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Implementing Precaution and the Substitution Principle Towards Norway's Energy Transition: Is the 2050 goal achievable?

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Abstract

The Substitution principle has a significant role in the energy transition. This pillar is considered a subset of the precautionary principle, aligned with the concept of sustainability. However, there has been rather limited research about a fundamental concept of the substitution principle in transition policy. Previous research has primarily discussed the substitution principle in the Swedish chemical policy. The case in the Sweden's control policy leads to a suspicion of Norwegian policy and its goal. A question has been raised about whether the 2050 goal to become a low carbon society is achievable. This study aims to examine the role of precautionary and substitution principles towards the Norwegian low carbon policy. The purposes of this study contain as the following: 1) to explore the role of scientific evidence and risk informed decision-making process, 2) to study how these fundamental principles would work in energy transition policy, and 3) to find out the possibility to reach its target.

This paper is derived from the in-depth exploration of interview participants' cognition, and public official policy documents. The study involved qualitative research with an interview platform and content analysis of policy documents. The in-depth interviews were conducted with semi open-ended questions. A sample was selected from individuals who have an educational background and work experience within the field of energy, risk and safety. The interview responses and data from the official policy documents were collected and thereby used for data analysis.

The findings indicate that the energy transition requires the substitution principle. The government has a critical role in pushing for a faster transition towards their low carbon ambitions. The fundamental principle of substitution is remarkably neglected. While the precautionary principle still has also received minimal attention. A comparison of research results between content analysis of policy documents and detailed interviews emphasizes the importance of scientific evidence and risk informed approach as it clearly plays a vital role to support decision-making. Furthermore, it was found that Norway still has a chance to achieve the long-term goal by 2050 if even more enhanced ambition on policy strategy. However, given the current ambiguity of ambition towards low carbon transition policy, it is unclear as to whether it could actually be accomplished. Even though most interviewees hold some optimistic beliefs, it appears that the pathway to reaching the target is still in doubt. Hence, the precautionary instruments should be implemented intensively and increasingly more ambitious policies, especially in terms of technology development.

Key Words: Substitution principle; Precautionary principle; Energy transition; Climate risk; Risk informed decision-making.

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Chapter 1 – Introduction

1.1 BACKGROUND

In recent years, environmental issues become a hot political topic in many countries around the world. These problems involve climate change, air and water pollution, wildfires, and so forth. It has been a public concern globally for more than 20 years. Most scientists have concluded that human activities mainly cause environmental damage. But from now on, it turned out that humans need to protect themselves from such extreme climate events and natural disasters. According to the World Economic Forum's Global Risks Report, the finding presents that climate risk is the biggest threat to humanity in, at least, over the decade (Charlotte, 2020). Proposing a policy is a measure to demonstrate a more progressive and responsible attitude towards environmental issues. Hence, climate risk is a major driver in politics these days, to design an effective policy moving forward to a green society.

Most people now have remarkably an awareness of global warming. The powerful nations in Europe are in a battle to become a leader in the energy transition in this era. Norway even is a small state but would become the main player in the global energy shift. The Norwegian government has a clear policy for climate change, which significantly contributes to pushing the energy transformation towards sustainability. According to the government official documents, a long-term policy goal has been presented with a low carbon strategy forward to 2050. This ambitious policy intends an increase in the emission reduction target up to 90-95 percent from the reference 1990 year (Norwegian Ministry of Climate and Environment, 2020a). Therefore, climate change has a crucial role in the national agenda of Norwegian policy, which leads to the energy shift to become a green society. As Norway is the exporter of oil and gas, thus there is no doubt that a need for the energy transition is a nation's big challenge.

The government has a role to determine a policy for the transformation. Refer to Norwegian policy documents, the analysis concludes that an effective policy aids to reduce the possible impact of climate change significantly (Norwegian Ministry of Finance, 2018b). However, policy-making is challenging whether a goal-setting is achievable, which in general should conform to reality. It is commonly known the policy has a large impact on people, businesses, industry, and involved parties. A decision needs support from risk-informed analysis for providing the overall picture and thereby leading to making a better choice. Accordingly, risk management is essential for policy-making to choose the right decision. Where Norway is one of the oil and gas producer, and its revenue has relied on the oil and gas industry. Therefore, it is not easy to achieve the goal without any loss in the economy, and there are also other risks associated with the transition.

There is a case of chemical policy in Sweden, that is considered similar to the ambition in Norway's energy transition. It is because the two cases have a link in terms of environmental policy and the implementation of the substitution principle. Sweden is well known as the

pioneer of chemical policy in Europe, has put forward a goal in a chemical control policy, which called for a phasing out of all human-made chemicals upon 2020 (see Löfstedt, 2014a). Unfortunately, the government's agency official report identifies that these objectives of sound management of chemicals in the 2020 year, will not likely be achieved, and it still requests continued actions. When looking back to the low carbon emission goal in Norway, Sweden's case is the motivation of this thesis to conduct research examined the possibility to fulfill the policy objectives of a long-term goal. Apparently, this would be a long journey for the energy transition in Norway. Rather, it cannot be denied that this is a pathway to sustainable development, which friendly to both humans and the environment.

1.2 PROBLEM STATEMENT

The world's main energy source comes from fossil fuels, including coal, crude oil, and natural gas. The scientists told us a story that the fossil fuels leading to a large amount of carbon dioxide (CO_2) emission, which is a cause of climate change (see e.g. IPCC, 2014; Oberthür and Ott, 1999; Romm, 2018). Based on several scientific papers, the impact of global warming contributes to extreme climate events, for instance, the case of Australia's wildfires. The global temperature has increased significantly today, and thereby people are alert to possible severe impacts of climate change. This is the vulnerability facing our planet. Accordingly, there is a need to strive for the transition to a zero-carbon emission society as soon as possible.

The transformation requires the replacement of fossil fuels with renewable energy sources with the supported technology in power generation. The core fundamentals concept applied to the transition is called 'substitution principle'. It is noted that the substitution principle has been used as one of the policy tools to deal with climate risk. Several scholars agree that there is a link between the substitution and precautionary principle (see e.g. Aven, 2014; Löfstedt, 2014). Hence, the substitution principle plays a crucial role in the energy transition, applied under a call for implementing the precautionary principle to manage risk when there is no scientific certainty.

As the shift to renewable energy needs the substitution principle, it is vital to note that the substitution is not limited to find alternative sources, but also including technology development to urge the transition. After reviewing the relevant literature, the finding is that there have been limited researches associated with the substitution principle, especially, in the field of the energy transition. Even there is some literature available about this field, previous research has primarily discussed the substitution principle in the Swedish chemical policy. Therefore, it is necessary to conduct a research in order to fill the knowledge gaps in this particular field.

Additionally, there has an example of environmental policy in Sweden. The main goal is phasing out all man-made chemicals upon 2020. Eventually, Sweden is unable to reach that target as it would. This Swedish's instance increasingly raises suspicion of Norway's policy and its goal, which brings into question whether transformation to a low carbon society by 2050 is achievable. In addition, it is in doubt that if the goal relies on realistic as it could be or

not. Altogether, these questions cast doubt on the process of decision-making and the role of scientific evidence and risk informed approach.

1.3 AIM AND OBJECTIVES

The thesis aims to study the role of precautionary and substitution principles towards Norway's transition policy and investigate how to reach its target of becoming a carbon-neutral society whether it is achievable within 2020. The government has the authority to determine and make a decision on public policy, and strategy, to match with the goal. Also, this study intends to explore the role of scientific evidence and risk informed decision-making. Therefore, this research will analyze and discuss data gained from policy documents compared to the responses to the questions in the qualitative interview.

The purpose of this research is to investigate, review, analyze, and compare the policy documents and individuals' cognition from the interviews. The following objectives are described in order to fulfil this aim of the thesis:

i) To review relevant literatures related to the precautionary and substitution principle, as well as the transition policy
ii) To study the case of Swedish chemical policy for a comparable discussion
iii) To investigate on the understanding of the energy transition
iv) To study and analyze the policy documents related to energy transition in Norway

1.4 SCOPE AND LIMITATION

The current study analyzes and discusses the role of precautionary and substitution principle in Norway's energy transition. It is aimed to answer the research problem on the possibility to reach the 2050 goal and the role of risk informed decision-making. In policy-making, My study will be based on the review of relevant literatures. The illustration of the Swedish chemical policy warns us of the possibility to miss the target of a policy goal. There are a number of researches have studies related to this area. On the other hand, there are less study of the energy policy in Norway. Hence, I will conduct the research and discuss the results related to the precaution towards the Norwegian energy transition policy to fulfill the research gap.

As the energy transition requires the substitution principle to find alternative renewable energy. It is evident that the doctrine of substitution is a subset of the precautionary principle. I aimed to study how these principles applied towards energy transition in Norway. An interview qualitative research is chosen to observe and analyze the response regarding the research questions. With a small group of interviewees, the results could be weak. Accordingly, I will conduct the content analysis from the policy documents to strengthen reliability of this research.

The limitation is obviously in relation to the language. Most original documents related to the Swedish and Norwegian policies are written in languages other than English. The information about these policies is conducted from different sources. I gathered the policy documents about

the policy statements and strategies from the government official webpage. Even there are some papers summarized in English, the information is not specified in detail. Therefore, the content analysis and discussion are based on the available documents summarized in the English version.

1.5 STRUCTURE OF THE THESIS

The structure of the thesis will be outlined briefly in order to facilitate the reading. This thesis contains totally six parts that covers an introduction part, a review of relevant literature, a research methodology, results and discussion, including a conclusion section. Whereas each chapter consists of several sections and its subsections related to that topic.

First of all, **Chapter 1** provides an overview of this research in order to introduce the background and motivation of my study. Next, **Chapter 2** presents the literature survey of the thesis. The relevant existing literature will be reviewed in order to build a theoretical basis for evaluating the research question. After that, **Chapter 3** and **Chapter 4** describes on the research methodology and its results related to the energy transition and policy in Norway. The methodology and method applied will be introduced and discussed. In addition, the discussion of the result will be described in **Chapter 5.** Finally, a summary of this master thesis regarding the research question will be drawn, including a general discussion and perspectives are provided in **Chapter 6.** Beside this, the recommendations for possible further research will be given in this section.

Chapter 2 – Literature Review

Climate change dominates the biggest risk globally for humanity over the decade. Scientists in the field have a consensus on the fact that the earth's temperature is increasing with respect to scientific conclusions and observations (Edenhofer et al., 2011; Romm, 2018). According to the IPCC Fourth Assessment Report (2007), "[m]ost of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." It is evident that human activities mainly cause to the climate issue. Even the scientists warn us about both the direct and indirect impacts of climate change, but these future consequences are uncertain. something might go wrong and then lead to an unexpected event. Also, there might be a case that the climate situation becomes worse than scientific prediction presently. Clearly, there is a call for 'precautionary principle' to tackle climate risk.

The transition requires the substitution concept, which is the main focus of this thesis. This fundamental is called 'substitution principle', aligned with the basics of sustainable development. It probably causes confusion to a distinction between the precautionary and substitution principle. The fact is the substitution principle definitely has a relation to the notion of precaution. Undoubtedly, this pillar of the transition links to the precautionary principle. It is well-known that the precautionary principle is remarkable as a rational solution to respond towards risk with the slogan 'better safe than sorry'. (DeKay, Patiño-Echeverri, & Fischbeck, 2009). Most scientists agree that actions should be taken seriously to restrict the consumption of fossil fuels to confront climate risk. The reduction of greenhouse gas emissions is a global goal today. The doctrine of substitution, which is the precautionary measures, applied in order to achieve this ambition. This intention to reach the goal needs to explore alternative energy sources and having new technologies emerge for the sustainability of humanity. Refer to the Intergovernmental Panel on Climate Change (IPCC) (2014), it states that "[t]he precautionary principle allows policymakers to ban products or substances in situations where there is the possibility of their causing harm and/or where extensive scientific knowledge on their risks is lacking" (p. 172). It is obvious that the substitution is one tool under the precautionary measures. Accordingly, the substitution principle is considered as a subset of the precautionary principle.

In this chapter, even though there has a link between the precautionary and substitution principle, both fundamental concepts will be presented separately into each section. It is necessary to understand the basis of these principles as both are a core of transition policy in risk management. Furthermore, this review will illustrate about policy-making in Europe as well as the role of evidence-based and risk-informed decision-making, including the case of the Swedish policy. Thus, these contents are useful to understand the basis of principles and regulations related to the energy shift.

2.1 PRECAUTIONARY PRINCIPLE

2.1.1 DEFINITION OF THE PRECAUTIONARY PRINCIPLE

The precautionary principle is well known as a decision support rule in the safety context. It is widely used in European regulation in order to address possible threats. There are many researches about this principle (see e.g. Balzacq, 2015; DeKay, Patiño-Echeverri, & Fischbeck, 2009; Jackson, W. & Steingraber, S., 1999). The precaution has an important role to confront the environmental risk, which is a major concern in the public nowadays. The interpretation of the precautionary principle has been defined in many ways. The following illustrates the examples of definitions available.

In environment policy, Kriebel et al. (2001) present that this principle is used to guide the policy-making with four pillars as the following: (i) taking preventive action when dealing with the uncertainty; (ii) shifting the burden of proof to the proponents of an activity; (iii) exploring a wide range of alternatives to possibly harmful actions; and (iv) enhanced public participation in decision-making process (p. 871).

While Aven (2015) explains simplified in general that the precautionary principle is known as a special case of the cautionary principle, related to scientific uncertainty and consider to either not starting any activity or implementing measures to reduce risk and uncertainties (p. 9). Additional, Jackson, W. & Steingraber, S. (1999) refer the definition of precautionary principle from a 1998 Wingspread consensus statement among participated scientists which defined this principle as "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically". These are examples of the definition available.

Consider to similar context, some people consider that we should not start doing the activity, but some might argue that we do not need to take any action because risk can be considered as acceptable. Refer to Wiener & Rogers (2002) they say that "the precaution need not man prohibition". In other words, we do not necessarily stop doing all activities that might be a potential risk.

As the numerous academics point out that there is no such agreement on the specific interpretation of the precautionary principle. If we consider the definitions of the precautionary principle from the Wingspread consensus statement, it can be classified into four dimensions. In the interesting study of Sandin (1999), he summaries the dimensions of the precautionary principle as (i) the threat dimension; (ii) uncertainty dimension; (iii) the action dimension and (iv) the command dimension. This demonstrates a broad interpretation of the precautionary based on the defined meaning.

In a nutshell, the precautionary principle is in relation to the scientific uncertainty. It is helpful to support decision-making. However, there is no consensus on the interpretation of this fundamental concept. The precautionary principle is defined differently. The experts admit that this can lead to fundamental issues, and it should not overlook this problem. So, there is a call

for the agreement on how to define this concept to avoid misuse of the precautionary principle (see Nilsson, 2004)

2.1.2 IMPLEMENTATION OF THE PRECAUTIONARY PRINCIPLE

The numerous academics point out that there is no such agreement on the specific interpretation of the precautionary principle. If the definitions of the precautionary principle are considered from the Wingspread consensus statement, it can classify into four dimensions. In the study of Sandin (1999), he summaries the dimensions of the precautionary principle as the following: (i) the threat dimension; (ii) uncertainty dimension; (iii) the action dimension and (iv) the command dimension. It demonstrates a broad interpretation of the precautionary based on the defined meaning.

According to Wiener and Rogers (2002), the main interpretation of the precautionary principle can be categorized as follows: (1) Uncertainty does not justify inaction; (2) Uncertainty justifies action; (3) Uncertainty requires shifting the burden and standard of proof. The level of aggressive response ranges from (1) to (3), respectively. Both version 2 and 3 are considered as lack of full scientific certainty. Yet, these two versions have the same problem to determine the proper action to deal with scientific uncertainty. In part of the third interpretation, Wiener and Rogers (2002) illustrate that this is the most aggressive version, similar to the case in the Swedish chemical policy. It is because the chemical products are judged as harmful until it can prove that this risk is acceptable. In this case, some scientists have criticized in this regard. It is a misuse of the precautionary principle.

Regarding the three versions of the precautionary principle, there is introduced to the topic of the conflicting errors. Wiener and Rogers (2002)7/15/20 1:11:00 PM explain the kinds of errors, which consist of false positives and false negatives. False positives mean any risk is presumed guilty until proven innocent. On the contrary, false negatives defined as any risk is presumed innocent until proven guilty (p. 321). It can be seen that the last interpretation is an error in false positives following the definition. These kinds of errors probably lead to countervailing risk, which is the adverse risks that result from taking any action to reduce the target risk. On the other hand, the unforeseen risks can increase. Thus, it is a matter for regulatory decisionmakers to consider other risks concerned instead of just focusing on only one single threat.

