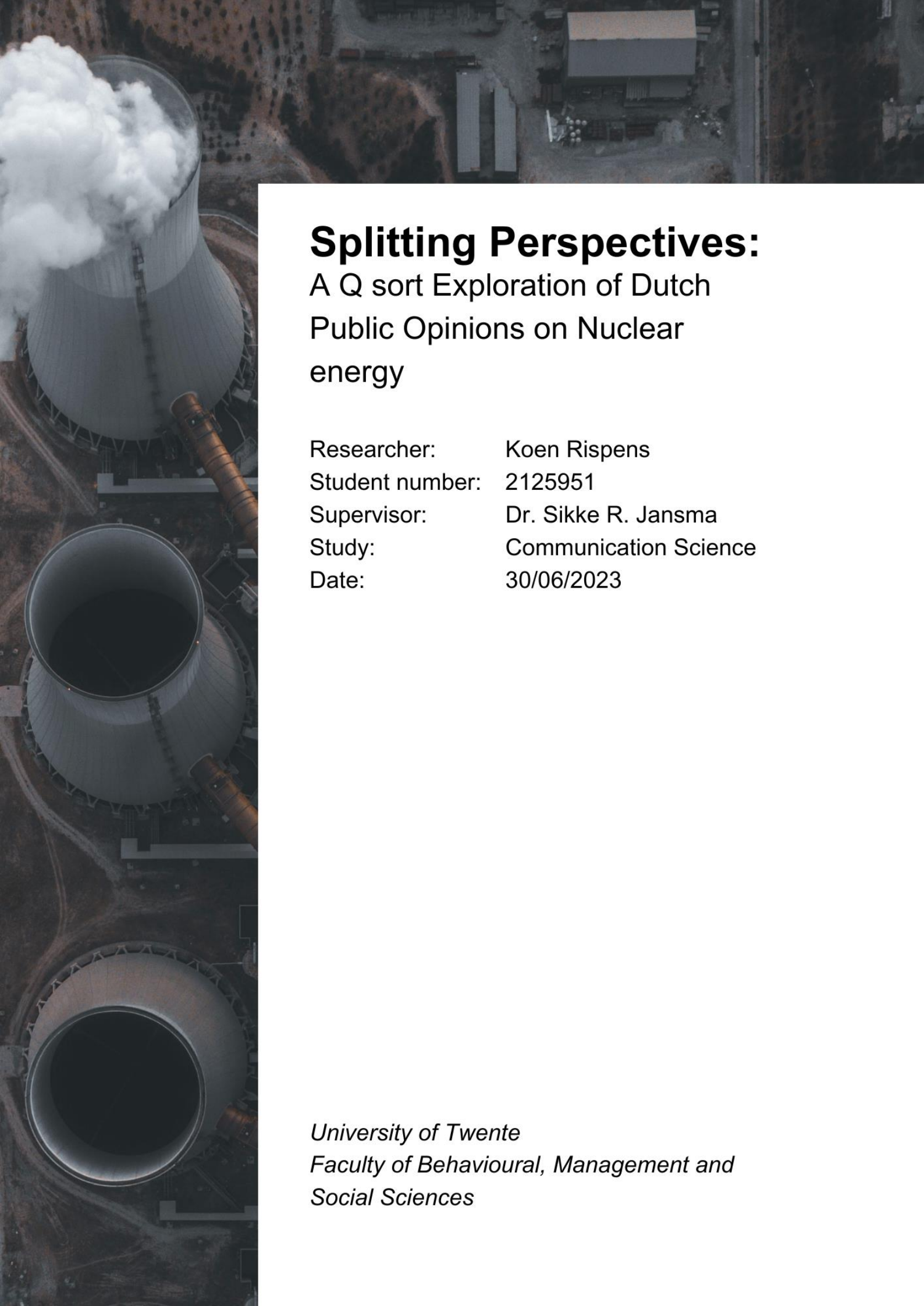

Splitting Perspectives:

A Q sort Exploration of Dutch Public Opinions on Nuclear energy

Researcher:	Koen Rispens
Student number:	2125951
Supervisor:	Dr. Sikke R. Jansma
Study:	Communication Science
Date:	30/06/2023

University of Twente
Faculty of Behavioural, Management and Social Sciences

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Abstract

Introduction: This paper reports on the differences in perspectives of Dutch citizens regarding the implementation of nuclear energy in the Netherlands**.** The Netherlands is currently reliant for 3% of their energy supply on nuclear energy, with plans being analyzed to increase this number to approximately 13%. Furthermore, The energy transition required to reach the Dutch climate goals of 2030 and 2050 require a thorough understanding of all possible energy sources, including nuclear energy. Moreover, this study reports on a deeper understanding on four different perspectives that people could have on nuclear energy, giving clear input for future research on this topic.

Method: The Q methodology was used in order to analyze the differences in perspectives of Dutch citizens. 39 statements divided over 13 different topics surrounding nuclear energy were used to do so. These different statements and topics aimed to fully encompass the broad range of talking points regarding the possible implementation of nuclear energy in the Netherlands. Examples of such topics were: impact of nuclear energy on the climate, comparison between nuclear energy and other energy sources, impact of nuclear energy on the local populace, nuclear waste management, etc.

Results: Within a sample of 18 participants of young Dutch professionals, four distinct perspectives could be identified and presented: 1) Nuclear energy as a necessity; 2) Nuclear energy as a risk.; 3) Nuclear energy as an economic booster; 4) Nuclear energy as a complex choice

Conclusion: These four distinct perspectives on nuclear energy show the diversity and similarities within the attitudes towards nuclear energy that the public holds. Furthermore, the results from this study show a need to understand these differences in order to push the public discourse further on nuclear energy.

1. Introduction

The global demand for energy is expected to rise with over 50% by 2050 (from 20 trillion kWh in 2018 to 45 trillion kWh in 2050) (U.S. Energy Information Administration, 2019). Yet, the way this demand is met is evolving and under constant discussion due to the pollution that comes from energy generation. Countries and societies all over the world are struggling with the dilemma of meeting this growing demand while also moving away from the usage of fossil fuels. The balancing act between an increase in energy production to meet this demand while also diminishing the total amount of emissions caused by this energy production is a complex issue, on a social, economic, and political level (Langlois-Bertrand et al., 2015; Potrč, 2021; Hall, 2016).

On paper, nuclear energy has the least total amount of emissions per Watt, is cheaper than fossil fuels and needs a relatively small space when compared to renewable energy sources such as wind or solar (Layton, 2008). Furthermore, it is a stable source of energy whose output can be adapted to the current energy demand. However, opting for nuclear energy also has its drawbacks. Concerns around safety, health, efficiency, emissions, non-degradable waste, and possible radiation pollution play a large role when a society and its politics form an opinion when debating on nuclear energy. With examples of disasters in the past, nuclear energy remains a controversial technology. Examples such as Fukushima, where a tsunami caused by a magnitude 9.0 earthquake hit Japan in 2011, causing a chain of events that resulted in radiation leaks and permanent damage to the reactors**.** Or the three miles island accident in 1979 where radioactive gasses and iodine were released into the environment. Next to these, there is another world-famous nuclear disaster, Chernobyl in 1986. Here, a test of reactor number 4 went wrong through a cascade of errors, resulting in a well-known nuclear disaster. Due to the dangers that these disasters exemplified, many demonstrations have taken place to combat decisions to build or expand a nuclear power plant, nuclear storage facility, or other

nuclear energy related plants such as refineries. Often times, these demonstrations are sparked by an accident in a nuclear power plant, such as protests in India after the Fukushima nuclear disaster (Prabu, 2022).

The implementation of nuclear energy has thus gone through many phases of public discourse over the years. Over time, public attitudes towards nuclear energy have changed drastically. Therefore, different countries and communities currently have their own unique look on nuclear power due to their current situation considering the energy mix, history, and geopolitical status regarding nuclear energy. Yet, each energy crisis can lead to a change in the direction and framework of the current energy policy of a country. To give examples of such a change, it is worth recalling that the fuel and energy crisis of 1973 and 1974 was one of the reasons for developing nuclear energy in France (Feldman, 1986). Due to this development, France has been a longtime prominent user of nuclear energy, with an energy mix consisting of nuclear energy for 68% in 2021 (U.S. Energy information Administration, 2023), making France the relative biggest user of nuclear power for their energy needs. The French have embraced nuclear energy and found ways to deal with its downsides. Yet, the implementation of nuclear energy has not been without its constant public discussion, as large-scale a French protest against nuclear energy can be dated back to 1972 all the way through the present day (. Another large societal shift in attitudes towards nuclear energy has occurred in Germany as they recently fully closed down their nuclear power plants in April 2023. Shifting from an energy mix that incorporates nuclear energy for one-quarter of its energy needs at its peak in 2010 (World Nuclear Association, 2023), to an energy mix that has expelled nuclear energy for good in 2023. In the case of the Netherlands, nuclear energy was seen as a promising energy source that could ensure a move away from the usage of natural Dutch gas in the 70's. Starting construction of new nuclear power plants in the 1950's and 1960's, nuclear power seemed to be implemented on a large scale. However, concerns regarding safety and the handling of

nuclear waste, resulting quickly led to fierce public discussion that eventually led to an almost complete closing of nuclear energy in the Netherlands. Currently, there is still one operating nuclear power plant for energy generation in Borselle, which is responsible for 3% of the Dutch energy supply and is planned to close in 2033.

