FACULTY OF SCIENCE AND TECHNOLOGY

MASTER'S THESIS

Study programme / specialisation: Risk Analysis/Governance	The *(spring/autumn)* semester, *(year):* Spring, 2023 Open / ~~Confidential~~
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Thesis title: Conveying Nuclear Risk A critical discourse analysis of nuclear risk communication in Norway	
Credits (ECTS): 30	
Keywords: Risk communication Nuclear power and SMR-technology	Pages: 113 + appendix: 116 Stavanger, *(15.06.23)*

Approved by the Dean 30 Sep 21
Faculty of Science and Technology

Conveying Nuclear Risk

A critical discourse analysis of nuclear risk communication in Norway

By
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Spring 2023

FACULTY OF SCIENCE AND TECHNOLOGY
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I do not know what decisions other people should make in order to successfully strive to be happy. I hope, however, that good risk communication will help consumers to make better decisions.

(Siegrist, 2014, p.1241)

Abstract

Nuclear energy is not a new topic of debate in Norway, as it has been a subject of political discourse for many years. Political parties, such as the Labor party have previously (1957) fronted nuclear power as part of a new industrial revolution, powered by modern science and technique. Norway is also a contributor of some of the world-leading research within nuclear sciences. However, nuclear accidents like Three Mile Island (1978), Chernobyl (1986), and Fukushima-Daiichi (2011) as well as protests from social and environmental movements have cooled down the further discussions of commercializing nuclear power in Norway. The debate stood still until recent developments following the energy-crisis, concerns about reliance on fossil fuels, and the founding of a company pursuing to establish commercial nuclear power in Norway. The debate about nuclear power is yet again on the agenda.

Previous research points to a lack of research on long-term issues such as political discourses about national energy and climate policies, or changes in the multifaceted public debate over time. This thesis does not focus specifically on political discourse but try to say something about how the nuclear industry is communicating risks of nuclear power and SMRs in Norway. It investigates the long lines by discussing previous debates and historic incidents as well as the current situation and updated perspectives of the modern technology. This is done by interviewing stakeholders of the industry, such as scientists, commercial actors, and regulators. By analyzing the different emerging discourses, the thesis finds many different interpretations and communications of the nuclear risks. The most significant findings are regarding ambiguities over management of radioactive waste. The commercial actors and the regulators legitimize safety of handling the waste in completely different ways. As all stakeholders base their risk evaluations on strong arguments and a scientific basis, it is difficult to determine any ‘right’ or ‘wrong’ answer. It is therefore recommended that further research or internal discussions are made to gain a more consistent risk communication in the industry. Even though the thesis found a great deal of competence and well thought out risk communication, there are indications of little awareness in some of the actions performed. The stakeholders are hesitant to characterize their actions as ‘strategic risk communication’, and the good performances could thereby be a result lacking a risk-knowledge basis in some areas. However, the discourses also signalize a growing focus and awareness of the importance of effective risk communication in the nuclear industry.

Acknowledgements

The research carried out in this thesis will first and foremost mark the completion of my master-degree in Risk analysis. This has been two years rich in content, challenges, and educational values.

Throughout my education I have always had a need to come up with something new, or an original idea. This need has sometimes gotten the best of me as I have learned that some things are better to do 'by the book' or as the French cuisine would say 'the established recipes are often the correct way of cooking something'.

The person who allowed me to pursue my original idea, and at the same time put me on the right track was my fantastic supervisor Marja. I want to thank her for all her time of guidance, help, and enjoyable conversations.

I want to thank all the great people I got to interview. You were all so kind, patient, and professional. Thank you for taking the time to answer my questions and making this research possible.

I need to thank my manager, first and foremost for interesting and inspiring conversations during several lunchbreaks. Also, for giving me the flexibility to conduct interviews and write my thesis.

I also want to thank my parents for sponsoring flights to Oslo, for me to be able to meet the interviewed representatives in person. This was a great experience, and I am grateful for your endless support.

Lastly, I want to thank my superb fiancé who's been forced to listen to endless readings of this thesis. Thank you for being so enthusiastic and supportive through this whole process.

Ingebjørg Strand Lende
15.06.2023

Table of Contents

1 Introduction

The idea behind this master thesis must have started with my curiosity for nuclear power and risk perception, I discovered in one of my first subjects at the University of Stavanger. It was a subject about risk perception and raised questions such as “why would someone rather live next to an unstable volcano than next to a modern nuclear powerplant?”. I must admit I did not have the sufficient knowledge on nuclear power plants or unstable volcanoes to make a judgment of the related risk of these scenarios at the time. What I understood from the subject is that peoples risk perceptions are not always rational, but rather emotional. People often feel more secure driving their car, than sitting on a plane with a pilot steering who’s got a lot more training flying a plain, then the average person has driving a car.

Concerns about the sustainability of reliance on fossil fuels, as well as the energy crisis have brought up the discussion of the value of nuclear energy again. I find this topic important and urgent because of the growing climate threat of global warming as well as the current energy crisis Europe is in.

The dictionary *Oxford Language* defines the term “convey” as “communicating a message or information”. It can also be defined as “making an idea, impression, or feeling known or understandable”. The reason I chose to use “Conveying nuclear risk” as a title, is because it captures the essence of the debate of nuclear power and related risks. At different times in history, nuclear power has been debated both positively and negatively and different actors are conveying different risk pictures of commercial nuclear power. Norway has been pointed out as a country with the fourth largest amount of thorium in the world, which can be used as nuclear fuel and energy production more valuable than all Norwegian oil and gas. The possibilities semes tremendous, especially in a time of energy shortage Europe is in today and for future energy demand. However, the hype over the tremendous possibilities has time and time again cooled down from societal resistance as well as political reconsideration after accidents like Three Mile Island, Chernobyl, and Fukushima.

In the wake of the current energy crisis, the discussion of nuclear power is yet again a debated topic in Norway. A new company named *Norsk Kjernekraft* (Norwegian nuclear power) was

founded in 2022. This company claims to have the business-plan to provide safe, secure, and sustainable energy from small modular reactors (SMRs) within the next 10 years. Norwegian politicians on the other hand, are not convinced the road to nuclear power will be easy, or the best way to produce energy at all.

This thesis investigates how the different stakeholders in the Norwegian nuclear power-sphere are communicating risks regarding the use of commercial nuclear power and the SMRs. It investigates the long lines by discussing previous debates and historic incidents as well as the current situation and updated perspectives of the modern technology.

1.1 Research questions

The main, and wholistic research question of this thesis is:

"How are risks related to nuclear power and SMRs communicated in Norway?"

In addition to the main research question, there will be three additional research questions, supporting what the thesis is investigating:

1. "How are risks of SMRs represented by the interviewed stakeholders?"
2. "How are the interviewed stakeholders legitimizing SMRs?"
3. "How are the interviewed stakeholders using communication strategies for effective risk communication?"

1.2 Research purpose

Nuclear power is nothing new in Norway, as Norway contributes with leading nuclear research at the Institute for Energy-Technique (IFE). However, commercially operated reactors have never existed in the country before. As the company Norsk Kjernekraft has been established, and the discussion about nuclear power in Norway is on the table, I want to put a spotlight on the related risk communication.

The purpose of this research is thereby in the broad sense about understanding how commercial operation of nuclear power would be possible and how the related risks are

evaluated. More specifically the thesis investigates how the different actors in the industry is communicating the risks.

By investigating this topic, I hope to gain a better understanding of risk communication as well as gather information that could be important for the continuous discussion about nuclear power in Norway.

1.3 Limitations of the research

The research in this thesis will be limited to interviews with The Institute for Energy Technology (IFE), and The Norwegian Radiation and Nuclear Safety Authority (DSA), and stakeholders from the commercial industry. I chose to interview these actors because they represent different aspects of the nuclear power community. I hope this will provide a solid basis for my research. Some of the background information is based on political views from the government, but interviews with political parties or decision makers in government are not carried out in this research.

The research will not investigate all types of nuclear reactors, it will be limited to focus on the SMR-technology. More specifically, the thesis will be focused on light water SMR-technology and the SMR-design proposed by Rolls Royce, as there are many different technologies and designs. The thesis will neither do a heavy analysis of media-reporting, even if it could be an influencing aspect of risk communication. This aspect is addressed, and some media reporting is used as background information, but it will not be the main material in the analysis.

The theoretical framework will mainly be focused on risk communication and some aspects from risk perception and evaluation. The process of assessing and evaluating the risks are not the main subject of this research. However, as risk communication is closely linked to how risk is perceived and evaluated, there will be some theory and interview-questions about risk perception and evaluation included.

1.4 Structure of the thesis

The thesis starts by mapping out the background for the debate about commercial nuclear power in Norway and addressing previous research about nuclear power and risk communication. The background will also entail a presentation of the SMR-technology and the current state of the global SMR development. Further, the thesis establishes the theoretical framework and central concepts used to analyze and discuss the data. The next sections include an explanation of methodology and data, followed by the analysis of discourses from the interviews. First a table with related discourses are presented followed by the analysis taking the theoretical framework into account. This is followed by a further discussion and conclusion.

1.5 Ethical considerations

All the participants in the interviews of this thesis received an invitation as well as a letter of information about the research project. The letter explained what rights the participants would have and that it was entirely voluntary to participate. It was clearly stated what purpose the research has, and the gathered data will not be used in any other context. A dialog has also been forwarded, to discuss representations of the participants and checking of citations.

2 Background

A timeline and a historic background for the nuclear debate in Norway is mapped out in the master thesis *Nuclear power from thorium – A solution for climate challenge?* (Sørlie, 2015). I will further use some of the information from this thesis, as well as a report from the EU Institute of Security, and the latest discussions from news outlets to establish the background of the debate about nuclear power in Norway.

2.1 The green resistance

In 1948 the Institute for Nuclear Energy, now Institute for Energy-technique (IFE), was founded in Norway (Sørlie, 2015). The institute was founded to study peaceful areas of use for nuclear power, such as electricity and powering ships. The institute built significant competence in the field, as well as a nuclear reactor that was finished in 1958 in Halden county.

The post-war period was characterized by optimism for technical solutions, including the possibilities for nuclear power (Sørlie, 2015). An example of this can be found in the Norwegian Labour party's (AP) policy program from 1957. It states that Norway was in the middle of a new industrial revolution, powered by modern science and technique. This revolution would include new inventions, new raw materials, and using nuclear power for peaceful purposes. The 1970's was also a time when several political parties agreed to move forward with nuclear power as an energy source, and the building was to be done by The Norwegian Water Resources and Energy Directorate (NVE). The advocates for nuclear power also changed the Norwegian term "atom kraft" which refers to the atom used in nuclear power and is the same word used when talking about bombs. This term was replaced with the term "Kjerne kraft" which refers to the core of the atom. NVE also published a booklet with information about the possibilities of nuclear power. At the same time a movement of resistance was growing in Norway and criticized the nuclear-positive information that was spreading. Different environmental groups and movements started to publish critical books and articles about nuclear power, and the movement grew with the youth leading the resistance. In 1975 the leader of NVE stepped down, partly because of the force of resistance. This led the discussion forward by putting a loupe on the relationship between experts and

politicians. Continuously, scientists at the Norwegian Institute of Public Health (FHI) warned about the dangers of nuclear power, especially the risks of radiation causing cancer and damage to people's genetic material.

The government was now split about the question of using nuclear power. The Liberal party (V), The Center party (SP) and The Socialist Left party (SV) was against, while The Labour party (AP) and The Conservative party (H) was the most positive towards nuclear power. In 1977 a committee was founded with the purpose of evaluating safety and the potential role of nuclear power in the Norwegian energy supply. In 1978 the committee concluded in strong favor of building nuclear powerplants, with 18 out of 21 members in favor. Still, there was a strong resistance against the use of nuclear power in the public. The last straw was placed in 1979 as the accident of Three Mile Island in Pennsylvania happened. The Norwegian people, the environmental movements and the Three Mile Island accident put the debate over nuclear power to rest. The Chernobyl accident in 1986 made the resistance even greater and is still being used as an argument against the use of nuclear power today.

2.2 The thorium optimism

The debate regarding energy production from thorium started in 2006 in Norway (Sørlie, 2015). Professor Egil Lillestøl at the Institute for Physics and Technology published many articles discussing the element. In the article *Norwegian Element can solve the energy crisis* (Vogt, 2006), Lillestøl listed positive aspects of using accelerator driven systems (ADS) based on thorium. He stated that the amount of thorium in Norway can produce energy at an estimated value of 250 billion US dollars. Lillestøl also explained that a uranium reactor has the possibility of "running wild", while operators would be fully in control over the reactions in an accelerator-driven reactor, eliminating the possibility of a meltdown. Another positive is that the residual waste from a thorium-reactor is very difficult to use for producing the uranium one would need for weapon production. After about five hundred years, the radioactive waste would not be more dangerous than the radiation from burnt coal.

In the years 2006 and 2007, these positive aspects of the accelerator driven nuclear energy from thorium was written about in a lot of articles and newspapers in Norway (Sørlie, 2015). These new revelations changed the previous basis for evaluating nuclear power in Norway's

energy mix. The Italian Nobel prize winner and pervious general director of the European Organization for Nuclear Research (CERN), Carlo Rubbia, forwarded a proposition for building an ADS-reactor in the 1990's. This development was also supported by the European Union, but the grants came to a stop as the estimated building cost was about 500 million euros. Lillestøl argued that Norway should finance the first prototype of the thorium-based reactor. This proposition was not met with a lot of enthusiasm in Norway. The case was discussed in a meeting in the Norwegian government in November 2006. The progress party (FRP) was the only party in favor of build the thorium-based reactor. The other parties shifted the focus of the discussion to continuing the oil and gas production with the addition of using carbon capture, as well as development of renewables. The progress party's motivation for nuclear power was concluded by the other parties to stem from economic profits and not environmental concerns. Environmental movements and IFE also expressed scepsis for large scale investment in nuclear energy from thorium. Most of the political parties still did not close the door to nuclear power completely but agreed to establish a committee for further investigation and gathering a factual basis on the topic. Thereby the Thorium-committee was established in 2006 by Norway's Research Council on behalf of the oil and energy department.

In 2008 the Thorium-committee presented their report (Sørlie, 2015). They concluded that all carbon-neutral technologies that can provide a sustainable energy future should be recognized, including nuclear power. Norway's thorium resources should be mapped out, as it is essential to know if thorium can be defined as an economic resource for future generations. Further, new technologies for thorium extraction should be studied. Testing of thorium in the reactor in Halden should be encouraged and this competence should be put to further use. Norway should strengthen participation in international cooperation by taking part in Euratom's fission program for thorium-reactors. The development of accelerator driven systems for thorium is currently outside of Norway's realm of capacity. It is therefore important to consider participating in projects and studies with the rest of Europe. Norway should also raise competence on nuclear waste management to international levels. A cooperation with Sweden and Finland should be valuable. Overall, the committee found that any nuclear activity in Norway, would need strong international merging of human resources. To succeed in nuclear ventures, Norway needs long-term commitment investing in basic research and university educations. This should be included in a national strategy with the

goal of developing sustainable energy sources. In any case, Norway should preserve competence in nuclear science and nuclear engineering to meet challenges related to the new nuclear period in Europe.

In 2011 there was another accident at a nuclear powerplant; Fukushima Daiichi (Sørlie, 2015). The powerplant was exposed to an earthquake measured at 0,9 on the Richter scale, and further hit by a 15-meter-high tsunami. This led to disconnection of power supply, continuously leading to disconnection of the cooling system of the cores. The three existing cores melted completely. The accident was measured to the highest level of incident, or "Major Accident", on the INES scale (International Nuclear and Radiological Event Scale). Even though the three reactors were stabilized within two weeks, there had been a large leakage of radioactive waste the first days. No incidents of deaths related to radioactive exposure has been registered, but about 100.000 people had to be evacuated to prevent that from happening. The Fukushima accident cooled down the optimism over nuclear power yet again. Environmental movements interpreted the accident as proof for their arguments, and the debate about thorium died out.

2.3 The energy crisis

It is difficult to determine exactly when the energy crisis came about in Europe, because the repercussions was noticed after a long chain of events. A report from the EU Institute of Security study found that the energy crisis stems from a combination of internal and external factors triggering the market and surging energy prices in Europe in 2021 (Popkostova, 2022). Both Europe and Asia had an unusual cold winter season from 2020-21. Texas (USA) also had freezing temperatures, leading to the supply of LNG (liquified natural gas) cargo not reaching Europe. Latin America generated less LNG than usual because of drought, and transit problems in the Panama Canal added to supply not reaching Europe. In the beginning of 2021 scarcity of shipping capacity during the covid-19 pandemic pushed LNG shipping rates to an all-time high. Energy demand increased in different countries after the pandemic, leading the first economies recovering from it to buy much of the available LNG.

A news report from 2021 stated that China asked their energy providers to "vacuum the world of energy, no matter the cost" (Hovland, 2021). This made China the largest LNG importer in

the world at the time. IEA (International Energy Agency) gathered data that showed gas consumption rising by 25 percent in the second quarter of 2021, making it the most significant increase since 1985 (Popkostova, 2022). This perfect storm also came from other countries such as Germany which was in the middle of pashing-out nuclear power and France which had problems with energy production because of maintenance on nuclear power plants. All these events, along with aborting the Nordstream2 gas pipe and Russia reducing the export of LNG are just some of the many factors causing the still ongoing energy crisis in Europe.

Although Norway is profiting from large scale gas exports and hydropower, there is a steep energy price for the consumer to pay (Hovland, 2021). The conflict between Europe and Russia is worsening the energy crisis, as Russia typically provides one-third of the gas consumption in Europe. The war in Ukraine and the stand Europe has made against Russia makes this crisis even more obstructive.

2.4 The SMR

The energy crisis might have been a good opportunity for nuclear advocates to awaken the debate over nuclear power again, as people have felt the repercussions of paying a steep energy price. The discussion is yet again in newspapers and on tv-debates as the new company *Norsk Kjernekraft* (Norwegian Nuclear Power), has gotten a lot of attention. Norsk Kjernekraft states on their website that the time is right for nuclear power in Norway (Norsk Kjernekraft AS, 2023). Further they state that nuclear power can provide Norwegian citizens clean and reliable energy at an affordable price, which is part of the UN's sustainability goal number seven. Norsk Kjernekraft also refers to resent assessments by the EU (Abousahl et al., 2021), which showed clear advantages of using nuclear power and no bigger disadvantages than using renewables.

Norsk Kjernekraft is also listing a plan they have for the years 2022-2025 (Norsk Kjernekraft AS, 2023). They want to identify areas that will be suitable for building SMRs. They also want to prepare the basis for a license and secure strategic industrial partners. Other points listed in their plan: communication and marketing, research projects with relevant institutions, and education – M.Sc./PhD theses. The reactor Norsk Kjernekraft is promoting building is the SMR. This reactor has an effect of 300 MW, compared to conventional reactors which has an

effect of more than 1000 MW. The cost of an SMR would have a much lower price tag than the conventional ones, at a maximum estimate of 20 billion NOK.

2.5 The 2023 debate

The 24th of January 2023, a debate program was broadcasted on the state-owned network NRK (Solvang, 2023). The debate was about the viewer requested topic "nuclear power". The debate host, Fredrik Solvang opened the debate by explaining traditional negative perceptions of risks related to nuclear power. He also noted that the belief holders of these negative perceptions might be of a particular age. Recent studies showed that 37 percent of Norwegians between the age of 18-29 years, is in favor of building nuclear power plants in Norway. The same study showed that 50 percent of all Norwegian men wants Norwegian nuclear power to solve the energy crisis. Solvang emphasizes that a lot of youth, especially young men have requested this topic for the debate program.

Nuclear physicist and communication director of Norsk Kjernekraft, Sunniva Rose, is asked about the company's plan in Norway (Solvang, 2023). Rose explains that they want to build SMRs that will contribute to the green transition and to produce safe, sustainable, and regulative power. She continues to explain that the SMRs would be mass-produced on dedicated factories making them less costly, less time-consuming to build, but still very effective. An SMR would be able to produce 2,5 TW hours of electricity each year, equivalent to what 150.000 households in Norway would use in a year. Another point Rose makes is about the regulative aspect of nuclear power. Renewables like solar, wind and even hydropower is not fully regulative. A nuclear power plant on the other hand, would be fully controllable and regulative.

Department head of environmental safety and radiation protection at IFE, Ole Christen Reistad, is next in line (Solvang, 2023). He was the leader of Norway's last nuclear reactor but does not want nuclear power production in Norway. He explains that previous experience indicates that it would be very difficult, time consuming and not productive for reaching climate goals. He also states that the safety as nuclear science stands today, is not good enough. Problems regarding accidents and waste disposal needs to be improved in multiple countries.

Rose responds by stating that nuclear power is the safest way of producing energy, compared to all other methods of energy production (Solvang, 2023). From a historic point of view, nuclear power has the lowest loss of lives per terawatt hour of energy production. Nuclear power does not even have the deadliest accidents, hydropower does. This argument is closed by Rose referring to a calculation done by the UN's science panel. If all countries with nuclear power plants updates their plants to modern standards, the world would have only one loss of life each 315th year. Reistad counters this statement by arguing that we have observed bigger nuclear accidents (like Fukushima) each tenth year, and that the industry needs to be robust enough to handle those accidents as they happen. Rose responds by stating that the power plants in use, as these accidents happened (Three Mile Island, Chernobyl, Fukushima) did not use modern standard power plants. Reistad continues by agreeing that the world needs nuclear power to reach climate targets, but he is not so sure Norway would need it.

Solvang continues the debate program by showing Statnett's (The system operator of the Norwegian power system) analysis of future energy demand in Norway (Solvang, 2023). Statnett estimates that the south region of Norway will experience a shortage of power supply as early as in 2026. Hadia Tajik, representing the governing Labour party, answers to this by stating that the energy and environmental crisis Norway is in calls for investigating all options. However, the government's plans do not entail nuclear power. Tajik argues that using nuclear power would be a longer and unsafe way to produce more energy at an affordable price. She continues to explain that the Labour party is open for more research on the topic, but they are not in favor of commercial building of nuclear power plants in Norway.

Rose responds to Tajik by stating that Norsk Kjernekraft will not ask for money or subsidies, the only thing the company will need is for the government to let them compete with other energy sources (Solvang, 2023). Tajik argues that even if they won't need direct subsidies, the government is responsible for other costs such as infrastructure and safe handling the waste disposal. She adds that there are still problems connected to waste disposal from the four previous research reactors in Norway. Rose responds by explaining how Norsk Kjernekraft will pay for waste disposal themselves, based on a Swedish business model.

Marius Arion Nilsen, representative from the Progress party, states that the party wants to help realize the use of SMRs (Solvang, 2023). Nilsen emphasizes that Norway would need more competence and information on the field, but nuclear power has a clear place in the future energy mix.