The interpretational issue of the precautionary principle is the challenge for policy-making. Even each nation in the European Union has applied the principle in different ways. So, it is difficult to say that which one is more suitable. It depends on the context. In discussions of Löfstedt (2011), a controversial issue has been the regulatory decision-making in the European Union. He summaries that “there is no clear consensus as to when risk or hazards considerations should be the basis for regulatory decision-making" (p. 149). As can be seen from the use of precautionary in Europe, the way to implement the precautionary principle is different based on the context. It conforms to Nilsson’s work. There is no standard method to implement the principle, even the countries in the same European Union (R. Nilsson, 2004). There is an example of Sweden’s case that proceeds the chemical policy in the position of extremist way, but not for the other nations. This presents that no standard to create the rules

and regulations for chemical control in the Europe Union. Likewise, McNelis (2000) also advocates at this point that no clear interpretation of the precautionary principle on how to take an action properly. A number of scholars are worried about this action because it may result in the protectionist abuses. Therefore, Nilsson (2004) provides the suggestions that the European Union have to reach an international consensus on the topic of adopting the precautionary principle.

Since it is not clear on how to use the precautionary principle appropriately, thus the practical issue of the precautionary principle is not limited in Europe only. However, the United States applie the precaution differently from the European Union. Balzacq (2015) states that "the EU places its faith on the precautionary principle while the US insists on cost-benefit analysis". It seems that the United States give more weight to economic than safety if consider a similar risk context. Many researchers have commented that "the conventional wisdom is that Europe endorses the precautionary principle and seeks proactively to regulate risks, while the United States opposes the precautionary principle and waits more circumspectly for evidence of actual harm before regulating" (Wiener & Rogers, 2002). It turns out to be the United States have more concern about economic risk, when compared with the European Union. Instead, the European Union is too much aware of safety concern. In the same way, Vogel (2001) summaries that the regulatory policies in the United States and Europe are currently opposite in the direction. Europe tend to be more risk-averse than the United States (p. 31).

By contrast, Wiener and Rogers (2002) provide the other conclusion by comparing through case studies consist of hormones in beef, milk production, mad cow disease in beef and in blood donations. Their recent work illustrates that the EU is more precautionary that than the US if consider regarding hormones in beef, while sometimes the US is more precautionary than the EU in the case of mad cow disease in blood (p. 317). The degree to apply precautionary in the US and the EU varies depended on the context. It is hard to judge which area applies more precautionary than the other. Thus, based on their study, Wiener and Rogers (2002) conclude that the use of precautionary principle is depended on the context of the particular risk more than on broad differences in national regulatory regimes.

2.2 SUBSTITUTION PRINCIPLE

Energy transition obviously requires the substitution principle for phasing out fossil fuels. Currently, there is no literature available discussed the importance of substitution principle in the energy transition. Most scholarly debates focus on controversial topics related to chemical regulation which consist of the definition of the substitution principle, a link with precautionary principle and the way to implement the principle. The substitution principle is one of risk management tools in the safety area to confront risk. This safety principle is not new tool at all, it is well-known among scientists. Indeed, the substitution has been long widely used in the economic innovative process (R. Löfstedt, 2014c, p. 544).

In regulatory context, it has been acknowledged as a part of environmental policies (Swedish Chemicals Agency, 2007). The substitution principle is initially applied in the Swedish precautionary policy. A summary of Lofstedt's work on the historical background in chemical

regulations, it is clear the application of the substitution rule has been solidly established in Swedish practice starting in the health and safety area and then entering the chemicals sector (Löfstedt, 2014). As reviewing literature in Swedish chemical policy, the substitution principle plays a crucial role in the chemical field which applied along with the precaution. However, this principle is not limited to chemical regulation only, but it also in the other regulatory contexts. A number of researchers found that the doctrine of substitution applied in the Swedish policy influences the European regulatory context significantly. Therefore, this review will present the main discussions of the substitution principle among academics and experts in terms of fundamental concept and implementation.

2.2.1 Definition of the Substitution Principle

The general meaning of the substitution is replacing one substance with another which has less dangerous. However, it is important to keep in mind that we have to distinguish between substitution, that is, replacement in general, and implementation according to the substitution principle (Möller, Hansson, Holmberg, & Rollenhagen, 2018). In addressing the issue of the proper definition of the substitution principle, experts have considered several available interpretations. Several scholars have defined the substitution principle in many ways. Even they are familiar with the substitution principle for more than a decade, there is no consensus on the meaning of this principle. Some statements of substitution principle focus on chemical substitution particularly. Some definitions cover the replacement of substance as well as the functional substitution. Some are defined in a comprehensive scope included many aspects.

According to Löfstedt (2014), he illustrates the definitions of substitution principle from various sources with regard to different criteria in chemical regulatory and risk management context as follow:

i) "Substitution is the replacement of one substance by another with the aim of achieving a lower level of risk." (CEFIC, 2005, p. 1)
ii) "Substitution of a hazardous substance or product signifies its replacement by a less hazardous substance, product or process." (Ahrens, Braun, Gleich, Heitmann, & Lißner, 2006, p. 22)
iii) "Informed substitution is the considered transition from a chemical of particular concern to safer chemicals on non-chemical alternatives." (Auer, 2006)
iv) "If risks to the environment and human health and safety can be reduced by replacing a chemical substance, mixture or product either by another substance, mixture or product or by some non-chemical technology, then this replacement should be made. All decisions on such substitutions should be based on the best available evidence. This evidence can be sufficient to warrant substitution even if it only consists of hazard information and quantitative risk estimates cannot be mad." (Hansson, Molander, & Rudén, 2011)

As the definition of substitution principle introduced by the European Chemical Industry Council, the statement i) is a well-known definition which interpreted in a narrow scope. In some point of view, the interpretation in statement i) is acceptable among academics and

experts. As also commented by Möller, Hansson, Holmberg, & Rollenhagen (2018) in the handbook of safety principle, they say that "[n]ot surprisingly, the chemical industry has issued statements that define the substitution principle as referring to chemical substitution only" (p. 610). The context in this statement is limited in the replacement of any substances, it is not included functionality aspect and other concerned. The reason is this interpretation aims to restrict the set of options in the substitution of chemical substances (Aven & Zio, 2017).

Refer Aven's perspective, he comments on Löfstedt's work that the definition i) is appropriate in most cases. Aven (2014) clarifies that referring to 'substance' in the statement i) is viewed in a broad sense. In part of 'less hazardous substance' and 'safer substance' used in other definitions of the principles, such as i) and ii), are captured by 'a lower level of risk' with the condition that risk is suitably interpreted (p. 569). Although the definition i) has been widely mentioned in several literatures, many authors disagree and point out that it is not sufficiently precise. It may lead to limitations when applying the principle in practice.

Based on the viewpoint of environmental protection, other definitions have been interpreted in different ways, e.g statement ii), iii) and iv). Several experts have argued that there is a need to define the principle in a wider context of substitution. A definition that specifies on the purpose to find another chemical only can limit the search process, so that non-chemical or other options are not investigated (Swedish Chemicals Agency, 2007). Regarding the study of Oosterhuis's research, "the hazardous substance does not necessarily have to be replaced by another substance. It can also be substituted by other means of fulfilling the function it had. Thus, a hazardous cleaning agent (e.g., a chlorinated solvent) can be replaced by a less harmful one, but [it] is also conceivable that the product or production process is redesigned in such a way that the cleaning step can be omitted" (Oosterhuis, 2006). In this sense, some authors believe the substitution principle should be defined in the way of taking the other aspects into account as well.

Both statements, ii) and iii), have been argued by many authors because of a broader perspective. Refer to the statement ii), this definition is suggested by Ahrens, Braun, Gleich, Heitmann, & Lißner (2006) and they claim that it has a wide scope ranging from substitution in general to risk management as a whole (p. 22). Löfstedt (2014) also advocates that the statement ii) has a much broader perspective than the first statement. The interpretation in statement ii) is not restricted to a hazardous substance that may harm humans and the environment, but it also focuses on the hazardous product and process. In terms of statement iii), it is defined by Charles Auer, the former Director of the US Environmental Protection Agency's Office of Pollution, Prevention and Toxics. Often, this explanation has been mentioned in academic literature related to the substitution principle. The scope of the definition iii) also allows substituting of a substance by non-chemical one. Therefore, these interpretations are available more options for substitution which is considered as more applicable.

Consider the statement iv), this meaning of substitution principle is presented by Hansson and other scholars and they claim that it is a more precise definition. It is mentioned in many pieces of literature including the report presented by the Swedish Chemicals Agency (KEMI). In the

study of Hansson et al. (2011), their definition is summarized by taking all aspects into account as follow: (1) the purpose of substitution, (2) whether the substitution is chemical or functional, (3) degrees of funtionality, (4) whether substances, mixtures or products are substituted, and (5) whether substitution is based on hazard or risk. This interpretation aims to apply in a variety context. Refer to Löfstedt's point of view, he believes that this is another extensive definition. He expresses his opinion that the statement iv) has "[a] more comprehensive and far reaching definition of substitution principle." (Löfstedt, 2014, p. 546).

Besides these, there are still other definitions available. Most authors admit that this is a major issue of the substitution principle. The fundamental problem of the substitution principle is a controversial topic similar to what happened in the precautionary principle. As we can see, it is clear that the universal agreement and consensus on the definition of the substitution principle have not been reached until today. However, there is a need to figure it out this matter. Many researchers accept that the understanding of a basic concept is important for properly implementing the substitution principle. It may lead to the misuse of the principle eventually if the consensus cannot be achieved. Thus, the substitution is required an international agreement on how to define the principle accurately.

2.2.2 IMPLEMENTATION OF THE SUBSTITUTION PRINCIPLE

In practice, the substitution principle can be seen as part of chemical policy and regulations in Europe and other counties over the world. This principle has been applied through legislation in different ways. The examples of EU legislation to control chemical products are presented in the study of Hansson et al. (2011). Hansson and other authors summary the legislations related to the substitution into three main approaches. Some legislations are product-specific approach which regulates the possible dangerous substances and/or mixtures on particular products. The cases are illustrated by Hansson et al. as follow; the Toys Safety Directive restricting the use of CMR-classified substances, certain allergenic fragrances and metals in toys (European Council, 2009), the Restriction of Hazardous Substances (RoHS) Directive regulating particular substances and groups of substances in electrical and electronic equipment (European Council, 2003), and the directive for medical devices including special restrictions on CMR-classified phthalates (Council Directive, 1993). While some legislations are substance-specific, and the others are criteria-based approach. As specified in the manuscript submitted by Molander and Rudén, the substance-specific legislations regulate particular identified substances in the lists and the criteria-based legislations defining a necessary set of criteria to identify substances that are need to be regulation (Hansson et al., 2011).

Regarding the REACH legislation, Hansson et al. (2011) note that REACH mainly focuses on the regulations in the context of substances and chemical mixtures and having less attention on the use of substances in products. There is a list of a substance of very high concern (SVHC) to classify a substance that may harmful. In terms of the REACH authorization process in the next step, some of the chemical substances may include on the authorization list (Möller et al., 2018). Before using those substances on the list, the permission is required. This authorization requirement is a key driver process in current EU chemicals legislation for replacing a

substance identified in the SVHCs list by the alternatives with less harm (Hansson et al., 2011; Möller et al., 2018).

In discussions of Löfstedt (2014), one controversial issue has been discussed about the different views on the use of the substitution principle. On the one hand, some authors support the belief that a substitution principle is a tool that has a lot of advantages. They focus on a number of outstanding examples that seem to be a success in the sense of substitution. In Löfstedt's work, he refers to studies of Schorling (2004) and Ahrens et al., (2006). These authors provide optimistic viewpoints on the use of substitution. Form Schorling's point of view, many regulators and stakeholders always believe that the substitution principle as a strong tool that works quite well in terms of phasing out dangerous chemicals because there is a lot of successful cases (Löfstedt, 2014, p. 547). As an illustration, Löfstedt tells us about a web-based catalogue, known as www. CatSub.dk, which is organized by the Danish Environmental Ministry to present the successful examples of substitution more than 200 cases.

Also, Löfstedt mentions the viewpoint from Ahrens et al., (2006) that , if we apply the principle properly, the substitution concept contributes to innovation and a cleaner our environment at the same time. Ahrens et al. point out the advantage we gain in terms of new technology and innovation including a clean and safe environment. To support this point, Löfstedt illustrates that there is an example of a successful substitution in the bleaching process with chlorine-free substance. As we all know that chlorine dioxide is considered a toxic substance which widely used for bleaching the pulp to make a white paper. The shift to the totally chlorine free (TCF) in the paper industry is a good example described on how the substitution principle works through strict regulation and leads to innovation (Löfstedt, 2014).

In addition, Löfstedt represents a viewpoint from studies of Lohse et al. and Lokke that there are other ways to promote the substitution as such the posting of chemical lists (p. 547). The chemical lists are provided by several agencies from different nations whether it be Sweden, Denmark and the United States. As noted by Löfstedt, the study of the Swedish Chemical Agency based on the evaluation of the database in 2009 concludes that the lists of hazardous substances are helpful for the end-users to provide more information and knowledge. Besides the chemical list, there are many methods available in order to encourage or enforce substitution as summarized by Hansson et al. (2011), for example, developing green chemistry, substitution plans, economic incentives, and so on.

On the other hand, the other viewpoints contend that substitution principle is not a perfect tool. Based on Löfstedt's work, he reviews the different perspectives from environmental NGOs, Swedish Chemical Agency, the study of Ahrens et al., and the UK Royal Society of Chemistry. Löfstedt tells a story about the different views on how to implement substitution principle to make the point that this tool does not ideally work well enough. He finds that a major problem with using the substitution identified by Ahrens et al. (2006) is similar to the view of the Swedish agency in the way that substituting one substance by the safer alternatives does not always result in reducing chemical risk because the hazardous substances have complex risk profiles (Löfstedt, 2014, p. 550). Overall, he believes that the view from the UK Royal Society is rather different from the perspectives of either the NGOs or the Swedish Chemical Agency.

Refer to the viewpoint of the UK Royal Society, they suggest us to consider the substitution principle as "…it would be more or less another tool in the risk manager's tool box." (Löfstedt, 2014, p. 551). That is to say, the substitution principle is deemed to be just one from many tools in risk management only. Löfstedt's point is a number of researchers in this field think that the principle does not work well as much as it could do (p. 547). When considering the case studies presented on his work, he sums up that this principle is just a blunt instrument.

Others even maintain that the substitution principle should be used with care. It can be seen from a number of failure cases through the unreasonable enforcement of chemical regulations (Löfstedt, 2014; Nilsson, 2004). Similarly, studies of Hansson and the others reveal the issues and the suggestion related to this controversial topic. They demonstrate that the limitations on the use of substitution principle exist in many aspects as follows (Hansson et al., 2011):

a) The implementation in safety purpose does not cover all dangers.
b) The substitution principle focuses on chemical replacement.
c) Applying the substitution rule has an ambiguous due to no preference for the objective priority criteria.
d) The use of substitution is limited to hazardous substances or products.
e) Insufficient risk assessment with lacking evidence based.

In terms of the recommendation, Hansson et al. (2011) underline that this tool is not an absolute principle, but it should be understood as an efficient first-hand method to meet the target in order to reduce chemical risk. The substitution is needed to apply together with the other safety tools as being a continuous development, what matters here is this principle cannot be used as a single decision. (p. 456).

Summing it up, there is a discussion on both an optimistic and pessimistic view about the use of substitution principle among academics and experts. From these viewpoints, it cannot be denied that the notion of substitution is a useful risk management tool in many ways. However, this tool is far from perfect. This fact is shared by several authors. Clearly, there still have some limitations even we may handle it right.

2.3 The Relationship between Precautionary and Substitution Principle

When it comes to the topic of substitution principle, a question has been raised whether this notion relates to the precautionary principle. As we can see in policy and regulatory context, a discussion on the substitution principle is associated with the use of the precautionary principle. While some are convinced that the use of substitution principle is considered as cautiousness against risk. Since the precautionary principle can be described as expressing a form of cautiousness, we could say that the substitution principle is just all about being cautious. In the report of the Swedish Chemicals Agency (KEMI), they admit that the discussion about the relationship between precautionary and substitution principle is somewhat unclear. Thus, the

Swedish agency point out that the difference between cautiousness in general and the precautionary principle should be clarified initially.

In terms of cautiousness, the basic concept of being cautious comes from mainstream decision theory and it related to expected utility maximization (Swedish Chemicals Agency, 2007). The expected utility maximization is an approach for decision-making to show the possible options with the probabilities in statistics. As illustrated by Swedish Chemicals Agency (2007), this approach is generally known as the risk-neutral decision rule.

The decision rules focus on avoiding the worst possible outcomes by taking alternatives with the opposite direction, for example, chosen either alternative for prohibition or no prohibition towards any substances (p. 21). The point is the possible outcomes from this method depended on the input information and assumptions. In theory, the exact values must be assigned to both outcomes and probabilities, but it does not be like that in practice. As we all know, the assumptions made may be wrong due to limited knowledge. The assigned probabilities can be imprecise in most cases. Consequently, the risk-neutral point cannot be precisely defined, and also cautiousness is not either precisely definable as well (Swedish Chemicals Agency, 2007).