The Netherlands is currently facing a difficult time regarding its energy production. This is due to the goals to completely shut down its gas extraction in the province of Groningen, move away from fossil fuel-based energy sources while simultaneously meeting the growing energy demand of the future and reduce the total emissions stemming from energy generation. Currently, renewable energy sources account for 40% of the Dutch energy supply, fossil fuel-based sources accounted for 56%, and nuclear power accounted for 3.7%, (Centraal Bureau voor Statistiek, 2023). This 3% of nuclear energy is much lower than the European average of 25% (Eurostat, 2022) while the Netherlands has been depending in the past on natural gas due to the large pocket of gas in the province of Groningen, current plans aim to close down all gas extraction by October 2023. Moving away from fossil fuels, Dutch society is challenged to meet the Paris climate goals of 2030 and 2050, which in turn pushes the debate around the expansion of nuclear energy in the Netherlands. As of writing, there are plans waiting for approval from the Dutch government and the local populace to expand the current nuclear power plant in the south of the Netherlands in order to increase the role of nuclear energy to 13% of the total Dutch energy production (thus an increase of 10 percentage points) (Rijksoverheid, 2022). This same plan was also proposed in 2009, but the Fukushima disaster in 2011 had indefinitely postponed this plan at the time.

This shows the complex issue at hand, on one side most agree on the fact that as a society, we all should move away from fossil fuels and its emissions, and move on towards renewable and low emission sources as much as possible. Yet, countries and societies are hesitant of using nuclear energy for this due to the experiences of the past and its major possible

drawbacks such as potential safety risks, the processing of nuclear waste, and the high initial investment costs. This makes the Dutch discussion surrounding the implementation of nuclear energy a highly complex topic, with many different positives and negatives that need to be weighed against each other. Due to this, it is relevant to investigate the reasoning behind the different Dutch public attitudes surrounding the implementation of nuclear energy, as this could give a deeper understanding of this complex public debate. This brings this study to its research question: "What are the differences in perspectives and attitudes of young Dutch professionals towards nuclear energy?". Answering this question could give a deeper understanding of this topic by providing a detailed look in different Dutch perspectives on nuclear energy. The results of this study could provide valuable input for future research by giving detailed information on the different perspectives on nuclear energy in the Netherlands.

2. Theoretical framework

The implementation of nuclear energy is highly complex, as a society needs to consider a lot of different aspects. These range from possible energy security benefits, the impact on the economy and energy prices, investment costs to the impact on local communities as well as how to deal with the risks of nuclear disasters and nuclear waste. In order to perform a Q-sort study, all aspects of a certain topic must be considered during the creation of a complete list of categories and statements. This requires a broad theoretical understanding of how people can view the implementation of nuclear energy. In order to get this broad understanding of the different aspects, a literature review was conducted on the following topics: Attitudes towards nuclear energy (section 2.1), risk perception of nuclear energy (section 2.2), and the role of nuclear energy in the energy transition (section 2.3).

2.1 Attitudes towards nuclear energy

The complexity of nuclear energy also allows for there to be complex attitudes on nuclear energy. People can be supporters, opposers, undecided, or indifferent on nuclear energy, all for various reasons. An attitude is described by Allport back in 1935 as a mental process of a person that organizes his/her perception of the world and orients his/her future behavior based on experiences and stored information. Another definition comes from Petty et al. (1994), who regards attitudes as a summary of evaluations of objects (e.g. oneself, other people, issues, etc.) along a dimension ranging from positive to negative. Both of these definitions define attitudes as something that is based on experiences, be it direct through people's own experiences or indirect through the experiences of others. This forms the three main components of attitude, according to Ostrom (1969). The first component is the cognitive (perceptual) component, which describes attitude as based on a range of information on the subject that is being reviewed, and the information accumulated in time by the person who made this assessment. The second component is described as an affective component as attitude reflects the usual faces and feelings, positive or negative, or assessments of the object being evaluated. The final component of attitudes is described as a conative component. This last component described the predictive value of attitude, which can be defined as a predisposition to respond and/or act in a certain way (Ostrom, 1969). Hence, an attitude can be partly evaluated, as it is based on the (in)direct experiences, and gathered information of the past. For nuclear energy, this means that an attitude can be formed based on the information that someone has gathered combined with the expected impact on the future of nuclear energy. Research states that attitudes can also shape the expected impact and future behavior (Glasman, & Albarracin, 2006). This means that someone's current attitude towards nuclear energy helps shape their prediction of the outcome, and thus impact, of a potential implementation of nuclear energy. If someone has a positive attitude towards nuclear energy, this person is more likely to

hold positive predictions towards nuclear energy. These could be for instance that Nuclear energy would be highly impactful in order to reach the climate goals of 2030 and 2050 due to the relatively high amount of low-emission generated energy. However, this also works if someone currently holds a negative attitude towards nuclear energy. This person could hold a high risk perception for nuclear energy, viewing for instance nuclear disasters as a likely event when a country decides to construct nuclear power plants. This would result in a negative predicted future, making this person thus more likely to hold a negative attitude on nuclear energy. Therefore, it is interesting to include the predicted impacts of nuclear energy within the statements of the Q sort of this study, as an attitude can also be seen as an evaluation of a topic.

Thus, as an attitude is formed based on the experiences, impressions and expected future impact, new experiences and impressions can reshape an existing attitude. As the Dutch populace do not often come in direct contact with nuclear energy due to the before mentioned minor implementation of nuclear energy in the Netherlands, making direct experiences of the impacts of nuclear energy seem unlikely. However, experiences might also come through others in the form of personal contact or indirect contact from the media. Think of documentaries, news articles, social media posts, official reports, etc.. Therefore, the general sentiment towards nuclear energy can potentially shift in a short period of time due to the fast distribution of these indirect experiences. To exemplify such indirect experiences and its consequences in the case of nuclear energy, a nuclear disaster would spark a high amount of media attention. According to Ho (2019), this raises the awareness of the possibility of a nuclear disaster due to this increase in media attention, which in turn can disproportionately raise the risk perception that the public has regarding nuclear energy disasters. This effect, also known as the crisis effect (Wegkamp, 2014), is shown through the increase in protests regarding nuclear energy, which are often triggered by events such as nuclear disasters in

Fukushima in 2011, Chernobyl in 1986, or Three miles in 1979. Next to nuclear disasters, other newsworthy events can also shift the attitude of the public, such as new reports, political debate, documentaries, or shows (Gupta et al., 2019). Therefore, even though the Dutch populace might not have directly come in contact with nuclear disasters apart from the consequences of the Chernobyl disaster in 1986, such events in foreign countries do impact the current attitude of the Dutch towards Nuclear energy. Furthermore, it is important to note that not only negative but also positive media attention can shift the attitude of nuclear energy in a more positive light for the same reasons.

In conclusion, the public attitude towards nuclear energy generally changes incrementally and is based on (in)direct experiences and gathered information of the past as well as the expected impact of nuclear energy. However, exceptions do exist to this rule, as sudden shifts in attitude can happen due to large scale events that receive a high level of media attention, which can change the public perception of nuclear energy, both in a negative or positive sense. An example of this is the Fukushima disaster in 2011, which changed public opinion negatively across the globe. For instance, the events in Fukushima led to Germany closing down its nuclear power plants and stopped the expansion of nuclear power in France. Yet some events can also suddenly push the discussion in favor of nuclear power, such as the Russia-Ukraine conflict, which has increased the costs of fossil fuels globally and therefore increased the need to discuss other energy sources, including nuclear energy. Therefore, it is important to consider recent events and developments when running a study that incorporates attitudes towards nuclear energy.

2.2 Risk perception of nuclear energy

The implementation of nuclear energy forces people and policymakers to balance out the risks and benefits. Some frame nuclear energy as a green and low-carbon energy that can

help mitigate climate change and increase energy security. However, others frame nuclear energy as a highly risky endeavor, using disasters with the likes of Fukushima in 2011 to remind the world of the potential catastrophic consequences of a nuclear power plant disaster (Żuk, 2023; Venables et al., 2009). In the case of nuclear energy, much can be said on the potential risks and ethical considerations. Building a nuclear power plant can be beneficial for society as a whole, but perhaps not equally so for the individuals living in proximity to this build site, as they experience the direct negative consequences of such a construction project (Venables et al., 2009).

Weighing the possible positive or negative consequences is an important step within risk assessment. However, the benefit often plays a less important role in the case of nuclear energy, as any possible damages are in most cases highly impactful (Renn, & Swaton, 1984) Due to this, it is difficult to find a site where the local inhabitants are willing to accept for instance a nuclear waste deposit, regardless of assurances that the technical problems have been solved and that there is little risk, now or after a thousand years, to those living nearby (Sjöberg & Thedéen, 2010). People do not always willingly accept benefits in return for what they consider to be health hazards to themselves, their children and/or their grandchildren. A dominant factor in this is the perceived risk aspect.

A risk is an expectation that something negative may happen (Sjöberg & Thedéen. 2010). Risk perception is therefore a subjective phenomenon, yet the possible consequences are not. Accidents and damages are real, both damaging the health and economic status of victims. People's anticipations usually have a basis in something real, including predictions regarding risks. Therefore, it is important to understand the concepts of risk perception in the context of nuclear energy. As people view the possible (sometimes catastrophic) negatives of nuclear energy such as the risk of nuclear disasters, constant radiation leaks and radioactive waste as extremely important due to the severity of the possible consequences, not solely

because of how likely these events are to actually take place (Renn, & Swaton, 1984). This is important to note, as the actual chance of something happening can be small, yet the risk perception can still be high.