2.6 Risk perceptions in the public

The societal analysis agency *Opinion* carried out a survey in the Norwegian population in February 2023. The results showed that 51 percent of the public agreed that Norway should build commercial nuclear power plants (Opinion, 2023). Only 37 percent disagreed. The younger generation has been the most positive for a longer period, but in the age group 'over 60 years old' there are just as many positive as negative respondents. All over, more people agree than disagree to the notion of building nuclear power plants. The survey also showed that members of the progressive party (FRP) are most supportive with 73 percent. The Left party (V) had 63 percent, the Conservative party (H) 58 percent, The Red party (Rødt) 52 percent, and the Green party (MDG) 52 percent. The agency argues that aspects like the electrical prices and the climate crisis can be the cause of nuclear power being popular across most political parties. The Norwegian broadcasting corporation NRK states in a news article that more and more people believe the solution to the energy crisis could come from nuclear power (NRK, 2022). NRK asked the Norwegian people the question: "Should Norway pursue nuclear power to solve the energy crisis?". 51 percent of men agreed, while 17 percent answered, "I don't know", and 32 percent disagreed. 16 percent of women agreed, while 42 percent answered, "I don't know", and 42 percent disagreed.

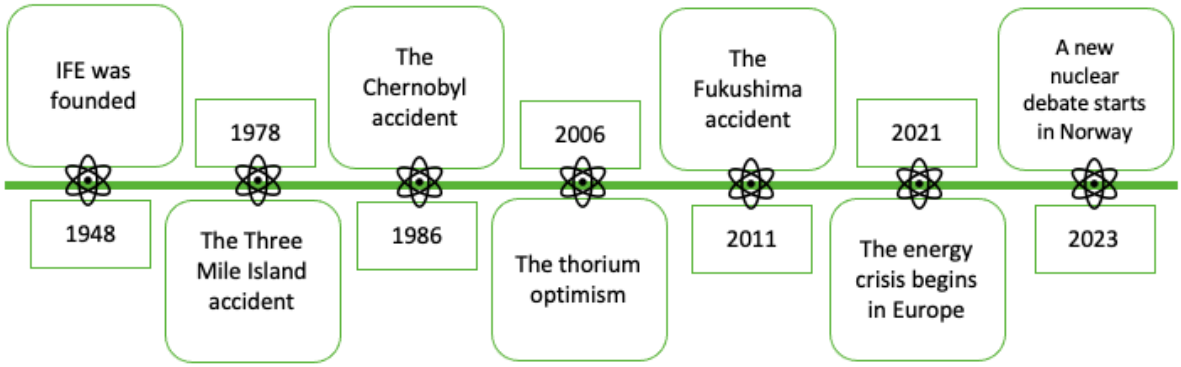

Figure 1: Timeline – Background of the nuclear power debate in Norway

As this timeline shows, there have been optimistic times for nuclear energy in Norway. IFE was founded to conduct research on nuclear energy in 1948, and the optimism for thorium-based reactors was present in Norway from 2006. However, there have been dips in the enthusiasm for nuclear power, especially after the three big accidents in 1978, 1986, and 2011. Alongside the energy crisis in Europe, nuclear power is yet again a debated topic in Norway in 2023.

2.7 Current state of the global SMR development

The information about the current state of global SMR development in this section, is gathered from the webinar: *SMR Readiness and the Launch of the NEA SMR Dashboard Confirmation* (Nuclear Energy Agency, 2023), as well as the report from this webinar: *The NEA Small Modular Reactor Dashboard*. The assessment for the Nuclear Energy Agency (NEA) Dashboard is based on information The Organization for Economic Cooperation and Development (OECD) gathered from verifiable public sources. Most of the sources are from third party references such as governments, regulators, financiers, and operators. The assessments are driven by objective criteria applied to information compiled from these sources. They are not the subjective judgements of analysts.

2.7.*1 What is a small modular reactor?*

An SMR is a smaller nuclear reactor, both in terms of power output and physical size, compared to conventional gigawatt-scale nuclear reactors (Nuclear Energy Agency, 2023). SMRs has a power output less than 300 megawatts electric (MWe), some as small as 1-10 MWe. These reactors are designed for modular manufacturing, factory production, portability, and scalable deployment. SMRs use nuclear fission reactions to create heat that can be used directly or for generating electricity.

2.1.1.1 *Safety:*

SMR designs is developed from over 60 years of experience in the nuclear energy sector (Nuclear Energy Agency, 2023). Many SMR designs incorporate what can be described as “passive safety”. This concept does not require active interventions or backup power to safely shut down. Lower power output and smaller cores of SMRs increases the efficiency of such passive safety systems. Many SMRs that are based on light water reactors (LWR) contains

very large water inventories for passive system cooling, even under extreme circumstances (example: loss of offsite power). The benefits of smaller inventories combined with high passive safety can lead to reduced offsite emergency planning zones (EPZ).

2.1.1.2 Flexibility:

The Clean Energy Ministerial NICE Future flexibility campaign (NREL, 2020) defines nuclear flexibility as:

> "The ability of nuclear energy generation to economically provide energy services at the time and location they are needed by end-users. These energy services can include both electric and nonelectric applications utilizing both traditional and advanced nuclear power plants and integrated systems (Nuclear Energy Agency, 2023, p.15)."

SMRs offer much needed flexibility to enable high shares of variable renewable energy by the reactors design to integrate into energy systems (Nuclear Energy Agency, 2023). The technology can serve as an important part of the flexibility solutions, supporting renewables' integration to maintain security of electric supply.

2.1.1.3 Costs and competitiveness:

Previous increasement in size of reactors have been replaced with scaling it down and relying more on multiple or serial construction (Nuclear Energy Agency, 2023). The competitiveness of the SMRs is linked to the serial construction in factory manufacturing, design simplification, standardization and modulization. SMR developers are taking advantage of the lessons learnt from sectors such as shipbuilding and the aircraft industries. SMRs will be smaller, scalable, and more affordable compared to large scale reactors.

2.1.1.4 Spent nuclear fuel and waste management:

The Nuclear Energy Agency states the following about spent nuclear fuel and waste management:

> "The nuclear sector is implementing proven solutions to manage spent nuclear fuel and nuclear waste. Regarding radioactive waste management, there is today a strong international scientific consensus that deep geological repositories (DGRs) are a safe

and effective approach to permanently dispose of high-level waste (HLW). The progress made so far on DGRs in several countries, with Finland, Sweden and France leading the way, has proven that DGRs are viable industrial-scale solutions for final disposal of HLW (Nuclear Energy Agency, 2023, p.16).»

2.7.2 Conditions for success

The Nuclear Energy Agency refers to a quote famously said by Henry Ford: "If I would have asked people what they wanted they would have said faster horses" (Nuclear Energy Agency, 2023, p.5). Ford transformed the factory manufacturing with standardization driving down costs, making widespread deployment of automobiles possible. This underlines the continuous discussion about how progress often is linked to technology and industry. Today we face a new wave of innovation central to social progress, economic growth, and the health of the environment – the production of energy.

SMRs are being developed to target hard-to-abate sectors where variable renewables and large-scale nuclear energy have limitations. These sectors include the following (Nuclear Energy Agency, 2023, p. 22):

- Coal replacement for on-grid power
- Fossil fuel cogeneration replacement for industries 3
- Diesel replacement for off-grid mining
- Fossil fuel replacement for district heating
- Energy and water
- Hydrogen and synthetic fuels
- Merchant shipping

Beyond the technical feasibility, there are other necessary conditions for the success of SMRs, structured around three themes: technologies, enabling conditions, applications, and markets (Nuclear Energy Agency, 2023). Strategic partnerships will be a key element for developing the technology successfully. It is also important to collaborate with research institutions and national laboratories for successful research, development, demonstration, and safety assessments. Technologies must be tailored to fit with the specific market applications, and governments and international organizations have a role to play in creating the enabling

frameworks. This includes policies, regulatory readiness, and legal aspects. Safe and secure SMR fuel supply chains are also an essential aspect, as is a responsible plan for the management of the back end of the fuel cycle. Human resources, such as: a pipeline of talent, public engagement, and trust, are all essential enablers of SMR.

3 Previous research

In this section I will refer to previous research of topics related to risk communication and nuclear power.

3.1 The Evolving Field of Risk Communication

The article *The Evolving Field of Risk Communication,* is a literature review evaluating recent debates over the risk communication field's current state and future directions (Balog-Way et al., 2020). The literature reviewed is a selection of prominent cognitive, cultural, and social risk communication appearing in the published literature since 2010.

This review starts off by explaining the influential role the Society for Risk Analysis (SRA) has played in the evolution of risk communication research (Balog-Way et al., 2020). From January 2010 to December 2019, 329 risk communication articles were published in SRA's flagship journal, *Risk Analysis.* Figure 2 is a depiction of the diversity from these articles based on 1379 collected keywords. Larger and redder words appeared more frequently in the articles, synonyms were given a common label, and words appearing less than three times were excluded.

Figure 2: Word cloud displaying article keywords (Balog-Way et al., 2020, p.2241)

3.1.1 Conceptualizing risk communication research

The field of risk communication has been shaped and reshaped over time. Risk has evolved from being strictly treated as the outcome of "objective" and "expert" risk assessments, where "lay" perspectives were considered subjective and irrational (Balog-Way et al., 2020). While the more modern perspective recognize that risk is not limited to risk assessments, but rather understood as a social construct. As the societal understanding of risk continues to evolve, the field of risk communication continues to evolve with it.

This article suggests that the understanding of risk in society is not the only factor shaping risk communication research. A particular example is how the risk communication community have replaced the deficit model with multi-way approaches, which include functions such as engaging audiences through meaningful dialog and deliberation (Balog-Way et al., 2020). The last decade has had an upsurge in debate over "What constitutes as *effective* risk communication?", where effectiveness refers to the degree to which a desired result is achieved. The debate was based on normative, instrumental, and substantive arguments for engagement in multi-way risk communication.

3.1.1.1 Normative arguments

Normative arguments did not stress any specific desired result for effective multi-way risk communication (Balog-Way et al., 2020). Individuals were described as the best judges of their own interests from a normative perspective. Scientists also noted that the democratic ideal of empowerment can only be achieved when individuals have a level of knowledge and awareness to establish a meaningful engagement.

3.1.1.2 Instrumental arguments

Instrumental arguments were focused on effective multi-way risk communication being a helping-tool for individuals, groups, and organizations to achieve desired results (Balog-Way et al., 2020). An example can be an instrumental behavior change goal, which requires risk communicators to know the best course of action to take. Other desired instrumental goals through multi-way dialog include fostering trustful behavior, enhancing legitimacy, consensus building, and conflict resolution. However, most of the research emphasized that not all instrumental goals are desirable in all circumstances and the result does not necessarily justify the means.

3.1.1.2 Substantive arguments

Substantive arguments stressed the ability of effective multi-way risk communication to generate new insights and improvements in availability and quality of knowledge (Balog-Way et al., 2020). Public participation brings different types of knowledge and experience to the discussion, which enable the creation and exchange of information.

3.1.2 Multifaced approaches for effective risk communication

The recent perspectives from these arguments reflect that there will never be one single generic version of how risk communication should be conducted (Balog-Way et al., 2020). Even though all reasons might not be acceptable, ethical, or effective in every circumstance, there are various valid reasons for engaging in mutual practice. Some arguments are valid in some contexts, but certainly not in others. Over the last decade, risk communication researchers have engaged with important events and issues, such as emerging technologies, hypotheses, and new channels for communication (Balog-Way et al., 2020). However, researchers also continue to engage in past reviews such as trust, framing, risk perception and public engagement, which are relevant for current challenges. The review consistently points to the requirement of a multifaced approach for effective risk communication, as no simple dominating formula for risk communication exists (Balog-Way et al., 2020). Limiting risk communication to certain attributes such as limiting psychological distance, communicating uncertainties, or using humor singlehandedly will probably not provide the desired results. Another point is that risk communication cannot be seen a single event, but rather a long-term commitment of meaningful evaluations to achieve lasting and positive outcomes.

3.1.3 The interdisciplinary field of risk communication

The article found that relying on a single, generic version of risk communication will be less productive than an open-minded exploration of the multiple forms existing in the inter-disciplinary field (Balog-Way et al., 2020). The interdisciplinarity was also found to be one of the risk fields greatest strengths, providing significant new advances. Topics such as transparency, public engagement and affective and emotional components particularly progressed by applying theories from different disciplines. The review concur that researchers

should continue to draw from different fields, including all types of social sciences and humanities to advance our risk communication understanding.

3.2 Support for nuclear power in countries of the European Union

The study *Support for Nuclear Energy in the Context of Climate Change: Evidence From the European Union* (Pampel, 2011), uses survey data from nations of the European Union to examine sociodemographic differences among individuals and national differences of support for nuclear energy.

3.2.1 Overall picture of risk attitudes towards nuclear power

Despite the improvements of modern nuclear power plants, the survey results from this study showed that nuclear energy is the least popular source of energy across all nations of the EU (Pampel, 2011). The results also showed that renewable sources such as solar, wind, hydroelectric, ocean and biomass are the most popular. Support for fossil fuels (gas, oil, and coal) is lower, but still has higher support than nuclear power.

The overall numbers show that:

- 56,5 percent believe that the risks of nuclear energy outweigh the benefits, and just 36 percent believe that the benefits outweigh the risks.
- 57,4 percent believe that nuclear energy poses a risk, 40,2 percent believe it poses some risk, 17,2 percent believes it poses a big risk, and 42,5 percent don't believe it poses a risk.
- 43,4 percent believe that nuclear energy use should be reduced, and 16,8 percent believe it should be increased.
- 60,6 percent agree that nuclear energy helps limit global warming
- 62,5 percent agree that nuclear power ensures lower and more stable energy prices.

The overall numbers reflecting attitudes about nuclear power is largely negative (Pampel, 2011). Even though a large majority agrees that nuclear power plants can operate safely, the majority still disagrees with statements that radioactive waste can be disposed safely and

properly protected against misuse. On the other hand, the results show most positive attitudes towards nuclear power's ability to help limit global warming and lower energy prices. However, these advantages do not outweigh safety concerns.

3.2.2 Nuclear energy support by country

Most national variables of economic development reduce support for nuclear energy (Pampel, 2011). Countries with high income, high human development, and noncommunist pasts has a lower support for nuclear power. Secular values and the presence of nuclear power plants in a country often increases support for nuclear energy. However, the only national characteristic with significant influence for nuclear power support is the presence of secular values and the presence of nuclear power plants in a country. Previous experience with nuclear power shows to be an important societal influence as they are the countries that are most supportive of nuclear power. France, Germany, Sweden, Great Britain, Belgium, Spain, Czech Republic, and Slovak Republic are countries with five or more operating nuclear powerplants. Slovenia, Lithuania, Romania, Bulgaria, Finland, and the Netherlands have one to four operating nuclear power plants. The results show that the remaining 15 countries of the EU without any nuclear power plants have an average lower support for nuclear energy.

- Countries with the highest support for nuclear power (in highest to lower order) (Pampel, 2011):
  Bulgaria
  Sweden
  Romania
  Hungary
  Finland

- Countries with the lowest support for nuclear power (in lowest to higher order) (Pampel, 2011):
  Luxembourg
  Greece
  Cyprus Republic
  Ireland

Austria

- Only five countries support nuclear energy more than fossil fuels (highest support to lower) (Pampel, 2011):
  Sweden
  Finland
  France
  Czech Republic
  Hungary

3.2.3 Nuances of nuclear energy support in the EU

Even though nuclear energy has overall low support in EU nations, it is viewed more positively when compared to fossil fuels (Pampel, 2011). Still, associated risks and safety concerns limits the general popularity, and few respondents view climate change as a reason to expand nuclear energy. The individual level results show that nuclear energy supporters tend to be groups with higher education, higher prestige jobs, as well as familiarity with the technology. The net effect of greater schooling and knowledge-based jobs might make people more comfortable with the sophisticated science and technology of nuclear energy. Educated professionals of the opposing group tend to have strong postmaterialist and environmental views.

The presence of operating nuclear power plants in a country mostly influence support for nuclear energy (Pampel, 2011). It could mean that positive attitudes are associated with positive experience with nuclear power from the past. Countries most reliant on nuclear energy usually have citizens who favor the technology and continued use. However, there are exceptions to this relationship of correlating attitudes. Even though Germany relies on nuclear energy for 23 percent of their electricity, there is strong opposition to using nuclear energy in the country. This led politicians to reject plans for nuclear expansion, and the government announced plans to shut down its 17 nuclear reactors after the Fukushima accident and related public concerns. Spain also relies on nuclear energy for 18 percent of their electricity, but in 2008 the government promised to gradually replace nuclear power with renewables.

The Fukushima accident publicized the dangers of nuclear power and could be a reason why national attitudes changed (Pampel, 2011). Factors relating to a country's cultural and political dynamics can override the influence of familiarity with the technology.

3.3 Environmental Debates over Nuclear Energy

The article *Environmental Debates over Nuclear Energy: Media, Communication, and the Public*, tackle some of the challenges in addressing research gaps in the related debate. The findings are based on studies from a global perspective using a variety of methodological designs, perspectives, and analyzing both online and offline settings.

3.3.1 The polarized debate over nuclear power

The article starts off by explaining that there often are two polarized sets of arguments in the environmental debates over nuclear power (Ho & Kristiansen, 2019). One argument focusses on the potential benefits of nuclear energy that can produce energy in a clean way because of the low carbon emission, reliable energy production, economic competitiveness, and stable electricity prices. The other argument is concerned with the possibility of ionizing radiation leaks, nuclear waste contamination of the environment, and potential adverse effects such as proliferation of nuclear weapons. The aftermath of nuclear incidents such as Fukushima-Daiichi in Japan, has led nations such as Germany, Switzerland, and Belgium to decide to phase out nuclear power. However, China, India, Finland, the UK, and the US are actively building new nuclear power plants.

Studies focused on news media coverage in North America and Europe have investigated the different framings that were used to depict nuclear energy after major risk events such as Three Mile Island and Fukushima (Ho & Kristiansen, 2019). The studies showed that the low carbon emission benefit was greatly attenuated in the media, while the potential threat of harmful radiation and detrimental potential was devoted heavy attention.

Other studies mostly based in North America and Europe, found that a general public relate aspects such as benefit perceptions, trust, and knowledge to positive acceptance of nuclear energy (Ho & Kristiansen, 2019). While risk perception is seen as a more negative aspect

regarding public risk acceptance. Public opinion studies have found that there has been a sharp dip in public acceptance of nuclear energy, by comparing studies from before and after the Fukushima accident.

3.3.2 Gaps in existing research

Even though there have been a substantial number of research done regarding nuclear energy and communication, there are still missing pieces in the research (Ho & Kristiansen, 2019). There has not been given much attention to the long-term issues, as many studies focus on shorter-term issues such as amplified risk in the aftermath of major accidents, risk perceptions in the public, crisis and risk communication research, and media coverage. Long-term issues such as political discourses about national energy and climate policies, or changes in the multifaceted public debate over time, are often overlooked in the literature.

Another research gap is about the risk characterization in the media coverage about nuclear energy (Ho & Kristiansen, 2019). There is a lack of multidimensional risk definitions capturing both benefits, adverse effects, probability, uncertainty, and impact of risks. A multidimensional approach would provide a more comprehensive picture of the dimensions of risks being discussed.

Despite the popularity and heavy use of social media, there is only a few studies conducted analyzing online discourses about nuclear energy (Ho & Kristiansen, 2019). Social media has an interactive nature that enables bottom-up communication and participation from the public. Investigating important questions regarding social media could provide empirical findings to further find needed answers.

3.3.3 Broadening the scope of risk communication

One of the contributions to this study, Arlt et al. (2019), attempts to provide empirical evidence of whether social media acts as an echo-chamber that polarizes public opinion or enables diverse discussions across online communities. The study showed to active discourses and interaction between seven diverse communities, different in terms of political affiliations, communication activity, and ways of discussing the topic (Arlt et al., 2019). The study also showed that news reporters, scientist, members of energy and environmental organizations

also participated in the online debates. Different from other studies pointing to social media as an echo-chamber, this study's findings point to social media as an facilitator for diverse viewpoints across multiple ideological lines.

Ho et al. (2018) identified and examined the effects of 19 factors on public perceptions of benefits, risks, and acceptance of nuclear energy (Ho et al., 2018). The study showed that the effects of predictors such as sex, education, public perceptions of benefits, risks and costs of nuclear energy, and trust had a much larger effect on public acceptance than scientific knowledge.

Oshita (2018) examined the effects of energy preparedness communication regarding public trust, emotions, and acceptance (Oshita, 2018). By using an experimental approach, this study found that emergency preparedness communication enhances people's trust, which can enhance their acceptance of nuclear energy. At the same time, emergency preparedness communication can also amplify people's negative emotions, decreasing public support for nuclear energy.

Perko et al. (2019) investigated media coverage of Fukushima through the lens of Chernobyl, by analyzing media coverage in Belgium, Italy, Norway, Russia, Slovenia, and Spain two months after the Fukushima accident (Perko et al., 2019). The study found that countries with more negative risk perception of nuclear energy, the Chernobyl accident was more often referred to in the media coverage of the Fukushima accident. The study conclude that the influence of the Chernobyl accident continues to influence news coverage of nuclear energy and public understanding of nuclear accidents.

Mercado-Saez, Marco-Crespo, and Alvarez-Villa (2019) investigated news frames, sources, and editorial lines in the Spanish media nuclear energy coverage (Mercado-Sáez et al., 2019). The study found that nuclear energy was not often covered from an environmental perspective, that political views were amplified in the coverage, and that views of interest groups were more often mentioned than views of the public or scientific experts.

4 Theoretical frameworks and central concepts

4.1 Defining risk

The term "risk" has many definitions and explanations. A classical definition of risk can be: the probability of an event combined with the magnitude of the losses and gains that it will entail (Joffe, 2003). There are also definitions only focusing on negative risk, such as: danger from future damage (Douglas, 1994) . Renn explains that all concepts of risk have one thing in common: the distinction between possible and chosen action (Renn, 2008). This means that an individual, an organization or a society will face several options of action, including no action, each of which is associated with potential negative or positive consequences. Humans have the ability to imagine different futures, anticipate consequences and further change outcomes within the given constraints. If the future was predetermined or independent of today's human activities, the term "risk" would not make sense.

This thesis will mainly rely on the definition of risk by Aven and Thekdi: Risk can be defined as a potential event (or series of events) with related consequences and uncertainty (Aven & Thekdi, 2021). This can be written as (A, C, U). A is the potential event, C represents the related consequences and U is the related uncertainties. The event can both represent an accident, a hazard, or an opportunity as well as "no accident".

Risk can be described by relying on frequentist probability. A frequentist probability P(A) equals to the fraction of times the event occurs when the situation considered can be repeated over and over again under similar conditions (Aven, 2015). Andersen (2022) argues that objective probability does not exist outside of controlled labs or casinos, and that it's not fruitful to entirely rely on frequentist probabilities in other situations (Andersen et al., 2022, p.989). When describing risk in a subjective way, one will have to base the probability of the event taking place on some type of knowledge. This knowledge can be defined as (K) (Aven & Thekdi, 2021). One can determine the strength of the knowledge (SoK), by what type of knowledge it is (historic data, a judgment, or an expert's judgement), and the level of agreement among experts. By evaluating the strength of knowledge we can define how strong it is, and thereby how much we should rely on it.

