face-to-face meetings, information office, local schools, internet, telephone hotline, letter and flyer with project information, presentation and discussion, films, animation, Q&A

CCS RISK COMMUNICATION IN BARENDRECHT, THE NETHERLANDS

Several stakeholders are involved in the project. Shell is the project owner and executive. OCAP is responsible for transport and compression of CO_2. Governmental stakeholders include the Ministry of Economic Affairs (EZ) and the Ministry of Spatial Planning, Housing, and the Environment (VROM), and the CCS project directorate (national level); as well as provincial executive (in charge of permit procedures), provincial council (observer to project proceedings), and the municipalities of Barendrecht and Albrandswaard (local level). DCMR, the environmental agency of Zuid-Holland, is also involved as a consultant and permitting authority, and a mediator for communication between parties (Brunsting and Mikunda 2010). More stakeholders are indirectly involved through the CCS Taskforce, which is a public-private partnership to realize CCS commercially. Members of the Taskforce include the Rotterdam Climate Initiative (RCI), Nederlandse Vereniging voor Marktwerking in Energie (VME), Stichting Natuur en Milieu (SNM), CCS Noord Nederland, EnergieNed, Ecofys, Shell, and CreativeEnergy (see the website: http://www.senternovem.nl/taskforceccs). The main sources of risk communication were the project developers, EZ and VROM, as well as the municipalities. As will

be seen later, they were the organizers of public meetings as well as providers of information.

All stakeholders participated in risk communication with different functions and extent of presence, as will be described in the sections below. The stakeholders come from different types of institutions: governmental, industrial and the civil society. In terms of the particular focus of this study, citizen participants, only a proportion of local residents living near the potential CCS injection site participated in risk communication, given the voluntary nature of participation.

Three types of channels were used: information center, public meetings, and the mass media. An information center funded by the national government and Shell was established to provide information to the public, as a response to the high information demand seen at public meetings the month before (VROM 2009). The aim was to have all relevant stakeholders provide information to Barendrecht residents during public participation and EIA. The information center provided leaflets and posters from a variety of sources, including the national government, the regional government, industry, and research institutes. Environmental NGOs were not involved. However, several information materials quoted the opinions of Stichting Natuur en Milieu (SNM) (pro-CCS) and Greenpeace (anti-CCS).

Despite involving both experts and citizens, mainly a top-down approach with the goal to "inform" the public was deployed, through several information meetings held in Barendrecht and Albrandswaard. Therefore the channel was not entirely interactive. In addition, two excursions to a CO_2 injection well were organized by the information center and project developer (Infopunt 2009). The internet was the most frequently used mass media channel. Several websites were created by different stakeholders. In addition, local newspapers were used as a channel of announcement, e.g. of the two excursions to the project site and of the information meetings in Barendrecht. For the latter, mail was also used.

The websites all included information on what climate change is, why CCS is needed, how CO_2 is stored, and regulations of CCS projects. Potential risks were described as minimal. Project-specific websites gave additional information on the relevant stakeholders, and some provided information on opportunities for participation, e.g. information evenings and CCS symposium. The website of Shell and the municipality of Albrandswaard provided the minutes of meetings and presentations at the meetings. A general CCS information website sourced by research organizations, NGOs, energy industries, the regional and national government, and universities, used few jargons in its information. No attempt to simplify the information was seen on other websites.