There is a multitude of events that can have an effect on the risk perception of the public, these are Media-attention, fear, knowledge level, experience, and the crisis effect (Wegkamp, 2014) For the case of nuclear energy, trust in authority also plays an important role for the public's risk perception (Whitfield et al., 2009).

Media attention can have a great effect on the risk perception of the general audience, especially when there is a multitude of messages. If a person receives a message about a possible risk within their media sphere, the chances are high that this person will have an increased risk perception towards this topic. This is due to the high amount of information that people receive and process through different forms of media. (Sjöberg, 2000; Wahlberg & Sjöberg, 2011). In the case of nuclear energy, this means that the fact that people first heard about nuclear technologies was in the shape of an all destructive bomb, shaping how society looks at nuclear related technologies. This might mean that various intuitive heuristics such as, availability, anchoring effect, avoidance of cognitive dissonance, and representativeness could play important roles in cognitive processing of any information associated with the word "nuclear", thus including nuclear energy. As some generations were regularly exposed to media with negatively loaded information about "nuclear", this effect might be more prevalent. (Yim & Vaganov, 2003).

Furthermore, people can have a higher sensitivity towards fear, meaning that someone can be more easily fearful than others. These people often have a pessimistic view towards risk and can therefore have a higher risk-perception than others. In a more extreme form, this can transform a high risk-perception into an unrealistic one. (Lerner & Keltner, 2001). Thus, fear can have a large impact on the severity of risk-perception, in which people can perceive a risk

as to have a higher chance of becoming reality than it actually is, and people can overestimate the possible negative outcome of a certain risk.

Experience also plays a role in the creation of a certain risk perception. When people have had an experience with a certain risk in the past, they will be more likely to create a relatively more realistic risk perception when they don't have a previous experience. However, in the case of nuclear energy, there are only few in the Netherlands who have had direct experiences with a direct negative consequence of nuclear energy due to the lack of large scale implication of nuclear energy in the Netherlands. However, nuclear protests did happen in the Netherlands in the 1970's and 1980's after the construction of nuclear power plants in the Netherlands and the Chernobyl disaster in 1986.

The fourth on the list of things that could heavily impact the risk-perception of the general audience is the crisis effect. To give an example of such an effect, Tobin (1995), Baan and Klijn (2004), and Merz et al. (2010) describe the crisis effect within the context of risk perception towards floods. Where people tend to acknowledge possible disasters the most when there actually is one or where one just happened. In the case of nuclear energy, this temporary effect has been shown after nuclear disasters. After the Fukushima accident in 2011, Kristiansen, et al. (2016) noted a temporary change in public opinion in Switzerland. This acknowledgement, however, quickly fades away when new safety measures are implemented. Yet, oftentimes, this trust is misplaced, as no safety measures can guarantee a 100% safety, resulting in not enough safety measures being implemented after the first meaningful one. This last effect is also described as the "dijk-effect" (dike-effect) by Baan en Klein (2004).

In the case of risk-perception towards nuclear energy, Yim and Vaganov (2003) also state that trust is also an important determinant in public risk perception. More specifically, the public trust in administrative agencies and firms, which can be eroded by a multitude of situations as described by Yim & Vaganov (2003). These situations can be for instance; 1)

agency/firm managers or regulators are unable or unwilling to respect the views of vulnerable parties; 2) Agency/Firm managers or regulators are unable or unwilling to fulfill promises, to maintain consistent levels of promised operational performance; 3) The risks or hazards associated with significant program failure appear very high and very long-lasting; etc.

In conclusion, the implementation of nuclear energy is a complex topic, as it forces people and policymakers to balance out the benefits against the risks. While some see nuclear energy as a green and low-carbon energy that can help mitigate climate change and increase energy security, others see it as a highly risky endeavor. This perception of risk is subjective, yet the possible consequences are real. People tend to be unwilling to accept health hazards in exchange for possible benefits to themselves and the people around them. Risk perception can be influenced by media attention, fear, knowledge level, experience, and trust in authority. When people have a higher risk perception, the possible negative outcome or the chances of a certain risk are overestimated. Therefore, it is important to understand the concepts of risk perception when discussing the acceptance of nuclear energy as this changes the perspectives on the disadvantages of nuclear energy. Despite the potential benefits of nuclear energy, it is crucial to also consider the potential risks and how these are perceived when discussing the possibilities of nuclear energy. Therefore, it is important to consider risk perception of nuclear energy when speaking of attitudes towards nuclear energy.

2.3 Nuclear energy and the energy transition

Cutting back carbon emissions in power generation is an important step in the battle against climate change. This transition from fossil fuels to other, low emission energy sources such as wind and solar is called the energy transition (Creutzig et al. 2014). The energy transition has been an important focus for European countries, yet a complex one, as each country has their own context when it comes to transition away from fossil based energy

sources and into renewable energy sources. As mentioned in the introduction, the Netherlands has relied heavily on the natural gas field in the northern province of Groningen since its discovery in 1959 (Centraal Bureau voor de Statistiek, 2019). However, the discovery of this natural gas field not only brought major financial benefits, as the social costs have also been major. Public opinion has dramatically shifted towards using gas as a major energy source in the Netherlands due to the earthquakes resulting from the extraction of this major gas field (van der Voort & Vanclay, 2015). Next to this, the Dutch government has been investing resources in order to increase the energy generation coming from renewable sources, with a goal to have 70% of all energy coming from renewable sources (NOS, 2022). In 2022, renewable energy sources accounted for 40% of the Dutch energy supply, fossil fuel based sources accounted for 56%, and nuclear power accounted for 3.7%, according to the Centraal Bureau voor Statistiek (2023). Overall, the Netherlands is now focused to move away from fossil fuels as much as possible after heavily depending on the largest European natural gas field in the province of Groningen (Centraal Bureau voor Statistiek, 2019).

Nuclear energy has also played a role in the past of the Dutch energy supply. As nuclear energy was a promising new technology in the 1950s and 1960s. It was expected to be the primary method of the Netherlands to move away from fossil fuel sources. However, plans for this grand implementation of Nuclear energy fell flat due to large public discussions and protests after the Chernobyl disaster in 1986, and nuclear energy has declined to only 3% of the Dutch energy supply since.

However, perspectives are changing and the current role of nuclear energy in the Dutch energy transition is described by the Dutch government as “a useful addition to other energy sources” (Rijksoverheid, n.d.). Next to this, the Dutch government provides a list of arguments that explains their reasoning in favor of a broader implementation of nuclear energy, the notable ones are: 1) The Netherlands needs all clean energy sources that are available, including nuclear

energy. 2) Nuclear energy makes the Netherlands less vulnerable due to the use of a wider range of energy sources. 3) Nuclear energy makes the Netherlands less dependent on energy import from foreign countries. 4) Nuclear energy has been proven to be a reliable energy source 24-hours a day. 5) Nuclear power plants require a low amount of space. As explained earlier, there currently are plans that are being analyzed to expand the power generation coming from nuclear energy in the Netherlands, yet these plans also take the opinions of the public as well as the opinions of the local populace into consideration. Studies show that there are differences in perspective when it comes to the implementation of nuclear energy. Venables et al. (2009) found that within a community that lives in proximity to a nuclear power plant, 4 distinct trains of thoughts can be found using the Q methodology. These were named: Beneficial and safe, Threat and distrust, Reluctant acceptance, & There's no point worrying, each showing major differences in the opinions between these perspectives. For the populace as a whole, events surrounding nuclear energy can drastically shift public support. Gupta et al. (2019) show that the percentage of American citizens that support nuclear energy can range from 77.91% in 1973 to a low of 36.96% in 1987, pointing towards major nuclear events and incremental societal changes of drivers in this change in public support. This shows that in order for policymakers to make the decision to include nuclear energy within a countries' energy mix, the current public opinion and therefore the current context of nuclear energy needs to be studied in order to gauge public support.

Yet choosing nuclear energy over other energy sources such as wind, solar, geothermal, etc. is not simple as all choices have their own positives and negative. The major downsides of nuclear energy are the associated risks and the high initial investment costs that are needed. The major advantages are low emission energy generation, increase in energy security, and an increase in self-reliance as a country (Jetten, 2022). Thus, the perceived importance of both these advantages and disadvantages are key to understanding a population's opinion on nuclear

energy. Next to this, an energy mix is always a mixture of multiple different energy sources, with nuclear energy only being one of them. In the context of the Netherlands, the energy transition has meant that the energy mix of the Netherlands is moving away from fossil fuel based energy sources and towards renewable based energy sources such as solar and wind (Jetten, 2022). This has been shown by the plans of the Dutch government to drastically expand the use of renewable sources (Jetten, 2022). The energy transition as a whole is perceived by the public as necessary in order to fight climate change (Anderson, et al. 2017), showing the perceived importance of the energy transition amongst the public. However, renewable energy sources also have their disadvantages, such as the impact on the local populace. This effect has often been described using the "Not in my backyard effect" (Burningham, 2000; Horst, 2007), as people do tend to want to make use of renewable power, simply not in their own vicinity due to the local negative impacts that these technologies have on local communities. Therefore, it can be argued that policymakers need to analyze the impact of all possible energy sources in order to foster the most public support during the energy transition. A deeper understanding of the attitudes that the public has on nuclear energy is therefore needed in order to know the perceived impact of nuclear energy.