4.2 Risk perception

4.2.1 Perspectives from psychological and social sciences

Representatives of civil society and the public responds to risks by their own constructs and images of a specific risk (Renn, 2008). These images are called *perceptions*. Human behavior is mainly driven by perception and not by facts, or by what is considered to be facts by risk analysist and scientists. Humans tend to link certain expectations, ideas, hopes, fears and emotions with activities or events that have uncertain consequences. However, people do not rely on completely irrational ways of assessing information. Evolution has led people to cope with dangerous situations by following relatively consistent patterns of creating images of risks and evaluating them. Risk perceptions is part of important aspects that risk managers need to take into consideration when deciding if a risk should be taken or not.

An example of how human behavior is driven by perceptions of risks and not by facts can be illustrated by comparing the activities of driving a car and riding a plane (Renn, 2008). When people are driving a car and imagine possible accidents, they tend to be under the impression that they will probably not end up hurting themselves at all. On the other hand, while riding a plane they will be under the impression that their life will be in danger if something should happen. This risk perception is not swayed by knowing of related odds or statistics of how many more people die in car accidents than in airplane crashes. The rationale of this thought process comes from the voluntariness and the ability to exercise personal control. When people are under the impression that they can control the risk, they will perceive it as less serious.

Qualitative evaluation characteristics can be split into consistent risk perception classes, also called *semantic risk patterns* (Renn, 2008, p.94):

- Risks posing an immediate threat, such as nuclear energy or large dams.
- Risks delt with as a stroke of fate, such as natural disasters.
- Risks presenting a challenge to one’s own strength, such as sports activities.
- Risks as a gamble, such as lotteries, the stock exchange and insurance.

- Risks as an early indication of insidious danger, such as food additives, ionizing radiation and viruses.

Renn explains that there are many open questions when it comes to risk perceptions (Renn, 2008). However, there is also a clear conclusion:

> "…abstracting the risk concept to a rigid formula, and reducing it to the two components, ´probability and consequences´, does not match peoples intuitive thinking of what is important when making judgements about the acceptability or risks (Renn, 2008, p. 144)."

4.2.2 The anchoring effect

In addition to cognitive processing of risk situations, people tend to stigmatize risk sources associated with specific dread (Renn, 2008). Stigmatization can lead to a social amplification of risk by the public outrage and regulatory responses feeding into the process. This process is further stimulated by the media reporting and the public's risk perception is often amplified beyond what could be explained in a technical risk assessment focused on probability and direct losses. In these situations, risk perceptions can make complex problems as individuals have difficulty interpreting low probabilities when making their decision. The more a risk provokes associations with an event, the more likely it is that the related probability will be overestimated. This is called *anchoring effect.* An example of this comes from how incinerating in waste disposal facilities evokes an association with harmful chemicals even if there is no way that they could be released into the environment.

Even though evaluating and managing risks is important, overestimation and underestimation of loss expectations are not the most important aspects of risk perceptions (Renn, 2008). People tend to resolve problems by focusing on the cues that sends the strongest and most affective signals, when faced with difficult trade-off between attributes, or the "right" answer is filled with ambiguity of evidence.

4.2.3 Social representation theory

Mainstream psychological research has often been focused on cognitive processes occurring when people are faced with risks (Joffe, 2003). Kahneman, Slovic and Tversky (1982) state that: "Cognitive psychology is concerned with internal processes, mental limitations and the way in which the processes are shaped by the limitations (Kahneman et al., 1982, p. xii)". In other words, this research has focused on the existence of lay error (Joffe, 2003). This entails lay people's tendency to be overconfident regarding one's own judgement of risk, and notions of faultiness of human information processing, called optimistic bias. An example of this perspective of weighing lay people's intelligence against authoritative science can be found in relation to the nuclear power debate (Joffe, 2003). Weighing the two against one another, demands lay people to evaluate the 'hard facts' without reference to other realms. However, lay people do not just process the 'hard facts' when thinking about such issues. Nuclear power is associated with many different emotions, such as fear of environmental destruction, and scientific and technological hubris. This emotional response can be just as legitimate as the scientific take on it, rather than a delusional deviation from the 'objective reality'. People question and seek answers about matters to their concern, instead of just perceiving and processing information like a machine.

Social representation theory (SRT) differs from previous dominant paradigms (Joffe, 2003). This theory sees beyond individual information processing, viewing lay peoples reading of risks as contents of people's repositories of knowledge and inter-subjective[1] experiences. The social representations that emerge from societies enter people's explanations of new events and understandings of phenomena. Cross-cultural comparisons show that lay people are not passive perceivers of ideas from experts and mass media (Joffe, 2003). Lay people rather forge representations in line with their concerns often driven by emotions, anxiety, and trust. The social representations are usually a shared understanding within a group, developed from communicative processes. This points to a clear blind spot in the previous psychological research: that it fails to consider 'intersubjective mobilizations of belief'. The social representations of risks are thereby not distortions of the 'hard facts', they are rather the 'reality' in the minds of those who look upon the risks.

[1] Inter-subjectivity: A relational term describing something that takes place between people or a way of thinking that a group of people share (Tranøy, 2021).

4.3 Risk evaluation

4.3.1 Tolerability and acceptability

The most controversial part of handling risks is the process of delineating and justifying a judgement of the tolerability or acceptability of a given risk (HSE, 2001). When a risk is "tolerable" it means that it is worth pursuing for the benefits, but it requires some efforts for reducing the risk to a reasonable limit. When a risk is "acceptable" it means that the risk is so low that additional action for risk reduction is not seen as necessary. The distinction between tolerability and acceptability can be used for evaluating a large range of risk sources and put them into what is called the "traffic light model". This model consists of a probability measure on the y-axis and the impact on the x-axis. The model represents acceptable, tolerable, and intolerable risk in different colors.

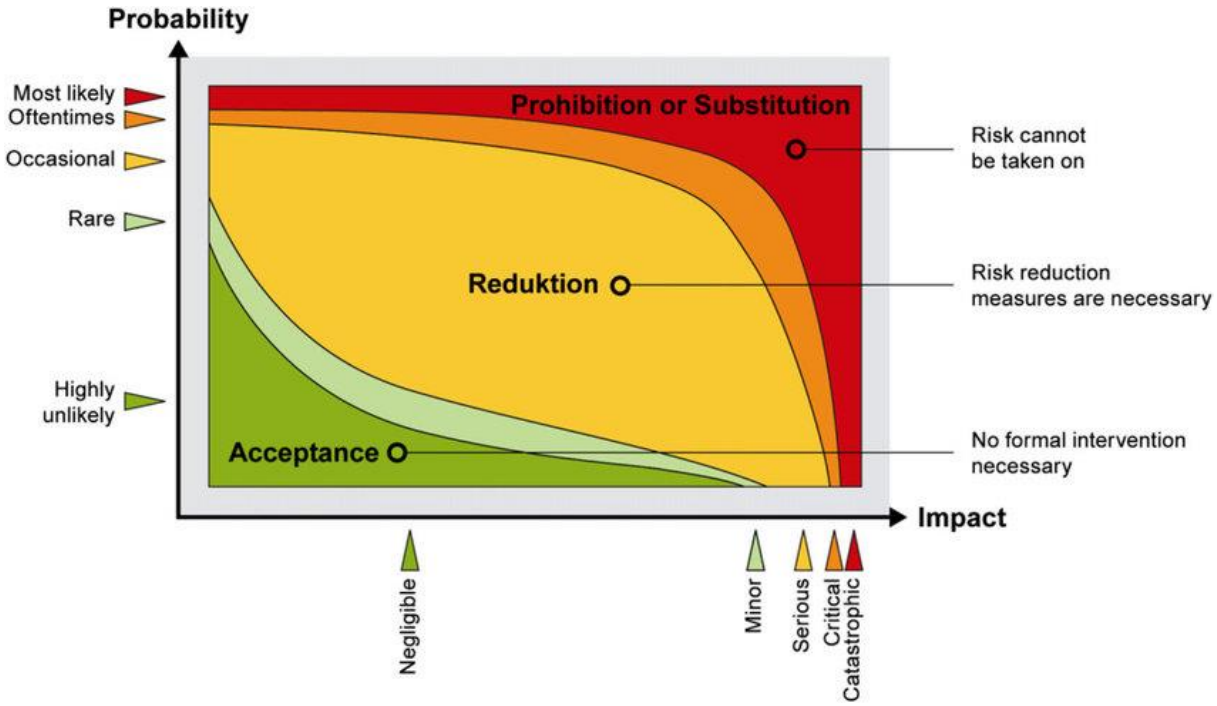

Figure 2: Traffic light model (Klinke & Renn, 2021, p.5)

Drawing the line between tolerable and intolerable risk, as well as tolerable and acceptable risk is one of the most difficult tasks of risk governance (Löfstedt, 1997). The judgement of acceptability and tolerability is contingent on using a variety of different knowledge sources.

Both risk estimates from the risk assessment stage and additional assessment data from the concern assessment from the appraisal stage needs to be included.

The traffic light model is an oversimplification of a risk picture but reflects the actual need for a judgement at the end of the evaluation process (Löfstedt, 1997). One is left with only three alternatives at this point: Taking no management action even though this could allow for doing additional research or collecting more information to reappraise the risk later, or to ban the risk, or to initiate risk mitigation or management actions. This important judgement must be made as transparent as possible for interested individuals and parties. The organizations responsible for the evaluation needs to have the skills, the assets, the background knowledge, and the sensitivity to come to an informed, balanced, and fair judgement.

Judgement and acceptability rely on two major inputs: values and evidence (Klinke & Renn, 2021). What society is supposed to tolerate can never be derived from investigating the evidence alone. In the same way, evidence is essential if one is to know whether a value has been violated or not. With respect to values and evidence three cases can be distinguished:

- **Interpretative ambiguity**
  Interpretative ambiguity is when there is unanimous agreement about the underlying values and what is regarded as tolerable or acceptable, but there is ambiguity of the evidence (Klinke & Renn, 2021).

- **Normative ambiguity**
  Normative ambiguity is when underlying values of what could be interpreted as tolerable or acceptable is disputed, but the evidence is clear and non-controversial (Klinke & Renn, 2021). The evaluation of this case needs to be based on a discourse about values and related implications.

- **Interpretative and normative ambiguity**
  Interpretative and normative ambiguity is when both the evidence and the values are disputed (Klinke & Renn, 2021). Assessors then need to find some common ground for characterizing and qualifying the evidence. Risk managers need to find a way to agree about the appropriate values and the related implications.

4.3.2 Including risk perceptions in risk evaluations

It is necessary that both scientific risk assessments and risk perceptions are included and considered in a comprehensive risk evaluation (Fiorino, 1989). A balanced and reasonable judgment will come from an evaluation based on a comprehensive set of criteria and attributes. If public concerns are to be included in the risk evaluation, one should rely on the results from existing risk perception studies to find the relevant criteria.

Within the field of risk assessment, the criteria of damage, probability and uncertainties are often crucial aspects for evaluating risks (Renn & Rohrmann, 2000). On the other hand, it can be a lot more difficult to determine a set of criteria reflecting public concerns. Even though it is difficult to determine universally valid aspects, empirical research shows that people tend to evaluate risks based on a large set of evaluation criteria.

The following aspects have been identified to affect people's risk perception on the severity of risks (Renn & Rohrmann, 2000):

- Expected number of perceived fatalities or losses
- Catastrophic potential
- Qualitative risk characteristics, such as voluntariness, personal control, familiarity, and dread
- Emotional associations with the risk (stigma)
- Trust in regulatory agencies and risk-handling institutions
- Social and cultural beliefs associated with the cause of risk or the risk-handling actors.

4.3.3 Assisting risk evaluation

> "Myths imply ambiguity, fuzziness and a holistic perspective. They are, however, reminders of the genuine forces that are inevitably present in the making of new technological eras. They can guide us through the clouds of uncertainty and ambiguity associated with new scientific advances and technological breakthroughs. Far from providing recipes for managing technologies and risks, they can help us to orient ourselves in the tension between courage and caution, and to create powerful images that provide sources for understanding and handling risks in modern societies. (Perls, 1973, p.240)"

As the citation of Perls (1973) explains, myths can create powerful images providing understanding for risks in modern societies. The *German Advisory Council on Global Change* (WBGU) organized several expert surveys on risk criteria and performed meta-analysis from risk perception studies (WBGU, 2000). This resulted in the identification and classification of nine criteria representing most of experts' and the public concerns. This classification includes social criteria and special attention to risks with extreme qualities. The classes were given names from Greek mythology and demonstrates the complex issues associated with these figures. The classes can further be put into the traffic light model and is later used for designing appropriate management strategies. Each risk class indicates a different pattern of complexity, uncertainty and ambiguity (WBGU, 2000). The class *Damocles* is both highly complex in its nature and described as multifaced webs of causal relationships where many intervening factors interact to affect the outcome of an event or an activity. Damocles is the risk class representing examples related to nuclear energy and will therefore be exclusively focused on further in this theory-part. The reference for the name Damocles (*Sword of Damocles*) comes from the myth about a figure from Greek mythology (WBGU, 2000). Damocles was invited by his king to a banquet where he had to sit under a sharp sword hanging from a wafer-thin thread. The myth does not tell if the thread snapped or not, but the story is a symbol of threat at any moment, even if the probability is low. This risk class relates to risk sources with a very high potential of damage, but a very low probability of occurrence.

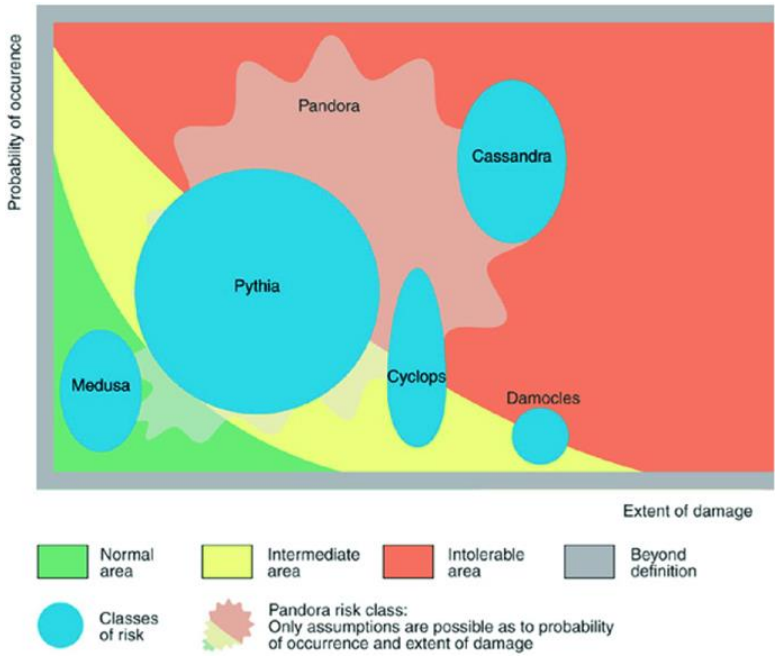

Figure 2: Risk classes (WBGU, 2000, p.63)

Figure 2 shows the risk classes located in the traffic light model. The aim of the classification is just this; to locate if the risks are in an acceptable or non-acceptable space (WBGU, 2000). This knowledge base helps risk managers to effectively select strategies and measures for handling the risk. To do so, central questions are proposed to be answered:

- **Is there any knowledge about the probabilities and the extent of damage?**
  Risks without any available knowledge on criteria for evaluating risks (see table 2), cannot properly be evaluated (WBGU, 2000). However, these risks might be of great importance as they are usually associated with desirable benefits (for example through innovations). The aim should be to ensure that more knowledge about the unknown risk potential is gathered. If there is no major hazard associated with the risk activity, routine monitoring can be sufficient.

- **Is the damage potential likely to be dramatic or even catastrophic?**
  Risks assessed to have high catastrophic potential, but low or unknown probabilities, can be classified as Cyclops or Sword of Damocles (WBGU, 2000). The Damocles risk class is characterized by a high disaster potential but probabilities that the potential will become reality is low and sometimes even minimal.

- **Is there high ambiguity associated with the risk under consideration?**
  A high degree of ambiguity can come from two reasons. The experts can rate the risks as higher than most stakeholder and the public (WBGU, 2000). In this case experts might warn society, but nobody seems to listen. In the other case the stakeholders and the public rate the risks as higher than most experts. In this case experts believe the risks are acceptable but relevant actors in society do not think so. The risk evaluation done by experts compared to the public might especially be inconsistent if the risk potential gives high anxiety among individuals, violates equity, or gives a high potential of social mobilization in the public.

4.3.4 Black swan metaphor

Another way of evaluating a risk, is to focus on uncertainties and the strength of knowledge we have about a risk. "According to the theory, it is highly improbable that anything should ever happen anytime, anywhere"(Aven & Thekdi, 2021). This is a quote from a cartoon-sketch of a person calculating risk in the book "Risk science" by Aven & Thekdi (2021). The quote introduces us to the idea of the black swan metaphor. This is also the thread in Nassim Nicholas Taleb's book "The black swan" (Taleb, 2007). His definition of black swans has become the most common interpretation of this metaphor. Taleb explains that the black swan metaphor stems from the surprising discovery of black swans in 1697. This discovery was surprising to people, because all swans observed in the Old World had been white up until this point. Taleb also discusses how in the 16th century London, the black swan was used a common metaphor for describing the impossible.

In retrospect we might not think of the event as a surprise or impossibility, because we have gained more knowledge, and our human nature is to make sense and find logic explanations about a situation (Taleb, 2007). Suddenly the black swan is predictable and explainable despite its previous phenomenon status. This last note is one of the three attributes of a black swan by Taleb's definition. Another attribute is that the event is unexpected and outside of the realm of regular expectations. Therefore, nothing in the past can convincingly point to its possibility. The last attribute is that the event carries an extreme impact.

Adding to this definition, Aven and Thekdi define a black swan as a surprising extreme event relative to one's knowledge (Aven & Thekdi, 2021). The different types of black swans are categorized in three groups depending on the relative knowledge about the events.

Table 4. Different types of black swans (Aven & Thekdi, 2021)

Unknown unknowns	Not known by anybody.
Unknown knowns	Known by some, but not everybody.
Known, but not believed to occur.	Known, but not believed to occur because of low judged probability and strong knowledge support.

The first type of black swan is called *Unknown unknowns* (Aven & Thekdi, 2021). These types of black swans are not known by anybody and have therefore not been assessed or

considered in any way. The second type of black swan is called *Unknown knowns*, meaning that they might be known by some, but not everyone involved. It might also be an outcome of a risk assessment missing the mark of the actual event taking place. The last type of black swan is called *Known but not believed to occur.* This judgement is based on low probability and strong knowledge support. In other words, it is a known risk event, but it is not believed to occur.

4.4 Risk communication

Renn (2008) refers to *The Committee on Risk Perception and Communications of the US National Research Council's* definition of risk communication:

> "…an interactive process of exchange of information and opinion among individuals, groups and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions or reactions to risk messages or to legal and institutional arrangements for risk management (US National Research Council, 1982, p.21)".

The traditional approach for studying and analyzing risk communication is gathered from a basic *Source-transmitter-receiver model* (Renn, 2008). In this model, a message is composed by a communication source, sent to a transmitter which decodes the message and records it for a target audience. Further, the message is forwarded to a final receiver who decodes the message and deciphers it's meaning. Renn explains that risk communication in some ways fits into classic definitions of communication but differs in that risk communication does not just want to exchange information between actors in society. Risk communication often has an intent to expose the target audience to a system of meaningful signals, which may change the receivers' perceptions of the issue or their image of the sender.

The objectives and requirements of risk communication can be split into the four following functions:

4.4.1 The function of enlightenment

This function is about how to get a message across. The function requires a type of risk communication that ensures all receivers of the message can understand the content of the message and enhance their knowledge about the risk in question.

The first stage of communication happens through the framing of a message by an information source (Dunwoody & Peters, 1992). Different topics can be brought up and sustained on the public agenda, only if the mass media, social institutions, or groups reports and adopts the topic as a part of their own agenda. In addition to social support, components

such as symbols and metaphors are important for the message being communicated effectively. Symbols and metaphors trigger the attention of potential receivers and shape the decoding process. Sources and transmitters can amplify components of the message by focusing on certain symbols. This could happen through the journalist portraying an incident in a certain way or signalize something that grabs the receiver's attention. The credibility of information sources also influences the message. The content of a message might pass through the selection filters of the transmitters and receivers, more easily from certain senders. Information from a group of Nobel laureates may well command public attention, while a press release from the nuclear industry may command much less credibility unless other parts of the message is compensating for impartiality doubts.

The major stations of risk communication can be split into three parts: the roles and function of sources, transmitters, and receivers in coping with risk information. Renn explains how this works by referring to the *Signal flow model for risk communication*:

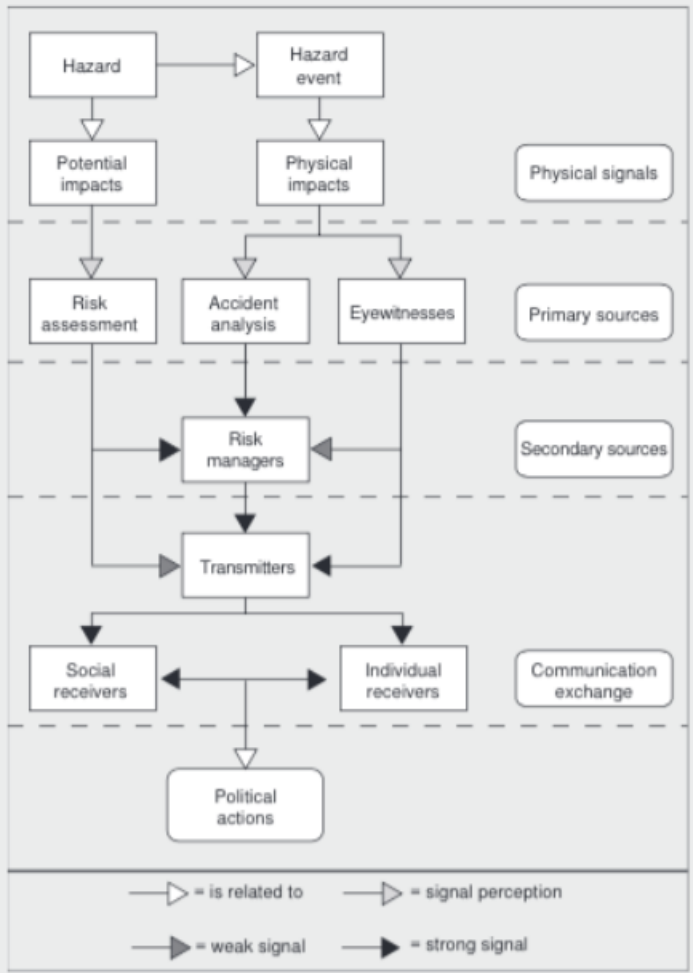

Figure 4: Signal flow model for risk communication (Renn, 2008, p.213)

4.4.1.1 Physical signals and primary sources of risk communication

The signal flow model shows the different signals and sources of these signals. From the top of the model, a section is dedicated to physical signals including hazards, hazard events, potential impacts, and physical impacts. Both nature and technology can be sources of hazardous events (Renn, 2008). Examples of this can be earthquakes, fires, explosions, pollution, or radiation. A scientific analysis tries to estimate the physical impact of an event, or to hypothesize about the probability of potential impacts. These estimates are often targeted to communicate information to other scientists or regulators by using a specialized or coded language. This language is not a way of keeping outsiders away from the elite community of scientist but serves a purpose by providing a common and precise language for explaining risks and hazards (Lofstedt, 2003). This internal communication is often not meant for conveying information to the public, but the communication is often investigated by public interest groups for "hidden messages". This causes a problem of scientist becoming reluctant to share information with non-scientist and a problem of distrust from many observers speculating about the scientific community.