A decision-making approach is the way of being cautious in safety context. The way of thinking has limitations due to the uncertainty of the assigned numbers. Based on this concept, Swedish Chemicals Agency (2007) summaries that the substitution principle can be considered similarly as applying cautious decision-making when we interpret the principle as a part of a general safety engineering tradition attempts to avoid uncertainty (p. 21). In the context of safety, we are able to control of chemical risk but it is hard to get rid of it completely.

Common sense seems to dictate that the substitution principle can be interpret similar to being cautious. On the other hand, the Swedish Chemicals Agency (2007) also identifies that the definition of the precautionary principle should not be interpreted as just consciousness. Being alert to danger does not cover all aspects of the precautionary principle. The meaning of the principle has more dimensions than that as discussed in many literatures. Even there is no consensus on the definition of the precautionary principle, it is broadly understood as a special case of the cautionary principle in accordance with the scientific uncertainty. The Swedish agency refers to some examples of the precautionary principle to summarize the main purpose of using this principle. Two main purposes of the precautionary principle are clarified as following (Swedish Chemicals Agency, 2007, p. 22): (1) being cautious, risk-averse, and on the safe side against possible dangers, and (2) be able to take any actions even in the absence of full scientific evidence. Scientific knowledge is a key point for the precautionary principle used as a tool for decision-making. To introduce the precautionary policy, the policy-making will consider the scientific evidence as well as the other aspects under the precautionary principle. The decision on policy-making is based on the level of evidence leading to the challenge on how to implement it. I will discuss further on this matter in the next section.

Be aware of the unknown outcomes is part of the precautionary principle. It is concerned with the scientific knowledge which affects the decision made. If we consider the notion of the substitution principle in overall, the precautionary principle is interpreted in the way of science-

based precaution which does not exactly the same as the meaning of substitution principle (Swedish Chemicals Agency, 2007, p. 24). To be clear, the Swedish agency explains that the precautionary principle takes the criteria into account when starting to take protective action in most cases whereas the substitution principle primarily is about a preference for one particular form of such protective action, for example, exchaging substance (p. 24). However, it cannot be denied that there is a relationship between two principles in either way. As noted by the Swedish agency, "the two principles are part of the same type of cautious thinking" (p. 24). The cautious thinking covers the principle as a whole whether it is full of scientific evidence. In this sense, it is also pointed out by the Swedish agency. that both principles are applied in order to support and strengthen each other.

Most of academics and experts readily agree that there is a link between precationary and substitution principle. According to Löfstedt (2014), he refers to the argument in the study of Hansen, Carlsen, and Tickner as the following manner:

> *Examining and substituting hazardous chemicals with safer alternatives is a key element of precautionary thinking and the availability of feasible safer alternatives or services should be seen as sufficient rationale under precaution to restrict or phase out the use of hazardous chemicals. (S. F. Hansen, Carlsen, & Tickner, 2007, pp. 399–400)*

Base on this statement, Löfstedt (2014) advocates the fact that implementing the substitution principle in the preventive policy is also inherently associated with the precautionary principle. It makes sense that the substitution principle is related to the precautionary principle to some extent.

Similarly, Aven (2014) also agrees with Löfstedt and other authors. As argued by Hansen, Carlsen, and Tickner above, they say the notion of substitution is a key element of precautionary thinking. To be more precise, Aven (2014) also refers to cautionary thinking instead in order to cover two specific cases, the cautionary and precautionary principles. As I mentioned earlier, the precautionary is a special case of cautionary principle. Both notions are quite similar unless the cautionary thinking is a general term of the principle to apply when we have scientific certainty. Consider the definition i) of substitution principle that I mentioned in the subsection above, we apply the principle in order to achieve a lower level of risk by replacing one hazardous substance with another well-known one which is maybe considered a safer substance. Referring to this interpretation, Aven (2014) explains that the use of substitution in that sense aligns with the cautionary thinking which is meant by we should take the action to reduce possible risk when there are no scientific uncertainties.

So far, the perspective of experts on this subject is in the same direction. The clarification aims to make the discussion clearer. As per the discussion above, the substitution principle does not definitely mean as same as the precautionary principle. Even the consensus on how to define the precautionary principle does not exist, but we all know that a basic concept is concerned about being aware of such harm and taken the actions, if necessary, to avoid risk. Of course, there is a close link between the two principles and supported each other. Therefore, it seems

obvious that the substitution principle has coherently connected to cautionary thinking which is interpreted as a part of the precautionary principle.

2.4 POLICY-MAKING IN EUROPE

Policy is essential to determine the country's direction and priorities in the future. Any actions are taken by governments namely public policy to solve a need or issue in society such as public concern (McCormick, 2011). Policy related to risk is considered as one part of risk analysis with a scientific basis (Aven, 2019). It also reflects on how the government responds to public attention such as transportation, climate change, a toxic substance, and so on. It comes as no surprise that the policy has changed over time which depended on many factors in accordance with the global situations. Since the Norwegian climate policy follows EU legislation under the European Economic Area (EEA) Agreement. Therefore, there is a need to understand policy-making in Europe in this era.

2.4.1 IMPROVING TRANSPARENCY IN REGULATION

Today, environmental issues become a hot topic in politics. Several public policies have been introduced to addressing these problems in order to reduce risk. Basically, an environmental policy is aimed to control human activities and thereby prevent harmful consequences on the biophysical environment and natural resources, as well as to make sure that changes in the environment do not have harmful effects on humans (McCormick, 2001, p. 21). Changing commitment to policy influences such a remodel in regulations, laws, and other instruments in order to achieve its objectives. As public policy has a broad impact on people, businesses, the nation's economy, and all concerned parties, the public trust is a key for policy-making and regulation. It is not limited to the environmental policy only but also covers other type of policies. A number of researches in the field seem to indicate that there has been changed in the style of governance because of the issues in the old model contributing to such a failure in regulation (see e.g. Lofstedt, Bouder, Wardman, and Chakraborty 2011; Lofstedt 2014; Greer and McLaughlin 2017; Frewer and Salter 2003). This transformation becomes important for policy-making these days with the increasing new roles of various actors influenced to make a decision for risk reduction.

Declining trust in government due to scandals from media coverage contributes to regulatory failure (R. Löfstedt, 2014a; Lofstedt et al., 2011). Sometimes, the judgement cannot wait for full scientific evidence, and then such a decision may go wrong leading to loss of public trust. Lofstedt, Bouder, Wardman, and Chakraborty (2011) call the traditional regulatory model as 'old consensus-style' and describe the features based on their studies as the following: (i) secretly consensus between policymakers and industry, and (ii) only a small elite group has empowered to make a regulatory decision (p. 409). The old consensus style in regulation can lead to the problem in policy-making. With the regulatory failure and no public participation, it appears that the trust in government decreases incorporated with media coverage and thereby it becomes worse (Greer & McLaughlin, 2017; Lofstedt et al., 2011). The mad cow disease which is one case has been widely discussed on the impact of losing trust in science (see e.g.

Lofstedt, Bouder, Wardman, and Chakraborty 2011; Jacob and Hellström 2000; Powell and Leiss 1997). Besides this, other examples are also illustrated such as the vaccines and chemical products. These are the case studies of failure associated with the old-style regulation. Therefore, there is a need to regain public trust in risk governance.

To solve the trust issue, several scholars have observed a change in the model of regulation from the old consensual style to be a more adversarial. They agree that the model of regulation has turned into the new style which is obviously different from the traditional model. The participation of citizens through any organizations and media becomes an important role in regulatory policy-making. Lofstedt, Bouder, Wardman, Chakraborty (2011) and the others state clearly that the new regulatory model is based on transparency, public participation, the pressure from NGOs and social as well as environmental values. These factors also entirely influence to regulation process currently. The power of policymakers and regulators decrease in the current regulatory style while increasing the role of other stakeholders equal to scientists and enhanced public participation (R. Löfstedt, 2014a; Lofstedt et al., 2011). This change is aimed to improve transparency in the regulatory process. It helps to encourage citizen engagement but decreases role in other stakeholders.

Despite enhanced transparency in the regulation process, there are still left some problems which probably occur initially when we start the new project, including unforeseen consequences after implement the policy (Lofstedt et al., 2011, p. 410). The scholars mention these outstanding issues whether it be teething problems and unforeseen consequences in their recent work. The absence of available knowledge may cause unforeseen circumstances due to the uncertainty. It is evident that it does not exist only with teething problems. The questions about the role of science in the new regulatory model have been raised among scholars (e.g. Lofstedt 2014). Most concern is the judgement on a policy should not solely base on what people believe, but consideration needs to focus on the fact. It links to risk perception as presented in the previous section.

To summarize, the scandals in such a failure of regulatory decision-making lead to a loss in public trust in government and scientists (Lofstedt et al., 2011). To regain public trust, there is a need for more transparency in the regulatory process. Several scholars point out that the role of new actors whether it be media and NGOs has increased significantly as well as public opinion, whereas scientists become less important than it used to be. Therefore, a current regulatory model emphasizes transparency and citizen engagement to address the trust issue due to past failure. However, a number of scholars find that some problems are still there and also probably have unexpected consequences later on even moving to the era of regulatory transparency.

2.4.2 Role of Evidence-Based and Risk Informed Decision Making

Disclosing information in regulatory decision-making becomes mandatory to rebuild public trust. The role of evidence-based and risk informed approach has been criticized from several experts. While the precautionary principle is not well defined, there is a challenge of policy-making and regulator when it comes to practice for making a decision on the transition policy. The interpretational issue of the precautionary principle is the challenge for policy-making. Even each nation in the EU uses the principle in different ways, thus it is difficult to say that which one is more suitable. In discussions of Löfstedt (2011), one controversial issue has been the regulatory decision-making in the European Union. He summaries that “there is no clear consensus as to when risk or hazards considerations should be the basis for regulatory decision-making" (p. 149).

In response to these challenges, the solutions have been suggested on several works. A number of academics agree on the point that the regulation should be established with basis on more evidence-based and risk-informed decision-making (Löfstedt, 2014; Lofstedt, Bouder, Wardman, & Chakraborty, 2011; Löfstedt, 2011). According to Lofstedt et al., (2011), they give a recommendation to do the scientific peer review of risk assessment used for regulations to review the assessment and take into account all risk aspects concerned before making the decision. This process is in accordance with the theory in risk analysis process. Additionally, the regulatory agencies have to focus on multiple risks instead of a single risk to avoid the other adverse consequences (R. Nilsson, 2004). On the one hand, the policymakers should have a better communication of risk and support the coverage of media based on the scientific facts, as well as constructive deliberation in public (Lofstedt et al., 2011). The policymakers and regulators need to distinguish the belief and fact to search for the actual risk to manage risk in the right way (R. Löfstedt, 2014a). With reliable evidence in science, the decision on what to do to prevent persons and the environment be safe from the toxic chemical could be implemented appropriately.

Mostly, environmental risk is considered having a deep uncertainty. When the future consequence is unknown, it is difficult for decision-making. The decision in policy-making should not only focus on the public concerns, but also need to give weight on scientific evidence and risk analysis. Policy teams are responsible for risk-based decisions at a project and operational levels and for informing risk-based decisions at the program and strategic levels (Mauelshagen et al., 2014). Thus, the policy-making needs effective risk management to informative the effect in all points of view. If we pay more attention to the environmental value, we may have economic losses. It is vague on how to implement the precautionary principle in a proper way for policy-making in order to balance between safety and economic aspect.

2.5 ILLUSTRATION: SWEDEN AND ITS CHEMICAL POLICY

2.5.1 VIEWS TOWARDS THE CHEMICAL CONTROL POLICY

Nowadays, people believe that Sweden becomes a global leadership role in sound chemicals and waste management. Nilsson (2004) is an opinion that the Swedish chemical control policy applies the precautionary principle in an extremist way. The chemical control policy has strictly implemented by using the precautionary principle, to enforce a law to ban or restrict the product concerned with chemical substances in Sweden as well as put forward the proposal of chemical regulation in the European Union. A core instrument is also applied, namely substitution principle, which is the replacement of hazardous, or potentially hazardous, chemical substances by less hazardous alternatives. (Hansson et al., 2011).

As per the interpretational issue of precaution, it could result in the misuse of the principle and thereby may lead to unforeseen consequences. Nilsson (2004) told that there are a lot of failure cases because the Swedish government applies the precaution on the chemical regulations based on the possible risks with, sometimes, lacking scientific evidence-based approach. The chemical regulations in Sweden have impact on some people and businesses. It is not fair enough for them. According to the statement on Nilsson's work, he comments that "[i]t has been widely realized that acceptance of an extremist interpretation of the precautionary principle such as that used by the Swedish government could prove to be seriously disruptive for society" (p. 115). Similarly, Löfstedt also has criticized about the chemical regulation of Swedish government. Löfstedt (2011) concludes that there are the discrepancies on the basic for regulatory decision-making among the member of the European Union. For instance, "the UK is overall more risk based than Sweden" (p. 149). With the interpretational issue, it comes as no surprise that why the implementation of precautionary principle is not applied in the same level.

2.5.2 THE SHIFT TO A TOXIC-FREE SOCIETY

Since 1960, the environmental issues have been placed in the Swedish political agenda. However, risk perceptions of these issues have changed significantly (Andersen & Liefferink, 1999). Refer to the official policy report (Swedish Environmental Protection Agency, 2013), the chemical policy there have three major challenges and 16 environmental quality objectives to achieve as the following: (1) Reduced climate impact, (2) Clean air, (3) Natural acidification only, (4) A non-toxic environment, (5) a protective ozone layer, (6) A safe radiation environment, (7) Zero eutrophication, (8) Flourishing lakes and streams, (9) Good-quality groundwater, (10) A balanced marine environment, flourishing coastal areas and archipelagos, (11) Thriving wetlands, (12) Sustainable forests, (13) A varied agricultural landscape, (14) A magnificent mountain landscape, (15) A good built environment and (16) A rich diversity of plant and animal life.

Löfstedt (2003) identifies that the objective of being sustainable forests has the greatest influence on current chemical control policy. Sweden's Chemicals Agency has published its

toxic-free environment strategy for the period 2015-2020. Consider the objective of a non-toxic environment, it states that "[t]he environment must be free from man-made substances and metals that represent a threat to health or biological diversity" (R. E. Löfstedt, 2003). Unfortunately, the Swedish Chemicals Agency, called Kemi, announces that its objective of sound management of chemicals by 2020 will likely not be achieved and continued actions will be required.

Refer to the progress report from the Swedish Chemicals Agency or Kemi, the reasons why the target has been missed was about total exposure to chemical substances, lacking knowledge of chemical and environmental properties, currently instruments, polluted area, information on hazardous substances in articles and difficulty to make a clear forecast. Based on the Swedish council's assessment, they say "[t]his objective will be very difficult or not possible to achieve by 2020, even if further action is taken. No clear trend in the state of the environment can be seen" (Nilsson et al., 2009). There probably was a sight earlier that it might be impossible to set targets to reach upon 2020.

2.6 SUMMARY

The literature review is studied covering the wide scope of the master thesis. Many theories have been proposed to explain the role of science in policy-making, risk perception, the precautionary principle and substitution principle. Most early theories of the precautionary and substitution principle which used in environmental policy-making are completely available from various papers. Although the literature covers a wide variety of such theories, this review focuses on five themes which emerge repeatedly throughout the paper. These themes consist of the policy-making in Europe, the regulation model, precautionary principle, substitution principle and the case study of the chemical control energy in Sweden.

Regarding the policy-making, most of the articles agree that the scientific facts and risk analysis are important and also provide the other suggestions for the better decision in policy-making. Furthermore, the use of the precautionary principle in environmental regulation is highlighted in several recent works. The scholars have similar comments on the interpretational issue of the precautionary principle, as well as the critique of the use of precautionary in the Swedish chemical control policy.

So far, most the literatures in the topic of precautionary and substitution principle are available limited in the Swedish chemical policy. I found that there is still lacking the research on the energy policy in regard to these policies. This is a gap of the research in the change of policy. So, I think further research could be conducted on the analysis of the energy policy in Norway. The research can study on the use of precautionary and the target setting. Besides, the comparison of the policy between two case studies of Sweden and Norway may provide a more clear picture of the role of risk-informed and analyze the possibility of the policy to become successful when it comes to practice.

Chapter 3 – Research Methodology

3.1 Research Design

Precautionary policies are introduced to overcome environmental risks. Clearly, the substitution principle is a subset of the precautionary principle. Setting goals and objectives of the policy would be more or less significant depending on whether it is possible to achieve them. As is demonstrated in the Swedish case, the objectives of becoming a toxic-free society by 2020 was not successful. In comparison, the question has been raised when considering the context of Norwegian energy policy. It would be meaningless to set target goals that could not be met in reality. The general question of investigating how realistic such a goal could be in this context, is the motivation for this research. It is an assumed that Norway would not realistically be able to become a low carbon society within is the long-term target time frame, similar to the case in Sweden. What is demonstrated within the Swedish case influences the hypothesis of this research. The research is aimed to gain the depth input information about perspectives of the energy shift and the current policy in Norway. Therefore, a quantitative method is chosen, which separates into two-parts: (i) content analysis of the policy documents, and (ii) interviews.