3. Methodology

3.1 Study design

This study is aiming to find different perspectives amongst the Dutch population on Nuclear energy and find the reasoning behind these differences. To answer the research question, the Q sorting method is a good fit , as it is a convenient method to study attitudes on complex topics and to find patterns in attitudes amongst participants (Bashatah, 2016).

Hence, Q-methodology can be used to explore different types of perspectives within a sample on a specific topic. More specifically, Q-methodology consists of systematically

ranking statements. Often, on a scale ranging from agree to disagree, with a limited amount of spaces for cards per step on this scale. After this, a short interview is conducted in order to touch on the opinions behind the final placement of cards, exploring the underlying reasoning of the participant. Combining the interview with the systematic sorting of statements, a detailed understanding of a participant's perspective on, in the context of this study, nuclear energy can be formed. Furthermore, the perspectives of multiple participants can be systematically compared to each other due to the individual systematic ranking of the statement. Next to this, the reasoning behind the different rankings can therefore also be compared between participants. Thus, the Q sort methodology provides the tools to find different perspectives on a complex topic and give a detailed overview of the differences between them. For these reasons, a Q sort was conducted to fulfill the purpose of this study.

3.2 Instrument

The categories themselves are thus aiming to achieve a broad range of statements that can encompass the opinions that people can have on nuclear power. As shown in the theoretical framework, an opinion on nuclear energy is made up through a complex process that spans a large time period and considers many factors. Therefore, the categories and the statements that were used in this study can almost all be described using three themes. Climate impact, Economical impact, and Risk perception as these were the main concerns found in similar studies such as Żuk (2023) and Venables et al. (2009). Next to these themes, categories were added in order to dive deeper into specific aspects of nuclear energy as these could be a focus point in someone's opinion, as also found in the results of Żuk (2023) and Venables et al. (2009). These additional categories are nuclear waste processing, Dutch policy, and impact on the living environment. Do note that these categories do share a slight overlap with the three main themes of categories, yet cannot be fully categorized amongst them. The final list of

statements that was used in this study can be found in Table 1. Note that this table has been translated in English for the sake of readability, the Dutch version that was used in this study can be found in the Appendix. These categories and its statements are designed to allow all possible different perspectives on nuclear energy to be displayed through the individual rankings.

Furthermore, in order to test the final list of statements, a pretest was conducted with five participants. In this pretest, the participants were asked to match all the statements with their corresponding categories according to the interpretation of the pretest participant. This pretest resulted in one category being deleted, three being redefined and almost a third of the statements receiving a varying degree of changes in order to make the writing style of the statements more consistent.

The final list of categories and their corresponding statements are presented in Table 1, aiming to incorporate all possible important aspects of nuclear energy when combined. Do note that all statements and their categories were translated from Dutch to English, as the study was conducted in Dutch. The original Dutch version of this table can be found in the appendix.

Table 1

List of Categories with their Corresponding Statements

Category	Statement
Climate impact of nuclear energy	Nuclear energy is important for solving the climate problem.
	Nuclear energy is not a green energy source.
	Nuclear energy is a good option in order to reduce the emissions from energy generation.
Nuclear energy in comparison to other energy sources	Nuclear energy is a worse option than other renewable energy sources.
	Nuclear energy is the best energy source in comparison to other energy sources, despite its disadvantages.
	Nuclear energy has a smaller impact on the region than other energy sources.
Necessity	The expansion of nuclear energy is necessary.

	It is wise to invest in nuclear energy as fast as possible.
	The expansion of nuclear energy is necessary in order to meet the growing demand of energy.
Nuclear waste processing	The waste processing of nuclear energy is being done in a responsible manner.
	Storing nuclear waste is not fair for the next generations of Dutch citizens.
	Having to store nuclear waste is a major disadvantage of nuclear energy.
Energy security	Nuclear energy is reliable because it delivers a constant and predictable amount of energy.
	The power grid becomes more resilient due to nuclear energy because it gets an extra option for generating energy
	Nuclear energy makes the power grid unreliable due to long closures of nuclear plants for maintenance and repairs.
Impact on the economy	Using nuclear energy strengthens the Dutch economy.
	The development and deployment of nuclear energy creates jobs and stimulates economic growth.
	The impact of nuclear energy on the economy is too small, as it creates a relative low amount and only specialized jobs.
Impact on the energy prices	Using nuclear energy will lower the average price of energy.
	Using nuclear energy makes the Netherlands more resilient for the price changes of energy.
	The effect of nuclear energy on the energy prices is too small to justify the use of it.
Investment costs	The investment costs of nuclear energy can be canceled out by the many benefits.
	The costs of building a nuclear power plant can be better used elsewhere.
	It takes too long before a nuclear power plant earned its investment costs.
Dependency on other countries	The war in Ukraine shows that nuclear energy is necessary in order for the Dutch energy grid to become more self reliant for events in other countries.
	Nuclear energy makes the Netherlands dependent for the resources needed for a nuclear reactor.
	Nuclear energy is needed because it makes the Netherlands less dependent of other countries by decreasing the usage of fossil fuels.
Risk perception	The chances of a nuclear disaster is too high to expand nuclear energy in the Netherlands.
	The Netherlands is too densely populated for nuclear energy due to the

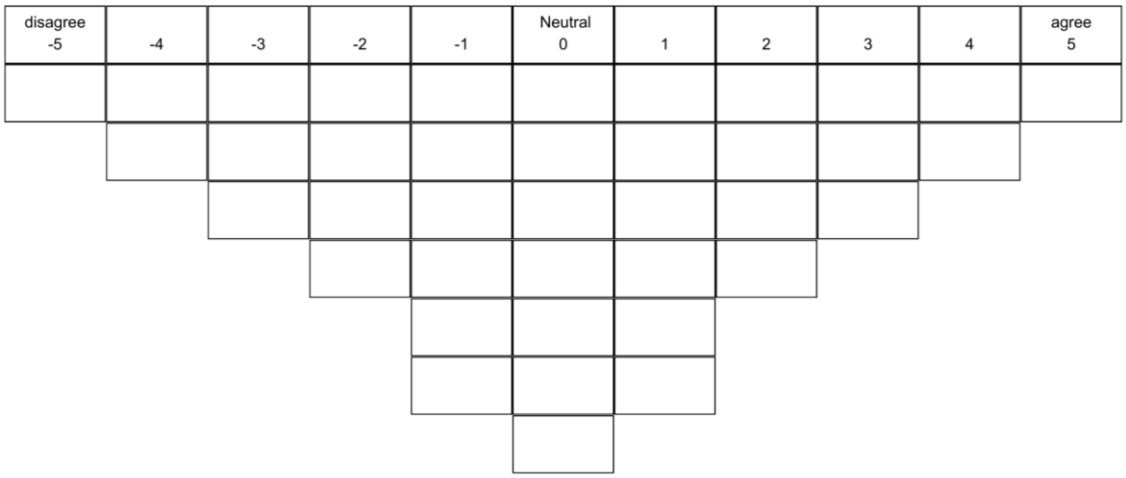
	risk of nuclear disasters.
	Nuclear energy is a proven safe method of energy generation
Vulnerability of the Netherlands for attacks	Nuclear power plants are vulnerable and strategic targets.
	The construction of new nuclear power plants makes the Netherlands a more attractive target for malicious countries or groups.
	The construction of nuclear power plants makes the Netherlands less vulnerable for attacks, because a single attack on a nuclear power plant can't cripple the entire energy grid.
Dutch policy	It is wise for the Dutch government to invest more resources in the construction of nuclear power plants.
	It is wise for the Dutch government to invest more resources in innovations within nuclear energy.
	It is wise for the Dutch government to close the nuclear power plant in Borssele.
Impact on living environment	Nuclear power plants ruin the landscape.
	Nuclear power plants have a low impact on the living environment.
	It is not wise to live next to a nuclear power plant.

Note. The contents of this table have been translated from Dutch to English. View the original Dutch version of this table in the appendix.

As mentioned before, the distribution of the final 39 statements is predetermined. It is common for a Q sort to approximately follow a normal distribution in order to force the participants to make choices on how to rank these statements in relation to each other. The Q sort used in this study divides the 39 statements on an 11 point scale, ranging from completely disagree to completely agree. A neutral option was also present. Following a normal distribution, this brings the final division of statements to 1 - 2 - 3 - 4 - 6 - 7 - 6 - 4 - 3 - 2 - 1 (visualized in Figure 1).

Figure 1

Structure of the Q sort



3.3 Participants

The 18 participants were sampled using convenience and selection sampling. The selection was based on a certain set of pre-requirements. Participants needed to fit within the age range of 18-30 in order to maintain the same age group within the 18 participants. Furthermore, participants needed to have lived in the Netherlands for at least 10 years in order to make sure that they are aware of the current context of nuclear energy in the Netherlands. This is due to the importance of context when speaking on nuclear energy, as explained in the theoretical framework. This brings the sample to a final list of participants that can be described as young Dutch professionals. Note that for a Q sort study, it is not required to have a sample that is representative of the greater population. This is because the Q methodology is aiming to find different perspectives, not how well each of these perspectives are represented in the population. Bashatah (2016) explains the sampling for a q sort as followed: “Sampling is for diversity and there is no aim of making statistical inferences – and this relates to the sampling. Q-methodology does not involve random sampling or aim to obtain a representative sample.

The results pertain only to the existence of certain perspectives" (p. 39) . Due to this, finding a representative study was not the aim of the sampling procedure.