A scientific risk assessment entails a deliberate selection of signals, that are often interpreted based on analysis of historic experience (Renn, 2008). The assessment can then provide information about what can be expected and potential hazardous events. Outside observers has a different way of interpreting importance of various events. Each physical event function as a source of millions of signals an observer collect and process. Which aspects of the event that is gathered is hence selective and subjective to everyone. Outside observers can perceive selected signals and information of an event from being a direct eyewitness or affected person. A car crash is a good example of how two eyewitnesses can give two very different reports of what happened because they select signals based on their own judgements of importance.

Another aspect of signals in risk communication comes from social amplification or attenuation. Hazardous events interact with psychological, social, institutional, and cultural processes in ways that can attenuate perceptions of risk and shape behavioral responses (Breakwell, 2000). Physical signals can transform into verbal expressions and messages,

transmitted through various communication channels (example: the media). The transformed messages can amplify or attenuate the signals from an event. The consequence of this might be that public attitudes change, institutions can decide to redirect their efforts, pressure on politicians may result in political changes, and the risk management system may be reformed.

4.4.1.2 Secondary sources of risk communication and transmitters

Messages of the primary sources are sent to the secondary sources, which are mainly the risk managers, but can also be scientific institutions or special interest groups (Bostrom et al., 1994). While these secondary sources are mostly interested in forecasting, analyzing, and managing the hazard by scientific investigations, transmitter and the public are in general more interested in the one incident reported or the consequences of a single hazard event.

Institutions have different purposes and will therefore often differ in selecting and processing signals from primary sources (Bostrom et al., 1994). Different risk assessments from different science camps may reflect a specter of interpretations. Even if the secondary sources relied on the same primary sources for information, the messages would still look like they were collected from completely different databases. This is not a result from bad risk assessments, but a result of institutions focusing on different aspects and problems, as further explained in the following:

> "In most cases, competing messages are not a product of misinformation, manipulation or even lying. Rather, every communicator has a different perspective in perceiving and evaluating the issue and is interested in conveying that perspective to the outside world. Fragmentation of information is therefore an inevitable side effect of plural interest articulation (Renn, 2008, p.217)."

Further in the risk communication process, transmitters carry the information through a communication exchange (Dunwoody & Peters, 1992). The transmitter has two essential roles: The first role involves receiving and processing information. Personal selection filters, evaluation strategies as well as professional and institutional rules, govern the selection of signals and their interpretation. The second role for the transmitter is to act as an information source by sending information to the final receiver. An example of this can be a journalist writing an article. There will be both conscious and unconscious changes of the original

information when the transmitter understands and records the message. Messages from several sources might also be integrated to the new message and comments may be added. Studies of the impacts of this transformation process justifies the conclusion that the media are not strictly reflectors of reality but reflect and highlight the concerns present in a society. The final product from transmitters is a mix of original and recorded messages. The final receiver is left with distinguishing between the information elements from the original source, and the additions made by the various transmitters.

4.4.1.3 Reception of risk information

Renn refers to factors from risk perception that demonstrate that public understanding of risk is a multidimensional concept and cannot be reduced to just probabilities and consequences (Renn, 2008). When it comes to risk communication, the final effect of the message sent, can be influenced by shaping the message and adding additional uncertainty and ambiguity, stemming from the receiver's risk perception. It is unlikely that the receiver decodes the original intent of the message letter by letter.

> "The common thread running through most risk communication studies is that public understanding is hampered by the complexity of the risk concept (Renn, 2008, p.221)."

Transmitters and receivers reduce the complexity by simplifying the message and focus on certain aspects regarded as relevant (Breakwell, 2007). This is just part of the reality of communication in modern societies and is part of the social construct which provides messages. The media usually report about events, not continuous performance. It could therefore be much more interesting for a journalist to write about an accident releasing radioactive material, than writing a story about a nuclear power plant's long safety record. The final receiver needs to be informed about the qualitative characteristics of risk as well as the mechanisms of risk perception. The communication should also include addressing questions about voluntary exposure, what possibilities there are of personal control, how the risk and related consequences are managed, and how catastrophic events can be avoided.

Risk communication can especially be difficult when dealing with semantic risks as they are associated with involuntariness, delayed effects, inability to be sensed by human organs, lack

of control, and unfamiliarity (Breakwell, 2007). It may be helpful to include democratic decision-making to deal with the impression of involuntariness, to handle the negative risk characteristics. Independence and impartiality of operating and regulating agencies may produce trust in the capability of managing the risks. Better knowledge about the risk and the associated technology can also better the problem of unfamiliarity.

4.4.2 The function of building up confidence in risk management

This function is about establishing a trustful relationship between the sender and the receiver of the risk communication.

With evolving complex technologies and progression of scientific methods, personal experience of risk has more and more been replaced by information about risks. Individual control has also been increasingly replaced by institutional risk management (Breakwell, 2007). This has led to the public relying more than ever on the credibility and sincerity of the actors they receive risk information from. Thereby, trust in institutional performance is very important. A trustful relationship between the public and control institutions can even compensate for a negative risk perception, and distrust can lead people to oppose even the smallest risks. Renn defines trust in the context of communication within social organizations as follows:

> "Institutional trust refers to the generalized judgment whether and to what degree the perceived performance of an organization matches the subjective and/or socially shared expectations of a variety of social actors and the public with respect to its assigned institutional function, including its perceived competence in meeting its tasks and its communication style in dealing with professionals, stakeholders, media and the public at large (Renn, 2008, p.223)."

Confidence can be closely linked to trust, and the terms are often used interchangeably (Renn, 2008). However, confidence is a more enduring experience of trustworthiness over time. Confidence can further be explained as a generalized impression of a continuous experience of trustworthiness of an organization based on its perceived performance record. People have

confidence in an organization if their prior trust in that source has not resulted in disappointment over a longer period.

Credibility is another term related to risk communication. Credibility is the degree of shared and generalized expectations that the organizational communication match to public expectations in terms of honesty, openness, responsiveness, and professionalism.

Renn identifies seven major attributes that constitutes trust, confidence, and credibility (Renn, 2008, p. 223):

- *Perceived competence*: Degree of technical expertise in meeting an institutional mandate
- *Objectivity*: Lack of bias in information and performance as perceived by others
- *Fairness*: Acknowledgement and adequate representation of all relevant viewpoints
- *Consistency*: Predictability of arguments and behavior based on past experience and previous communication efforts
- *Sincerity*: Honesty and openness
- *Faith*: Perception of goodwill in performance and communication
- *Empathy*: Degree of understanding and solidarity with potential risk victims

4.4.3 The function of inducing risk reduction through communication

This function is about persuading the receiver of the message to change their attitude or behavior with respect to a specific cause or class of risk. Psychological research about attitude and attitude change has given some answers to how receivers of information assign trust, or other attributes such as competence, to a communicator (Breakwell, 2007). These research results are usually discussed in the framework of persuasion.

Factors that have been found to enhance the persuasiveness of communication include the following (Renn, 2008, p. 231):

- *Attractiveness of information source*: Attractiveness is composed of similarity of positions between source and receiver, likability of the source and physical attraction.

- *Sympathy of information source*: This refers to the possibility of a receiver identifying with the source or its motivations.
- *Credibility of source*: Among the components tested are perceived competence, expertise, objectivity, impartiality and interest in the source.
- *Suspicion of honest motives:* Receivers do not detect any hidden agendas or motives behind the communication effort.
- *High social status or power of communication source:* The effect of these two variables depends heavily upon the issue and composition of the audience.

As these factors suggests, a communicator is likely to make a lasting impression on the audience if they are easily identifiable and likable, also if the message appears honest, accurate and fair (Renn, 2008).

4.4.4 The function of cooperative decision-making

This function is about providing the conditions for an effective stakeholder involvement on risk issues so that all affected parties can take part in a conflict-resolution process (Renn, 2008).

> "Many people like to act on the assumption 'better safe than sorry'. At the same time, however, people have an interest in a large variety of products, low prices and the comfort and convenience of modern technologies (Renn, 2008, p. 242)."

With this perspective in mind, it is important to address how to communicate and give a complete and balanced risk picture, as well as information about benefits to stakeholders and the public (Renn, 2008). Renn states that the most important part of effective risk communication is to gain the public's impression that the risk communicator has performed their regulatory or risk management task without major flaws. However, risks are only acceptable if they at the same time can provide sufficient benefits.

4.4.4.1 Strategies for risk communication regarding risks with high ambiguity or controversy

These risks trigger highly controversial and emotional responses and are often associated with public outrage (Renn, 2008). The risks may or may not be uncertain. The negative attitudes

towards these risks can come from different views about the legitimacy of the product or involuntary exposure to the risk. Involving all stakeholders is inevitable for effective risk communication. These risks require new and unconventional forms of stakeholder involvement, such as mediation, citizen panels, and open forums with special groups and others. The goal of these exercises is to reflect on related values, to build trust, and to find solutions acceptable or at least tolerable for all participants.

5 Data and methodology

In this section, the methods used in this thesis will be explained. I will rely on interviews for collecting data and critical discourse analysis as the analysis method. The interviewed organizations, type of interview conducted and the length of them is gathered in an overview in the following table:

Number:	**Organization:**	**Type of interview:**	**Length:**
1	Institute for Energy Technology (IFE)	Group interview (Three representatives)	One hour and 15 min
2	Norwegian Radiation and Nuclear Safety Authority (DSA)	Group interview (Three representatives)	55 min
3	Commercial industry	Individual interview	One hour
4	Commercial industry	Individual interview	45 min

5.1 Interview methodology

An interview can be defined as a qualitative research technique, exploring interview object's perspectives on a particular idea, program, or situation (Boyce & Neale, 2006). Interviews provides the possibilities of collecting detailed information and researchers has direct control over the process flow as well as a chance to clarify certain issues during the process if required. Interviews can be carried out face to face, over the telephone/internet or in a group setting. The interview can vary in structure from spontaneous to highly structured conversations. Qualitative research often calls for a semi-structured interview, leaving the researcher flexible and responsive throughout the interview. This way content can evolve, sequence of questions can change, and the researcher can go more into initial responses to gain a more detailed answer to a question. The semi-structured interviews are often guided by an interview guide or themes and issues to be covered during the interview. The interview can have considerable differences is length. Interview data is often recorded and then transcribed to produce text that can be further analyzed.

5.1.1 Steps carried out in the interview process

Preparing for the interviews of this thesis, I relied on *A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input* (Boyce & Neale, 2006).

The first step was formulating an information-letter for the companies I wanted to interview. The letter included information about the research, its purpose, what it entails to be part of the project, privacy, voluntariness, and rights of the attendants. The letter was formulated based on guidelines from the University of Stavanger and sent to *The Norwegian Agency for Shared Services in Education and Research* (Sikt.no). The companies were contacted by e-mail and the interviews were scheduled. Next, I formulated an interview guide for each interview. I tried to keep the questions quite similar to each interview, but also tailored to the actor I planned the interview for. The companies were also informed about some of the questions I would ask them, so that they could be prepared for what the interview would consist of.

The interviews were intended to be group interviews, including representatives with different roles. I anticipated that this would give room for the representative with the best knowledge on each question to answer, or that I would get multiple perspectives from the group. The interviews with IFE and DSA was carried out as planned in group interviews face to face. The interview with the commercial actors was split into two personal interviews over a video-meeting on Teams. This was due to difficulties in scheduling a face-to-face group meeting.

In all the interviews I started by introducing myself and my research. I recorded the interviews on my phone as well as on my computer. I started asking questions by following my interview guide and let the representatives that felt like answering take the lead. Some questions were skipped or reorganized as I saw fit during the interview. The interview situations will further be described as follows:

5.1.1.1 IFE Interview

The interview with IFE was set up as I contacted a representative recommended by my supervisor via e-mail. Through this communication I requested to carry out a group interview with about three representatives from the organization who could be able to give me answers to my described research questions. I met as scheduled for the interview at the IFE office in Halden. One of the representatives met me by the entrance and followed me to a meeting

room. I was informed not to wonder around the building by myself and would have to be followed by someone if I needed to go anywhere in the time I was there. The atmosphere was somewhat formal, but still relaxed as the representatives was very warm and welcoming. The interview lasted for one hour and 15 minutes. The representatives background and expertise area are presented in the following sections.

- First representative - IFE1

The first representative works as chief scientist at IFE and program manager of the Halden Human Technology Organization program. The representative has a background in engineering and cybernetics and has been working at IFE for 33 years. The representative started working with systems in control rooms but also started working with human factors from 2001. The representative will be displayed as IFE1 in the analysis.

- Second representative - IFE2

The seconds representative from IFE came to the organization as a student in psychology, taking part in an experiment conducted at IFE. Further, the representative started working as a researcher at IFE. The representative worked as a researcher within psychology and human factors for 18 years, before becoming a department head and a research director. The representative will be displayed as IFE2 in the analysis.

- Third representative – IFE3

The third representative from IFE works as a principal engineer in the Control room Design Interaction Department. The representative has about 30 years of industry experience and has been working at IFE for the nine last year's supporting researchers, running simulators, developing scenarios, and working with operational displays. The representative's background is in operations and has operated nuclear power plants in the US Navy as well as in commercial industry in the United States and in Sweden. The representative will be displayed as IFE3 in the analysis.

5.1.1.2 DSA - Interview

I started by contacting the office of DSA via e-mail. I got in contact with one of the directors at DSA and requested to carry out a group interview with about three representatives from the

organization who could be able to give me answers to my described research questions. The director gave me a chance to choose the departments I was most interested in interviewing, and we landed on choosing one representative from each department. I figured this would give me a wider range of input and perspectives for my research questions. I did not handpick each representative, but I expressed that different departments could be valuable. I met at the office of DSA in Oslo. I was welcomed by the front desk and followed to a meeting room. The atmosphere was professional and somewhat formal but also relaxed as I was offered coffee and introduced to the representatives I would interview. The interview lasted for 55 minutes. The representatives background and expertise area are explained in the following sections.

- First representative – DSA1

The first representative works in the Department of research and development in International Nuclear Safety. The representative has been working with nuclear safety issues at DSA for the last 10-12 years. The representative is now working mostly with the nuclear safety aspects in relation to the emergency preparedness and international projects. The representative has background as a nuclear physicist and nuclear power engineer. The representative will be displayed as DSA1.

- Second representative – DSA2

The second representative works in the nuclear safety section at DSA. The representative has been working at DSA for one and a half years and specializes in the transport of radioactive material as well as safety on nuclear research reactors in Norway. The representative has a background in nuclear engineering. The representative will be displayed as DSA2.

- Third representative – DSA3

The third representative works in the section for emergency preparedness and response assessments. Norway has a national board responsible for the management of nuclear or radiological accidents or events, headed by DSA. DSA is thereby responsible for doing national threat and risk assessments regarding nuclear emergency preparedness. That responsibility lies within the representative's section. The representative will be displayed as DSA3.

5.1.1.3 Commercial Nuclear Industry – Interview 1 – SH1

I started by contacting the representative, requesting three specific representatives as I had sought out the representatives, I thought would be the best fit to answer my questions. We had some trouble scheduling a time to carry out the interviews, as the representatives had a very busy schedule. In the end I was able to interview two representatives, but we had to carry them out separately because of the busy schedules. For the same reason, we landed on carrying out the interviews via the communication platform Teams.

The interview with the first representative was quite unformal regarding setting and dress code. We met as planed via teams, and the representative was engaged and easy to talk to. The interview lasted for one hour.

The representative will be anonymized and only presented as a person from the nuclear industry. The representative will be displayed as Stakeholder 1 (SH1) in the analysis.

5.1.1.4 Commercia Nuclear Industry – Interview 2 – SH2

As previously mentioned, we carried out this interview via the communication platform Teams. This interview with the second representative was somewhat unformal, as we spoke via Teams. The representative was also engaged and easy to talk to. The interview lasted for 45 minutes.

The representative will be anonymized and only presented as a person from the nuclear industry. The representative will be displayed as Stakeholder 2 (SH2) in the analysis.

5.1.2 Transcribing and storing data

After conducting the interviews, the data was stored in two separate password protected units. The data was handled with confidentiality, leaving insight only to me and my supervisor.
To transcribe the interviews, I used a data program called *Cockatoo* to automatically generate text from the recorded sound files. Even though the tool was helpful, it duplicated a lot of words. I read through all the text while listening to the recordings to edit the duplicated words

and check that everything else was correct. After transcribing the interviews and writing the analysis, recordings was deleted on all units.

5.1.3 Strengths and weaknesses of method

A clear advantage of using interviews as a method, is that they provide a lot more detailed information than what is achievable through other data collecting methods such as surveys (Boyce & Neale, 2006). Another strength of the method is that people are often more comfortable giving out information by having conversations, rather than filling out a survey. Interviews also provide valuable information that can reveal the same stories, themes, issues, or topics emerging from the interviews, making ground for further generalizations.

A weakness of the method is that it can be prone to bias (Boyce & Neale, 2006). Representatives interviewed might want to argue for their own interest due to their stake in the company. Interviews can also be a time-intensive activity because of the amount of time it takes to conduct interviews, transcribe them, and analyze the results. Another challenge of the method is that the interviewer needs to avoid yes or no answer, use appropriate body language and keep their personal opinions in check.

Another aspect to consider is that two of my interviews was conducted as group interviews, while the other two was conducted individually (Boyce & Neale, 2006). A strength of group interviews is that they can provide more nuanced and unfiltered feedback than individual interviews and are easier to organize than several individual interviews or large surveys. A weakness of the group interviews is that their small size leads to low external validity[2] and the researcher may "cherry-pick" responses that fit their hypotheses.

5.2. Discourse analysis

A discourse analysis is a qualitative research method for the study of written or spoken language in relation to its social context, aiming to understand how language is used (Luo, 2019).

[2] External validity: the extent to which you can generalize the findings of a study to other situations, people, settings, and measures.

A discourse analysis can be defined as:

> «...an ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices. The 'discussion', in other words, is the object of analysis; discourse analysis sets out to trace a particular linguistic regularity that can be found in discussions or debates (Hajer & Versteeg, 2005, p. 175).»

Discourse analysis is in other words, the study of language-in-use (Hajer & Versteeg, 2005). This analysis stems from an interpretative social constructionist tradition in social sciences. The tradition has an anti-essentialist ontology; meaning it assumes the existence of multiple, socially constructed realities instead of a single reality, governed by unchangeable natural laws. The approach takes a critical stance towards "truth" and emphasizes aspects of communication in which knowledge is exchanged. A particular discourse has its own argumentative rationality and can thereby highlight the democratic quality of a discussion. This quality can be understood by the concept of *deliberation.* Deliberative qualities are characterized by inclusiveness, openness, accountability, and participants opportunity to learn through dialog. Attention to specific situational logic such as historical, cultural, and political context is also central, as the reality is specified as socially constructed and the account for truth arises. One of the strengths of discourse analysis is its capacity to answer "how" questions. The analysis can help highlight why certain definitions do or do not catch on, or how mechanisms by which a policy does or does not come about.

The discourse analysis can focus on aspects such as (Luo, 2019):

- Purpose and effect of different types of language
- Cultural rules and conventions in communication
- How values, beliefs, and assumptions are communicated
- How the communication relates to the social, political, and historical context

5.2.1 Distinguishing critical discourse analysis

> "In a world and in a time characterized by economic crises, war and conflict, the ability to critically reflect is more important than ever. In the post-war positivist theory

> of science, researchers were not to question – or assess – the facts examined, either in a positive or negative sense. This is unproblematic in the natural sciences: chemists and geologists do not criticize chemical and geological processes; they describe and explain. They rightly do so, because they relate to the mineral realm, not to the human realm. Within the cultural and social sciences reality is characterized by power and opinions. This reality can be objectionable. Researchers must therefore identify, document, and criticize factual empirical conditions using good arguments (Kalleberg, 2013, pp. 69-70)."

To further distinguish *critical discourse analysis (CDA)* from other types of discourse analysis, I will rely on the introduction to CDA by Joar Skrede (Skrede, 2016). There are many different traditions and focus areas of discourse analysis. As this introduction to CDA is heavily influenced by Norman Fairclough's approach, the thesis will further follow the same approach.

All discourse analytical approaches are concerned with language and communication, but not necessarily or specifically at a sentence level (Skrede, 2016). The linguistic[3] component of CDA distinguishes the approach from other more abstract forms of discourse analysis that do not pay special attention to language in the linguistic sense. Nevertheless, many who work with critical discourse analysis choose to cut out close reading of text. At the same time, there are many linguists who are not always interested in including larger societal structures in their analysis. Macropolitical issues are often toned down in favour of detailed analyses of texts. An exception that unites both traditions is Fairclough.

Fairclough mainly focus on analysing text with the purpose of mapping out relations between discourse and society. CDA is different from other types of descriptive linguistic studies, primarily describing structures of language without questioning why and where the text was produced. CDA examines which ideological[4] interests the text might conceivably serve. Fairclough claims that discourses are ideological because they contribute to maintain or challenge power relations (Fairclough, 1992).

[3] Linguistic: The study of language (Cambridge Dictionary, 2023b)
[4] Fairclough defines ideology as representations of the world that help establish and maintain power relations, domination, and exploitation (Fairclough, 2003).

At the same time, it is important to emphasize that exercise of power is not all negative (Skrede, 2016). When critical discourse analysts talk about power, it is not only "negative" power such as domination and oppression that is meant. They also refer to invisible power structures such as making people think they'll be happy by buying a specific product. A society also depends on power to function properly. We vote in elections and have a system where the government has legitimate power over others. If we go to the doctor, we recognize that he has a certain power over us and can prescribe certain treatments. However, it is not this form of power that is the main concern of critical discourse analysts. It is when power is exercised in a way that has adverse consequences for certain social groups that it is made the subject of critical analysis (Fairclough, 2015). Power is often tolerated because it is concealed in a way that would not have been tolerated if it were fully visible. Fairclough also points out that power is primarily located in the "unsaid" and implicit. The most effective form of power is to make others want the same thing as yourself, and that can be done through controlling other people's thoughts and desires. This is the primary understanding of power that critical discourse analysis is concerned with analysing: how certain ideologies naturalize and emerge as the best, or better yet, as the only alternative we have. At the same time, critical discourse analysis is also concerned with showing how things are kept off the political agenda. One can analyse texts to find out how alternatives are reduced by linguistic means.