The focus of this research is on the implementation of precautionary and substitution principle in energy policy. In-depth exploration was preferred, as a quantitative experimental study might not be the best option for this research. Instead of conducting numerical measurement, e.g. survey, with a large sample, qualitative methods seemed more suitable because these approaches have less control, while being more interpretive. However, the research was limited by the number of samples. Therefore, the content analysis of policy documents was been added to strengthen results of the research. Qualitative methods with content analysis and an interview platform have been selected to describe and gain in-depth insight from the key informants into the notion of the precautionary and substitution principle that is applied within transition policy.

Due to some limitations during the pandemic of COVID-19, the interview-based study was adjusted to collect data from a small target group, known as a pilot interview. The target group of this research is individuals such as experts, researchers, and working professionals who either have knowledge or experience in this field related to the energy transition and its policy. The intent of such a targeted group is to get results based on real-world knowledge in order to analyze the individuals' beliefs in regard to the interview questions and in turn addressing the hypothesis. Thus, a semi-structured interview method as a pilot study was conducted to answer these questions of this research for further content analysis.

3.2 DATA COLLECTION AND ANALYSIS

Data was collected based on a systematic review of relevant literature and targeted interviews. Regarding existing literature, the information related to the case studies was mostly gathered from online platforms, such as Oria, Google Scholar, and the Norwegian government webpage. In the study of the Norwegian policy, following recommendations by the thesis supervisor, it was decided to conduct the semi structured interviews using open ended questions.

The interview invitations were sent via email to 22 target participants, although a limited number of responses were received. The target interviewees were selected by focusing on the individuals who had the background knowledge and experience in the energy field as well as risk policy. In order to gain a better insight into the possibility of achieving the low carbon goal through energy policy, semi-structured interviews were conducted with six interviewees who accepted my email invitation.

In this research, in-depth information was required to answer the thesis's problem. The open-ended questions, including some probes to get more information, were prepared for the interviews. Due to the outbreak of the COVID-19 virus, the online platform was the only option for communication. The interviews were conducted through an online meeting and lasted approximately 45-60 minutes each. Answers were both voice recorded and documented in note taking. All interviews were recorded with consent. In addition, the interview results were transcribed precisely, and the key themes were categorized. See table 1 as follow.

Table 3.1 Categories of Interview Questions

Relevant Topics	Interview Questions	Key Themes
Areas of Expertise	1. Tell me about your background and experience? 2. What is your current work about? • What are your responsibilities at work?	Energy Transition Energy Policy HSE and Safety
Energy Transition	3. How is energy transition important?	Reason for Energy Transition
Substitution Principle	4. In your opinion, what will be the most potential source for future energy?	Energy Alternatives Sustainable Energy
Energy Transition	5. What are the main challenges in terms of legal, economic, costs and benefits to health, and environmental impact for the energy transition in Norway? • What are the risks we may confront? • What are the benefits of the energy transition?	Challenges to Energy transition

Table 3.1 Categories of Interview Questions – (continue)

Relevant Topics	Interview Questions	Key Themes
Substitution Principle	6. What is required for the energy transition in Norway to achieve its goal?	Requisites for Energy Transition Driving Force to Transition
Substitution Principle	7. What is your expectation on the future of fossil fuels in a low-carbon society in terms of the risks and benefits?	Energy Transition Phasing out Fossil Fuels Low-carbon society
Precautionary Principle **Substitution Principle**	8. How familiar are you with the notion of precautionary principle and substitution principle?	Understanding the Notion of Precaution and Substitution
Precautionary Principle **Substitution Principle**	9. How do you define the precautionary principle and the substitution principle?	Understanding the Notion of Precaution and Substitution
Precautionary Principle **Substitution Principle**	10. How the precautionary and substitution principles are applicable to the energy transition? • What are the pros and cons of using these principles?	The Use of Precaution and Substitution Towards Energy Transition
Precautionary Principle **Substitution Principle**	11. To what extent precautionary and substitution principles should be implemented in Norwegian climate policy? • Do we need to completely ban or phase-out the fossil energy? • Is it possible to completely replace fossil fuels with alternative resources?	Extent of Implementation Principle
Precautionary Principle **Substitution Principle**	12. As the transition goal to become a low-carbon society by 2050, whether the implementation of current instruments in Norway according to these principles are sufficient for the energy transition? If not, what will be further requirements?	Precautionary Measures Policy Goal

To analyze the data, a qualitative content analysis was conducted in a systematic and methodical manner for the pilot interview study. Content analysis is a research method that is directly related to messages of selected documents. This analysis method is aimed to describe inferences and interpretations on various characteristics of key informants, the receiver, the

context in communicating and so on. Data with the same message was then grouped into categories based on the aim of the study. This involved coding all the data before identifying and reviewing key themes. Each theme was examined to gain an understanding of participants' perceptions and motivations. The interview results analyzed, discussed, and externally validated using comparisons from policy documents and relevant literature, before coming to conclusion.

All collected data from performed interviews and the reviewed available publications were then used to study the hypothesis with comparison to the content analysis of policy documents, which will be thoroughly discussed in the following chapter.

3.3 LIMITATION

One of the limitations during this research was the matter of access to a limited number of experts and practitioners. Twenty-two invitations were sent to the target group, unfortunately, only six of the invitations were accepted. In addition, response times to the requests for interviews were quite long which is attributable to disruptions and uncertainty revolving around the COVID-19 pandemic.

Another limitation is that, the topic of the precautionary principle and substitution principle are very specific and not extensively well known, even to experts in the energy field. This limits the number of potential interview candidates. Additionally, in general the pandemic of COVID-19 caused some constraints in terms of communication and schedule arrangement.

These limitations to the research consequently led to reaching a lower number of participants for the interview then what was originally desired. Accordingly, the content analysis of policy documents was added to supplement the research designs. However, there also was a narrowness of the document selection because most papers were written in Norwegian, not English.

Chapter 4 – Results

4.1 Content Analysis of Policy Documents

4.1.1 The Selected Documents

The policy documents were chosen from the Norwegian government website. The aim was to conduct a content analysis within a specific scope of the thesis. The questions were raised focusing on the precautionary and substitution principle towards Norwegian's strategy and plan for moving forward to become a low carbon society. The types of documents that were gathered and analyzed consisted of the White papers, official reports, the strategy documents, news articles, and press releases.

Norway's climate policy lead to a need for the energy transition. The Ministry of Climate and Environment has responsibilities to determine the climate and environment strategy. While the Ministry of Petroleum and Energy focuses on finding alternative energy to replace fossil fuels. However, both ministries significantly get involved in the green transformation. While the Ministry of Foreign Affairs is responsible for the policies concerned with international cooperation. In terms of the Norwegian economy, the documents are published by the Ministry of Finance. Thus, these agencies play an important role to design the policies for the energy transition.

I determined that these documents could be considerably useful in answering the problem of the thesis. Information and understanding were gained with regards to the Norwegian states' goals in becoming a low carbon society by 2050. Hence, the policy documents were analyzed and then created the contents related to the questions of this research. Table 4.1 below shows the list of the documents linked to the data analyzed.

Table 4.1 Listing the Documents

Publishers	Documents selected	Type	Data analyzed
Ministry of Climate and Environment	Norway's Role and Interests in Multilateral Cooperation (2019)	White paper	Strategy and Role of Norwegian multilateral policy
	Norway's Climate Strategy for 2030: a transformational approach within a European cooperation framework (2018)	White paper	Contextual data on strategy and ambition to green transition
	Better growth, lower emissions – the Norwegian Government's strategy for green competitiveness (2017)	Plans and Strategy	The strategy for green competitiveness, principles and supportive policy to transition

Table 4.1 Listing the Documents – (Continue)

Publishers	Documents selected	Type	Data analyzed
Ministry of Climate and Environment	Norway steps up 2030 climate goal to at least 50 % towards 55 % (2020)	News Article	Contextual data on strategy and ambition to green transition
	Norway's Fourth Biennial Report (2020)	Report	Data on reporting progress towards Norway's 2020 target
	Norway's Seventh National Communication (2018)	Report	Data on the latest national circumstances, policies, and measures related to climate change
Ministry of Petroleum and Energy, Ministry of Climate and Environment	The Norwegian hydrogen strategy (2020)	Press release	Contextual data on strategy and ambition to develop hydrogen-related technologies for substitution.
	Important milestone for CO_2 projects achieved (2020)	Press release	Data on reporting progress of technology lead to faster transition
Ministry of Foreign Affairs, Ministry of Climate and Environment	Norway signs agreement on funding for Green Climate Fund (2020)	Press release	Data on promoting substitution
Ministry of Foreign Affairs	Common Responsibility for Common Future (2017)	White paper	Data on policy agenda for globally sustainable development towards 2030
Ministry of Finance	Long-term Perspectives on the Norwegian Economy (2017)	White Paper	Data on the future of Norwegian greener economy
	Climate risk and the Norwegian economy (2018)	Official Norwegian Reports	Data on confronting climate risk and economic risk

4.1.2 IMPORTANCE OF ENERGY TRANSITION

The energy transition has become a challenging political topic globally. After investigating the policy documents, a major agenda of the energy transition policy links to climate change. Therefore, it is not surprising that the energy shift in Norway is driven by climate policy. A need for transformation is caused by significant climate risk. Most scientists have reached a consensus on the global warming issues and the IPCC report has been clear in this matter. It is evident, based on several studies, that greenhouse gas emissions lead to an increase in global temperature rapidly and thereby result in the raising rising rate of occurrence of extreme weather events (Norwegian Ministry of Climate and Environment, 2017a, p. 8). The Norwegian government has decided to take serious actions to deal with this risk because it may

lead to unforeseen consequences. The White papers and other documents mention the scientific research in this matter as the evidence basis for supporting the government's decisions. According to the White paper of Norway's Climate Strategy for 2030, "[t]his explains why we urgently need to reduce global emissions and take steps to adapt to unavoidable climate change" (2017a, p. 9).

After a review of the literature, it could be said that the energy shift to become a low carbon society in Norway is associated with climate policy proposed by the Ministry of Climate and Environment. Clearly, global warming will impact Norway in terms of temperature fluctuations (Norwegian Ministry of Finance, 2018b). The policy documents state the importance of becoming a green society as it is mainly concerned with the environmental perspective. Thus, there is no doubt that a need for the energy transition to reduce greenhouse gas emissions is due to mitigating climate risk. It is well known as sustainable development, which is a current global trend. The climate policy in Norway depends on a call from the European Union under the Paris Agreement for the target of greenhouse gas reduction, thus the Norwegian government has determined a long-term policy following the agreement with the union. The policy documents state clearly that Norway wishes to become a low-emission country by 2050.

4.1.3 CLIMATE RISK VERSUS NORWEGIAN ECONOMY

Norway plays a role as an energy producer. Norwegian economy, without a doubt, relies on the export of oil and gas. The revenues from petroleum activities are essential to the state's welfare to citizens. A question has been raised on the impact to the Norwegian economy, as phasing out of fossil fuels would affect to the oil and gas export sector. It is important to note that we would not want to end up facing a new risk after tackling climate risk. The government's report investigates and analyzes this matter. It means that this is also a concern for policymakers and regulators, including the public. The official report has been published to clarify the actual risk confirmed by research results of long-term perspectives on the Norwegian economy. The report is based on a risk-informed systematic approach to the authorized persons, the parliament, to determine the long-term strategy. It reflects that the scientific-based analysis can assist the decision-making process. An increase in the present ambition shows that the government has more or less confidence in reaching climate goals.

In reference to the studies of the Norwegian Petroleum Directorate, the finding is that the oil and gas industry will largely no longer encourage economic growth due to a decline of demand worldwide (as cited in Ministry of Finance, 2017, pp. 4-5). To avoid business disruption, it is a good opportunity to be a leader of the energy transition because Norway has potential and will have a competitive advantage in renewable energy. The official Norwegian report (NOU) on 2018 identifies "[a]n overall assessment of key risk factors indicates that the Norwegian economy is relatively resilient in a scenario with moderate climate change" (p. 5). The government defines risk associated with the impact of climate policy and technological developments for the transition to a low-emission society as 'transition risk' (Norwegian Ministry of Finance, 2018a, p. 16). They believe that this risk is acceptable compared to climate

risk. However, it also depends on effective policy instruments and transition costs. The government concludes this matter on the official report that transition risk is still manageable as long as the costs are not excessive and come along with the effectively driven policies (Norwegian Ministry of Finance, 2018a). Thus, there are conditions in order to become successful in energy transformation as well as dealing with climate risk effectively at the same time.

In conclusion, the report presents that the Norwegian government perceives risk related to energy transformation and developing new technologies and considers giving priority to mitigating climate risk. The government admits that climate risk is important to realize and has taken actions to respond to such a risk thoughtfully. Hence, the strategy in climate policy is aimed to reduce emissions while still maintaining the state's welfare. This is an economic problem to occur following the transition, but the government believe that this risk can manageable.

4.1.4 THE AMBITION AND STRATEGY FOR THE TRANSITION

Global climate change has an extreme impact on humanity based on several scientific observations over the decade. In Norway, the Norwegian Parliament is called 'The Storting' which has responsibilities of establishing climate policy overall (Norwegian Ministry of Climate and Environment, 2018). The government documents indicate that Norway has a strong position in climate policy and the intention of moving forward to a green society. The Norwegian official report presents the climate targets until 2050 as (Norwegian Ministry of Climate and Environment, 2018): (1) Reduce emissions by 30 % by 2020, (2) Reduce emissions by at least 40 % by 2030, (3) Climate neutrality by 2030, (4) Low-emission society by 2050.

Recently, Norway takes a challenge to reflect its ambition in mitigating climate risk with proposing an increased target up to at least 50% and until 55% by 2030 compared to 1990 levels to reduce carbon consumption under the Parris agreement (Norwegian Ministry of Climate and Environment, 2020b). The Minister of Climate and Environment, Sveinung Rotevatn, claimed on the news article that, "[n]orway is one of the first countries in the world to submit a strengthened target under the Paris Agreement. [t]oday's decision is an important step towards a low emission society in Norway". It reflects the effort of the government to become a pioneer in the global energy transition. Somehow, this step could encourage other developed countries being even more ambitious in carbon reduction. The report indicates that the new opportunities from the transformation will emerge in terms of green competitive advantage. Common sense dictates that Norway would gain more advantages than the others if being in the frontline of the energy shift.

In reference to the strategy for green competitiveness (2017), the expectation of a low-emission society should be accompanied with an increase in value creation and high employment, as well as a better environment. It means the government is attempting to balance the environmental aspects and financial contributions to sustainable development. The strategy for 2030 was launched to achieve the 55% emissions goal before moving forward to a long-term

target for 2050. It shows that the government has a step by step plan. It seems the focus is on the transport section. There is the intention to reduce carbon emissions more in this sector. So far, Norway is quite a success in reducing emissions in the transportation sector. However, carbon reduction strategies should be implemented more thoroughly in other sectors as well, in order to reach the long-term goal. At this point, the strategy documents present that the government has policies for agriculture, aviation, and shipping sectors. These all conform to climate policy and the first goal is to achieve the emission target of 2030. If this target is unable to be achieved, the long-term goal would be far away from realistic.

The government always has been exploring alternative energy, and recently, the Minister for Petroleum and Energy, and Minister for Climate and Environment of Norway presented the strategic plan for hydrogen at the press release on the 3rd of June 2020. The Minister of Climate and Environment Sveinung said that "[h]ydrogen will be an important contributor towards a low emission society, particularly for transport and industry. We have strengthened several of the instruments bringing hydrogen solutions closer to the market" (2020). This is a new opportunity in the substitution of fossil fuel with renewable energy. The coming hydrogen fuel means that there still is space for fossil fuels to remain our energy source in the future green society. However, clean hydrogen requires the technology of carbon capture and storage in production. The literature indicates the government will increase funding for conducting further research about this new technology. There also is an international agreement to support the development of capture, transport and storage of CO_2 (CCS), which presents a more progressive in the new technology (Ministry of Petroleum and Energy & Ministry of Climate and Environment, 2020). This can be another option since renewable energy sources, such as wind or solar, also have constraints.

4.1.5 THE NOTION OF PRECAUTION AND SUBSTITUTION IN CLIMATE POLICY

Scientists have suggested that precautionary measures should be taken to prevent disaster from climate change. It is well known that there is a need for a shift to a green society because of climate risk-mitigating factors. The precaution principle is requited to deal with climate risk. The precautionary measures involve the substitution concept directly to both the replacement of fossil fuels and the type of technology. Neither the precautionary principle nor substitution principle has been specified in the policy documents written in English and there is no fundamental concept specified in the documents. Nevertheless, an expression in these documents clearly implies the concept of precaution and substitution.