The demographics of the final Q-sample are presented in Table 2, gathered from the demographic questionnaire that was presented to participants before the Q sort started. As explained, the sample is fairly young, including mostly well-educated people between 20-30, with an average of 23 years of age (SD = 2.38). 7 participants have completed a Secondary education or similar, 6 did (or are doing) a study at a University (of applied science) without achieving a degree, 2 achieved a bachelor's degree and 3 a Master's degree. The political views of the sample are self reported to be slightly left leaning on average, while also being relatively progressive. To further explain this, the political preferences of the participants were asked on a 9 point Likert-scale, with point 5 acting as a neutral, thus centralist, option. The average score on the scale of left-wing to right-wing was 3.9 (SD = 1.60), and thus slightly left-leaning. On the scale of conservative to progressive, the average score was 6.4 (SD = 1.54), and thus relatively progressive on average.

Table 2

Age & Political Preference demographics of the sample

	Age	Political preference	
		Left - Right*	Conservative - Progressive**
Average	23.18	3.94	6.41
Std. Deviation	2.38	1.60	1.54

* Measured using a 9 point likert scale, with 1 being left-wing, 5 being central, and 9 being right-wing.
** Measured using a 9 point likert-scale, with 1 being conservative, 5 being central, and 9 being progressive.

Table 3

Gender & Education level demographics of the sample

Variable		Amount	Percentage
Gender	Male	11	55.00
	Female	9	45.00
Education level	Secondary education or similar*	7	38.90
	University (of applied science) without a degree*	6	33.30
	Bachelor's degree*	2	11.10
	Master's Degree*	3	16.70

*These are direct English translations of the Dutch counterpart within the education system as the education level within the Dutch education system was asked.

3.4 Data collection procedure

As explained earlier, the data collection itself was split up into three parts, a demographic questionnaire, the Q sort, and the follow-up interview. Accompanying each part was a set of verbal instructions and checks to make sure that the participant knew what was expected of him/her. The Q sorts were conducted physically in a separate room in order to prevent outside distractions. The entire process went as followed: First, the participant was introduced to the study, where the researcher gave a short overview of the three upcoming parts of the study. It was explained that the study is not testing the participant or the knowledge that the participant may have, it was looking for the perspective of the participant with the knowledge that they currently believe to be true. Therefore, it was also made clear for the participant that there are no wrong answers, only correct ones. After this brief reassurance, a consent form was presented that explains the process of the data collection method and the data safekeeping to the participant. Next to this consent form, a one-page demographic survey was presented on paper. That concluded the first part of the participation, which meant that the Q

sort could commence. The researcher briefly explained the Q-sort method and showed the pyramid as described in Figure 1. Participants then received the advice of first presorting the statements in three piles, agree, neutral, and disagree in order to prevent having to switch around many cards at the end of their Q-sort. No time limit was instructed, participants could take as long as they felt they needed for the Q-sort itself. Once the participant indicated that he/she has finished their sorting, the follow-up interview commenced. Where first, the researcher focused on the most outer statements, then moving on to the agree section as a whole, then the neutral section, and lastly the disagree section. At the end, a brief summary of the entire Q-sort was formed together with the participant in order to get a list of the most important arguments. Questions could be asked throughout the entire process, however, questions regarding the interpretation of the statements could not be answered, as answering these could influence the way different participants interpreted these statements. Questions regarding the interpretation were answered by the researcher by using a simple remark "All spots of the pyramid need to be filled at the end".

3.5 Data analysis

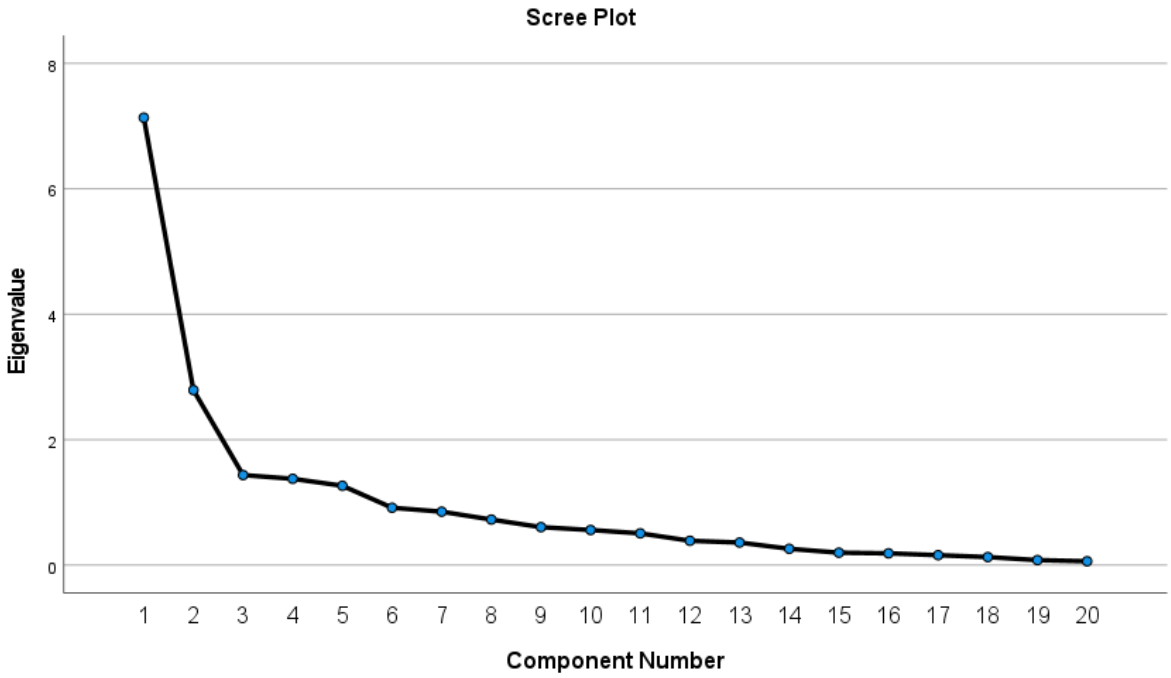
The analysis of the Q sort methodology can be viewed as a mix between qualitative and quantitative method, as the analysis shares resemblances with both (Hayne, 1998). First, participants are grouped based on their sorting by using a factor analysis, then, each grouping will be analyzed using the sorting itself and the follow-up interviews.

After conducting the Q sorts and interviews, the data was analyzed using SPSS. Factors were identified through the principal component analysis and rotated using Varimax. The first helps to explain the maximum variance for each factor of the dataset. This can be seen in the scree plot (Figure 2), where the factors are shown by their eigenvalues, with the highest eigenvalue on the left, and the lowest on the right. It is agreed upon to look for the 'elbow' shape in a scree plot in order to determine the amount of extracted factors (Cattell, R. B., 1966),

which would be on factor 3. Together, this explains 57.16% of the variance, as shown in Table 3.

Figure 2

Scree plot of the Unrotated Factors



However, the explained variance and eigenvalues are not the only things to consider when deciding on the number of factors that should be extracted. As the Q methodology aims to find as many insights as possible, it can be argued to look for insights in the fourth and fifth possible factor, as there is another, albeit smaller, drop of explained variance between the fifth and sixth factor. This is because there is more to look at than just the Q sorts themselves, the follow-up interviews can provide key insights between the reasoning of someone's ranking, as well as the individual interpretation of the presented statements. Furthermore, the sample just reached the rule-of-thumb requirement of 18 participant, as the Q sort included 39 different statements. For these reasons, the fourth and fifth factor were also explored qualitatively in order to look for insights beyond the statistical analysis of the data. As further described in chapter 4.2 & 5 the qualitative analysis of the fifth factor did not yield any notable results. The fourth factor however, did yield notable results. Including 4 factors instead of 3 moves the

explained variance from 57.16% to 64.34%. Using a minimum factor loading of .6, 8 participants loaded on factor 1, 2 loaded on factor 2, 2 loaded on factor 3, 2 loaded on factor 4, and 2 loaded on factor 5, as can be seen in table 4. No participant loaded significantly on multiple factors, and two did not load high enough on any factor, as can also be seen in Table 4.

Table 4

Total Variance Explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.510	36.167	36.167	5.957	33.096	33.096
2	2.436	13.532	49.699	1.926	10.698	43.794
3	1.343	7.459	57.157	1.903	10.575	54.369
4	1.293	7.184	64.341	1.598	8.878	63.247
5	1.212	6.733	71.074	1.409	7.827	71.074

Table 5

Rotated Component Matrix

	Factor				
Participant	1	2	3	4	5
P5	.849				
P1	.835				
P8	.835				
P2	.819				
P7	.803				
P6	.801		.420		
P17	.771				
P13	.715				
P14	.326	.778			
P11		.631	.457		
P4	.334	.484	.431		.418
P15			.726		
P12			.689		
P3				.791	.307
P18		.312		.689	
P10	-.307	.412		.535	
P9		.304			.798
P16	.521				.619

Note. The cutoff point for a significant loading was chosen to be < .6. Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalization

4.2 Qualitative analysis

Thus, initially extracting 5 different factors should yield 5 different perspectives on nuclear energy based on the statements that were used in this study. After deciding on the

number of factors to be extracted based on the factor analysis and the context of the study, each factor was analyzed on a qualitative level. This process begins by analyzing the sorting of cards of participants within a factor, specifically, by looking at the statements that are placed in the most extreme spots of the Q sort. In the case of this study, these were the statements that received a sorting score of +5, +4, -4, and -5. The statements in these spots will generally show an overview of the main arguments of a participants' opinion. After this, the audio recordings of the follow-up interviews were analyzed in order to extract quotes that substantiate the consensus within a factor. Combining both the ranking and the audio recordings results in an in-depth look into the different perspectives of the participants. As mentioned earlier, this qualitative look at factor 5 did result in the deletion of this factor. This is due to the factor consisting out of two participants that had a significant loading. Combining this with the realization during the qualitative analysis that participant 16 misread a small amount of the statements, resulting in multiple errors during the sorting of the cards. Analyzing the interview of this particular participant shows an actual clear match with the first factor, where he/she scored a loading of .525 in the factor analysis (see Table 4). This leaves one participant within this factor that filled in the Q sort according to their attitudes towards nuclear energy correctly. One participant does not make a factor since there is no other data to compare the data of this single participant with. Therefore, it was decided that four instead of five distinct factors could be truly identified and analyzed on a qualitative level within the sample that was found during this study.