Similar to the information provided on the websites, the information materials explained about climate change, why CCS is needed, and the risks of CCS. The information provided by the national government did not have a value-focus, e.g. did not address the impacts of property value, which is a pressing issue in the opinions of local residents (Brunsting and Mikunda 2010). The provincial government provided information on how the public could be involved in the process. The information provided by the project developers and TNO was largely of a technical nature. Graphics were used to illustrate certain technological concepts, but were inconsistent in

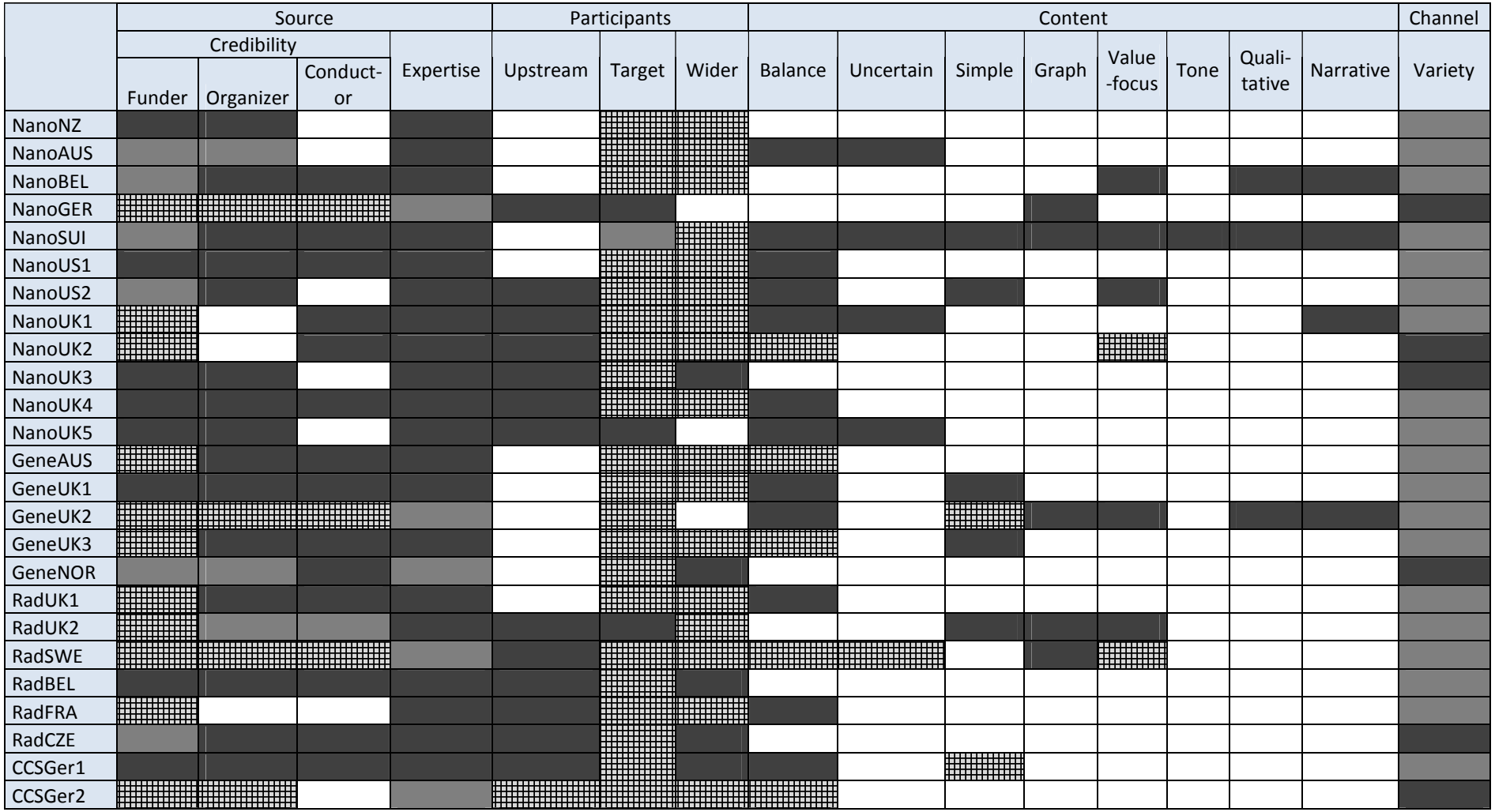
quality. For example, while some graphics were correctly scaled, the scale of others was out of proportion. Moreover, the other research institutes provided even more specializing and technical information in English. Generally, the information materials presented a balance of positive and negative viewpoints on CCS. Although at times using words to assure the safety of the project, the project developers strived to provide objective information.