In reference to the precautionary principle, the policy statements indicate implicitly that there is no scientific evidence which can accurately predict future consequences of climate change (see e.g. Ministry of Finance, 2018). In this sense, the precautionary principle has to be applied to manage that risk. The 2018 official Norwegian report on the climate risk also states that "[w]e recommend a set of general climate risk management principles for both the private and the public sector" (p. 10). Even if it is not mentioned directly, it is implicit referring to the precautionary principle. In terms of the substitution principle, the government has presented

several policies related to this concept, both of substituting directly and encouraging substitution either way. For example, the strategy of hydrogen fuel and CCS technology development. Even the basic policies about wind and solar energy. I found that the new technology is significantly to promote the substitution required leading to the low carbon society. Without supportive technology, it is impossible to generate power from renewable sources. The development in technology is a key for the energy transition and climate policy. Norwegian policy to provide funding in the technology development tends to go up every year.

4.1.6 THE PROGRESS FORWARD TO THE TRANSFORMATION BY 2050

Setting goals is mandatory in policy-making and it should correspond to reality. Norway has proposed a long-term climate policy to become a green society by 2050. It is still unclear whether the goal achievable. The government has implemented a lot of measures such as regulatory, economic, and research based. The policy documents dictate the first priority is on the coming target of 2030. The documents stipulate that there is significant progress in many areas whether it be the CCS technology, hydrogen fuel, and so on. The government tends to implement progressively more ambitious instruments to reach the new target emissions upon 2030. If the government still maintains to implement the measures in this level or even more, it would be possible to reach the target for 2030. Although it is also dependent on many other factors. On the other hand, the goal of a green transition within 2050 is still vague. It is difficult to say whether we could meet the target. The documents do not specify that much about the 2050 goal. It is mentioned that this is a long-term goal only. Even though there is a lot of progress in technology and ambition in carbon emissions, the likelihood to meet the target is still in doubt. There is no clear statement in the policy document with regards to this matter.

4.2 INTERVIEWS

4.2.1 AREAS OF EXPERTISE

Interview participants were asked to explain their background and experiences in the related field, since it is important to know how much they understood regarding the energy transition, and what their professional background and current job is, as well as their responsibilities at work. Common sense holds that people perceive in any matter differently and respond in different ways. This could also make it clear to reflect public opinions in society and the difficulty for policymakers to make the right decision.

Observations and results show that all participants are from various professional backgrounds such as professor, master student, researcher, project coordinator and manager, risk consultant, HSE and safety engineer. However, the participants have a background and work experiences associated with the scope of this research. The difference in perspectives on the energy shift and the policy involved represent the variety of public opinions in society.

As I observed from the data collection, the viewpoint towards energy transition and its policy resulted in different aspects depending on their area of expertise, experiences, and current

work, including background knowledge. It was found that the educational background and work experiences affect the understanding of energy transition, but it turned out that most respondents agree correspondingly to enhance the level of enforcement of regulation to be more extreme. Therefore, the area of expertise was grouped with respect to the participant's current profession as Group J, Group P, and Group E. See the summary as below.

Table 4.2 Coding for Interviewees

Group	Coding	Profession	Field
Group J	**Junior Researcher 1**	Safety and risk consultant	Risk Management
	Junior Researcher 2	Junior Researcher	Industrial Asset Management
Group P	**Practitioner 1**	Project Coordinator	Renewable Energy
	Practitioner 2	Project Manager as a Principal Consulting	Oil and Gas Markets, Supply Chains, Renewables and Energy Transition
	Practitioner 3	Senior Technical Safety Engineer	HSE and Safety
Group E	**Expert 1**	Senior Researcher	Social science in Sustainability Transitions
	Expert 2	Professor	Energy Transition

4.2.2 EXPLAINING MAIN CAUSES FOR THE ENERGY TRANSITION

To begin with the first question in regard to the energy transition, the participants were asked about the importance of this transformation. For what reason, we need the shift to energy alternatives instead of the traditional energy resources. There are several reasons which lead to a need for the energy transition. Accordingly, the results represent the perception of the problems that we are confronting and the desire to seek alternative energy sources.

The results show that the participant's opinions were all in the same direction when it comes to this theme. All of interview participants mentioned the environmental issues and environmental risks, especially, climate change as the main cause to this transition. Carbon emissions were described as the key problem of using fossil fuels. Each group revealed their viewpoints on this matter in detail, with slight variations.

In reference to group J, both respondents provided the response clear and concisely that it is because of climate change as to why there is a need for the energy transition. Junior researcher 1 said:

> *"Energy transition is important as the world evolves to more environmentally friendly and sustainable resources." (Junior researcher 1)*

Besides this, the response of Junior researcher 2 also mentioned another reason to support the transition which was the risk perception related to the scarcity of fossil fuels. Junior researcher 2 explained that:

> *"... even though [the energy transition] initially started for the fear of non-availability of fossil fuels in the near future. It [the change] is now evident that the transition to greener forms of energy is more needed to reduce the carbon emissions and mitigate the climate risks." (Junior researcher 2)*

Similarly, the interviewees in in group P believe that there is a need for the energy transition and the main cause is associated with environmental issues. Climate change and other environmental impacts were raised as the key factors to for a change in energy source. Their viewpoint on this matter is similar to the previous group. Although other concerns were also stated in the responses, eventually the most important cause was the climate issues.

Practitioner 1 presented that the energy transition today is not the first time in history. The transition has happened before since the wood was replaced by coal. Then, the second shift was substituted by fossil fuels. Even those transitions happened with different concerns from the current shift, but the main cause always has been to find a better energy carrier. In this transition to occur, the interviewee believes that it is because of climate change. See the excerpt from the response of Practitioner 1 as follows:

> *"Normally, when energy transitions that happened before, you have moved from a poor energy carrier to a better energy carrier. What has happened now is pretty much that we have this challenge of climate change which has been known about for almost 100 years, but it is really in the last 20 years. It [Climate change] has got mainstream attention and, of course, this is being a discussion on how severe it is, what can we do, how should we do it. Most experts agree that the main way to mitigate or stop climate change is to go from CO_2 intensive energy resources to less CO_2 intensive energy resources. So, pretty much, it [the main reason for the transition] is climate change this time responsible for this position." (Practitioner 1)*

The response above was similar to the viewpoint of Practitioner 3 which also mentioned the problem of climate change that contributes to a need for the energy transition. At the same time, Practitioner 2 accepted that the main reason is the environmental perspective, but also that there are other aspects to trigger this ambition, such as new technology and business opportunities. The response of Practitioner 2 was noted:

> *"Today, we are being that more and more on this moving forward not because of the need for it [the renewable energy sources] or environmental perspective, but the technologies are now competitive, and some economic benefits are in place. For example, electric vehicles are about to become cost competitive with fossil fuel cars. It will be superior in just a couple of years in terms of cost and performance." (Practitioner 2)*

In group E, the responses were similar to the rest participants. Expert 1 illustrated that the broad view of the energy transition is aimed to reduce carbon emission which causes climate change. However, biodiversity is also another problem as Expert 2 mentioned:

> *"It [fossil fuels] are the largest contributor to climate change. It is kind of obvious that you need an energy transition if you are going to reduce greenhouse gas emissions. But it [energy transition] is also very complex because it goes into every sector of society whether it be houses, buildings, the way you travel, what you buy. So, this [energy transition] is a key question together with biodiversity. You have this tension like onshore wind farms and biodiversity concerns, and so on. I mean there are tensions and conflicts between the two, but there are equally important in my view." (Expert 2)*

So far, the participants indicated that the energy transition is needed and important. Obviously, environmental issues were a top priority leading to the transition. Climate change seems to be the powerful driving force behind the transformation in this era. However, there have been other supportive reasons to accelerate a need for transition, whether it be technology development, resource scarcity, competitive advantage, or economic aspects. Furthermore, biodiversity becomes a major concern as well as climate change. Thus, the following table shows a summary of all responses according to this question.

Table 4.3 Illustrates the Reasons Behind to Energy Transition

Group J	Group P	Group E
• Environmental issues • The scarcity of fossil fuels	• Environmental issues • New technology • Business opportunities.	• Environmental issues • Biodiversity

4.2.3 Explaining Energy Alternatives to Substitution

As the energy transition requires the substitution of existing energy sources with renewable alternatives, the interview participants were asked their perspectives on energy source with most potential for the future. This question aimed to present the viewpoint on the opportunity to substitute the traditional energy sources with better options in the Norwegian context.

Considering the responses in group J, both participants mentioned that wind energy will be a high potential energy source in the future, especially in Norway. Besides this, Junior researcher 2 told us further that solar energy may become a crucial role in the long term as noted:

> *"I expect the wind energy to take the lead into the short-term future, the next 10-15 years to come. and then the solar energy will be the long term bet with the availability of advancement in battery technologies." (Junior researcher 2)*

In group P, the practitioners illustrated the variety of available energy sources. Mostly, wind energy was mentioned as having high potential in Norway. However, wind power is highly

unstable. Consequently, producing electricity from wind power alone is not sufficient for the demand. As Practitioner 1 responded in this matter, we cannot rely on only one particular renewable source currently because there still have constraints in terms of a steady supply of power, diversified geography, and so on. The respondent identified that we should use a combination of renewable energy options. The following is an edited excerpt from the interview.

> *"So, it is hard to give a precise answer [about the most potential source today]. I think maybe the one that will dominate the world the most in the next 20 years is probably solar energy because it is so easy to integrate into buildings and cities and the price has just been falling like 100 times over the last 40 years." (Practitioner 1)*

In the same way, Practitioner 2 also said:

> *"I think most of the energy will be produced from solar, but at least the wind will also have quite such a special here because of just a lack of available land basically. Also, we come up with a way to produce solar much more efficiently than wind energy today." (Practitioner 2)*

Besides, Practitioner 3 explained that the most potential energy source is dependent on the geographical location and when it comes to the context of Norway:

> *"In Norway, I would say wind energy because I saw many companies have invested now. Another one might be, for example, "Carbon Capture project" which is already the stating here in Norway. I hope this one [carbon capture and storage] will be the biggest one in the future." (Practitioner 3)*

In group E, the experts stated that traditional energy sources still play a crucial role during the transformation. They were of the opinion that fossil fuel consumption will continue, along with the new technology to capture CO_2 from its use in order to reduce the emissions. While a mix of renewable energy sources will be a remarkable alternative supply for power generation. Therefore, Expert 1 mentioned that future energy will be produced from a multitude of different sources. The following is a short excerpt from the interview:

> *"Unfortunately, I still think that sources such as oil and gas, and coal will be important also for quite some time. Then, obviously, solar and wind are increasingly the two most promising also because if we want a transition to occur fast enough. Of course, hydropower to the extent that it is still going to be relevant in many places. I think [the potential energy will be] a mix of different sources." (Expert 1)*

Similar to the response of Expert 2, there are two options available. Firstly, it is obvious that the one will be electricity which comes from renewable energy sources:

> *"If any country could electrify the whole society it would be in Norway that is because we have this huge amount of hydro. We have good resources for wind, both of offshore and onshore, and actually some potential also for solar." (Expert 2)*

Alternatively, hydrogen can be another option as Expert 2 noted that "…hydrogen might play an important and bigger role in the future energy system". The respondent also told us that hydrogen can be produced from natural gas combined with the technology of carbon capture and storage that opens the way to force the oil and gas industry to continue with natural gas within the carbon-constrained world. In this regard, the expert mentioned further:

> *"I think there are strong interests in hydrogen built on industries and the oil and gas sector and so on. When they feel the pressure more and more from political authorities and social movements and so on, they will have to move in the direction of hydrogen." (Expert 2)*

Yet, Expert 2 still believes that the potential energy in the future is moving towards electrification more than hydrogen.

After the data collection, it became evident that there is no such renewable energy source that can be used on a stand-alone basis because these power sources are intermittent. Although renewable energy consumption is increasing, fossil fuel still maintains to be used. In reference to all responses, several energy resources have a strong potential to be alternatives for the future. The common viewpoints expressed that the sources with most potential were solar, wind, and hydro. Besides these, natural gas also was discussed in terms of having lower carbon emission compared to petroleum products. The carbon capture and storage technologies are developing to reduce the greenhouse gas emissions from petroleum production. Table 4.4 below includes a summary of the mentioned results.

Table 4.4 Identifies the potential energy sources for the future

	The Future Energy Sources
Group J	Solar and Wind
Group P	A combination of renewable energy options, along with carbon capture and storage from fossil fuel.
Group E	A multitude of different sources whether it be wind, solar, and hydro. Also, fossil gas consumption is continuing with carbon capture storage.

4.2.4 EXPLAINING THE CHALLENGES TO ENERGY TRANSITION

The interview participants were asked to explain about the challenges for this transition in the Norwegian context. The scope of challenges was limited in terms of legal, economic, costs and benefits to health, and environmental impact, including risk and benefit. The key message of this question reflected the risk perception of the participants towards the energy transition.

Considering group J, Junior researcher 1 said that the legal challenge was not a huge concern in Norway. However, both respondents thought that the challenges will rather be in the economic aspect. On the one hand, Junior researcher 1 told us that this transition will impact a lot on the oil and gas industry. On the other hand, Junior researcher 2 explained a concern about

the domestic demand for renewable energy, which also related to economic risk. The response of Junior researcher 1 and Junior researcher 2 will be presented respectively:

> *"…it [energy transition] has great impact in economy as the economy in Norway mostly based on oil and gas. Replacing it [fossil Fuels] with alternative resources means a lot of changes in the business environment. So, I think the risks include social and economic risks." (Junior researcher 1)*

> *"…if Norway wants to expand wind energy to reduce greenhouse emissions from its traditional oil and gas, it needs to have a connected grid with the rest of Europe. Since Norway already produces sufficient power from hydro energy, it cannot use wind power again for local power usage. The real challenge is the interconnected energy grid with the rest of Europe." (Junior researcher 2)*

With these challenges, the risk associated with the economic loss was taken into account. In terms of the benefit, the interviewees from this group had the same opinion, that this transition is beneficial mainly to the environment. In addition, Junior researcher 2 mentioned that there are new business opportunities from the new alternative of energy sources. See below the response to this matter.

> *"The primary benefit of the energy transition is mainly the reduce carbon emission and clean energy production and the secondary benefit to Norway is that it can diversify its economic market and generate alternative revenue other than from oil and gas." (Junior researcher 2)*

In group P, Practitioner 1 illustrated that the economic challenge may be one of the obstacles to the transition in Norway because the entrepreneurs and society will lack the motivation to step out of fossil fuel. The respondent mentioned:

> *"The cost of hydropower is pretty cheap, and people already think that Norway has very clean energy. It is not so much political view to get more renewable energy to phase out the fossil fuels used for transportation and industry. Also, in some cases at least with the low oil prices we have today, it is also cheaper to use oil and gas, and coal. At least, there are no real CO_2 taxes. You have some carbon credits but they are quite low compared to the actual costs to society of CO_2 emissions." (Practitioner 1)*

Based on this point, the practitioner believes that we may confront political risk. There still has been a controversy related to renewable energy in terms of cost and benefit to health. Accordingly, some people will be against renewable energy and then it becomes obstacle for the transition. The respondent explained in this matter that the main problem of renewable energy is the high price and thereby making it difficult for all to afford. Furthermore, there also is a risk associated with the limitation of renewable energy. In addition, one argument was raised against the energy transition as described:

> *"Climate change is more in the background and it does not really trigger the fear response in people because you do not know how it will impact you. Maybe, [people might think*

that] it is not that bad, especially, here in Norway where it is quite cold. So, it is just such a difficult problem to tackle because it does not seem like a big problem really." (Practitioner 1)

Even though Practitioner 1 noted that the benefit we gain from the transition clearly was about addressing environmental issues. Yet, the following explains the respondent's concern:

"This [climate change] is a big risk to humanity because we really rely so much on a stable climate. Now, we are gradually increasing the temperature. People just agree that that is not a smart thing to do. We should really try to fix that. However, it is difficult [to confront climate risk]. It will take times and a lot of investments. Even though we know some of the ways to do it [dealing with the environmental issues], we do not know all of it." (Practitioner 1)

Compared to the previous response, Practitioner 2 also asserted that economic risk is the most concerning. Besides this, there is still some kind of challenge in legal for onshore wind. Additionally, the respondent remarked:

"…I think we are struggling a bit in kind of understanding that we have enough hybrid to stay our own energy needs. I think that is partly true, but it is also part of misunderstood…" (Practitioner 2)

Accordingly, it may lead to a lack of ambition in seeking renewable energy in production because of inaccurate demand forecasting and then impact the loss of competitiveness. With regard to risks and benefits, Practitioner 2 was of an opinion that Norway may face political risk because the transition is going too slow these days. However, the opportunities are still out there as the respondent said:

"I think eventually offshore wind will become cheap enough to compete with, for example, natural gas in continental Europe. […] There is also a lot of incentive for energy as demanding industry in Norway which also distributes to the Norwegian economy" (Practitioner 2)

It means that Norway could be able to have an international competitive advantage in the renewable power industry, apart from the positive aspects towards the environment and healthcare.