5. Findings

In the following section, each of the factors will be presented. First, an overview of the most important statements will be presented using a table. In this table, all statements with an average score of above 2.5 or below -2.5 within a factor are presented with their respective

average score. This provides a clear overview of the most important topics that play a role within the attitude towards nuclear energy within the participants of a factor. Next, a detailed description is given that uses direct quotes from the follow-up interviews in order to combine all gathered data of a factor. This method of reporting ensures a comprehensive overview of each factor and the differences between the other factors. Do note that the quotes that are presented were translated to English by the researcher, as the interviews were held in Dutch as this was the native language of the participants.

5.1 Factor 1: Nuclear energy as a necessity

Table 6

The Average Ranking of Most Relevant Statements of Factor 1

Statement	Average score
Nuclear energy is important for solving the climate problem	3,375
It is wise for the Dutch government to invest more resources in the construction of nuclear power plants.	3
Nuclear energy is a good option in order to reduce the emissions from energy generation.	2,75
Nuclear energy is the best energy source in comparison to other energy sources, despite its disadvantages.	2,625
Nuclear energy is a proven safe method of energy generation	2,625
The expansion of nuclear energy is necessary.	2,5
It is wise for the Dutch government to close the nuclear power plant in Borssele.	-2,5
Nuclear energy is a worse option than other renewable energy sources.	-2,625
The Netherlands is too densely populated for nuclear energy due to the risk of nuclear disasters.	-2,625
Nuclear energy is not a green energy source.	-3

The chances of a nuclear disaster is too high to expand nuclear energy in the Netherlands.	-4,125

Note. Only statements that have an average score > 2.5 or < -2.5 within this factor are presented in this table

The first explained factor and thus perspective on nuclear energy can be described as people that are in favor of a broader implementation of nuclear energy. The main arguments for this are the low emissions, especially when compared to fossil fuel sources, high reliability, predictability, high energy output, and the relative low amount of space needed when compared to other energy sources, as can be seen by the scores in Table 6. Due to this, it was often mentioned that nuclear energy can be a better, or for some even the best, energy source. A participant simply put this by stating that "There is no better option for your stable energy generation". Another participant explained the need to implement nuclear energy in relation to climate change:

> "I think that we have to save the climate, as in our generation, and I think that we can't get there in the Netherlands with the current methods for energy generation. We don't have power from water, our solar power is minimal, and we just have to add an energy source."

The participants that loaded significantly on this factor described the necessity to implement nuclear energy because of the fight against climate change and how nuclear energy could (or should) be more widely implemented. Furthermore, nuclear waste and safety are not perceived to be major downsides for nuclear energy, as both are perceived to be managed responsibly. In the case of nuclear waste, it was mentioned that either storing nuclear waste is a responsible method of processing this waste or that it is a required evil if the Netherlands truly aimed to phase out fossil fuels. Next to this, the low risk perception of this first factor can be described

by the following quote: “If we build a nuclear power plant in the Netherlands, the focus on safety will be so heavy that it will be ok”.

Another participant noted that the risk must be taken in order to save the climate, showing that nuclear energy is, according to them, good for the climate: “I think that if we look at it like “Oh, there is a chance of a nuclear disaster.” And that’s relatively small, especially when you compare it with the chance of the climate destroying the earth”.

To conclude this first factor, these participants clearly show a perspective of necessity when it comes to nuclear energy, mostly due to the high impact it has to fight climate change as a green energy source that can replace fossil fuel. Other reasons for this necessity are the impact on energy prices, an increase on energy security, and less dependency on other countries for the Dutch energy needs. Furthermore, safety was not a concern for these participants as the perceived risk was low and the current method of nuclear waste disposal is either good or good enough according to the participants within factor 1.

5.2 Factor 2: Nuclear energy as a risk

Table 7

The Average Ranking of Most Relevant Statements of Factor 2

Statement	Average score
Having to store nuclear waste is a major disadvantage of nuclear energy.	4
Nuclear energy is reliable because it delivers a constant and predictable amount of energy.	4
Storing nuclear waste is not fair for the next generations of Dutch citizens.	3
Nuclear power plants ruin the landscape.	2.5
Nuclear energy makes the power grid unreliable due to long closures of nuclear plants for maintenance and repairs.	-3
Nuclear power plants are vulnerable and strategic targets.	-3

It is wise for the Dutch government to close the nuclear power plant in Borssele.	-3
Nuclear power plants have a low impact on the living environment.	-4.5

Note. Only statements that have an average score > 2.5 or < -2.5 within this factor are presented in this table

The characteristics of the second factor can be described by the participants being against nuclear energy, mostly due to the perceived threat of daily operations and nuclear waste, as can be seen in table 8. The important distinction between this factor and the previous factors that have concerns about safety is that next to viewing nuclear disasters as dangerous, they also view the daily operations of a nuclear power plant as a potential risk. Especially when it comes to the potential of radiation leaks that damage the health of the local populace. In order to explain this reasoning, both participants that loaded significantly on factor 2 drew a parallel with the Dutch company "Tata Steel". This company has been the focus point of public discussion for years, and recently gathered new media attention due to a report that showed that the emissions from their steel plant are much higher and more harmful to the local populace than was reported in the past (Geraets & Schulpen, 2019).

> "My thoughts on disasters is that we are well secured, yet I do wonder if people know exactly what the emissions are. If you compare it with Tata Steel, a very extreme difference, but the government has also allowed that. So there is also a bit of trusting the government in that. And I think that that is what it is, you have to trust that everything goes well."

The participants within factor 2 see nuclear energy mainly as a high risk energy source, yet they do see some possible positive effects. As one participant noted, the possible reliability of nuclear power, as can also be seen in table 8: "I think that nuclear energy is a constant process, so it will probably be highly reliable."

Aside from these positives, both participants did express that nuclear energy simply is not the best option as an energy source due to the risk associated with this technology and that other sources might be better. One of the participant explained his views towards nuclear energy and other energy sources as followed: “I think that nuclear energy can still be used, but I think that other sources are better because nuclear energy is risky.”

Thus, to conclude the second factor, Nuclear energy as a risk, participants viewed nuclear energy as an irresponsible choice for the current energy generation of the Netherlands. This is mostly due to the high perceived risks of not only nuclear disasters, but also more unknown health hazards that are not clear as of now but could become clear in the future.

5.3 Factor 3: Nuclear energy as an economic booster

Table 8

The Average Ranking of Most Relevant Statements of Factor 3

Statement	Average score
The expansion of nuclear energy is necessary in order to meet the growing demand of energy.	4
The development and deployment of nuclear energy creates jobs and stimulates economic growth.	4
Using nuclear energy strengthens the Dutch economy.	3
The investment costs of nuclear energy can be canceled out by the many benefits.	3
Using nuclear energy will lower the average price of energy.	2,5
Nuclear energy has a smaller impact on the region than other energy sources.	-2,5
The costs of building a nuclear power plant can be better used elsewhere.	-2.5
Nuclear energy makes the Netherlands dependent for the resources needed for a nuclear reactor.	-3

The construction of new nuclear power plants makes the Netherlands a more attractive target for malicious countries or groups.	-3
Nuclear power plants have a low impact on the living environment.	-3

Note. Only statements that have an average score > 2.5 or < -2.5 within this factor are presented in this table

Participants within the third factor focused on the economic consequences of implementing nuclear power in the Netherlands, mostly viewing it as a financial investment that can repay itself by increasing the prosperity of Dutch citizens. As explained by a participant: “For me, it is important that everyone in the Netherlands can properly turn on their heating in the winter. Nuclear energy makes the Netherlands less dependent in that.” Thus, this increase in prosperity is mostly due to the independence of the Dutch energy grid, the decrease in use of expensive fossil fuels, especially after the invasion of Ukraine, and the reliability and predictability that nuclear energy could bring to the Netherlands in the future. This reasoning also shows in the average scores of statements, as shown in Table 7. Ukraine was often mentioned in the context of the consequences it has had on fossil fuel prices. A participant put it as followed: “Even if Putin thinks “screw all of you”, we will still have a proper heating system here”.

However, these participants did agree that a nuclear power plant has a large impact on the local area due to the constant risk of a nuclear disaster and possible radiation leaks. Also noting that people in the surrounding area will be heavily impacted by this looming risk. “The risk is very low, the consequences can be very high. That is why it [a nuclear power plant] shouldn’t be in a residential area, for instance. Put it in a meadow or something”.