The aim of critical social research is to better understand how society works, how it produces both beneficial and undesirable effects, while at the same time attempting to suggest how the adverse effects can be eliminated (Fairclough, 2003). The goal of a critical discourse analysis is further to show that language is an important part of transformation in a society. Societal changes affect many aspects of our social lives; therefore, language must necessarily also be affected, the same way changed use of language affects society again. This is the central idea that language stands in a dialectical[5] relationship with larger structures in society. To understand what is going on in society, we must take language into account.

5.2.2 Strategies for legitimization in discourse

Reyes (2011) studies the relationship between discourse and social practices framed within

[5] Dialectical: Discovering what is true by considering opposite theories (Cambridge Dictionary, 2023a).

the scope of Critical Discourse Analysis (CDA) (Reyes, 2011). Further, the study analyzes the linguistic ways in which legitimization is constructed in discourse. To account for the relation between social practices and discourse, special attention is given to the linguistic choices in a message. This is done by applying tools from Systemic Functional Linguistics (SFL) for analyzing linguistic representation of legitimization in discourse. The study builds on categories of legitimization in discourse proposed by Van Leeuwen (Van Leeuwen, 2007).

Legitimization refers to the process of speakers accrediting or licensing a type of social behavior (Reyes, 2011). Legitimization is thereby a justification of a mental or physical behavior, enacted by argumentation that explain our social actions, ideas, thoughts, declarations, etc. The act of legitimizing relates to a goal, often seeking support and approval. This is often done by presenting a proposal as 'the right thing to do' or the appropriate proceeding within a social group. The origin of the term 'legitimization' refers to making something legal or legalized. In this context the term is used when talking about semantics of justification, and in conversations where arguments are used for legitimization. The different strategies for legitimization in discourse will be explained in the following sections.

5.2.2.1 Legitimization through emotions

This legitimization strategy appeal to emotions. As social actors, people evoke different types of emotions to legitimize actions or words to construct, impose, debate, or legitimize certain perceptions of reality (Reyes, 2011). The effect of emotional feedback from any speech event can be understood through associations from socio, cultural, historical and political nuances. An example can be the mentioning of the word 'terrorist', which evoke a series of nuances in the receiver's mind, linked emotionally to previous experiences that has constructed meanings.

Fear can often be the most effective emotion to trigger a response to achieve a goal (Reyes, 2011). Humans can employ this trigger to achieve some of the most challenging goals, such as persuading someone to risk their life, going to the front line in a war. The legitimization can be constructed linguistically through speech by creating an enemy and further demonizing it.

5.2.2.2 Legitimization through a hypothetical future

Legitimization through a hypothetical future can occur when referring to something connecting our past, present, and future (Reyes, 2011). The present can be displayed as a time that require crucial decisions about actions to take. These actions connect a cause that has occurred in the past, and a consequence which can occur in the future if certain actions are not taken. Only this way we can enjoy a successful future. An example of the display of two optional futures is presented in the following figure:

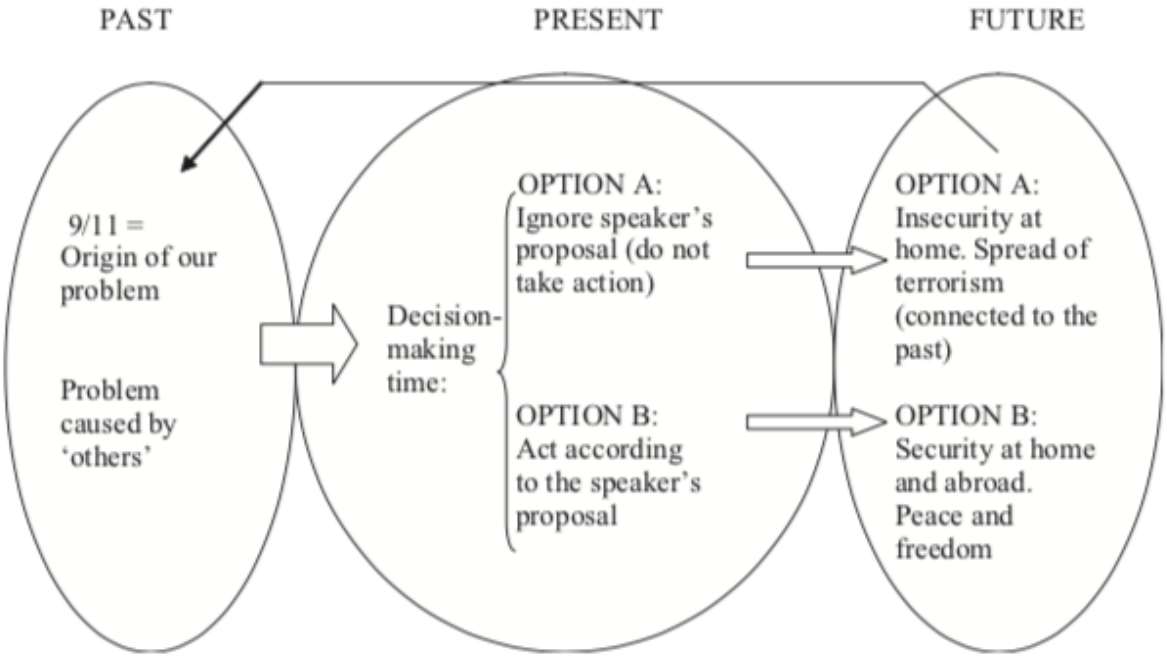

Figure 5: Legitimization of arguments through a sample timeline (Reyes, 2011, p. 793)

5.2.2.3 Legitimization through rationality

This strategy presents that the proposed action-taking is made after a heeded, evaluated, and thoughtful procedure (Reyes, 2011). In other words, the speaker presents their choice as rational. In this context rationality is seen as a social construct within a cultural group. The rational arguments are thereby something that makes sense and is seen as the right thing to do, in relation to morals and values of the community. An example can be political leaders justifying responding to a war they did not start relating to justified violence or what we call self-defense. Another example of someone justifying their actions can be someone arguing that they listen to experts in order to make a decision. Their actions are consequences of consulting with other sources to verify or support their decisions, and they thereby present

themselves as well-heeded, considered, and rational. Another tool to use rationality can be when a speaker emphasize that they understand the importance of presenting a decision that has been seriously considered and examined from many different angels (Reyes, 2011). This shows how the speaker use rational constructs shared within a culture to justify specific actions.

5.2.2.4 Legitimization through voices of expertise

This strategy refers to the voices that the speakers bring into the speech event to support their positions (Reyes, 2011). The position is thereby strengthened by an authorization or authoritative speech. An example of this being done can be when a newsreader presents something and mentions the source of this information. Politicians can also evoke a voice of expertise or institutional authority that support claims presented. However, politicians can be equally blamed with the voices of expertise they bring in the discourse if connected future mistakes are made. A speaker can also use this strategy by quoting authorities, using the voices of expertise to back up the speakers' decisions.

5.2.2.5 Legitimizing through altruism

This strategy is about legitimizing actions by proposing them as beneficial to others (Reyes, 2011). Helping others, especially vulnerable groups, the poor and innocent is often well perceived in a society as it will make other people's lives better. This can help the process of justification as it leads attention away from judgement about the selfishness of the speaker.

Lakoff (2009) argues that this legitimization strategy plants an idea that develops into the plot of a story. Lakoff calls this "The fairy tale of the just war (Lakoff, 2009, p. 26)". This is demonstrated through an example from a scenario in Iraq (Reyes, 2011). Saddam Hussein is the villain, citizens suffering under the evil villain are the victims, and the USA undertaking sacrifices, defeats the villain, and liberates the victims is the hero.

5.2.3 Building a critical discourse analysis

A critical discourse analysis is an interpretive method for analyzing text (Luo, 2019). This entails making interpretations based on both details of the material and on contextual aspects. There are many different approaches and techniques for conducting a critical discourse

analysis. The thesis will rely on following some specific steps to avoid any confirmation biases. A confirmation bias can be described as the tendency to seek out information that supports a preexisting belief, resulting in ignoring any information contradicting those beliefs.

Step 1. Defining the research question and selecting the content of analysis:
Begin with a clearly defined research question and select a range of material appropriate to answer it (Luo, 2019).

Step 2. Gather information and theory:
Establish the social and historical context, and further construct a theoretical framework to guide your analysis (Luo, 2019).

Step 3. Analyze the content for themes and patterns
Examine various elements of the material. Relate elements such as words, sentences, paragraphs, and overall structure to attributes, themes, and patterns relevant to the research question (Luo, 2019).

Step 4. Review the results and draw conclusions
Reflect on the results to examine the function and meaning of the language used. Consider your analysis in relation to the broader context to draw conclusions that answer the research question (Luo, 2019).

Since critical discourse analysis is concerned with the relationship between different institutions, organizations, and societal structures, critical discourse analysis requires the inclusion of other science theories in the analysis (Skrede, 2016). Therefore, critical discourse analysis often contains much macro-sociological theorizing compared to discourse analytical approaches, which operate primarily at a linguistic level. This makes the approach attractive and relevant for the analysis of social science phenomena.

The thesis will, as Skrede (2016) states is required, include other science theories in the analysis. The theory from risk perception, risk evaluation and risk communication will be incorporated together with the critical discourse analysis-approach.

6 Critical discourse analysis

In the following analysis, citations from the interviewed stakeholders are presented. The subchapters 6.1, 6.2, and 6.3 will display the connected research questions, and the citations will be presented in a table with the identified discourse. The discourse analysis will respectively be conducted following each discourse.

6.1 How are risks of SMRs represented by the stakeholders?

In this section of the analysis the associated discourses will be analyzed connected to the research question: “How are risks of SMRs represented by the stakeholders?”. The analysis will take a closer look at how the stakeholder talk about risks, which risks the stakeholders highlight and thereby how they represent these risks.

6.1.1 Discourse: Risks of opportunity

Discourse 1
(1) IFE3: The conventional designs, they were built based on designs from the 50s and 60s, and it was always planned to be large scale. This large production of electricity is all normally in the at least 1,000-megawatt range, and then some of them are up to 1,400 megawatts. All construction is done on site so it's a large production to get all of this done in a large area with thousands of people and lots can go wrong. And it just takes time to do that because you have to build it somewhere and then ship it. With SMRs, everything's been shrunk, and then when you talk about going from 1400 megawatts to 300 megawatts, that's naturally gonna be a smaller footprint. I think the Rolls Royce design is kind of neat because they plan to build a containment-type building over the top, and then do all their construction underneath so that weather doesn't affect them at all. So SMR is really modular design. It is much smaller and there is a modular thought process behind it instead of trying to bring piece by piece and put it all together. At least 10% is done there instead of, what the case might be right now in the larger environment, you might get 20% done manufactured someplace else and then the rest of it has to be done on site.
(2) SH1: The hallmark of SMR, or the only premise for being called an SMR, is that you have an output of maximum 300 megawatts electric, and then there are exceptions like the 475 megawatts like Rolls Royce. The reactor unit itself is smaller. And if it's smaller, if you have exactly the same technology, given everything is the same, then you have a bigger surface area per volume, so physically it's easier to cool down. There are also less consequences if something were to happen because there is less radioactive material. And it's also a little more manageable if things are smaller. You have far more devices that you can rely on if one device needs to be shut down due to some upgrades, then the other can operate, and you can still get a lot of power from the system. Especially in Norway, where the grid is not so large, compared to other larger countries, so there is a limit to how much power you can get out of one point or into a transformer station. In Norway it is typically around 1400

megawatts, that is the maximum on one transformer. So then it makes more sense to be able to spread things out. Also, it makes more sense in terms of grid development. It becomes more vulnerable if you have a lot of grid, or if you need a lot of grid for it to work. Losing one transformer might lead to losing 1400 MW. But if you have the production units spread out, then it's far more robust. Then there's far more redundancy in the system.
(3) DSA2: Hydrogen explosions, it might happen due to the overheating of the fuel that hydrogen can be created. But there has been some improvement in the designs. So for instance, larger accidents cannot occur because you have all your, primary coolant system, systems of piping are inside of the vessel. So you quite reduce the risks of losing coolant, for example, to initiate these hazards. But let's say, it could happen, but the risks are much lower from previous designs. Due to their smaller size, so they have quite lower release if an accident happens, than the larger reactors.
(4) DSA2: There is some values that you put on risks. So for older generation reactors, the risk was quite higher than the one that SMRs is aiming for now. So I think for light water reactors in the past, it was around 10 minus four failure per year. So now we are aiming at much lower risks. So 10 to the minus 6 to 10 to the minus 8. So, basically it is safety enhancement that we are looking at. And also there is some economic aspects which has to be proven in the future because we don't have any SMRs that has been built so far. Also we have operability differences, because now in the older generations, we have quite on the human factor sides, it is quite investigated into detail, but for SMRs, it is not.

Analysis: Risks of opportunity

In this discourse, opportunities of SMRs are discussed. This entails how the stakeholders represents opportunities of going from a conventional reactor to a small modular reactor. When talking about risk, there is often more emphasis on the potential negative consequences. However, as explained in the risk theory (section 3.1), risk is a distinction between possible and chosen action, and can be associated with both positive and negative potential consequences. The stakeholders were asked to explain the main differences of conventional reactors and SMRs.

IFE3 explains how the designs of reactors have developed and how going from a reactor with a 1400-megawatt output to a 300-megawatt output will leave a much smaller footprint in all aspects. The supply chain and the building of the SMRs will also be simplified, reducing manpower needed on site and reducing risks of accidents while building it.

SH1 points to the benefits of having multiple units to rely on for electricity, the consequences of an accident would be reduced, and the whole grid would be more robust than relying on one large unit for power.

DSA2 explains that risk assessments of conventional reactors and SMRs show a significant reduction of estimated risk. Even though accidents still can happen, their size and design reduce the risks significantly. DSA2 points to the fact that there is no operational experience with SMRs, meaning that economic aspects and human factors are not yet investigated or proven, as they are with conventional reactors.

All representatives have some similar description of how the SMR-design is a more manageable reactor than the conventional one. But they also highlight some different aspects. While all stakeholders agree that the SMRs does have many advancements, DSA is the only actor emphasizing that these advancements are not yet proven in practice.

6.1.2 Discourse: Public safety vs. Power security

Discourse 2
(5) SH1: Safety is something you must work on all the time. You have to have a good safety culture, and you have to feel like you can speak up about things. It has to be handled properly, it can't just go into oblivion. So it's a good thing that we're not in the Soviet Union. The reactor RBMK, was the one that blew up in Chernobyl, it had a design flaw about it that needed to be dealt with. But it was not delt with because it wasn't interesting to hear about things that could go wrong. Whereas in Norway that culture is different. I think most people will recognize that it is possible to speak up about things that are not good.
(6) SH1: The premise must be that it is developed in the West and licensed under the Western regime. So it doesn't help much that you have a reactor that works in China, for example. This is also a security policy issue. When choosing a nuclear technology, you are exporting and importing radioactive material, it is very important that where you import it from, that you have good relations with them. So it's nice if it's a member country of NATO, for example. So, for example, what is happening with Russia now, you see that it is not so wise to trust Russia over time. So you might have a few decades where it's fine, but then it goes wrong. So it's a good idea to engage with countries that you expect yourself to be friends with for a hundred years. So you have stable supply chains and all that kind of stuff.
(7) SH1: When you talk about renewable energy for example, and you say it's not going to be a problem with wind, that sometimes there will not be any wind, so sometimes there won't be electricity, it's not going to be a problem. People realize it's going to be a massive problem Everything has risks associated with it. One needs to reflect upon the balance between risk and reward. It's the same thing with bus and car or road or something like that as well. There are risks to it, but you still need road in the same way that you still need stable electricity. And it works better for society having things that protect us from a cold winter for example. It's intuitive, I think.
(8) IFE3: From the operations standpoint, the test reactor in Halden ran safely for 60 years without really any major problems and yhe research was well funded all the time. I think that says a tremendous amount about what has actually come out of the research. The Halden reactor was never a commercial reactor. It never produced electricity for the town or for anyone else, but the research that was done in that reactor provides safety across the world with fuel design today. That's always one of the most important things when you talk about a nuclear reactor: fuel, how it's designed, and that it is able to maintain its integrity in the event of an accident.
(9) IFE1: We are doing research for safety, and we are going for a public meeting in Halden. The people there will be interested in safety aspects of nuclear power in general, as well as safety of SMRs compared to the conventional reactors.
(10) IFE3: And they are safe. I'm 100% certain of that. They are much safer.
(11) IFE1: The question was whether it's safe enough. Then the answer is yes

(12) IFE3: The nuclear is built on worst case scenario. Well, unless you have a 20-meter tsunami, which is not expected ever.
(13) DSA3: To start off, we talk about risk. Risk is on very different levels. And risk is very well defined. What risks are, you can calculate. And how we do it is very different from accidents, or from malicious acts. So in our field, we often not only talk about risk, but we talk about hazards when it comes to emergency response and preparedness. And one of the difficulties for us is that many of the things we need to prepare for have a very low probability, but might have very high consequences. And also we have no frequencies to look at. Most of the things never have happened before. So, we need to do a lot of judgment when it comes to how we evaluate the answers. And we also cooperate with other organizations like the Norwegian Directorate for Civil Protection. They have a national risk assessment where they compare different risks between different areas of society. And we cooperate with them on how we evaluate nuclear risks versus other risks.
(14) DSA3: The second thing I think you asked about was in case of an emergency, in case of an accident, how wide ranging the consequences will be and depending on the size of the reactor and depending on the emergency it could be far stretched. It could go very far. As we have seen earlier. When it comes to the radioactive fallout, and the radioactive release that is dispersed through the atmosphere, it can be wide-ranged and it is a matter of how much radioactive is released and what kind of concentrations you will have in the environment. And then you would have a further dispersion within the environment, and you would have accumulation, and it could be concentrated and have impacts on both the ecosystems and on the food production industry. And even on export industries and things like that.

Analysis: Public safety vs. power security

This discourse is split into two parts. One discourse is about potential safety issues and negative risk, while the other is relating to risks of not having nuclear power to rely on for power security. The stakeholders were asked open questions relating to risks and safety, enabling them to highlight aspects with the least possible guidance or input from myself as interviewer.

The stakeholder represents potential safety risks quite differently. SH1 is again not representing any specific negative risk related to safety that would apply to commercial operation of SMRs in Norway. SH1 represent the conditions that would allow for Norway not to have issues that are known from previous nuclear accidents. SH1 also represent national power security aspects that would be beneficial using SMRs.

Stakeholders from IFE represent SMRs or the nuclear in general to be safe, unless something very unexpected should happen. They base their representation on experience from the nuclear field.

DSA has a different representation of safety issues of SMRs. They explain thoroughly that there are many aspects they evaluate about risks of the nuclear, like public safety, hazards, malicious acts, emergency response, and preparedness. Assessments are done by looking at frequencies, making judgements and through co-operating with other organizations. In this discourse, a patter emerges from DSA about the unwillingness to base evaluations on judgements. This will further be addressed in the discussion.

This discourse says something about how the different stakeholders represent risks and how they evaluate them. As explained in the risk evaluation theory (Section 4.3), the distinction between acceptable, tolerable, and intolerable risk can be expressed in a traffic-light model. Even though SH1 is not addressing how safe they evaluate the SMRs to be in this discourse, it is clear from the overall interviews that they evaluate the risks to be acceptable. They evaluate risks to be very low and are more concerned about risks of power shortage in Norway without the use of SMRs. IFE states clearly that they also evaluate the risks to be acceptable. DSA does not give any clear statements of where they would place the risks of SMRs in the traffic light model, but they highlight safety related risks that they are concerned about. DSA also emphasizes that it is very important to have some experience to draw conclusions from, which they don't have of SMRs. I will argue that this means that they evaluate the risk as either tolerable or intolerable. The estimated low probability of risks regarding nuclear power in general, could point to a tolerable risk evaluation, while the lack of experience-data with SMRs specifically, could mean that it would be evaluated at intolerable until data is gathered.

6.1.3 Discourse: Potential new challenges

Discourse 3
(15) IFE2: We're addressing potential challenges, like risks. So we try to be in the forefront and we have assumptions and hypotheses about what can happen and what can be the challenges, especially when we focus on the human and on the interaction between the human and the system. So that is where we do our research. And the goal there is that we, in our research reveal challenges so that the industry actually avoids doing it in a bad way. So, avoidance of potential risk, I would say.
(16) IFE1: An example of potential new challenges can be related to multi-units. If you have SMRs where there are several multi-units, you have six or 12 units in one place. The questions we need to ask are: how many operators should there be? How many people in the crew? How many can you operate at the same time? What should the design of the control room be? That's questions that are open now, that people ask us about. Even though we don't necessarily assess the risks or find every solution, we try to find the right questions to ask regarding future challenges in multi-unit.
(17) SH1: We are envisioning building dozens of SMRs over the next ten years. And if we're going to build dozens, we need thousands of employees, maybe tens of thousands. It's not necessarily just employees, but we also need companies that can support it, that build things, maintain things, run service and inspections and are stewardship for the nuclear power plants. You need a lot of people if you're going to build dozens of reactors. There will be a need and demand for dozens, maybe hundreds, of such reactors, perhaps in the next 30 years. So I think those things might be the biggest challenge.
(18) SH2: I think the biggest risk when financing this privately is what you call political risk. That will be the biggest risk. We need to get to a place where we are more secure, that we will have support, political support.
(19) SH2: Human factors are something that IFE actually research and is a world leader in, so it is very interesting. It's kind of general, you probably know that, because it's not about nuclear power specifically, it's about how we interact and assess these things and behave in different situations whether it's on an oil platform, nuclear power plant or coal-fired power plant.
(20) DSA3: One important aspect of licensing is to ensure ownership. So they would need to prove some way or another that they will not go bankrupt, or if they go bankrupt, that all issues involved with that is taken care of. And that's a difficult point to prove. So it's not just enough to have money, you need to have much more than that. And when you are planning, I think it's very important also to take into consideration that the regulations we have today, not necessarily will be the regulations we have tomorrow, or in 30 years time it may be much stricter. And all the demands and all the requirements, you need to be able to fix that. And not only be able to fix what we have today.

Analysis: Potential new challenges

This discourse is about how the stakeholders represent potential new challenges of SMRs.

IFE2 explains that they try to reveal potential challenges and thereby provide the nuclear industry with knowledge, so that they can avoid potential risk. A lot of their work is focused on interaction between the humans and the systems. IFE1 further explains that future challenges of SMRs will be answering questions regarding multi-units and human interaction with the systems.