At the same time, Practitioner 3 noted that at the beginning of transformation. Norway could face challenges from the economic and legal aspect, as these commonly occur. Despite the mentioned challenges views were mostly similar to the rest of the participants, the respondent was rather worried about the shortage of skilled workers in the renewable energy industry. It might be a minor problem in the near future but slow down the transition significantly.

In Group E, the challenges in economy and politics were also highlighted. The response of Expert 1 noted:

"Energy transition in Norway is a bit different from most other places. We need [energy transition] in terms of our emissions. We need to transition in transport, but that is related to something else and it is mostly about our exports. Of course, we have from the production of oil and gas we have emissions, but Norway is main role in the transition would be to shift our exports from fossil fuel to any other industry. Our exports are important not for our energy security, but for our welfare and employment. So, then the main challenge is to manage to create some sort of political feasibility or legitimacy around changes in that sector. And the risk is of course more economic. The kind of impact that has on employment and maintaining a welfare statement and so forth." (Expert 1)

As a consequence, the expert said we may face resistance to change. See the excerpt from this interview:

"If you are talking about what is the risk if we do transition, I would say there is of course a risk. Lets say that the burdens and the costs are not evenly distributed. So, you will have some losers in terms of jobs and income which again could cause a lot of social resistance and anger and these things, which then spills over to politics. So, that is perhaps one of the risks that a transition might lead to." (Expert 1)

Similar to the viewpoint of Expert 2:

"Well, the biggest challenge is in a way that you make a lot of money in oil and gas. It's connected to jobs, income for the state, the welfare state, and so on. It is difficult for the state to intrude too much into all the different sectors. We are also part of the global economy, so we compete with others. It is always disbalance between other concerns than the environment and also what is done net nationally. So, I [Expert 2] think I would say the biggest obstacle list that we are so well off and we don't want to lose that [The government's revenues and state welfare]." (Expert 2)

In addition to the challenges we need to overcome, there also has a risk-return trade-off. The following is the benefit we gain from the transition as noted by Expert 1 and Expert 2, respectively:

"...all the benefits would be to reduce economic risk. The other benefits of course that I [Expert 1] believe that it would contribute to shifting. It [the transition] might reduce emissions of course, but it also might help the impact on the balance of power between different actors which then you might see that a transition in Norway might have some impact on other places as well. Maybe it could lead to other countries taking similar steps, and it might shape the negotiations that we have at the international level and so forth. The overall benefit is reducing economic risk and making it more possible that we can reach climate targets." (Expert 1)

"One is the fear of losing home, incomes, state income, and welfare, and society, but the other kind of what is being emphasized more today is that the green shift or the green transition also gives business opportunities. So, you have a narrative that is getting

stronger and stronger in relation to the business and industries. Since we know to a large extent where we need to go in terms of reducing emissions, transforming society, and so on. There's also this story about how this can give you a competitive advantage. You can create new businesses and then generate a new society. So, it is not only all about losing, but it is also creating something new that secure the welfare." (Expert 2)

In conclusion, the following tables present a summary of the results to this question.

Table 4.5 A Summary of the Energy Transition Challenges in Norway

	The aspect of challenges
Group J	• A great impact in economy • The interconnected energy grid for renewable export
Group P	• Challenge in the economy • Society has less motivation to transition • Balancing cost and benefit to health • Skills shortages
Group E	• Economy and politics • Balancing cost and benefit to health

Table 4.6 A Summary of Major Risks and Benefits of the Energy Transition in Norway

	Risks	**Benefits**
Group J	• Social risk • Economic risk.	• Good to the environment • New business opportunities
Group P	• Merchant price risk • Economic risk • Political risk • A shortage of skilled candidates	• To reduce climate risk and beneficial to other environmental aspects. • International competitive advantage of the renewable power industry
Group E	• Political risk • Social risk	• Environmental perspectives and reduce economic risk • New business opportunities • International competitiveness • Power in Negotiations

4.2.5 EXPLAINING WHAT ARE REQUISITES FOR ENERGY TRANSITION

In this question, the interviewees were asked about what is required for a successful energy transition. This key topic was related to the notion of substitution. The standard way of thinking about the pathway towards the energy transition is that it is the search for sustainable fuel sources to replace fossil fuels. The question was aimed to investigate the interview participants' opinions in this matter and observe whether they perceive the doctrine of substitution.

As the response from group J, Junior researcher 1 focused on the economic risk and mentioned that:

> *"…due to the adaptation period that the current businesses need to reshape themselves according to the new demand." (Junior researcher 1)*

Apart from this, Junior researcher 2 presented the belief that policy-making plays an important role in order to support and more pushing in part of industry section to take actions for the transition and explained further that:

> *"It [Energy transition] requires clear energy policy considering all the relevant stakeholders and external factors that can affect the policy and I feel its more important to include the big oil and gas players like Equinor into this transition. Public – Private integration is very vital for the quick success for this transition to happen." (Junior researcher 2)*

In group P, there were very diverse opinions held concerning a need to support the transition. Practitioner 1 responded that we need to reduce our reliance on fossil fuels as much as possible and then provide incentives to people, including implementing energy-saving measures. For all these requirements, the role of government was highlighted throughout the transition process. The interviewee illustrated an example of renewable energy applications for buildings and the following excerpt is the part of the interview:

> *"So, there is really where we need to put in the focus first, but it is like long term processes. It needs governments and regulations to energy requirements for new buildings and upgrading buildings. You need to avoid cities just growing larger and larger, and people are living in large suburbs, but you need to find out how we can make denser cities that is also nice to live in. Somehow, you need to give people some personal benefits if they make choices that have low CO_2 emissions. For example, you could put some taxes on petrol or airplane travel, and you could give that money back to people as maybe some kind of universal basic income. At least, normal people need to see some benefit of actually doing that position." (Practitioner 1)*

Alternatively, Practitioner 2 was the opinion that the focus should be capturing carbon consumption in the industry in order to become a low carbon emission society faster. The respondent provided the reason that some sections have a lot of progress to the transition such

as plastic waste and sort of new technologies. Yet, some parts are moving forward to sustainability quite slowly, especially, the oil and gas industry section.

While Practitioner 3 said that a need for the energy transition should consist of human dimensions, incentives, and new market opportunities. Firstly, the practitioner's thought expressed that the highly skilled people related to the new energy systems are less available, thus we need those people who have adequate knowledge to fill into the upcoming businesses. Then, incentives are required to necessarily support the transition in terms of funding and taxes, which all these are associated with the government's actions. Lastly, new market opportunities are required in order to seek outsider demand for balancing domestic oversupply and also deal with the economic risk from the impact on the oil and gas industry. An excerpt from the interview of Practitioner 3 is shown below.

> *"Yes, the first is people [who are highly educated and skilled about the new systems or technologies]. Second is the incentive [supported by government]. [Thirdly] I think we need to see also the opportunity in another country. Because if you invest just here in Norway, it just five million peoples. I think you need to make it able to operate in another country and make it like an export product, the completed product. You can just install it in another country too. So, that you can sell it." (Practitioner 3)*

In a part of the response of group E, Expert 1 clarified that there are two scenarios whether it be not exporting oil and the second is mostly about Norwegian emissions. If we focus on the Norwegian emissions only, then the interviewee noted that:

> *"To achieve that goal [low carbon society], we can of course maintain our oil and gas exports. So, that it is easier than doing something about the oil and gas exports. Then I think it is about we need to reduce an energy transition in Norway without doing something about our exports is simply then all you have to do I suppose is to reduce emission from oil and gas production." (Expert 1)*

In order to do that, the expert believes that reducing emissions in only one sector, such as transportation, is not enough. It was mentioned that it needs to cover the other sectors as well and somehow it will have impact on being a petroleum products exporter eventually because we have to reduce our consumption of fossil fuels by limiting the production. In this case, it will directly impact on the oil business and then the economy which will be more difficult to transition practically as said by the expert. The following is the excerpt from interview:

> *"We need to decarbonize other sectors than energy in order to become a low-carbon society, and then it goes beyond the energy sector. You have all the other sectors that are emission intensive, [For example], transport, agriculture, domestic industry. Then, of course, there are a number of things that can be done to reduce emissions. Let's say electrification and carbon capture storage of oil and gas production that will reduce emissions. I think that some of those steps are already being taken and it is about revamping or increasing those types of measures." (Expert 1)*

In addition to this, Expert 2 had an opinion that the government needs to get involved into this transition and thus mentioned that:

> *"I think we need parliament and politicians who actually are willing to pay for it [funding and other incentives]. They [the government] have to support for innovation and also stricter regulations. So, you [the government] need to adjust the tax system, [and then] it becomes super expensive. I would have put on more taxes and I would increase the carbon tax. So, emitting greenhouse gases gradually more and more expensive to make the alternatives cheaper. I think you [the government] need measures like this in order to get the transition at its level of speed that is since necessary." (Expert 2)*

In brief, the interviewees were on the same page claiming the support from government is markedly necessary for the energy shift. Obviously, there is a call for supportive policies such as incentives, a research and development funding, human skills development, etc. These approaches are used to promote substitution as it is a key step moving forward to the transition. Eventually, reducing carbon consumption has to go beyond replacing in any particular sector. The transformation should cover both society and industry sectors. It would have a broad impact on all sectors, including the Norwegian oil exports and production. Therefore, the government has to get involved and subsidize to propel the change.

Table 4.7 below includes a summary of the results according to this matter.

Table 4.7 Illustrates the required actions for the energy transition

Group J	The entrepreneurs and businesses in the oil and gas industry have to prepare themselves for the energy transformation as well as a call for government support in terms of policy incentives
Group P	There are very diverse opinions held concerning a need to support the transition. The common response was incentives. Apart from this, we need to reduce our reliance on fossil fuels as much as possible and focus on reducing consumption in the industry section, including human aspects, as well as exploring new markets for renewable energy.
Group E	Reducing carbon emissions need to go beyond the energy sector but covering the other sectors, including petroleum export. Also, it requires a support from government.

4.2.6 Explaining the Future of Fossil Fuel in Low Carbon Society

The participants were asked their expectation on the role of fossil fuels in a low carbon society focused on the risk and benefit we will gain. Undoubtedly, the role of fossil fuels will be less than before in the new society which limits CO_2 emission and be more friendly to the environment. As a consequence, there may be a risk that we have to deal with, and of course, it needs to compare with the benefits gained from the low carbon society. The question was

raised in order to observe the participants' thoughts on the future of fossil fuels in the energy transition.

There was a similar viewpoint on the benefit gained from the low carbon society. According to the responses of group J, it is no great surprise that the respondents spoke about the environment. The interviewees noted that it will be better for the environment in the long term and there will be less air pollution. Nevertheless, the use of fossil fuels will be gradually reduced, but it will not happen tomorrow or very soon. As an example, Junior researcher 2 said:

> *"My expectation is that the fossil fuels will decline in the future but in a gradual manner. For example, still fossil fuels are required for the production of high-grade plastics which are used in the wind turbine blades. However, for any new investment on oil and gas fields at this point of time, there are more risks in terms of the economic and environment compared with the benefits." (Junior researcher 2)*

In group P, Practitioner 1 also was an opinion that we need to use fossil fuels in the future at least within the decade, but new technology will be coming up as an option to capture the carbon emission. There will be a risk that comes along with that technology, whether it be cost or the safety aspect. Here is an excerpt from the interview below:

> *"…Then, of course, it will not be so critical to phase them [fossil fuels] out so fast if you are able to [capture the emission by using the carbon capture and storage]. But then you have the whole issue that if you will do something to try and capture the gas, you will increase the cost. Also, when it comes to carbon capture and storage, how can you store the CO_2 and other greenhouse gases in a safe way. Maybe we can make them into products, that could be an option. Ideally, the world would not have to rely on fossil fuels. Being more realistic, it will be really difficult to phase them out even in the next 50 years." (Practitioner 1)*

Similarly, Practitioner 2 noted that it is impossible to get rid of fossil fuels with the current technology. It would work in some sectors such as transportation, but not as a whole section in our society. Even though there are some opportunities in alternative substitution, but it takes time to develop and overcome the limitations. However, the practitioner was still having a positive view.

Similar to the response of Practitioner 3, fossil fuels could not be just phased out easily. The demand of fossil fuels will go done slowly because of alternative energy sources. However, the interviewee said that the risks will be there due to the change, but still manageable and what we will do is worthy compared to the benefit from the low carbon society whether it be reducing climate risk, aquaculture industry growth, competitive advantage from new business opportunities, and so on. At this point, Practitioner 3 was of the opinion that risk will be based on how we can balance the use of fossil fuels and renewable energy and the environmental issues at the international level. Although becoming a low carbon society could help us in terms of environmental perspectives, the respondent argued that:

"Even though Norway has a concern about the environment, but another country did not care [about the environment] enough, you still get the impacts [impacts from climate change] anyway. I think it [climate change] becomes the big issues here in the global situation. On the big scale not only just to our country, but other countries must be [working] hand in hand." (Practitioner 3)

The response of the expert from group E, was not much different from the others. The use of carbon capture and storage was highlighted and how it will be used in the future. Meaning that fossil fuel will still be used in the low carbon society. This technology seems underdeveloped and has limitations in many ways for now. Thus, risk will emerge due to the new technology similar to what was mentioned earlier by the other interviewees. The following are edited excerpts from the interview of Expert 1 and Expert 2, respectively.

"I think a low-carbon society requires much less usage of fossil fuels, that is obvious. The only way you can have fossil fuels in a low-carbon society is to have some sort of capture technology on all combustion of fossil fuels, and we know that we can have some carbon capture storage but its physically impossible to build the necessary CCS capacity to match even a fraction of the carbon emissions from fossil fuels." (Expert 1)

"Well, I think carbon capture and storage has been the first thing they did. They [scholars] argued that carbon capture and storage could save coal and then now it is supposed to save natural gas. The carbon capture and storage has proven to be very difficult, very expensive, hard to get funding for and has gone much lower than what the advocates kind of wanted to go. So, I think there will be some room for fossil fuels by 2050." (Expert 2)

On the one hand, the experts have a strong belief that there still is a need for fossil fuels in the future. With the limitation of the current technology, Expert 1 identified that we will need to reduce our consumption of fossil fuels drastically including more and more actions. That could be a risk related to the export of oil and gas if we have to reduce the production. Moreover, it will be difficult to reach the target of pursuing efforts to limit global warming to 1.5°C according to the Paris agreement and Expert 2 does not think that we could do that based on the current situation. The future of reaching this target is still in doubt. So, this can be one risk that we may not be able to achieve its temperature reduction target.

On the other hand, Expert 2 mentioned that coal will be phasing out very soon as we can see the imposing policies from the other counties in Europe such as Germany and the UK. Despite reducing the use of fossil fuels which will be good for the environment to some extent, it does not mean that we are far away from climate disaster as noted by Expert 2 below:

"Even if we stopped with fossil fuels today, we will still have climate change due to the concentration of greenhouse gases in the atmosphere. It will also make a huge impact on local emissions and pollution. So, the health benefits from electrifying the transport sector are huge and the same with industries if we get rid of these worst coal-based industries and so on. We will have much lower emissions of other pollutants too and so the health impact would be yielded." (Expert 2)

In summary, it appeared that responses to this question were not much different. it is obvious that the transformation always comes aligned with new opportunities and the major benefit is about sustainable development for humanity. The process to change takes time and there are several emerging risks from technology development. The respondents have the same opinion that a need for fossil fuels will continue even with becoming a low carbon society. Yet, it is well known that the demand for fossil fuel tends to gradually decline. Therefore, it seems to me that it is difficult to get rid of fossil fuels from our society and the future is still in doubt.

The following table illustrates a summary of the results.

Table 4.8 Illustrates the Future of Fossil Fuels in the Low Carbon Society

Group J	The demand for fossil fuels will gradually decline. However, there is still a need for fossil fuels in some industries. Accordingly, there are risks in terms of economic and environmental impacts compared with the benefits. It is evident that the benefits are more towards environmental perspectives.
Group P	It takes time to phase out fossil fuel consumption, at least a decade or even longer dependent on many factors. Developing new technologies to support the transition comes along with emerging new risks in terms of cost and safety aspects. Yet, some believe that these risks are manageable when compared to benefits gained.
Group E	The experts strongly believe that there still is a need for fossil fuels in the future. The risks can be in terms of the constraints to new technologies and renewable energy, including the inability to reach our emission target. While the benefits are clearly related to the environment and new business competitiveness.

4.2.7 Explaining How Familiar With the Notion of Precaution and Substitution

The energy transition is driven by precautionary policies which are associated with the notion of precaution and substitution, all participants were asked how familiar they are with these principles. We can see that the energy policies are based on the fundamental principle of precaution, being aware of climate and other risks. Also, it is found that there is a significant link to the substitution principle. It is important to understand the basic concept of these principles in order to implement it wisely towards the energy transition. Thus, this question was expected to illustrate whether both principles are well-known among the people in the related field.