Three information meetings were organized to inform the local residents about CCS and the project (Shell 2008; Gemeente Albrandswaard 2008). The goal was to inform the public about CCS and the project. The same independent chairman was used for all meetings. In the first meeting at Barendrecht, the project developer gave presentations on the EIA process and opportunities for participation, the technology of CCS, their previous experiences with similar technologies, and risk issues. VROM also presented at the meeting, explaining climate change and introducing the CCS project. In the second Barendrecht meeting, the national government was absent. The project developer again presented project details, while TNO presented the technical details. For both procedures, questions were raised mainly in the following aspects: project details, tender procedures, safety, social/financial aspects, and the choice of Barendrecht. The meeting in Albrandswaard was an ad hoc meeting to inform the local residents (Gemeente Albrandswaard 2008). Participated alongside the local residents were representatives of the municipality. The presentations were similar to those at the Barendrecht meetings. After the presentations, participants could question and discuss with experts from EZ/VROM, DCMR, , OCAP, TNO and Shell.

Two excursions were organized by the information center and the project developer to allow citizens to visit the CO_2 injection well. Despite announcement on the information center website as well as in local newspapers, the turnout was low, of whom only a small proportion were not involved in CCS or the project (i.e. "true" local residents) (Brunsting and Mikunda 2010).

Component	**Risk communication of CCS in Barendrecht**
Source (funder)	Shell, EZ and VROM
Source (organizer)	Shell, EZ and VROM, municipalities of Barendrecht and Albrandswaard
Source (conductor)	Facilitators
Objective	To inform the public
Participants	All relevant stakeholders, local citizens
Content	Websites and information center striving to provide objective but mainly technical and specializing information; public meetings with experts presentations and Q&A sessions; excursions to allow citizens to gain first-hand experience with the project
Flow	Project developers -> citizens, national government -> citizens, scientists -> citizens
Channel	Information center, interaction, internet and local newspapers.

APPENDIX 6. EVIDENCE FOR THE HYPOTHESES IN PRACTICE-BASED LITERATURE



CCSNL	

	Strong evidence found
	Some evidence found
	No evidence found
	Not available

NanoNZ Nanotechnology focus groups in New Zealand
NanoAUS Citizens' panel on nanotechnology in Australia
NanoBEL Citizens' panel on nanotechnology in Belgium
NanoGER nanoTruck in Germany
NanoSUI Publifocus on nanotechnology in Switzerland
NanoUS1 Consensus conference on nanotechnology in the US
NanoUS2 National Citizens' Technology Forum in the US
NanoUK1 Nanodialogues - a people's inquiry on nanotechnology and the environment
NanoUK2 Nanodialogues - engaging research councils
NanoUK3 NanoJury in the UK
NanoUK4 Citizens' panel on nanotechnology in the UK
NanoUK5 Small Talk on nanotechnology in the UK
GeneAUS Consensus conference on gene technology in the food chain in Australia
GeneUK1 GM Jury in the UK
GeneUK2 GM Nation in the UK
GeneUK3 Consensus conference on GM food in Norway
GeneNOR Public dialogue on industrial biotechnology in the UK
RadUK1 Consensus conference on radioactive waste in the UK
RadUK2 Stakeholder engagement on LLW disposal in the UK
RadSWE Public consultation on nuclear waste in Sweden
RadBEL Local partnership on LLW disposal in Belgium
RadFRA Risk communication on HLW disposal in France
RadCZE Risk communication of nuclear waste management in the Czech Republic
CCSGer1 CCS risk communication in Ketzin, Germany
CCSGer2 CCS risk communication in Beeskow, Germany
CCSNL CCS risk communication in Barendrecht, the Netherlands