SH1 and SH2 express that they are aware of challenges such as political risk for a commercial company, and challenges regarding workforce and the amount of people that would be needed for building and operating SMRs in the future. When asked specifically about challenges regarding human factors, SH2 responds by stating that it is very interesting, and that IFE has a lot of knowledge about it.

DSA is asked about potential challenges a commercial actor could have regarding licensing SMRs. DSA3 explains that one important aspect of licensing is to ensure ownership. The challenge would thereby be to prove that they will not go bankrupt, that issues involved will be taken care of if they do, and that they are able to meet future new regulations that could potentially be stricter than what they are today.

In this discourse, the stakeholders are addressing quite different topics. In some ways this is expected, as the stakeholders serve different interests. As noted in the risk communication theory (section 3.4.1.2), every communicator has a different perspective in perceiving and evaluating the issue and is interested in conveying that perspective to the outside world. On the other hand, these differences in communication could damage the institutional trust of an organization. This will further be addressed in the discussion.

6.1.4 Discourse: Black swans

Discourse 4
(**21) DSA1**: One thing, which are not being discussed right now, in many levels, the back end of the fuel. The waste stream that this new type of fuel will generate, how to tackle that. I mean, this is an area which is right now up in the agenda internationally. Even at IAEA, I have seen that recently they have asked new proposals to talk about it, because you can easily build something, but you have to think before how you dismantle it, how you decommission it, and what to do with the waste. There is a big question mark there. So that also needs to be addressed.
(22) DSA2: The new design features like using the same control room for multiple sites like these are things which have not been done before. That is one of them. And maybe human factors also. So how the humans would interact with this technology. Because there is a science behind how to assess human behavior in certain accidents, for instance, or non-conventional situations, which now we cannot really predict for SMRs, because we don't have the operational experience.
(23) DSA1: And one of the difficulties is, Fukushima is a very good example of this, when you start to plan, make safety systems, and do your safety assessments. There's always some assumptions you take. And when you start to move outside those assumptions, where the conditions aren't as you expected, then suddenly nothing is valid anymore in the safety assessments. And then you could have a situation that's bigger than you planned and suddenly the situation is very different. And that also needs to be taken into account when you are planning a plant and when you are planning preparedness related to a plant. You also need to take into consideration if someone willingly wants to harm a plant, and how do you arrange to mitigate that. That's also part of it.

Analysis: Black swans

This discourse is identified as a Black swan discourse, because of the meaning of the metaphor. As explained in the risk evaluation theory (section 3.3.4), the black swan metaphor symbolizes unexpected or unforeseen events with extreme consequences.

DSA1 states that there is still a big question mark regarding decommissioning, and that international organizations as IAEA even wants to have more conversations about this issue. DSA2 talks about the lack of operational experience of multiple SMRs overlooked by the same control room, and how humans interact with these new types of systems. DSA1 also explains how the Fukushima accident is a good example of how a safety assessment can lead to a very different situation than anticipated, when one must lean on too many assumptions instead of experience data.

As explained in the risk evaluation theory (section 3.3.4), the black swan events can be split into different types. I argue that this discourse in centered around two types of black swans. The first one is the ‘Known, but not believed to occur’, because DSA relates potential risks to previous nuclear accidents like Fukushima. These accidents are known about, but not believed to occur because of the low probabilities. The second black swan is the ‘Unknown, unknown’, these types of black swans are not known by anybody and have therefore not been assessed or considered in any way. I argue that this can also be a type of black swan DSA is concerned with because there is no operational experience with SMR’s.

All the concerns represented by DSA are centered around uncertainties and the lack of experience that can say something about risks of SMRs. Basing decisions on weak strength of knowledge could potentially lead to an unforeseen event with catastrophic consequences, based on knowledge from previous nuclear accidents. The discussed issues could thereby represent potential black swan events.

6.1.5 Discourse: Sword of Damocles

Discourse 5
(24) SH2: I think there's quite a big gap between what the common people thinks and what's realistic. We relate to what risk actually is. Of course, if we talk about something that could go wrong, we don't relate to what the common people think, because that's miles away from what the reality is. We deal with facts and figures.
(25) SH1: There are things that are possible, it's just that the probability of what is possible is extremely low. And if it's extremely low, then you have to stick to the fact that it is extremely low. It's theoretically possible that you'll have a meltdown, and it's theoretically possible that something will blow up. But if something is theoretically possible, it's not a 50/50 probability that it will happen. In the case of a release of radioactive isotopes with some significance, the probabilities are extremely small, in the order of one in a hundred million or so in any given year, meaning if the world were to build tens of thousands of modern reactors you wouldn't expect any of them to have a significant release over a lifetime of even a hundred years. Even though the probability of a release is extremely low, contingency plans will still be in place in order to handle any conceivable situation.
(26) DSA3: To start off, we talk about risk. Risk is on very different levels. And risk is very well defined. What risks are, you can calculate. And how we do it is very different from accidents, or from malicious acts. So in our field, we often not only talk about risk, but we talk about hazards when it comes to emergency response and preparedness. And one of the difficulties for us is that many of the things we need to prepare for have a very low probability, but might have very high consequences. And also we have no frequencies to look at. Most of the things never have happened before. So, we need to do a lot of judgment when it comes to how we evaluate the answers. And we also cooperate with other organizations like the Norwegian Directorate for Civil Protection. They have a national risk assessment where they compare different risks between different areas of society. And we cooperate with them on how we evaluate nuclear risks versus other risks.
(27) IFE3: And they are safe. I'm 100% certain of that. They are much safer.
(28) IFE1: The question was whether it's safe enough. Then the answer is yes
(29) IFE3: The nuclear is built on worst case scenario. Well, unless you have a 20-meter tsunami, which is not expected ever.

Analysis: Sword of Damocles

In this discourse, I have gathered citations where the stakeholders talk about the risk characteristics of nuclear accidents; low probability and high consequence. As explained in the risk evaluation theory (section 4.3.3), risks assessed to have high catastrophic potential, but low or unknown probabilities, can be classified as Sword of Damocles. The Damocles risk

class is characterized by a high disaster potential but probabilities that the potential will become reality is low and sometimes even minimal.

SH1 explains that the common risk perceptions of nuclear power is far from what the real risks of SMRs actually are. As stated in the risk perception theory (section 4.2.1), human behavior is mainly driven by perception and not by facts, or by what is considered to be facts by risk analysist and scientists. Public understanding is often hampered by the complexity of the risk concept, as low probabilities and high consequences are often very difficult to estimate for a non-risk expert.

SH1 builds on this, by explaining how the risks are theoretically possible, but not really realistic to take place. SH1 also notes that one would always have a contingency plan if something where to happen, even though the risks might not be dangerous to people.

DSA2 also points to the fact that risks of nuclear accidents often have a low probability, but could have very high consequences, which is difficult to estimate.

IFE1 and IFE3 express that they evaluate SMRs to be safe, unless something very unexpected happens. This also relates to the associated low probabilities and potential high consequences.

Even though all stakeholders agree that there are low probabilities associated with SMRs, there are some differences in how they represent the potential consequences. SH1 and SH2 are not so focused on the high consequences and argues that common risk perceptions are quite different from reality. IFE is confident about the safety of SMRs, and express that an event that could cause a hazard is not expected. However, DSA is conveying a different risk picture, as they are quite concerned about the potential high consequences and the lack of experience with SMRs. As this metaphor closely relates to the black swan metaphor, it will further be addressed in the discussion.

6.2 How are the stakeholders legitimizing SMRs?

As explained in the method part of this thesis (section 5.2.2), legitimization refers to the process of speakers accrediting or licensing a type of social behavior. Legitimization is thereby a justification of a mental or physical behavior, enacted by argumentation that explain our social actions, ideas, thoughts, declarations, etc. Legitimizing discourse can happen through strategies of emotion, a hypothetical future, rationality, voices of expertise or altruism. This analysis will look at how the stakeholders are legitimizing, or how they are not legitimizing SMRs.

6.2.1 Discourse: Regulatory readiness

Discourse 6
(30) SH1: For licensing a reactor design in Norway, it will be quite beneficial to have that same type of reactor be licensed elsewhere first, for instance in the US, Canada or the UK. That will create a good precedence, also aiding approval of the design in Norway. And then it's being built very simplified, so that the small modular reactors are going to be, there's not going to be anything very special about them, really, so you don't have to change that much from country to country in the first place. Previously, the approach to licensing might not have been as nuanced and risk informed as might have been appropriate, facilitating little differentiation between different designs and power outputs. If you wanted to build a 10-megawatt nuclear power plant today, a tiny nuclear power plant, you'd still have to use licensing on large nuclear power plants. That means a safety zone of several kilometers, and then there are slightly different types of safety zones, and within that safety zone, you could put a 5,000 MW reactor or you could put a 10 MW reactor. And it's pretty obvious that a 10 MW reactor offers a lot less risk than a 5,000 MW reactor, or multiple reactors totaling 5,000 MW would be able to represent. So, yes, there's nothing wrong with basically using a risk-based approach here in Norway, for example, because we have a regulatory framework that is function-based, rather than performance-based. There is room to be able to use a more risk-based approach. As an example, there was a U-boat anchored in Norway with a reactor in it. Then a risk-based approach was used to say that it was okay to have it anchored in Norway. One can use a similar methodology. You look at what can actually happen. What happens if you have that kind of wind direction if something happens and so on. So that kind of approach is much more sensible to use than a fixed standard that exists in other countries.
(31) DSA2: Regulations depends on the country. So whether it's very prescriptive regulations that we are looking at. I can give an example of the USA. Our regulation in Norway are not that prescriptive, so we quite have some degree of freedom on what to, what's the take. So we leave it to the operator actually to justify safety. So for the US, it can be a challenge for them, for example, because they have quite prescriptive regulations, so they would have to work a lot on the regulations in order to approve such new technologies. While in Norway, we might also, the challenge would be to base our analysis on bigger countries, like for example the USA or France, that have a more

comprehensive regulatory framework than we do in Norway. So these are the challenges that the national community has to work on.
(32) DSA1: In the conventional nuclear reactors, there was operational experience. So, we had more knowledge of what may happen or what can happen. So if we can define the risk, it's consequences multiplied by frequencies. So in the old or the conventional reactors, we have those frequencies of events or probability of an event that may occur. But when we talk about the SMRs, these are in the development stages. They claim that it has much lower risk, but that risk has no operational experience. It has not proven yet, so that provenness is not on the table yet. So being a regulator, then we are bound to use the same methodology that we were using for the conventional reactors to these reactors.
(33) DSA3: When it comes to requirements concerning the siting and how big the area you should allocate. We don't have any numbers, but we will require that it's sufficient, that it's enough space, and it needs to be justified and explained how the operation should be and also decommissioning work and so it would need to be a sensible size and well explained by its plan the way it is.
(34) DSA3: We do not have any detailed regulation of how much passive safety systems or active safety systems would be there. It would be ultimately, as you said, when the design would come on the table, when it is done, then we can analyze based on that because what we said previously we are not responsible how the plant is designed or made we are only responsible what the consequences of risks that would come up to the society through that. That is basically our main concern. Our job is to say what needs to be in place to do it in an acceptable way. And the decision on nuclear power would be a political decision. And you will have both active and passive safety systems. But there will always be a risk, even though the probability will be lower and lower, you will still have some risk that you need to manage. And you will need to have emergency preparedness if it should happen.
(35) IFE2: The regulatory within nuclear, I don't think there are anyone stricter.
(36) IFE1: They have extreme power. They can shut you down for a year.
(37) IFE3: The nuclear is heavily regulated and the regulator does have a lot of strength and power over how you operate and when you can operate. You have to basically ask their permission to start up, whenever you're ready after an outage or a trip or anything. If you trip, you have to provide them a detailed explanation of why you tripped, and if there was an underlying condition you have to resolve that before you can start up. From that standpoint, it's a very, very detailed process. I think about it because sometimes I get so frustrated when I see oil refineries that basically blow up or have major fires, and six months later, they're back online and nobody even questions that. Twenty miles down the road is a nuclear power plant that operated through a hurricane and continued to operate at full power for seven days with their staff stuck on site. But does anybody bring that up and make a big deal of when everything else is basically wiped out in the area and a refinery is catching on fire? It's like, oh, it's okay. It's just a refinery, not a nuclear power plant.

Analysis: Regulatory readiness

In the background section of this thesis (section 2.7.2), I referred to conditions for success, made by The Nuclear Energy Agency (2023). In these conditions the agency states that governments and international organizations have a role to play in creating enabling frameworks, including regulatory readiness. The stakeholders where asked questions regarding licensing of SMRs in Norway.

SH1 explains that a risk-based approach would work better for getting SMRs licensed in Norway, than a fixed standard often used in other countries. This would entail not using the same licensing for all sizes, designs, and power outputs of nuclear power plants. SH1 refers to how a U-boat carrying a reactor was approved for anchoring in Norway by using a risk-based approach. SH1 also explains that an approved SMR design in another western country would be beneficial for getting the same design licensed in Norway.

DSA2 also refers to how other countries often have a more prescriptive regulatory framework, and that an operator actually would have a bit more freedom regarding how to justify safety. Basing Norwegian regulations on other countries comprehensive framework could thereby also be a bit challenging.

DSA1 points to the fact that they do not have any data to lean on, or to prove the theories about SMRs being safer than conventional reactors, as the SMRs are still in development stages. DSA1 further states that Norwegian regulators are then bound to use the same methodology that is used for the conventional reactors.

DSA3 confirms that there is no fixed framework for how big of a safety zone or how much passive safety systems one would need to get an SMR licensed. However, the operator would need to justify a safe plan for the operation and the decommissioning. DSA3 emphasize that the decision to allow licensing of commercial SMRs would ultimately be a political one, and that there will always be some degree of risk that would require emergency preparedness.

IFE1, IFE2 and IFE3 discuss that the regulator of nuclear power is very strict in Norway. One fault could shut the operation down for a very long time, and one needs to document that the

fault is fixed in a very detailed manner. IFE3 explains that the process can be frustrating, as other industries do not have the same standard to follow after an accident or a fault.

In this discourse, there are some similarities but also some differences in the way stakeholders legitimize SMRs. SH1 legitimize that a risk-based approach would be appropriate to license SMRs, by referring to the difference in size, design, or power output an SMR would have compared to a conventional reactor. This can be recognized as legitimization through rationality, by how the stakeholder refers to these evaluations and makes the arguments make sense. SH1 also uses the example of a U-boat to show how it's been approved previously in Norway. This can be a way of legitimizing through voices of expertise. Since it has been approved by authorities in Norway before, the argument that it can be licensed by using the same approach gives it institutional authority support.

This is somewhat similar to what DSA is saying about a freer standard for proving the required conditions. The difference is that they cannot legitimize the safety improvements of SMRs before they have operational experience data to lean on. Before that they would be bound to regulate SMRs on the same conditions a conventional large-scale reactor would be regulated. I will therefore argue that this a case of anti-legitimization through lack of evidence to make a well heeded, considered, and rational decision.

IFE do not comment on how regulations should be specifically. However, the discourse does imply that the stakeholders evaluate nuclear power operations to be more heavily regulated than necessary. This is legitimized by comparing required proceedings after a fault in the nuclear industry to a similar scenario in the oil industry. I argue that the discourse is legitimized through rationality and emotions. Legitimization through rationality, because the discourse compares two industries that share the possibility of accidents, but one is more heavily regulated than the other. Legitimization through emotions, because the discourse indicates that the reason for the heavy regulations might be unjustified, when compared to other industries.

6.2.2. Discourse: Management of radioactive waste

Discourse 7
(37) DSA2: The nuclear waste is stored in intermediate storages, basically. Different countries store them generally outside. Different technologies can be used to store it, and we have to ensure that control is always established for the storage. And it is quite difficult to say, let's say, in 300 years that there will still be control on these storages, for example. So this is an issue. But on the long term, the aim is to actually find a solution for this, either through putting it in deep geological repositories or also there are different type of solutions which has not been quite investigated or funded yet. It could be to used as fuel in other research reactors with high nutrient flux. So the risk would be lower based on experiments that were done. This has not been quite investigated, given the attention that it shoots, I think.
(38) DSA1: It's a general consensus in the nuclear industry that more research needs to be done. As I told you, when we talk about the fuel, so it has two processes. One is the front end, one is the back end. What the industry is right now working on is on the front end, how to produce the fuel. But when it comes to back end, when it is taken out of the reactor and stored, and it will include, I mean, what kind of waste stream that is being generated. It needs to be researched more, how to dispose it all. This needs to be talked about. This needs to be researched more before we can say, okay, this is our future.
(39) DSA3: This is a very dangerous thing. I mean, that spent fuel is a dangerous thing. And nowhere except Finland, a solution has been started. And wherever it has been started, they come across new problematic arenas in the air. Anything which is generating heat, you store it under the ground for thousands of years. You need to be very much sure that it should be retrievable if something happens to it. We are talking about thousands of years, let's say after 30 years, 50 years, you think that what your design was is now totally wrong, what would you do then? You need to retrieve it. So this is something which needs to be addressed. And you could also have human errors, that you discover that something wasn't properly handled before it was deposited. Or that you discovered there's a leak, or that some material was being deposited that shouldn't have been. So, it's a very complicated issue.
(40) SH2: The regulations Norway has is an expression of what we Norwegians feel and think. We have an example, I'm not exactly saying specific points, but there are some things in our radiation regulations that are a hundred times stricter than the international Western regulations. There's no reason for that. We're talking about a very proper international regulatory framework, and then we're going to be ten or a hundred times better without there being any reason for that.
(41) SH2: There are two sides to this case, is it a good solution in terms of placement and how to deal with that. That would be a debate of localization that would certainly happen. But I think it's very strange if someone actually thinks that a solution invented in the mid-80s, that was spent almost 40 years checking and researching that this is supposed to be safe and good, and I don't think there's anything other that's as proven as that. That it's not a technologically good solution, I think that's very strange. This solution is also something that the EU science panel is taking on, which they also conclude is safe. It is the safest

way to handle hazardous waste. And they've also looked at what's the worst that could happen in the future, even if we think this will stay in place, nothing should happen. Then, however, one must say in an analysis that something is happening anyway. It begins to seep out, it begins to leak out radioative particles. What can we expose future people to? That's the ethical side of it. Is that okay? Are we inflicting something on the people of the future that we say is not okay to do? The research shows that the extra dose of radiation that future people may be exposed to in the worst case is far below the so-called natural background radiation we are exposed to all the time. The concrete figure that they have come up with in Finland when they have done their research on it is that in the worst case, people can be exposed to an annual extra radiation dose all the time, so you have to say what it is you are exposed to. An annual extra dose of radiation, which is the same as what you get when you eat two bananas a year. It is quite strange to think that this is not a good solution and that this is not safe. That's what we're exposing people to.

(42) SH2: What we believe, or don't just believe, but as the situation is today, Norway has to build a landfill for radioactive waste anyway. We can't get away from that, because we already have this waste. And the amount of waste from nuclear power plants is so small that there is no need for more than one landfill to be built. So to say we can't build nuclear power plants because we don't have a landfill... We already have to do that. Then it's much better to also build nuclear power and get a lot of energy and get a lot of good out of it. So we're getting a lot more out of the landfills we have to build anyway. So opting out of nuclear power as part of the energy mix in Norway, is not the same as opting out of landfill.

(43) SH1: The existing methodology today is simply to dig the waste deep into the ground where it comes from. So you take it off the ground, put it into the reactor, then it becomes radioactive, and then you take it out again, and then it gets temporarily stored on the surface, and then it gets pushed back into the ground. So with bore hole technology, maybe a mile or something like that, into the ground, there it is placed in barrels of steel, concrete, copper, in geological formations that have no permeability to water. So water can't get in, and water can't come out, really. And then, you can't get any radioactive material transported up really. But if you do analysis for it, you can do it, but then you have to remove part of the barrier that really exists, you just say it doesn't exist. And then you have to set up something, which won’t doesn't really happen, but you say it's happening. And then you look at how much the radiation dose gets on the surface. And then you also add on to it, you say somebody lives up there, and lives for a very long time, and eats all the food that's there, and drink all the water that's there when it's exposed to the radiation that's coming from the ground. What would the radiation dose be? And then it equates to two bananas extra radiation-dose per year. So it's nothing.

(44) SH1: My point is that if you want to make it really difficult for yourself, then you can do it. So you really just have to try to communicate better than the industry has done so far. What we are already doing now is far more than good enough. Hopefully young people today, they get it. They are the ones who will run the country in 50 years. Maybe their kids again then. But yes, so we're trying to influence with common sense, really.

Analysis: Management of radioactive waste

This discourse is about management of radioactive waste. The discourse shows two quite different evaluations of how harmful the radioactive waste is, and how this is legitimized.

DSA2 starts by explaining how the radioactive waste generally is stored today. The stakeholder states that new solutions for long-term storing of the waste is in development, but not quite investigated yet. DSA1 builds on this by stating that the back end of the fuel and how to store it safely needs to be investigated more, and that this thought is a general consensus in the nuclear industry. DSA3 express a lot of concerns regarding the nuclear waste. These concerns are legitimized by referring to potential future scenarios. The radioactive waste is very dangerous, and even the leading solutions for waste-handling experience problems. It needs to be retrievable if something where to happen, the design might be outdated after some time, there might be human errors when handling the waste, and there might be a leak. These are all legitimizations by referring to an unwanted hypothetical future. By stating that the radioactive waste is a very dangerous thing, it can also be legitimized through emotional associations to danger.

SH2 express that Norwegian regulation is an expression of the public's perception of risks. However, the Norwegian radiation regulation is far too strict. This is legitimized by comparing the Norwegian regulations with the international western regulatory framework. By referring to the international regulation, a strategy of legitimization through voice of expertise is used.

SH2 was asked to give a response to the claim that there is no sustainable solution for handling the radioactive waste in a long-term perspective. SH2 answers to this in citation (41) by stating that the solution for handling waste used today has been checked and research for over 40 years and is very well proven. SH2 refers to the EU science panel's evaluation of the solution, and that they have concluded that it is safe. This is a way of legitimizing through rationality by explaining how well investigated the solution is. It is also legitimized through voices of expertise by referring to evaluations done by the EU. SH2 also adds that it would be a very strange thing to claim, that this is not safe. This can be a legitimization through emotion, as it can make the audience recognize this feeling and make them more sceptic to the claim.

SH2 and SH1 both argue against the claim that the storage solution is not good enough, by referring to an analysis also conducted by the EU. This analysis investigated what future people might be exposed to if there should be a leakage of radioactive waste. The results show that the extra dose of radiation future people may be exposed to in the worst case is far below the natural background radiation we are already exposed to all the time. This extra dose of radiation would equal to the same exposure one would get by eating two additional bananas a year. This is also a way of legitimizing through voice of expertise by referring to the EU and legitimizing through rationality by referring to how well evaluated the risks are. It is also legitimized through a hypothetical future by referring to estimates of future risk. The banana example can be a legitimization through emotion as we normally associate bananas with very little danger.