Responses indicated that it seemed the precautionary principle was known among the participants to some extent. However, some have heard about the notion of precaution, but it is not a really clear understanding. Only a few participants were somewhat familiar with this principle due to their educational background in the risk field. On the other hand, no one was too familiar with the notion of substitution.

Beginning with group J, both have known about the notion of precaution, especially Junior researcher 1 who studies in this field. Unfortunately, none of them had familiarity with the substitution principle. The interviewees admitted that this notion was totally new for them. As an example, Junior researcher 1 said:

> *"I am not familiar with substitution principle but as a worker in risk field, I would say precautionary principles are widely implemented in Norway." (Junior researcher 1)*

Likewise, the responses from the participants in group P were similar to the previous group. Some told that they knew a little about the precautionary principle just in general concept, but all were unfamiliar with the notion of substitution. As an illustration, the response of Practitioner 3 is provided below.

> *"Actually, I did not [familiar with these two notions]. I didn't realize that it is separated into two groups, but I think I have heard the most about the first one, precaution. [The precautionary principle is] only one that has been talked [about] a lot in business." (Practitioner 3)*

In group E, it is no great surprise that the notion of substitution was not been known among experts. While Expert 1 was not familiar with the precaution and substitution at all, Expert 2 had heard about the precautionary principle before. Although, the substitution principle was new to Expert 2 as well.

In brief, the notion of precaution was known among the participants in this research. Most have heard about the precautionary principle, but not an in-depth understanding. Only one was familiar with the precaution to a deeper extent. In contrast, all participants admitted that they have never heard about the principle of substitution. The following table shows a summary of mentioned discussions.

Table 4.9 Illustrates the Acknowledgment in the Existence of the Notion of Precaution and Substitution

Group J	Only one respondent is familiar with the notion of precaution to some extent, both are unaware of the substitution concept.
Group P	Some have heard about precaution, but the rest had no idea about the notion of substitution.
Group E	One respondent is familiar with the notion of precaution to some extent, but not with substitution. While the other has never heard about these concepts before.

4.2.8 VIEWS ON DEFINING PRECAUTIONARY AND SUBSTITUTION PRINCIPLE

When it came to this question, the participants were asked to explain the way they defined the precautionary and substitution principle based on their understanding. The question was raised because it was essential to investigate in what level they understood these principles. It is well

known that understanding of the fundamental concept is needed for proper implementation. Thus, the results were analyzed in accordance with this purpose.

From the previous questions, it is understood that most participants did not know much regarding the notion of precaution and substitution. The responses were based on their general understanding. The respondents were requested to define the principles in their own way. A brief explanation about the general concept of the precautionary and substitution principle was provided to all participants because some were completely unfamiliar with these principles.

In group J, the respondents told that they knew about the precautionary principle to some extent. It was mentioned that the principle is widely used in Norway. The definition of precautionary principle was provided by Junior researcher 1 and Junior researcher 2 and is shown below, respectively:

> *"Precautionary principle is the initiative of not taking and action if the results are harmful for environment and humans." (Junior researcher 1)*

> *"This [precautionary principle] is a method of making decisions with detailed analysis and review with caution on what might be the end result. But the uncertainty associated with the end results makes the decision-making more challenging. May be its decision-making under uncertainty." (Junior researcher 2)*

The interviewees in the first group were both not familiar with the notion of substitution, as mentioned earlier. Therefore, they could not give a definition of how the substitution principle would be. See an example from the response of Junior researcher 2 below.

> *"This method [substitution principle] as I read is to find out a substitution solution for an existing solution." (Junior researcher 2)*

Looking at the results of the responses from group P, most participants had no previous familiarity with the principles, which was an obstacle to respond to the question. For the precautionary principle, Practitioner 1 gave an example based on their own understanding. The respondent mentioned the precautionary principle is about attempting to switch from, for example, fossil fuel cars to electric cars to avoid local air pollution. It was interpreted that precaution can be defined as taking actions based on the decision to confront risk where refers to 'local air pollution' in this context. Clearly, it is related directly to substitution as the respondent noted about the replacement of fossil fuel cars with electric cars.

While Practitioner 2 defined the precautionary principle as:

> *"The precautionary principle is that we do not even know what is going to happen, but it is needed to be cautious and try to avoid the potential harm, because we do not know the effect it has" (Practitioner 2)*

I suppose that it means we should be cautious even lacking available knowledge and respond in a way to avoid such harm. At the same time, the respondent also provided the definition of the substitution principle as:

> *"I think, at least what I understand, it [substitution principle] means you are able to replace some kind of related to the process with more sustainable" (Practitioner 2)*

Furthermore, another respondent mentioned that the precautionary is similar to when there is a need to shift the fossil to green energy which could not be completely done within the next day to come. Practitioner 3 defined the precaution by explaining how to implement it that several measures should be planned wisely, step by step with taken many considerations into account. I interpreted this response that a reason why we need a plan to take any actions because at the beginning we were lacking the knowledge to implement the right measure. Thus, what the practitioner said it meant that the precautionary principle is linked to lacking available knowledge.

With regard to the substitution principle, no one in group P has known this notion before. However, the respondents were asked to express what was the definition of substitution principle would be. An example of response from this group is illustrated as below.

> *"Substitutions what I understand is completely change or replace by something that means in my opinion what I understand maybe like I stop [using] the oil automatically. [In the case that] I don't have oil and I don't have gas, I use something else, for example, hydrogen, water, electrical that what I understand." (Practitioner 3)*

In the last group, Expert 1 provided the definition of precautionary as the following:

> *"I suppose the precautionary principle would to me seem like in terms of policy it [precautionary principle] would be about introducing policies or not introducing policies as a precaution to mitigate risk or avoid taking unnecessary risks." (Expert 1)*

Regarding the excerpt from the interview above, it is about decision-making whether the policies should be taken to tackle that risk. Reducing emissions was raised as one example of implementing the precautionary principle when we consider that the risk to not take any actions is probably high. Also, the expert mentioned that we can be cautious without necessarily know either what the costs or the benefits are. I think it means implementing the precautionary actions are still required even the absence of full knowledge to that risk, for example, climate change.

Besides this, Expert 1 defined the substitution principle based on considering the context of the energy transition as below.

> *"In terms of considering the topic that we have discussed, maybe it [substitution principle] has something to do with substituting other social practices or technologies. But being confronted with this notion without having talked about transitions, I think I would be more in the dark" (Expert 1)*

While another respondent in this group who have heard about the precautionary principle, thus the excerpt from the response of Expert 2 mentioned:

> *"The standard definition [of precautionary principle] is something in the lack of evidence. On the opposite you should not do it [the risky activities]; you should not build; you should not explore." (Expert 2)*

In terms of the substitution principle, Expert 2 said:

> *"[Substitution principle is] replacing fossil fuels with renewables. You have this principle also, called best available technology (BAT), which is also in law. If you are going to use a technology that has to be the best available technology. If you have an old technology and want to substitute it with something new that has to be BAT technology. So, the substitution would be replacing combustion engines with electric engines. Also, you can have it [substitution principle] in the different sense. You can substitute car driving with bicycling and walking and so on which is also a part of the transport policy in Norway. So, you should either walk or cycle instead of public transport and a personal car which is also a kind of substitution." (Expert 2)*

Based on the response of Expert 2, it means the key point is the substitution principle did not limit the scope only the replacement of energy sources. It was interpreted to cover in other aspects, such as the functions and technology replacement.

So, to sum it up, it is difficult to provide the proper definition without understanding the concept. With limited knowledge, most respondents defined the precautionary principle as a decision rule whether the actions should be implemented and the way to tackle the target risk even there is no scientific certainty in that matter. As I observed, the respondents interpreted the precautionary principle rather covers the basic idea of this principle in a broad sense. I assume that it is because the precautionary principle is straightforward. Conceptually, the precautionary principle is easy to grasp. On the other hand, it turned out that most respondents considerably got stuck on the definition of the substitution principle. This principle was interpreted directly as a substitution to sustainable energy. As a consequence, I think the explanation in the fundamental concept was still ambiguous due to incomplete understanding of a basic concept.

4.2.9 Views on The Use of Precaution and Substitution Towards Energy Transition

After observation of how the precautionary and substitution principle would be defined, then the interview was flown directly into the next question. It was related to the implementation of these principles towards the energy transition. The participants were asked to reveal the viewpoint in what way the precautionary and substitution principle could apply to the transition, including the pros and cons. This question was aimed to investigate the importance of using these principles associated with the transformation which was an essential part of this research.

In group J, the respondents said that the precautionary principle is used when we are surrounded by risk with highly uncertain. The substitution was considered as one measure of being cautious for dealing with climate change. It seems that they assumed the precautionary and substitution principle were part of each other. They explained that these principles can be implemented through policy-making. One response from the interview identified that these principles would work in the way to propose long term alternatives solutions to confront risk. Also, the following is shown an example of the excerpt from another response which reflects the viewpoint of Junior researcher 1 on how the principles are applied.

> *"In energy transition, policymakers should consider the risks involved in, and plan the transition. So that the negative effects should be minimized." (Junior researcher 1)*

Next group, most participants also stated that precautionary and substitution would apply when facing risks by taking the actions to protect humans and the environment from any potential harms. Regarding the pros, there was a similar response in the way of dealing with the risks, especially, climate risk, beforehand when we are not sure what the consequences could be. Besides this, some respondents identified further that it could help to understand the risks and make it easier to decide good policy if we have more understanding of those risks. Some also mentioned specifically that the substitution might lead to new business opportunities for economic growth. On the contrary, there was various views on the cons of using these principles.

As said by Practitioner 1, it is obvious that precautionary and substitution are applied through policies and regulations which considered as the state's measures in the national level to support the transformation. See the excerpt from the interview response as below.

> *"So, you can really group a lot of the national measures we do into both substitution and precautionary. But the large background from doing an energy transition that is mostly linked to the precautionary measures." (Practitioner 1)*

Due to lacking knowledge on the concept of these principles, Practitioner 1 assumed that the cons might be there would have other available risk models that fit well to the energy transition rather than precautionary and substitution. The excerpt of this response was noted:

> *"I do not know what other kinds of models exist, but of course, it could be one risk is there which is it could be other models that fit better. Also, it is other problem with this is saying that all models are wrong, but some are useful." (Practitioner 1)*

On the one hand, the practitioner had a belief that the energy transition is mainly based on the precautionary principle. On the other hand, the other pointed out that the transition basically requires the substitution principle significantly rather than precautionary. The response of Practitioner 2 mentioned:

> *"I think energy transition is available about the substitution principle. Well, sometimes it starts at the precautionary principle, and then it changes to the substitution principle because we figure it out that we have to find the alternatives." (Practitioner 2)*

However, one of the cons regards to this matter was identified by Practitioner 2 that when we do not know much about that risks, then it could end up being too much cautious. This could lead to misuse of precautionary principle. In this sense, it matches with what is mentioned in the related literatures. The scholars remind us that there are some kinds of conflicting errors when using the precautionary principle that may lead to countervailing risk eventually.

Meanwhile, Practitioner 3 presumed that there is no different in precautionary and substitution principle. The respondent was of the opinion that these principles would work well if getting supportive of the government. It was mentioned that in practice these principles would work for the long-term period in advance.

In group E, Expert 1 was of opinion that the precautionary and substitution could be meaningful to phasing out fossil fuels. Conversely, the respondent told that the precautionary principle could be considered as a broader approach than the another one. However, the substitution principle still has the weakness according to presuming that the substitution is all about replacing the old technology. The response of Expert 1 mentioned:

> *"I think for an energy transition to happen fast enough, we need to target the phasing out of fossil fuels much more radically. You could say that following a substitution principle would support that, but it is not sufficient. I think we need something else as well." (Expert 1)*

While Expert 2 noted:

> *"I do not really see any disadvantages with those two principles except that it might reduce the income from certain activities which should be of course something you have to balance." (Expert 2)*

As the response is shown above, the expert disclosed the view that both principles are important to the energy shift, especially, the substitution principle. These would work by introducing the policy and associated with the government's action. Even so, there would probably exist other risks more than climate risk due to implementing such a measure to reduce the emission. The respondent also mentioned that not only looking for substitution with renewable energy, but we should be able to sell our new power also.

Consequently, the participants supposed that both principles can be seen in the policies, especially, the precautionary principle. Due to unclear understanding, most respondents found the difficulty to respond to this question. Most responses were highlighted about the precautionary principle significantly. Some thought that the substitution principle is one part of implementing the precautionary principle. Certainly, the pros to apply the principles on the energy change were mentioned as well as the cons that somewhat some respondent's views reflected that these principles were not having such a significant role in this transition.

4.2.10 Explaining to What Extent We Should Implement Precaution and Substitution

The participants were asked to explain their opinion on which way should we implement the precautionary and substitution principle in relation to the energy shift. The question was aimed to investigate whether these principles should be applied in an extreme way or better to be less. The extreme way can be seen in the Swedish case study which they have introduced the measure that completely bans the chemical substance. Thus, the response in this question will useful for the research to comparative with the chemical policy in Sweden.

As the result from the group J, a respondent mentioned that there is no need to entirely ban fossil fuels; see as below.

> *"I do not think fossil energy needs to be completely banned, however transition will be held so smooth that it should keep the environmental risk level not greater than the current situation." (Junior researcher 1)*

While Junior researcher 2 argued that phasing out fossil fuels is the only way leading zero-emission. Nevertheless, they believe that it is possible to stop using that kind of fuel in case of having better technology available and incremental knowledge.

In the next group, Practitioner 1 suggested that we should be even more cautious than where we are nowadays. The respondent told that when considering all aspects and the risk concerned, we still get a lot of advantages to implementing the precautionary actions in this matter. At the same time, we also need to balance how to implement these principles. The following is the excerpt from the interview.

> *"I would say it is almost impossible [to completely ban fossil fuels]. [Although] maybe you could do it, but then you will have a lot of other disadvantages." (Practitioner 1)*

Similarly, the response of Practitioner 2 also said:

> *"We will get away all the CO_2 consumption simply through supporting the alternative technologies rather than banning the fossil." (Practitioner 2)*

To be clear, the quote above represented that totally banning fossil fuel is not the best solution to reduce emissions but developing alternative technology would be a better option. From this point, it is in doubt for the respondent whether we should go toward such an extreme way like prohibit using all fossil fuel.

Following this, the viewpoint of Practitioner 3 is not different from the others in this group. The respondent recommended to begin with intense measures for shifting to be green environment fast enough such as strict laws. However, there will still have some need exist for fossil fuel in the future. Thus, it is not necessary to phasing out all that sort of fuel.

As per Expert 1's perspective, it would be possible to absolutely ban fossil fuel even it seems to be difficult. The point is we do not need to go in that extremely way due to negative economic consequences. Nonetheless, strict measures as well as radical societal changes are required for phasing out fossil fuel as much as necessary which means these principles should be applied extremely to some extent and effectively. The response of Expert 1 in this matter is shown below.

> *"Banning the production of fossil fuels tomorrow is a completely theoretical discussion. It is not going to happen basically. So, it is fine to discuss it, but it has really no feasibility. But I do think that we need to have a more long-term goal of reducing our dependence on fossil fuel exports radically." (expert 1)*

Apart from this, another expert mentioned:

> *"It is possible to do so [completely ban fossil fuels]. If they do not want to do it, they have to go and capture and storage in place. This is only option they have left" (Expert 2)*

With regard to the response, most participants expressed the views that this question is difficult to specify what the right answer is. Obviously, the participants supposed that all precautionary measures should be taken seriously as well as introducing more incentives to accelerate the transition. However, there is not much conflict in their responses. Most of them believe that we do not need to completely ban fossil fuels in order to reduce carbon emission even it would probably be possible to do that because it may lead to unforeseen consequence is called countervailing risk. The potential opportunity was mentioned mainly on the new technology called 'carbon capture and storage'. Besides this, it was noted to natural gas that there is a solution to make the energy be even cleaner with the available technology.

4.2.11 Views on The Possibility of Norway to Become a Low-Carbon Society by 2050

Finally, the last question was raised to ask whether Norway could achieve its goal by 2050 to become a low-carbon society. The purpose was to investigate the participant's views on the possibility of Norway reaching the target. I was expected to gain the input information to compare with what happened with the Swedish policy towards a non-toxic society target.

In group J, the respondents did not provide a specific response in regard to this matter. They just said that it would be possible if extra measures were taken and more developing in technology including creating new innovation. They supposed that something may go wrong during the process such as new challenges and some unforeseen negative consequences.