A participant also formulated this differently, showing trust in the overall safety of a nuclear power plant yet would not feel safe when he/she would live next to a nuclear plant. “If it [a nuclear power plant] would be put somewhere else, I would trust it. However, if it would be near me, and that might be a bit hypocritical, I would not trust it”.

Concluding factor 3, the participant showed a high interest in the independence of the Dutch energy grid and thus also the independence of the energy prices in the Netherlands. Furthermore, the participants did deem the potential risks of nuclear power and the impact that it has on the local populace as a highly important subject.

5.4 Factor 4: Nuclear energy as a complex choice

Table 9

The Average Ranking of Most Relevant Statements of Factor 4

Statement	Average score
Nuclear power plants are vulnerable and strategic targets.	2,5
Nuclear energy is important for solving the climate problem.	2.5
Nuclear energy is reliable because it delivers a constant and predictable amount of energy.	2.5
The power grid becomes more resilient due to nuclear energy because it gets an extra option for generating energy	2.5
The impact of nuclear energy on the economy is too small, as it creates a relative low amount and only specialized jobs.	-2.5
The waste processing of nuclear energy is being done in a responsible manner.	-2.5
Nuclear power plants have a low impact on the living environment.	-3
Nuclear energy makes the Netherlands dependent for the resources needed for a nuclear reactor.	-3
Nuclear energy is not a green energy source.	-3
The investment costs of nuclear energy can be canceled out by the many benefits.	-3.5
It is wise to invest in nuclear energy as fast as possible.	-3.5

Note. Only statements that have an average score > 2.5 or < -2.5 within this factor are presented in this table

The fourth factor can be described as a conflicted opinion on nuclear energy, as these participants weigh the pros and cons of nuclear energy and do not share an attitude that is clearly in favor or against nuclear energy. This division in opinion shows in Table 9, as there is a large list of opinions that just managed to cross the threshold of an average score of >2.5

or <-2.5 in order to be included. A participant explained this conflict within themselves towards nuclear energy as followed: “There is definitely a conflict in my feelings towards nuclear energy. The fact that I do think that it is necessary, but I still find it very eerie”.

The characteristics of this group are seeing nuclear waste as a large problem, and that the impact of a nuclear power plant is major for the local area and communities. This impact is mostly described as large due to the risk of a nuclear disaster as well as the impact of actually constructing such a plant. This can be seen by the averages scores in Table 6, and is also described by the following quote:

> “Nuclear power plants have a large impact on the local populace, especially when something goes wrong because they can get cancer or die, or I don’t know. And especially since the Netherlands is densely populated, if it [a nuclear disaster] happens, then you have got a massive problem.”

Do note that some participants explained that these negatives can be solved or reduced by governmental intervention. Yet, the participants within this fourth factor do acknowledge the benefits that nuclear power could bring to the Netherlands, these being a more independent power supply as well as more stable energy prices. Oftentimes, the war in Ukraine and the increase in price of fossil fuel based energy was mentioned as highlighted by what a participant has said:

> “If I look at now, and that the Netherlands is actually very dependent and that, it [nuclear energy] can be a good method that we can use to eliminate that. So that we are less dependent. Everything that helps to stay more self-sufficient is good according to me.”

To conclude this factor, participants noted that nuclear energy has its pros and its cons and that the decision to build nuclear power plants should be a well-thought-out and researched one. A participant noted:

> "I assume that the people that decide on this know what is best for the Netherlands. However, if it is not absolutely necessary then I say to please put the money in something else such as healthcare, education, those kinds of things."

5.5 Similarities between the factors

Furthermore, there are some agreements amongst multiple or even all the identified factors next to these differences. All factors agreed that nuclear disasters could have a disastrous effect, the disagreement lied in the perceived chance that such an event can take place in the Netherlands. Furthermore, all factors agreed on the high negative impact that nuclear power plants can have on local communities, such as an uncomfortable feeling, or a nuclear power plant simply being an unattractive building complex. Some of the positive aspects of nuclear energy, its reliability and increase of independence, did get recognized throughout the four identified factors. However, factors 2 and 4 do note that this high reliability and independence does not make nuclear energy fully worthy of implementation, as there are still considerable downsides that need consideration. Lastly, all factors also agreed upon that nuclear energy might be necessary in order to meet the energy demands of the future. The statement "The expansion of nuclear energy is necessary in order to meet the growing demand for energy" got an average score higher than 1.5 in every factor, with an average score of 2.05 across all participants. This shows that besides its downsides, the participants did all agree upon that nuclear energy might be necessary for the future, despite the differences in overall attitude and perspectives surrounding nuclear energy.

6. Discussion and conclusion

6.1 Main findings

According to the results that are presented in this study, four clearly defined perspectives can be identified. Each perspective acknowledges the need for the Dutch energy transition yet has a different conception on the practical plan to execute this transition. The first and largest perspective amongst the Q-sample is Nuclear energy as a necessity', is based on the conception that nuclear energy is the best, or one of the best options within the Dutch energy transition to move away from fossil fuels. The second perspective on nuclear energy that is presented is called "Nuclear energy as a risk" and views nuclear energy as a high risk and irresponsible energy source. The participants within this factor therefore have a relative high risk perception of this technology. This is not only based on the risk of a nuclear disaster, but also due to potentially unknown threats of daily operations and nuclear waste disposal, such as radiation leaks. The third perspective is named "Nuclear energy as an economic booster" and sees nuclear energy as a benefit towards the Dutch economy by lowering the average energy price by lowering the dependence on foreign fossil fuels. Furthermore, the increase in self-reliance of the Netherlands is also viewed as large positive of nuclear energy. The fourth and final perspective that is presented in this study is named "Nuclear energy as a complex choice". This perspective describes the pro's and con's of nuclear energy and does not have a clear pro- or anti- nuclear sentiment.

Next to the differences that were identified between the factors as described above, some similarities were found that span across the different factors and can therefore not be used to identify a difference in these factors. However, as these similarities did play a role in the creation of the participants' attitude towards nuclear energy, it is relevant to present these next to the differences in attitude. First off, all factors acknowledge the disastrous consequences that a nuclear disaster could have. The risk perception of such an event however differs, as for

example the first factor viewed nuclear disasters to be highly unlikely due to the advancements in technology and strict regulations regarding safety. The second factor, however, viewed potential human errors as a reason to never fully trust such high consequence technologies. Another agreement between all factors is that nuclear power plants have a large impact on surrounding local communities due to an uneasy feeling coming from such power plants due to the direct risks of a nuclear disaster. This is an interesting agreement as the study of Venables et al. (2009) identified distinctly different attitudes towards nuclear energy within the populace that live in the proximity of a nuclear power plant. A positive impact that all factors are in agreement on is the benefit of reliability and independence that a nuclear power plant could bring. Regarding the context of this study, the consequences of the current war in Ukraine were often mentioned throughout the follow-up interview across all factors as an extra financial incentive for the Netherlands to move away from foreign fossil fuels. Lastly, all the differently identified factors did recognize some need to implement nuclear energy in order to meet the future energy demands of the Netherlands. The roles that nuclear energy could play did differ between participants, as some noted that nuclear energy could potentially work as a method to fill the gap within the Dutch energy supply due to the phasing out of nuclear energy until renewable energy sources can catch up. Others, especially amongst factor 1, noted that nuclear energy could also indefinitely fill the gap caused by the phasing out of fossil fuels. Some go even a step further and note that the Netherlands should even take the French approach and mostly rely on nuclear energy to meet the majority of the Dutch energy demand. Therefore, similarities amongst the different factors can be identified, as shown above. However, even within these overall similarities, some differences can still be found.

The results of this study are concurrent with other Q-sorts on nuclear energy, as it is clear that the implementation of nuclear energy is a very complex and dividing topic. Results can be compared on a detailed level, as parallels can be drawn between the results found in this

study and other similar studies performed in recent years. Clear similarities can be found between the factor “Nuclear energy as a necessity” and the factor in the study of Venables et al. (2009) called “beneficial and safe”, as both studies identified a factor that perceived nuclear energy as a proven safe technology that has major national benefits. Furthermore, the factors “Nuclear energy as a risk” in this study and “Threat and Distrust” from the study of Venables et al. (2009), as both show a distrust in the government and a high-risk perception towards nuclear energy.

6.2 Practical and Theoretical Implications of this study

The results of this study contribute to the existing theoretical knowledge surrounding public discourse on complex topics such as nuclear energy. Furthermore, it adds knowledge on the use and analysis process of the Q methodology for the analysis of attitudes on a complex topic such as nuclear energy. The four different factors provide an in-depth understanding of the differences and similarities within four distinct attitudes towards nuclear energy. These differences and similarities provide practical usage for anyone dealing with nuclear energy and public reactions and discourse towards nuclear energy. By having a deeper understanding, this reaction and discourse is easier to understand and react to. This is for instance useful for policymakers, that can use the information gathered in this study when having to decide on the usage of nuclear energy or any other energy source within the larger context of the energy transition. Apart from policymakers, this deeper understanding can also be used by communication professionals when he/she when creating media on developments within nuclear energy or the energy transition, as one can play into the expected public reactions and discourse stemming from the four different perspectives and attitudes identified within this study.