SH2 explains in citation (42) that since Norway already have radioactive waste from research reactors, the country would have to build a landfill for the waste even if the country doesn't build commercial reactors. SH2 argues that Norway should therefore build both landfills and commercial reactors so that energy is produced, and good things come out of it. This is a way of legitimizing through rationality by explaining what needs to be done without any of their own motives taken into consideration. It can also be a way of legitimizing through altruism as it is proposed as something that would help Norway.

SH1 explains that the solutions used today is far more than good enough and they hope the future generations that will make further decision will understand it, as they try to influence with common sense. This can be a way of legitimizing through rationality as SH1 justifies the action to be evaluated and well thought out.

I will argue that these different evaluations of the harmfulness of radioactive waste is a case of interpretative and normative ambiguity, as explained in the risk evaluation theory (section 3.3.1). Even though all the stakeholders agree about the values at risk, I argue that what is regarded as tolerable is not agreed upon. DSA characterize the radioactive waste as very dangerous that there are no proven solutions for yet, while SH1 and SH2 regard it as something very manageable. The evidence is thereby clearly disputed.

6.2.3 Discourse: Public opinion

Discourse 8
(45) IFE3: I think there's a few places that feel like they're ready for commercial nuclear power. Halden is definitely ready. They've had it for 60 years without really even noticing as a whole. I know that one of the big things always comes up about competence in things. And every country that starts a new program has to build that competence. But the good thing is that you have two countries on both sides of you that have tremendous amount of competence. Workers also flow to new, interesting things. You see it in the US all the time. As soon as there's a new plant or a new thing that happens, people move because they want something new and exciting to do. I think if Norway were to start, competence would be the least of the problems because you would have an initial influx to support the start, and then you have the time to build the rest of it. In that time, you start that the training process. Also, you don't have to have college-educated individuals for every phase of that project.
(46) IFE1: I totally agree. I think we can import people from the US and from Sweden. Absolutely. We have the experience. We don't have to build, like you say, the whole thing of a university. We don't have to build industry from the bottom, but we can import to operate it. And we have an example in Norway of a high technology industry in the petroleum business. We have a quite strict regulator there, Ptil, which is good even in some of our topics like human factors. And Norway have shown that we can run a complex industry. So that's not a problem. Whether people are ready for it, that's also a question of public acceptance.
(47) NK2: We see that an increasing proportion of Norwegian people are positive to nuclear power. The latest survey from Opinion just over a month ago, 51% answered exclusively yes to «Should Norway build nuclear power plants in Norway». 12-13% answered don't know. 36-37% answered no. That means it's a majority. There are many more who answer yes than the amount who answer no. That's a really interesting number. We see that there is increasing interest and support for it. I have been part of the debates since 2011, now for twelve years. I have seen how the questions and objections around nuclear power have evolved. It's much more nuanced. Looking at my experiences of being in that debate, I would say that there is a much more grown-up, mature, and interesting debate now than there was about ten years ago. I think it's important to find the right time. That's why we're going to continue to talk to people, to politicians, businesses, municipalities, everybody who's involved in something like that. And then we see that so far, things are going in the right direction. So I think the development can go faster than what I had hoped for.
(48) NK1: The public seems ready for nuclear power in Norway
(49) DSA3: What we can say is that we follow the development of commercial nuclear power, and we follow the discussions. And we also have meetings with parties like Norsk Kjernekraft and the universities and others trying to do something within this field. So it's very interesting. But we have no opinion on consumer. What we can say is that you need to do a lot of things. Also when it comes to regulations and when it comes to building up authorities

Analysis: Public opinion

In this discourse the stakeholders where asked if they thought the Norwegian public was ready for implementing commercial nuclear power in the Norwegian energy-mix.

IFE3 states that they believe people in a lot of places in Norway would be ready, especially Halden who's had it for 60 years without noticing it in many ways. IFE3 states that one of the things that is often discussed in the context of this topic is the available competence. IFE3 argues that this would not be a problem for many reasons, such as the competence from neighboring countries, that Norway could expect an initial influx of people wanting to join the development, and that one would not need every worker to be college-educated. In this statement legitimization is done through rationality, hypothetical future, and emotion. It is legitimized through rationality by referring to the competence available in neighboring countries and how Halden is probably ready for commercial nuclear power because of their experience with it. The legitimization through a hypothetical future is used by explaining how Norway would have access to the needed competence for building the industry. The legitimization through emotion can be indicated by the description of how people in Halden is quite comfortable with nuclear power.

IFE1 agrees with IFE3 and adds that Norway has a lot of experience with running a complex industry from the petroleum business that could be applied to a nuclear industry in many ways. IFE1 adds that whether Norway is ready for a commercial industry is a question of public acceptance. IFE1 uses some legitimization strategies through rationality by referring to the knowledge Norway has from the petroleum business.

SH2 refers to a survey, showing an increasing support for nuclear power in the Norwegian public. SH2 further explains that they experience a more nuanced discourse then earlier in the nuclear power debate. Their strategy is to continue to talk to stakeholders and so far the development seems to go faster than previously anticipated. SH2 uses some legitimization strategies through rationality by referring to an independent survey. SH1 states that people seem ready for nuclear power in Norway, without using any specific legitimizations for this claim. However, from a holistic view of the discourses, this claim is backed up by legitimizations through public support.

DSA3 explains that they follow the development and discussion about commercial nuclear power, but they don't have any opinion on consumers. DSA thereby refers to a necessary legitimization from the public for commercial nuclear power to be established in Norway.

6.3 How are the stakeholders using communication strategies for effective risk communication?

In this section the discourses will be analyzed considering how communication strategies for effective risk communication are used. The analysis will be based on different aspects from the risk communication theory (section 4.4). Aspects investigated will be: How the stakeholders ensures that all receivers of the message can understand the content of the message and enhance their knowledge about the risk in question, how the stakeholders establish a trustful relationship between the sender and the receiver of the risk communication, how the stakeholders persuade the receiver of the message to change their attitude or behavior with respect to a specific cause or class of risk, and how the stakeholders provide the conditions for an effective stakeholder involvement on risk issues so that all affected parties can take part in a conflict-resolution process.

6.3.1 Discourse: Familiarity

Discourse 9
(50) SH2: Rolls-Royce is well known, and people have a personal relationship with the company, perhaps without even knowing it, as they do build aircraft engines for many of the aircrafts we have in Norway. Most of us have been on an airplane with Rolls-Royce engines, for example. It is similar to the consequences. The probability is low and it's a very safe way to travel. But then it becomes dramatic if something happens. But this is something we expose ourselves to.
(51) SH2: I think it's extremely important to read through any text carefully many times, and ask questions such as: Is it easy to understand? I'm very strict about it. It's not a strategy, it's just the way you have to go about it. If I think it's a bit unclear, then it's probably unclear to most people as well. Because I have a PhD in the topic, so then it should be extremely easy for me to read, at least. I mean. It's kind of a strategy, after all. It's something I've trained myself in, also through the experience I have with running a blog and communicating through social media. I think it's a really good training tool, really. Communicating. You can, for example, use Instagram and practice communicating messages. I think it's a good training for people who want to learn. Then you have to concretize, you have to kind of get it down to a small package. But it's about thinking who is the recipient. What does the receiver know? What things should you assume the recipient already knows. You can't always link to all sorts of things and early reports and blah blah blah. Then we probably would have 20-30 links in an article that we write. I don't click on 30 links in an article that I read myself. And then you can't expect the reader to click on a single one of those links. But it may be that the explanation can be found in a link. And I'm also very strict about us being nice and polite. Things shouldn't be able to be read sarcastically or anything like that.

(52) SH1: And I think that, when you talk about renewable energy for example, and you say it's not going to be a problem with wind, that sometimes there will not be any wind, so sometimes there won't be electricity, it's not going to be a problem. People realize it's going to be a massive problem. Everything has risks associated with it. One needs to reflect upon the balance between risk and reward. It's the same thing with bus and car or road or something like that as well. There are risks to it, but you still need road in the same way that you still need stable electricity. And it works better for society having things that protect us from a cold winter for example. It's intuitive, I think.
(53) SH1: I think it's really just about telling people what it's all about. When we talk about waste, for example, I'll tell you what it is. The used fuel from the reactor is quite radioactive and people can't directly interact with it. Instead of not talking about it, it's better to acknowledge risks and explain the ways in which this risk will be handled. The point is that there is such an extremely small amount of waste that it is very possible to handle it properly. It's essentially the same kind of perspective you can say about everything else. Solar paneling is also extremely dangerous if you eat it. But you don't expect people to eat it. It's really just common sense, and I think common sense is what we're going to appeal to the vast majority of people. If we're going to license a nuclear power plant Norway today, then it's really a given that it's going to be extremely secure. The risk profile will also actually be far lower than hydropower plants that we have in Norway. If something were to happen to a dam at a hydropower plant, for example, the consequences would be far greater than if something were to happen to a nuclear power plant.
(54) IFE2: Even though the systems are highly automated, like they are in many airplanes, we still need people there. And we still have to address how to design all of this new concept in a safe way.
(55) IFE3: I try to tailor every presentation when I think about who my audience will be. And if I need to start from the very basic, okay, this is nuclear power and this is where we start. For the Tekna presentation I knew that I was speaking with engineers, or a majority of engineers. So, I shifted the presentation to discuss the different types and specific reactor types and had that discussion. So it's very, very focused on who you talk to. If you talk to 13 year olds, they're gonna have a completely different view on things. I think it's very important that you have that discussion and think about who you're talking to.
(56) DSA1: In the United States, they have around 80 or 90 reactors, commercial reactors, up and running now. And most of these would be, they have gotten, most of all of them have got the life extension till 60 years. Now they are planning for 80 years. So, let's say if all of these decommissioned in 2055, then they really have a crisis. Because in their energy mix, nuclear energy is a big part. It's similar in Russia, similar in France, these countries which have big nuclear programs. But then it matters. They need another source and if the the natural sources are not enough. But in Norway, how many reactors are running here? Zero. So that's different, I think it's not right to make an analogy in our case.

(57) DSA3: As we talked about earlier, we have many target audiences when we are discussing risk and we are very aware of that, and we discuss it on very many levels so both on a very technical level and on a very non-technical level depending on who we are talking to.
(58) DSA2: I think what we are trying to establish at the DSA is an open communication with the public. So if we have any questions, like for example you today, we are happy to share what we know and to communicate our knowledge.

Analysis: Familiarity

In this discourse the stakeholders use familiarity to communicate risk effectively. This happens through open communication, tailored presentations of information, or by comparing elements of nuclear power to something people are familiar with, as this analysis will show. The stakeholders were asked in various ways to explain how they communicate risk and how they ensure all audiences understand the information being communicated.

SH2 explains that the SMR producer Rolls Royce is a familiar brand, and that most people have been on a plane with a Rolls Royce engine. SH2 further explains that the probability and consequences of a nuclear power plant and an airplane is quite similar. The probabilities of something happening are very low but if something happens the consequences can be dramatic. I argue that this is a very effective way of communicating risks. The familiarity of an airplane can be much easier to understand than probability multiplied by consequences. It can also be an effective way of reducing risk perceptions through communication, by connecting risk associations with risks of being on an airplane.

SH2 also explains how they always evaluate how easily a text can be understood whenever publishing something. SH2 carefully evaluates what audience the content will reach and what knowledge the receiver would need to understand it. SH2 also highlight that it has been a good training to use social media, because one must concretize the content to a smaller package, than in other outlets. SH2 is also focused on making it easy for the reader by not having to look things under many links to understand the content, and not writing anything that can be understood as sarcasm. In this context SH2 points to many important factors for effective risk communication as all communication is carefully considered as well as the receiving audience. The training of concretizing information to a smaller text is also very smart, as it rules out the chance of the receiver getting confused by too much information. The

communication on social media can also be an effective way of communicating risks of high ambiguity or controversy. As explained in the risk communication theory (section 4.4.4.1), these risks trigger highly controversial and emotional responses, therefore involving all stakeholders is inevitable for effective risk communication. These risks require new and unconventional forms of stakeholder involvement, such as mediation, citizen panels, and open forums with special groups and others. The goal of these exercises is to reflect on related values, to build trust, and to find solutions acceptable or at least tolerable for all participants.

SH1 also compares the risks of nuclear power to risks of other familiar things, such as hydropower plants. SH1 emphasize that it is important to weigh the balance of risk and reward when making an evaluation, stating that it is better to have something that works when the cold winter is coming. SH1 uses many familiar aspects in this communication as well as pointing out the benefits, not only negative risk. This can be a very effective risk communication as explained in the risk communication theory (section 4.4.4):

> "Many people like to act on the assumption 'better safe than sorry'. At the same time, however, people have an interest in a large variety of products, low prices and the comfort and convenience of modern technologies (Renn, 2008, p. 242)."

By highlighting the convenience of this technology, SH1 underlines the positive aspects of the risks involved. This is also important for persuading a receiver to change their attitude towards nuclear power.

In citation (53) SH1 explains that their strategy when communicating is to be open and honest about both negative and positive aspects of the related risks. SH1 emphasize that they try to communicate with common sense. SH1 make the risks familiar by referring to risks of other energy sources already established in Norway, and thereby familiar to Norwegians.

IFE2 explain that even though the SMR-technology might be developed, there is still work to do in developing systems surrounding SMRs. This is done by comparing humans interacting with SMR systems, to the autopilot function in planes. This can be recognized as a familiar way to understand this concept. IFE2 states that the SMRs probably need to be overlooked by humans, just as planes still have pilots. As mentioned earlier in the analysis, this is a very

good way for effective risk communication to audiences without much knowledge of risk or nuclear power.

IFE3 explains how they are very aware of who they are talking to when communicating about different topics. IFE3 try to tailor all presentations to every group from thirteen-year old's, to educated engineers. As pointed to in this analysis, tailoring the information to your audience is very important, as it can create more familiarity with an unfamiliar topic.

DSA1 explains how energy security is a different issue in Norway than in other countries by comparing the different energy-mix existing in those countries. This is a good way of familiarizing the topic being discussed. Interestingly enough, SH1 also pointed to the energy-security in the Norwegian energy-mix, by comparing stability of SMRs and windmills. The difference is that the arguments are completely opposite. DSA1 argues that Norway will not have the same need for nuclear-energy as other countries, while SH1 argues that there will be unstable energy-security.

DSA3 explains that they have many target audiences and that risks are discussed on many different levels, both in a technical and non-technical manner depending on who they are talking to. DSA2 adds on to the previous statement by explaining how DSA try to be open for dialog with the public. As described in this analysis, understandable and open communication is very important to practice for effective risk communication.

6.3.2 Discourse: Engagement

Discourse 10
(59) IFE1: We communicate our research result to departments, to ministries and to the research council, mainly to say that this is important, and that they should support future research as well. We have been a little bit too quiet in Norway and I think nuclear in Norway has not been a topic at all. Now it has turned around because the CO2 situation has been completely different. Now that the discussion has comes up on nuclear, I feel that very many people just doesn't know anything about it. Alongside this evolvement we have changed our strategy a little to just be more open to go out with articles. We had a long chronic about the SMRs role in in Teknisk Ukeblad. That's done to provide information about what we do, and also, I wanted to counter the argument that Norway has no competence.
(60) IFE2: We have been a little silent down here, but now it is time to let Norway know that we have a lot of competence and many decades of research which is relevant for the discussion. So, our goal is to be open about that and let the stakeholders know that we have a lot of the competence that is required in the discussion. And then the people making the decisions will have a more informed decision basis.
(61) IFE2: Our purpose with the talks that we do to the society and different stakeholders in Norway at least, is not to convince anybody, it's to provide the knowledge that we have. Because I think the Halden Project and the competence we have here has been a well-kept secret for many years, so now it's time to show that we have a lot of expertise on nuclear safety in Norway. And that's one of the main goals of us having the talks that we have.
(62) SH1: We're communicating to every demographic. It is perhaps more important for us to address the younger generation. We have to think from a centennial perspective, and we have to have a population that is aware of what it is and comfortable with that kind of thing. They are also the ones who are going to study. So we want them to choose things that are relevant to us. Since we need so many people, possibly. And so, communication might be aimed more at girls. For boys, they are easier to convince, it seems.
(63) DSA3: We do risk assessments or hazard assessments all the time. And on occasion we publish it in reports. I think it was in 2019. Our target group is both the general public, media, but also decision makers, authorities, and diversity plans. When it comes to the authorities and the ministries, we have a very active dialogue with them. And we have these reports. But our main way of communicating with the general public is through the media.
(64) DSA1: In our rules we have provisions to make hearings before we make a decision. So if we decided to give a license for example for a facility or for an activity, it is usually put in a hearing and put in public and anybody can raise concerns that we can take into account before we make our final decision.
(65) DSA3: What's commonly done is that we send it out to concerned parties, authorities, interest organizations, NGOs, and residents locally. And in addition having an open room where anyone who has a distinct interest may have a say.

Analysis: Engagement

This discourse is about how the stakeholders are engaging in risk communication and how engagement efforts are made. The stakeholders were asked varying questions about how they communicate and who their target-group for communication is.

IFE1 states that they communicate their research to departments, ministries, and the research council, mainly to express the importance of the research and to get support for future research. IFE1 explain that they have been a little silent because nuclear power has not been a very popular topic discussed in Norway. The efforts they are doing communication-wise today, was the intention many years ago, but was not done because of the lack of interest. IFE has now changed strategy by being more engaged in the conversation by talking to people and publishing articles. This effort is made to share knowledge about what is done at IFE and to counter the claim that there is a lack of competence on the topic in Norway. IFE1 mention many important aspects of effective risk communication in this discourse. Being engaged and expose the competence of an organization helps build perceived competence in degree of technical expertise and perceived sincerity by being open and honest.

IFE2 also emphasize that the organization have been a bit too quiet. IFE2 states that they have now made an effort to show people that there is a lot of competence on nuclear power that can be important in the discussion of commercialization. This strategy could help both politicians and the public make informed decisions. IFE2 continue by explaining that the talks they have are not to persuade anyone, but to give people a more informed decision basis. This discourse also points to other different aspects for effective risk communication, such as sincerity and fairness in acknowledging that there are different viewpoints to this debate and that IFE is not there to persuade anyone.

SH1 explain that they are communicating to every demographic and that they focus a lot of their efforts towards the younger generation and girls. This is because the younger generation might choose to study relevant subject for the nuclear industry and might be the once making future decisions in it. SH1 target girls with their communication because they seem a bit more difficult to reach. This shows a clear strategy for persuading the audience with their communication, which can be very effective. The stakeholder is aware of areas or

demographics that are important and hard to reach which is important to consider. SH1 is also focused on providing information to create awareness which can be a good tool for establishing faith in an organization.

DSA3 explain that their risk communication has many target groups such as the public, the media, decision maker, authorities, and diversity plans. They also publish reports with information about risk assessments they conduct. DSA show awareness of how they communicate by explaining that some target groups are communicated with actively, while others are mainly communicated with through the media. This discourse shows examples of sincerity by being open and honest.

DSA1 and DSA2 refer to provisions they have to make hearings before any decision is made. This gives everyone a chance to raise concerns that will be taken into account before a final decision is made. DSA3 adds that this is usually sent to concerned parties, authorities, interest organizations, NGOs, and local residents. This is a very good example of inducing risk reduction through communication and providing conditions for effective stakeholder involvement.

6.3.3 Discourse: Scientific basis

Discourse 11
(66) SH2: There are two reports we almost always refer to, and that is the EU science panel's report that came out about two years ago, which they prepared in connection to discussions on whether nuclear power should be considered green and sustainable, which they concluded in favor of. It is a long and comprehensive scientific report. To me, it's no surprise what's there. I'm very familiar with it. They haven't researched to write it, but its a compilation of research. So for me, it was familiar. But it's terrific that the report is so new. And I think they made some calculations as well. You want to look at this with risk, for example. It can be concluded that nuclear power plants, all of the ones that exist in the world today, are just as safe as wind power. It includes both new and old power plants, but all nuclear power plants have been replaced with new types of power plants. Not what is found here, but what is built in Finland, for example. So, one can expect one death per 1000 years. There's nothing even close to being as safe. So it's a report that we use, we always use it. It came out two years ago. And then we have another one which is from the United Nations. It's a science report, after all. The EU report deals extensively with precisely the risks associated with accidents. Also, this went even further into risks for nature, environment and health. And also concludes there that there is nothing as safe and environmentally friendly, nature-friendly and climate-friendly as nuclear power. There are plenty of good references in those reports as well.
(67) SH1: What our perspective really is, it's just basing information on data. So it’s not based on subjective opinions. And I think that's going to work, because that breaks through the noise.
(68) IFE3: What we heard in visits to all the member countries, in regulators all over the world. They want production of nuclear power to be science-based. I don't know if you read the Atomic Energy Act from 1954 in the US? They say that the use of nuclear power shall be based on the latest scientific knowledge. So that means that they put money into research on nuclear and that's why the US is paying us so much money to do research on it. And it's one of the few industries I feel that has really put money into, for example, human surveillance in the control room.
(69) IFE1: When you ask about how we communicate, we can add that we present all the results for all the projects and studies that we do to member countries. The sharing culture within the nuclear is very big across countries, so everyone really want to share their experiences.
(70) DSA3: We do risk assessments or hazard assessments all the time. And on occasion we publish it in reports. I think it was in 2019. Our target group is both the general public, media, but also decision makers, authorities, and diversity plans. When it comes to the authorities and the ministries, we have a very active dialogue with them. And we have these reports. But our main way of communicating with the general public is through the media.

Analysis: Scientific basis

This discourse is concerning how the stakeholders are using a scientific basis for effective risk communication. The stakeholders were asked varying questions about how they communicate and who they communicate with.

SH2 states that they always refer to the EU science panel's report, because it is based on a compilation of research and is very new. In this report it was concluded that nuclear power should be considered a green and sustainable energy-source. It also calculated that estimated loss of lives from a nuclear accident is one per thousand years, which SH2 emphasize is far better than any other energy-source. Another report they often use is published by the UN which also concludes that nuclear power is the safest, and most environmental and climate friendly energy-source there is. SH1 also explain that they always base information on data because that is the most effective way of communicating. Basing information on established research and data is an effective way of communicating risk as it reflects sincerity and perception of goodwill. It is also a good way of building up confidence in the risk communication by referring to sources backing up your statements.

IFE3 explain how they have experienced members of the nuclear industry in different countries voicing that they want the production to be science based. IFE3 refers to the US Atomic Energy Act from 1954 where it says that the use of nuclear power shall be based on the latest scientific knowledge. IFE3 further emphasize that the nuclear industry is one of the few industries where certain safety issues are thoroughly funded for research. IFE1 adds that the nuclear industry in general has a great culture in sharing experiences across countries. This discourse also shows the stakeholders pointing out the importance of a scientific basis, and an awareness in the industry for sharing data and experiences. This is important to communicate as it builds institutional trust and perception of goodwill in performance and communication.

DSA3 explain that risk communication is based on risk assessment and hazard assessments they conduct regularly. This information is also published in reports on occasion. This openness and attention of basing risk communication on assessments is also a good example of using a scientific basis for effective risk communication.