6.3 Limitations

However, one must be careful to not extrapolate the results found in a study using qualitative methodology across the entire populace. This is due to the selection in the sampling and the relatively small sample size when compared with qualitative studies. The main reason for choosing the Q methodology is to get a deeper understanding on the differences and agreements in perspective on a particular topic, the goal is not to find how these different perspectives relate to the populace as a whole. For these reasons, it cannot confidently be said that the four identified perspectives on nuclear energy that were found in this study are the only ones present in the Dutch overall populace, as clearer understanding might be formed using a larger and more selective Q-sample. This thus also means that more distinct perspectives could be found through an increase of studies on this complex topic. Therefore, the four distinct attitudes and perspectives that were identified in this study could be more precisely defined in the future due to new insights stemming from future research. Furthermore, a more selective Q sample could have helped to clear up some of the similarities overlaps between the final four factors. The current Q sample only included a relatively highly educated group of young Dutch professionals within the age range of 18 - 30 years old. Bashatah (2016) explains that selecting a sample by predetermining categories of participants based on demographics that are expected to have different opinions on the studied topic will most likely yield more different perspectives. By including more distinct groups of participants based on demographic variables such as perceived knowledge level on nuclear energy or different age groups in conjunction with a more selective participant gathering process could have resulted in a more detailed description of the extracted factors (Lee, 2017). For example, the potential fifth factor that had to have been deleted due to the limitations of the data could be rediscovered in such future research. However, this does not mean that the identified factors within this study lose

reliability, they simply could have been defined in greater detail by using a more distinct and precise sample.

Next to this, the found factors were most likely influenced by the crisis-effect, not only by the expected consequences on fossil fuel-based energy sources due to the invasion of Ukraine, but also by the crisis effect of Tata Steel. The invasion of Ukraine specifically is discussed in each of the four factors, showing an increase in the perceived need to move away from fossil fuel-based energy sources. In the case of factor 4, a parallel was drawn between the Tata Steel situation and nuclear power due to possible hidden dangers. This shows a potential crisis effect (Wegkamp, 2014) due to Tata Steel, increasing the risk perception of hidden dangers and lowering the trust in governmental organizations. Due to the temporary nature of the crisis effect (Wegkamp, 2014), this effect could fade in some capacity over time. However, as Tata Steel and nuclear energy are different topics of discussion, Tata Steel could also very well have been an example that was top of mind when describing such a potential lingering risk when it comes to nuclear energy.

6.4 Recommendations for future research

Taking the aforementioned limitations in consideration when interpreting the results of this study, clear opportunities for future research can be identified. First off, the deeper understanding in the different identified attitudes and perspectives can be a valuable input for future, grander scoped studies on this topic. As it is still unclear how these four different attitudes and perspectives are distributed across a larger population such as the Dutch populace. Furthermore, other distinct perspectives can still be found in the future, similar research on this topic. The fifth factor that had to be disregarded due to the amount of significantly loaded participants could potentially be found again and analyzed in future research. Lastly, the four distinct perspectives and attitudes that were found in this study might be more clearly identified by using data from future research on the public discourse on nuclear energy. Future research

could also focus on the different contexts that the attitudes will have in the future, as this context is always evolving. As mentioned throughout the report, the crisis-effect stemming from the consequences of the conflict in Ukraine and the reports of Tata Steel in the Netherlands play a significant role in the context, and therefore the findings, of this study. Comparing different contexts in the future could potentially provide valuable insights of the crisis effect, as well as a deeper understanding of the public discourse surrounding nuclear energy and the energy transition in the Netherlands.

6.7 Conclusion

The aim of this study was to look into the differences in attitude and perspective of the Dutch populace on the implementation of nuclear energy in the Netherlands. While doing so, the Q methodology has allowed for a detailed look into the differences in reasoning and interpretation of Dutch citizens and brought multiple interesting insights. The Netherlands has a unique context with nuclear energy and the energy transition, as it has historically been a large user of natural gas and is aiming to rapidly move away from fossil fuels during its energy transition. Nuclear energy could play a role in this, as long as the different perspectives and attitudes of the Dutch populace towards nuclear energy are understood and respected.

It is clear that the possible integration of nuclear energy within the Dutch energy transition is a complex and dividing topic of discussion, as it includes many different perspectives and ways of thinking. Yet all distinct perspectives showed the need for an energy transition, the disagreement lies in the preferred method and timing of energy generation. This preference within the participants is most likely stemming from their attitudes and risk perception towards all possible energy generation methods, including nuclear energy. Four distinct perspectives were extracted from a Q sample of 18 participants; 1) Nuclear energy as a necessity, 2) Nuclear energy as a complex choice, 3) Nuclear energy as an economic booster, & 4) Nuclear energy as a risk. Apart from the clear distinctions between these perspectives,

some similarities were identified such as a high perceived negative impact on local communities coming from the construction of a nuclear power plant, or that nuclear energy could bring a large reliable energy source within the Netherlands, or that nuclear energy could potentially make the Netherlands less reliant on other countries for its energy needs. The implications of this study in a practical sense is providing a deeper understanding behind the reasoning behind the found perspectives on nuclear energy. This creates a deeper understanding of the public discourse around the possible implementation of this technology within the Dutch energy transition in the future. The importance for the Dutch government and its people to reach the climate goals of 2030 and 2050 is too high to not at least analyze the option of expanding nuclear energy in order to reach them (Rijksoverheid, n.d.). Therefore, further scientific study behind the difference and similarities towards the public opinion of all possible energy sources is important for policymakers to make informed decisions, including nuclear energy. Understanding the different reasons behind what the Dutch people feel and think towards nuclear energy provides a solid base for continuous active discussion on how the Netherlands aims to fulfill their energy needs in a sustainable manner for the future.

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Appendix

Table 8

List of Categories with their Corresponding Statements, original Dutch version

Category	Statement
Klimaat impact van kernenergie	Kernenergie is belangrijk voor het oplossen van het klimaatprobleem
	Kernenergie is geen groene vorm van energie
	Kernenergie is een goede optie om de uitstoot van energieopwekking te verminderen
Kernenergie in vergelijking met andere energiebronnen	Kernenergie is een slechtere optie dan andere hernieuwbare energiebronnen
	Kernenergie is de beste energiebron in vergelijking met andere energiebronnen, ondanks de nadelen
	Kernenergie heeft een kleinere impact op de regio dan andere energiebronnen
Noodzaak	Het uitbreiden van kernenergie is nodig
	Het is verstandig om zo snel mogelijk te investeren in kernenergie
	Het uitbreiden van kernenergie is noodzakelijk om aan de groeiende vraag van energie te voldoen
Kernafval verwerking	De afvalverwerking van kernenergie wordt op een verantwoordelijke manier gedaan
	Het opslaan van kernafval is niet eerlijk tegenover de volgende generaties van Nederlandse inwoners
	Het moeten opslaan van kernafval is een groot nadeel van kernenergie
Energiezekerheid	Kernenergie is betrouwbaar omdat het een constante en voorspelbare hoeveelheid energie levert
	Het stroomnet wordt door kernenergie weerbaarder omdat deze een extra optie krijgt voor energieopwekking
	Kernenergie maakt het stroomnetwerk onbetrouwbaar vanwege langdurige sluitingen van kerncentrales voor onderhoud en reperate
Impact op de economie	Het inzetten van kernenergie versterkt de Nederlandse economie
	Het ontwikkelen en inzetten van kernenergie creëert banen en stimuleert economische groei
	De impact van kernenergie op de economie is te klein, omdat relatief weinig en alleen specialistische banen creëert.

Impact op energieprijzen	Het gebruik van kernenergie zal de gemiddelde prijs van energie laten dalen
	Het inzetten van kernenergie maak Nederland weerbaarder voor prijsveranderingen van energie
	Het effect van kernenergie op de energieprijzen is te klein om het gebruik ervan te verantwoorden
Investeringskosten	De investeringskosten van kernenergie kunnen weggestreept worden door de vele voordelen
	De kosten van het bouwen van een kerncentrale kunnen elders effectiever worden ingezet
	Het duurt te lang voordat een kerncentrale zijn eigen investeringskosten heeft terugbetaald
Afhankelijkheid van andere landen	De oorlog in Oekraïne laat zien dat kernenergie nodig is om het Nederlandse stroomnetwerk zelfstandiger te maken voor gebeurtenissen in andere landen
	Kernenergie maakt nederland afhankelijk van andere landen voor de grondstoffen die nodig zijn voor de kernreactoren
	Kernenergie is nodig omdat het Nederland minder afhankelijk van andere landen maakt door het gebruik van fossiele brandstoffen te verminderen.
Risicoperceptie	De kans op een kernramp is te hoog om kernenergie uit te breiden in Nederland
	Nederland is te dichtbevolkt voor kernenergie vanwege het risico van kernrampen
	Kernenergie is een bewezen veilige manier van energieopwekking
Kwetsbaarheid van Nederland voor aanvallen	Kerncentrales zijn kwetsbare en strategische doelwitten
	Het bouwen van nieuwe kerncentrales maakt Nederland een aantrekkelijker doelwit voor kwaadwillende landen of groepen
	Het bouwen van kerncentrales maakt nederland minder kwetsbaar voor aanvallen, omdat een enkele aanval op een kerncentrale niet het volledige elektriciteitsnetwerk kan platleggen
Nederlands beleid	Het is verstandig voor de Nederlandse overheid om meer in te zetten op het bouwen van kerncentrales
	Het is verstandig voor de Nederlandse overheid om meer in te zetten op innovaties binnen kernenergie
	Het is verstandig voor de Nederlandse overheid om de kerncentrale in Borssele te sluiten
Impact op leefomgeving	Kerncentrales verpesten het landschap
	Kerncentrales hebben weinig impact op de woonomgeving