7 Discussion

The analysis will further be discussed following each related research question. The main arguments will be pointed to in the conclusion.

7.1 How are risks of SMRs represented by the interviewed stakeholders?

With this research question I wanted to find out how the stakeholders talk about risk, which risks the stakeholders highlight and thereby how they represent these risks.

From the discourse about 'Risks of opportunity', I found that all stakeholders highlighted some positive aspects of SMRs. This was interesting to note, as risk often has a narrower focus of only negative consequences. As explained in the analysis, all representatives have some similar description of how the SMR-design is a more manageable reactor than the conventional one. But they also highlight some different aspects. While all stakeholders agree that the SMRs does have many advancements, DSA is the only actor emphasizing that these advancements are not yet proven in practice.

The discourse about 'Public safety vs. Power security' highlight quite different views. When talking about related risks, SH1 was much more focused on the positive aspects of using SMRs than the potential negative consequences. In contrast, DSA3 had a much more concerned view of the potential consequences. IFE1 and IFE3 emphasize that they consider the nuclear to be safe, based on their knowledge and experience. In the analysis I also pointed to how the discourse indicates quite different underlying risk evaluations, which is consistent throughout the analysis. As explained in the risk communication theory (section 3.4.1), organizations have different purposes and will thereby often differ in selecting and processing information. Different risk assessments from different science camps can further reflect a specter of interpretations, even if based on the same base of data. This is not a result of bad risk assessments, but rather a result of organizations focusing on different aspects and problems.

In the discourse 'Potential new challenges', the different focus of risks continues. SH1 and SH2 is focused on challenges like political risk and needed work force for building SMRs, IFE focus on human factors and continuing research for future risk avoidance, and DSA is

focused on ensuring ownership of the SMRs. As explained in the analysis, this can be expected, as the stakeholders serve different interests. On the other hand, as stated in the risk communication theory (section 3.4.2), institutional trust is the general judgment of perceived performance of an organization. This includes the organizations perceived communication style in dealing with professionals, stakeholders, media, and the public at large. A trustful relationship can compensate for a negative risk perception, and distrust can lead people to oppose even the smallest risks. A more uniformed stance on risks would thereby radiate agreement across the organizations, which would especially serve a commercial actors as nuclear power already is perceived as a topic of ambiguity.

The discourse 'Black swans' shows how DSA differ from the rest by highlighting major uncertainties that could lead to unexpected or unforeseen events with extreme consequences. Their concerns are centered around uncertainties and the lack of experience that can say something about risks of SMRs. DSA is referring to previous major accidents like Fukushima, to underline what could happen.

The 'Sword of Damocles' discourse is about the problematic phenomena of estimating risks with low probabilities and potential high consequences. Even though all stakeholders agree that there are low probabilities associated with SMRs, there are some differences in how they represent the potential consequences. SH1 and SH2 are not so focused on the high consequences and argues that common risk perceptions are quite different from reality. IFE is confident about the safety of SMRs, and express that an event that could cause a hazard is not expected. However, DSA is conveying a different risk picture, as they are quite concerned about the potential high consequences and the lack of experience-based knowledge of SMRs.

It was mentioned in the analysis that the 'Black swan' and the 'Sword of Damocles' are two closely related metaphors. In risk science there are a lot of these metaphors that are used to make meaningful associations, so that risk assessors can understand different aspects of complex risk. This is also my intention to showcase by comparing the metaphors. The black swan might be a shared way for the stakeholders to understanding the risks when we talk about the 'Known, but not believed to occur' type. However, DSA could also interpret the potential risks of SMRs to be of the 'Unknown, unknown' type. This would not correlate with the risk descriptions from other stakeholders than DSA. In other words: the Damocles

metaphor is relevant for all stakeholders, as they agree risks of SMRs is a case of low probabilities but high consequences. The difference is that DSA consider risks of SMRs to potentially come with new unknown, unexperienced, unevaluated risks.

Overall, the results show some clear differences in how the stakeholders represents risks of SMRs. The commercial stakeholders (SH1/SH2) represent mostly benefits or risks of opportunity, the researchers (IFE) also represent benefits as well as potential challenges with commercialization of SMRs. On the other hand, the regulators (DSA) are more concerned about risks of SMR's. DSA represents risks that they argue there is not sufficient data for evaluating yet. As explained in the risk evaluation theory (section 3.3.1), one of the most controversial parts of handling risks is justifying an evaluation of the tolerability or acceptability of a given risk. The traffic light model is an oversimplification of a risk picture, but it addresses the need for a judgement at the end of an evaluation. As referred to, 'Sword of Damocles' is a metaphor used in risk classification. Myths imply ambiguity, fuzziness, and a holistic perspective. Such metaphors can help us interpret uncertainty and ambiguity associated with new scientific advances. The risk evaluation theory (section 3.3.3) identifies nuclear energy as a typical Sword of Damocles risk. This means the risk can be located in the intermediate and intolerable area of a traffic light model. It is important to emphasize that the risk classification through metaphors is contingent on both risk assessments and risk perceptions, as it is recommended in a comprehensive risk evaluation. As DSA emphasize, there is no available knowledge on criteria for evaluating risks of SMRs, and the risks can therefore not be evaluated properly. However, the risk evaluation theory further explains that these risks might be of great importance as they are usually associated with desirable benefits, for example through innovations. The theory further recommends ensuring more gathering of knowledge about the unknown risk potential.

7.2 How are the interviewed stakeholders legitimizing SMRs?

With this research question I wanted to investigate how the stakeholders legitimize SMRs and what this could further say about their risk communication.

From the discourse about 'Regulatory readiness' there are many interesting views of nuclear regulations in Norway. SH1 legitimized a risk-based approach for licensing SMRs, on the grounds that this has been approved in Norway in one scenario with a U-boat. DSA on the

other hand, do not seem very open to this idea, even though they agree that Norwegian regulations are less prescriptive than in other countries. Yet again, DSA is very focused on the lack of experience knowledge and available data-pool for risk evaluations. They also emphasize that they would be bound to use the same methodology for SMRs that is used for the conventional reactors. My thought here is that DSA is referring to a very rigid way of looking at assessment options. The theoretical framework for this thesis is not very focused on the risk assessment process specifically, but I will argue there are many sufficient ways of conducting an assessment. In the theory (section 4.1) it is argued that frequentist probabilities should not be the only method used when assessing risks outside of a casino or laboratory, as the circumstances and conditions often vary in "the real world". I understand DSAs argument about the dangers of purely relying on assumptions that could lead you to a very unexpected result. However, the SMR is described as a smaller version of a very well-known conventional reactor. Even if the new advances of passive safety systems are not proven in practice yet, I argue that it should not be hard to mathematically prove that a much lower power output equals to lower risk. This leads me to reflect on how any innovations would be possible if all industries were regulated in the same way. To this point, IFE also refer to the rigid nuclear regulations, by comparing the nuclear industry to the petroleum industry. I argue that this could be legitimized by authorities because of public risk perceptions.

In the discourse 'Management of radioactive waste' SH2 explain that the regulation in Norway is an expression of what Norwegians think and feel. In other words: it is an expression of public risk perceptions. The risk perception theory (section 3.2.1) characterizes nuclear power as a risk perceived as posing an immediate threat. The more a risk provokes associations with an event, the more likely it is that the related probabilities will be overestimated (Anchoring effect). An example of this comes from how incinerating in waste disposal facilities evokes an association with harmful chemicals even if there is no way that they could be released into the environment. Risk perceptions are not swayed by knowledge of related probabilities of how many more people die in car accidents than in airplane crashes. The rationale of risk perceptions comes from the voluntariness and the ability to exercise personal control. So even if the Norwegian radiation regulations are a hundred times stricter than the international Western regulations, it might still be in line with Norwegian risk perceptions. As explained in the risk perception theory (section 4.2.4), the public are not passive perceivers of ideas from experts and mass media. People forge representations in line

with their concerns often driven by emotions, anxiety, and trust. The social representations are usually a shared understanding within a group, developed from communicative processes. This leads me to argue that risk communication is the exact way one can challenge these regulations. By changing the public's perception of the risks, the regulations would also be led to change through political pressure. By looking at the 'Public opinion' discourse one can also argue that this effect is already happening as many of the stakeholders see Norway as well prepared and the newly conducted surveys (section 2.6) show positive attitudes towards nuclear power in Norway.

The further discourse about management of radiation is very interesting as both the regulators and the commercial actors legitimize their opposite statements very well. DSA characterize the radioactive waste as a very dangerous thing that there are no proven solutions for yet, while SH1 and SH2 regard it as something very manageable. As argued in the analysis, the different answers could be a case of interpretative and normative ambiguity. Interpretative and normative ambiguity is when both the evidence, the underlying values and what is regarded as tolerable or acceptable is disputed. As stated in the safety discourse analysis, there is disagreement about acceptability of potential risks. The theory (section 4.3.1), argue that assessors then need to find some common ground for characterizing and qualifying the evidence. Risk managers need to find a way to agree about the appropriate values and the related implications.

An example both SH1 and SH2 used for legitimizing management of radiation, is an example about the future dangers of radiation being equal to eating two extra bananas a year. I argued in the analysis that this was a strategic way of legitimizing SMRs because of the value of the source of information in addition to the harmless association of bananas. Even if this type of argument might be effective to some target groups (I place my money on people unfamiliar with nuclear power or radiation), I will argue that it might not be ethical. My first point is that by referring to 'future' it can be misleading as most people might interpret this as the near future, but it is more relevant in hundreds or a thousand years from now. As found in the previous research (section 3.1.2), not all instrumental goals are desirable in all circumstances and the result does not necessarily justify the means. Some arguments are valid in some contexts, but certainly not in others. I argue that this example could be unethical as it can be misleading, at least it is a very unprecise way of assessing risks. I will also argue that the

public's ability to evaluate risks should not be underestimated. People do not rely on completely irrational ways of assessing information. Evolution has led people to cope with dangerous situations by following relatively consistent patterns of creating images of risks and evaluating them. Risk perceptions is part of important aspects that risk managers need to take into consideration when deciding if a risk should be taken or not (section 4.2.1).

7.3 How are the interviewed stakeholders using communication strategies for effective risk communication?

With this research question I wanted to find out what communication strategies the stakeholders use, and how aware they are of them.

Even though it was clear to me from the discourses that all stakeholders use risk communication strategies, I did not get the impression they were all aware of using them. Through-out the interviews a lot of the stakeholder started off by stating that they did not use any specific strategies, but as the conversation progressed, they were more inclined to name-tag their actions as strategies. This tells me there is a lack of awareness for strategically communicating risks.

From the 'Familiarity' discourse, it is clear that all stakeholders sometimes function as a transmitter. As explained in the risk communication theory (section 4.4.1), this entails carrying information through a communication exchange. This requires a type of risk communication that ensure all receivers of the message can understand the content of the message and gain a better understanding of the risk in question. The first stage of communication happens through a framing of the message by an information source. This would not be something the stakeholder have a lot of influence on as most people have been exposed to information about nuclear power in the past. However, it is therefore very important that the stakeholders serving as transmitter of information to an already opinionated audience, use effective strategies. The effective strategy highlighted in this discourse is the use of symbols familiarizing the risks. Airplanes, cold winters, hydropower, solar paneling, autopilots, and energy-mixes in other countries were used as familiarizing symbols. This can

trigger the attention of a potential receiver, shape their decoding process, and amplify certain components of the message.

SH1 mentioned that they are very focused on checking and evaluating what message is being published. This is important as the media can reduce the complexity by oversimplifying the message and focus on certain aspects that are regarded as most relevant. The media often report about events, rather than continuous performance. It could therefore be much more interesting for the media to report about a nuclear accident, rather than a nuclear power plant's long safety record.

In the previous research (section 3.1.1), I found a description of the democratic ideal of empowerment as only achievable when individuals have a level of knowledge and awareness to establish a meaningful engagement in the risk discourse. The Nuclear Energy Agency (section 2.7.2), also referred to the importance of creating public engagement and trust as a condition for the success of SMRs. The discourse about 'Engagement' shows how the stakeholders provide the conditions for effective stakeholder involvement through engagement. As I have pointed out many times in the analysis and that is also relevant to this discourse, SH1 and SH2 continuously point out the benefits of nuclear power. This can be a very effective tool in risk communication because risks are only viewed as acceptable if they also provide sufficient benefits. With this perspective in mind, it is also important to give a complete and balanced risk picture.

From the previous research (section 3.1.1), it was explained how the risk communication community have replaced the deficit model with multi-way approaches. This entails including functions such as engaging audiences through meaningful dialog and deliberation. This evolvement has upsurged from a debate over what 'effective risk communication' is, where 'effective' refers to the degree of achieving a desired result. This is something that I also found an awareness for in the discourses. SH1 and SH2 engage with audiences through different medias trying to reach specific audiences to achieve desires results. Scientists from IFE states themselves that they have been a bit too silent earlier, as the debate haven't been a topic. Now, as this climate has changed, they are engaging in spreading valuable information that can help people get a more informed decision basis and showcasing the competence Norway have in this field. DSA also referred to a lot of different channels and target groups

they are communicating with. This is also a very affective way to communicate because risks with high ambiguity and controversy can trigger highly emotional responses and can be associated with public outrage. The risks therefore require unconventional forms of stakeholder involvement, such as mediation, citizen panels, and open forums. These exercises can help reflect on related values, build trust, and find acceptable or at least tolerable solutions for all parties.

If commercializing of SMRs will be established in Norway, I argue that a public engagement would constantly have to be maintained. Referring to the previous research, all articles reviewed point to the fact that many countries which previously had operating nuclear power plants are deciding to phase out this form of energy. The articles explain this as a repercussion of political pressure after accidents like Fukushima. Spreading knowledge and engaging the public will therefore be essential in Norway as well, as a measure for not repeating the history in these countries.

Another way of establishing a trustful relationship between the sender of information and the receiver of the risk communication can happen though referring to a scientific knowledge-basis. As explained in the risk communication theory (section 3.4.2), with the evolvement of complex technologies and scientific methods, personal experience of risks has bit by bit been replaced with information about risks. This has further led to individual control being replaced by institutional risk management, and a public reliant on credibility and sincerity of the information sources. By referring to a scientific knowledge-basis, the stakeholders can build confidence and trust in their risk management. All stakeholders show a very good awareness and use of a scientific basis in the discourse. The different expressions of risks can, as previously discussed, be explained by the different interests of the organizations.

8 Conclusion

Because I did not have a lot of knowledge on this topic at the beginning of my research, I did not form any hypothesis. I stand firm in my decision as I do not think I would have been successful in predicting all the different answers I have found. My biggest takeaway is that there is a lot of very intelligent people working in the nuclear industry, and I am very grateful to have gained a lot of insights to this field. The purpose of this research was to gain a better understanding how commercial operation of nuclear power would be possible and how the related risks are evaluated. More specifically I wanted to investigate how the different actors in the industry are communicating the risks.

I argue that I have gained a better understanding of risk communication, and some of the findings from this thesis might be relevant in the continuous debate about nuclear power in Norway. First, I argue that there are a lot of different representations of risks from the different stakeholders. Some of them are more focused on potential benefits of SMRs, while others see major red flags and unanswered questions regarding the potential risks. This can be explained by the different interests the organizations serve, but I think it would be beneficial for the whole industry to strive for a more consistent and predictable discourse. This will help every organization gain institutional confidence from other stakeholders, such as the public. It would also be crucial for the nuclear community to be more unified if SMRs would be commercialized in Norway. They would need to establish a well-functioning communication both internally and externally, for a chance to establish a sustainable support from the Norwegian public.

One of the biggest disagreements was about the management of radioactive waste between the commercial actors and the regulators. I will conclude that the framing of the related risks equaling to two bananas could be a dangerous way of arguing. I would advise finding better symbols that reflect a more precise risk picture, as the argument could be picked apart and viewed as misleading. I also think the time is right for a bigger discussion about the strict regulatory framework the nuclear industry is under. To me, the narrow risk assessment approaches seem to belong in a time of grave disassociation and purely negative risk perceptions of nuclear power. I also think this discussion would be important to enable future technological innovations. If every invention would be regarded as a possible black swan, we

would still be stuck in the stone ages. This is not an argument for overlooking the possible unforeseen events, but further discussions should be made to clarify the possible need for regulatory changes.

I will also argue that there is a great deal of competence in communicating risks. The risk communication is overall handled with caution and preciseness, but my impression is still that there is a lack of awareness regarding risk communication. The risk communication is regarded as actions of common sense and logic, rather than strategies for effective risk communication. Yet, the discourses also signalized a growing awareness around the subject.

I believe I have only scratched the surface of the discourses from this topic and would therefore highly recommend it to be researched even more. As explained in the background, nuclear power has been a debated topic in Norway before, but the circumstances in today's Norway might serve as the final perfect storm for commercialization of nuclear power.

I think this also points to a different discussion about the democratic ideal of empowerment through knowledge and awareness in Norway. When considering the claim that individuals often are the best judges of their own interest, who is then responsible for educating the Norwegian public about the nuclear form of energy, so that people can make an informed decision? I do not have the answer to this question, but I share the same hope as Siegrist (2014), displayed in the front pages of this thesis: It is difficult to determine what decisions other people should make in order for them to be happy, but I hope that good risk communication can help consumers make better and more well-informed decisions.

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Appendix

Letter of information

INFORMASJONSSKRIV

Vil du delta i forskningsprosjektet:

"Conveying nuclear risk: A critical discourse analysis of nuclear risk communication in Norway"?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke hvordan forskjellige institusjoner og selskaper kommuniserer risiko for bruk av atomkraft i Norge. I dette skrivet ønsker jeg å gi deg informasjon om målene for prosjektet og hva en deltakelse vil innebære for deg.

Formål
Formålet med prosjektet er å bidra til økt forståelse av risikokommunikasjon som fenomen samt hvordan risikokommunikasjon blir håndtert innenfor kjernekraft. Fokuset er rettet mot kjernekraft og SMR teknologien, og videre hvordan forskjellige aktører vurderer og kommuniserer relatert risiko til regjerningen, det norske folk, og andre interessenter. Oppgaven er skrevet i samtid med en energikrise i både Norge og resten av Europa. Dette er en av drivkreftene bak den nye interessen for mulighetene for bruk av kjernekraft i Norge. Selv om dette kan beskrives som en omdiskutert og kontroversiell energiproduksjon, har EU og FN nylig vist til analyser hvor kjernekraft er trukket frem som et sentralt ledd til å redusere energimangel og global oppvarming. Selskapet «Norsk Kjernekraft» er en av aktørene som ønsker kjernekraft som energikilde i Norge, ved bruk av små modulære reaktorer (SMR). Fokuset i oppgaven vil dermed være rettet mot SMR-teknologien.

Hvem er ansvarlig for forskningsprosjektet?
Marja Katariina Ylönen: marja.k.ylonen@uis.no / tlf: 518 31 506

Hva innebærer det for deg å delta?
Jeg ønsker å intervjue deg i kraft av din posisjon i (Blank). For å belyse min problemstilling og mine forskningsspørsmål vil jeg bruke kvalitativt intervju og diskursanalyse som forskningsmetode. Intervjuet vil ta ca. 45-60 min, og vil omhandle dine tanker, vurderinger og erfaringer rundt risikokommunikasjon sett opp imot kjernekraft i Norge. Opplysningene vil bli registrert med lydopptak og transkriberes, og oppbevares på to ulike digitale enheter. Eventuelt: Under intervjuet vil jeg benytte meg av notatblokk og/eller pc for notater.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan oppbevares og brukes dine opplysninger
Jeg vil bare bruke opplysningene om deg til formålene jeg har fortalt om i dette skrivet. Jeg behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Opplysninger som kan identifisere deg vil bli anonymisert i masteroppgaven. Det vil kun være meg som student og min veileder som har tilgang til personopplysninger om deg og lydopptakene under prosessen med masteroppgaven. Lydopptakene fra intervjuet vil bli overført fra en passord beskyttet mobil til PC, og deretter til ekstern harddisk som vil bli oppbevart innelåst. Lydopptakene vil bli slettet umiddelbart etter transkribering. Informantene vil ikke kunne gjenkjennes i en publikasjon.

Dine rettigheter:

- Innsyn i hvilke personopplysninger som er registrert om deg, samt å få rettet eller slettet opplysninger.
- Få utlevert en kopi av transkribert intervju, samt godkjenning før publisering av direkte sitater.
- Å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.
- Å få innsyn i hvilke temaer og spørsmål jeg ønsker å stille.
- Når som helst trekke tilbake deltagelse i intervju og publisering av oppgitt informasjon.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til forskningsprosjektet, ønsker gjennomlesning av sitater fra deg og øvrig data basert på ditt intervju, eller vil trekke deg fra prosjektet:

- Faglig ansvarlig for forskningsprosjektet, Marja Katariina Ylönen: marja.k.ylonen@uis.no / tlf: 518 31 506
- Student og forfatter, Ingebjørg Strand Lende: i.s.l@live.com / tlf: 90094324
- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17

Med vennlig hilsen,

Ingebjørg Strand Lende (student) Marja Katariina Ylönen (veileder)

Samtykkeerklæring
Samtykke kan innhentes skriftlig (herunder elektronisk) eller muntlig. NB! Du må kunne dokumentere at du har gitt informasjon og innhentet samtykke fra de du registrerer opplysninger om. Vi anbefaler skriftlig informasjon og skriftlig samtykke som en hovedregel.
Jeg har mottatt og forstått informasjon om prosjektet «***Conveying nuclear risk: A critical discourse analysis of nuclear risk communication in Norway»***, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ❑ å delta i intervju.
- ❑ at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)

Interview-guide

1. Can you explain who you are, and how you represent your company and what role you have?
2. What is the company bringing to the table that is new in the nuclear field in Norway?
3. What challenges do the company have regarding production of nuclear energy in Norway?
4. How is the company assessing risks of the SMR technology? What type of SMR is at question?
5. What types of risks are included in the operating of SMR's in Norway? And how is the company communicating this risk assessment to stakeholders?
6. How is the company communicating risks/benefits to different stakeholders? Who are the main target groups of your risk communication?
7. Nuclear power can be described as a controversial topic with related ambiguities and negative risk perceptions among stakeholders. How do you strategize you risk communication with these issues in mind?
8. Both politicians and IFE have issued claims that Norway still needs more research before building reactors and taking the technology to use in practice. Do you agree? Why/why not?
9. Communication from experts can sometimes be too technical for stakeholders and the public to be understood accurately, how do you handle this when communicating?
10. Do you have a strategy for making sure stakeholders concerns and needs of sufficient information is met?
11. Do you believe Norway is ready for implementing nuclear power plants in the Norwegian society? Please, explain why? What is different this time?
12. Commercial actors have stated that they are not looking for any subsidies from the government and will handle the nuclear waste disposal themselves. How do you evaluate the risks related to waste disposal over a longer period? How do you communicate this risk?
13. What do you believe it would take for the technology to be able to compete with other energy sources in Norway? And in what timeframe could that happen?