For the result in group P, one practitioner responded in this question that:

> *"[It would] probably not [achieve the target by 2050]. but I think it is easy to set goals and to find out where we want to go. Actually, getting there in practice probably requires even more efforts than we see today." (practitioner 1)*

This mentioned response was considered based on the current situation and the Practitioner said that it has to focus on the pragmatic view. An important point is that direct incentives are needed to be provided, for example, deducted taxes and return it back to people, as stated by Practitioner 1. While others were of opinion in positive that Norway could reach its goal. The response of Practitioner 2 mentioned:

> *"Yes, I think that the technology will make it happen. I think with something that is starting to be more visible now is that the cooperation from the company is doing [taking the actions such as green policy and other projects] regardless of whether the government is looking for it." (Practitioner 2)*

The respondent supposed that our strong ambition in energy shift would contribute to achieving that target eventually. Likewise, Practitioner 3 agreed that it is possible to get there. Even so, more measures are required as well as support from the government.

According to the response in group E, Expert 1 said:

> *"By 2050 I certainly think it is possible to become a low-carbon society. Obviously, there are a lot of areas that need to change in terms of the policy." (Expert 1)*

The goal could be reached if increasing the level of ambition of many of the current policy strategies. The main point is that whether the export of petroleum products is still there or not. It would be easier to be a low carbon society by still keeping export activities. However, the respondent also explained further that it would be seen less optimistic in this matter when considering more realistic.

At the same time, Expert 2 pointed out that it is hard to be precise about possibility to achieve the goal because it depends on many factors as well as the climate situation. Nevertheless, it should be possible based on theory. At this point, it seems to me that the current instruments available are not sufficient enough and lacking scientific knowledge about climate change. As said by the expert, if the climate is getting worse, people will even more cautious than we are recently. Accordingly, there will have more policy, stricter regulations, and faster transition.

The following table shows the summary of result.

Table 4.10 Illustrates the Possibility of Norway to Become a Low-Carbon Society – (Continue)

	The Possibility to Reach the Goal	Suggested Measures
Group J	This goal achievement is hard to predict. To be optimistic, it would probably be possible with increasing ambition through more instruments.	• Introducing more measures • Technology development and new innovation • Be aware of new challenge and unforeseen negative consequence.
Group P	Most were of the opinion that it would be possible to achieve its goal. While another one realized in the opposite way when considering it realistic.	• Be aware of new challenge and unforeseen negative consequence. • Technology development • Incentives • Support from the government • Strong ambition in energy shift
Group E	There is the possibility to achieve its goal, but somehow not likely. This matter is needed to take many aspects into account including increase precautionary measures.	• Gain more knowledge about risk • Increasing carbon taxes • Radical societal changes • Technology development • The more ambitious strategy of policies

Chapter 5 – Discussion

5.1 Risk Towards Energy Transition

5.1.1 Scientific Evidence and Risk Informed Approach

Risk informed approach plays an important role to provide the overall risk picture to decision makers. Also, policy-making is influenced by risk perception to some extent. Sometimes, it far from a real risk. As the observation, the energy transition is called for among the public because people are worry about climate change, sustainable energy sources as well as biodiversity and so on. It is becoming radical need recently. However, this fear probably results in the misuse of precaution similar to the Swedish chemical policy. There have a lot of example of prohibit chemical regulation which got criticisms from the scholars and academics. In the case of energy policy, it may share the same fate because it is well known that a full scientific knowledge related to climate change is not available. From the responses from the interview, there is no consensus on policy-making. Various perspectives on the policy were suggested by the participants. There is a need for scientific evidence to help the diction makers to choose the right choice.

Refer to the result of this research, it was investigated on the main causes that lead to a need for the energy shift. Mostly, the transition is required because of the environment issues such as climate change, air pollution and so on. As the observation, all participants agree that the climate risk is the main reason for transformation in order to reduce carbon emission. They claimed that this risk is based on scientific evidence. However, it is still a controversial topic in many aspects. Even though some people always believe that the climate issue is just a fake narrative.

As per the Intergovernmental Panel on Climate Change in 2007, the report concluded from its review of a wide range of evidence that the warming of the global climate system is now unequivocal, and that it is highly likely that most of the increase in global average temperatures seen since the mid of 20th Century comes from human activities such as energy production coupled with other changes such as global de-forestation by greenhouse gas emissions (IPCC 4th Assessment Report, 2007). Based on Pidgeon (2012) , he mentioned that “[w]ithout major efforts to reduce emissions, it is likely that we will see further warming this century that breaches the internationally agreed threshold for dangerous climate change” (p. 952). This sound makes sense for accelerate the transition. I sympathize with him because we can see the change in the weather today and some disasters over the world. I think it is clear that the emissions are needed to reduce for mitigating the climate risk. Otherwise, there still is lack of scientific knowledge to some extent. What the scientists can do now, just predict the negative consequences that might come.

To deal with risk, it is important to understand that risk in order to take the right actions. Even so, the full of scientific knowledge can be absent and it likely to happen, especially, a risk with

deep uncertainties. As said by Cox (2012) , the most challenge in risk management is to deal with the kind of risk is characterized by deep uncertainties because of unknown future. In the case of the energy transition, the future outcomes of climate risk are still in doubt. Deep uncertainty can be categorized from these criteria: (i) well-validated, trustworthy risk models giving the probabilities of future consequences for alternative present decisions are not available; (ii) the relevance of past data for predicting future out-comes is in doubt; (iii) experts disagree about the probable consequences of alternative policies—or, worse, reach an unwarranted consensus that replaces acknowledgment of uncertainties and information gaps with groupthink—and policymakers (and probably various political constituencies) (Cox, 2012). However, it is out of my scope. I will not go further than this. Therefore, it is obvious that the climate risk can be considered as having high level of uncertainties.

Due to lack of scientific knowledge, then it is hard to make a good decision in creating a policy. In this point, the responses from the interview shows that several precautionary measures were proposed to deal with risk in different aspects. It reflects that they were not sure on the future consequences. Actually, I also suppose that the energy transition is associated with a lot of risks, not only a few ones as same as the result from this research. Some respondents were of opinion that the actions should be taken wisely step by step whenever the knowledge is available. In order to do that, more information and available knowledge are needed to describe risk properly. With the new style of regulation today to emphasis on transparency, the role of scientists is less than the old model as one of stakeholder (R. Löfstedt, 2004, 2014a; Lofstedt et al., 2011). This still can lead to loss in public trust due to failure in policy-making and regulations as explained by several scholars, including unforeseen consequences.

The question has been raised that why the environment issues became a public concern today. Increasing role of media and NGOs has been significantly towards energy transition, especially, encouraged the fear of the consequences of environmental issues. Recently, scholars, policy maker, and the other had been less information bias toward climate change because media coverage has always represented this issue of human contributions to climate change (Boykoff, 2011). According to this research, most respondents were alert to the change in climate and believe that this is the main cause for the transition. The participants were all perceived on how important that risk is and willing to go for the change. It was reflected by the responses that they all advocated to increase the ambition on policy strategy and implement stricter regulation even more to accelerate the shift because some expressed that the transition is seemed to be slow these days.

On one hand, I think the results from the interviews link to risk perception to some extent. the responses are diverse depended on individuals' opinions. The problem is no clear direction on which way we will go for mitigating climate risk. So far, as I can see there are exist several alternatives whether it be sustainable energy, more green energy from natural gas with carbon capture and the storage, and so forth. These solutions are not perfect. The interview respondents also noted to the limitations for doing in each way. They admitted the fact that we are lacking knowledge in regard to this matter as well as insufficient scientific evident. Following this, we may face with countervailing risk by reducing climate risk after all. I presume that the interview

results can represent public opinion. People have different backgrounds and knowledge. So, it came out as various ideas and hard to find the conclusion.

On the other hand, the results in content analysis of policy documents show that the government information is supported by the scientific-based assessment. The documents tell a great deal about climate risk compared to transition risk to make the point that it is worthy to give priority to climate risk and the other risks can be manageable. When considering the evidence, I do admit that I agree with the government to take this step forward to green society and having less concern about economic risk. I can see that a scientific evidence and risk-informed have a significant role in terms of credibility. It helps to make a decision easier because of the reliability of information. Even though it does say nothing about whether the goal is achievable, the science evidence provides a reasonable data to support the decision makers.

Summing it up, it is obvious that scientific evidence and risk-informed should be given a priority in order to make the right decision because even the new style regulation is aimed to improve transparency, still teething problems have been found as well as unforeseen consequences. It is related to the risk perception towards risk also. As the illustration, the Swedish has too much worry on the chemical contributing to an extremely way to implement the precautionary measures to ban all chemical substance without scientific proof (R. Löfstedt, 2014a; Lofstedt et al., 2011; R. Nilsson, 2004). Therefore, it is important to give more weight on risk-informed and scientific based to better decision-making in the policy. Certainly, public participation is also required, but we should not ignore the scientific evidence. Furthermore, risk communication has to be highlighted following the recommendation from several scholars. Obviously, it links to the role of scientific evidence and the way we describe risk.

5.1.2 RISK-BASED DECISION-MAKING

Introducing precautionary policies is about making the decision to confront the potential harm. In the book wrote by Aven (2015), the processes of risk management consist of planning, risk assessment, and risk treatment. A decision-making is in the last stage in the process which is very important. The main responsibility is to undertake considerations and weighing all aspect concerned, including making a decision by balancing all various concerns (Aven, 2015, p. 8).

In terms of policy, a policy maker takes this responsibility to implement precautionary instruments. Refer to the research, I found that the respondents mentioned in this point as well. As I mentioned earlier, the decision-making should be based on the scientific evidence. Aven (2015) mentioned that risk analysis plays role as a decision support tools. Risk analyst have a duty to inform risk to decision maker. Whereas the risk analysis does not give the direct answer and no hard recommendation on what to do, only provide a risk description that will represent the available options as being the choices to make (p. 140). This is the way of risk informed decision-making process would work.

For the result of this research, I found that most suggestions on the policy strategy are in place whether it be carbon taxes, R&D funding, and so on. It needs to increase in terms of ambition and awareness towards risk that leads to the more radical implementation of precautionary

measures. In addition, the incentives are necessarily required for changing humans' behavior. It is emphasized among the participants that the decision should be made by considering and balancing all concerns. I think their responses were match with what said by many experts in this field. Besides the climate risk, the respondents perceived the possible harms to both economics, society and other aspects. Common sense of the respondent seems to dictate that economics risk is the important concern in the Norwegian context.

As you can see, it is not only climate risk that we have to consider. I totally agree with the others that it is significantly hard to make a right decision whereas we have more than one aspect to worry about. However, the results are not based on a proper assessment. Therefore, it is obvious that an obstacle to making a decision. While the result in content analysis helps me to see a clear picture of the role of risk informed decision-making. Based on a scientific assessment, climate risk seems to be significant rather than the economic risks related to the transition. The Norwegian government believes that the transition risk is obviously manageable. It is evident that the risk-informed have a crucial role for decision-making.

Thus, the decision process is significantly important in risk management. The harder to describe risk under high uncertainties, the more difficult to decide the right solution. There is no one answer for all risks similarly to the energy shift. As an example of Swedish policy, the failure of regulation is caused by making the wrong decision. Most scholars have always warned us that the worst scenario would occur and contribute to unforeseen consequences, especially, when we are lacking scientific based. The decision on policy-making should be based on risk informed approach with taking into account all aspect concerned.

5.1.3 SUMMARY

To sum up, the analysis of policy documents supported with a proper scientific risk assessment can inform an actual risk which is climate change. It considerably helps to reduce a concern that contributes to an easier decision. At the same time, the interview result reflects people always have worry about the possible harm or risk. Without evidence and assessment, it hard to make a decision. Basically, we cannot confront with all risks because of limited resources. Also, it would be helpful to have further work about risk perception as it involves in policy-making whether it be energy policy or chemical policy. Risk perception is related to the fear of such a risk. In this sense, the precautionary principle has been used to address human dread (R. Nilsson, 2004). When we include feeling to making a decision, we may overlook the real risk. It is obvious that the role of scientific based and risk informed should be emphasized for a better decision. Besides this, the risk informed approach becomes an essential support tool for decision-making.

5.2 A NEED FOR ENERGY TRANSITION

5.2.1 THE SUBSTITUTION AND POLICY CHANGE

Not only scarcity of fossil fuels, but the environmental issue is a vital factor to accelerate the global energy transition. Increasing of extreme weather events have been seen over the world in the past few years. People have noticed the effect of climate change which is a biggest global concern. Meanwhile, the energy transition has a wide impact on many sections. When it comes to the controversial topic of renewable energy, all arguments are associated with energy policy, industrial policy, climate policy or the combination all of these policies (Edenhofer et al., 2011; G. Hansen, 2013).

On the one hand, the precautionary measures have been applied to address chemical risk. The instrument that can be often seen in Swedish policy which is prohibit policy. Nilsson (2004) noted that the precautionary principle has been implemented in the way of ban or severely restrict chemical products. Basically, the product are banned and then replace with the alternative safer product instead which obviously related to the substitution (p. 112). On the other hand, the energy transition is about shifting to the sustainable energy instead of non-renewable energy such as fossil fuel. In the result of this research, the participants were asked about a need for the transformation. The response presents the participants' thought that reducing carbon emission is the main target. As the main cause of climate risk, there is a need for renewable sustainable energy which is a trend these days. The replacement of traditional sources with the renewable energy sources are required as well as substitution in terms of lower price, technology development and new innovation. So, it appeared that whether the change in policy is either in terms of chemical or energy, these all call for the substitution. I think this is a basic need when you want to change something.

The question has been raised whether the substitution is enough for the transformation. As a matter of fact, there was further requirements in order to substitution. Many responses were mentioned the role of government to support, for example, incentives, taxes, funding and policies. As the result, I suppose that the supportive from government is important for the transition. It is the way to encourage the substitution. A technology development also takes a significant part to promote the substitution. in part of the policy documents also state clearly that there is a need for the substitution to push forward the transition. The government has implemented the instruments to considerably force the substitution. Most policies conform to the interview responses. My own view is that the direct substitution cannot happen alone. It required the support methods. with regard to comparative the results between content analysis and interview, I found that the new technology such as the carbon capture and storage is essential to promote the substitution. Therefore, the transition could not occur if there is no development in this field to support the use of renewable energy.

5.2.2 THE ROLE OF GOVERNMENT AND POLICY-MAKING

To successful shift to new chapter of energy source, we also need the supportive from the government. Recently, Norway plays a role in the global energy transition by taking serious actions to deal with the climate change. This is aimed to accelerate the energy shift to the future. The Norwegian energy policy shows an ambition to find energy alternatives as well as addressing environmental issues. One of a matter to show their ambition is increasing the target to reduce the carbon emission. Norway is claimed to be the first nation to submit its intention proposal to reduce the amount of carbon emission.

To illustration, the international agreement has been established to combat the climate change, called Kyoto Protocol, which is the United Nations Framework Convention on Climate Change (UNFCCC). The climate treaty requests an international cooperation to reduce greenhouse gas emissions. The negotiation occurred in Kyoto Protocol was not only based on scientific knowledge, but it was also related to perceived or real interests of each state (Oberthür and Ott, 1999). There are 197 parties have ratified the protocol. Many countries who signed on the international treaty have introduced energy policy following the commitment and show the intention to be a leader of the energy transition. it is important to noted that Norway is the one who attempts to meet ambitious climate change mitigation targets.

The Norwegian energy policy has been launched according to a commitment to greenhouse gas emissions mitigation. The government implements several instruments to achieve the target for many years including the funding support. Even some respondents told us that the transition today is moving forward too slow, we can say that Norway is in the frontline for this change, especially, transport section. Similarly, Sweden is taking a lead as a pioneer for introducing the chemical policy because of taking the actions seriously to control the chemical by the government.

With regard to the interview response, it seems to me that not all people realise about the environmental issues or even acknowledge that much the scientific evidence about the climate disaster which still being a discussion topic. The participant said that the negative consequences from climate risk are unclear and the disaster probably will not happen in our generation. I agree with this point that people may think that this risk is far away from them, then they will be less awareness regarding to the energy transition. The respondent's message is that the incentive is necessarily important for this transition and the government has to play this role to support this matter in many ways.

From the substitution, I observed form the participants response that it is hard to specify what will be the primary energy resource for the future instead of fossil fuels. Clearly, renewable and clean energy is the solution for the energy transition to deal with the environmental issues. There are several energy resources available to produce clean energy. But if we do not have a clear direction to what the main energy source for this shift, it contributes to the problem in policy-making to support for the energy transition. The unclear direction makes this transition becomes slowly as it could be. Also, no clear direction on how we do with the traditional energy

resource, fossil fuels. The future of fossil fuels seemed to be ambiguous. It is time for the government to step in and make the decision.

As an illustration, studies of van Alphen, van Ruijven, Kasa, Hekkert, & Turkenburg (2009) have indicated “the early dedication of the national government to reduce Norway's CO_2 emissions has led to a remarkable consistent build-up of a national CCS innovation system” (p. 53). Nowadays, the carbon capture and storage are the option left for continue using fossil gas to limit the carbon emissions as mentioned by the expert in the interview. However, it is still under development. The key is the substitution cannot be done by itself. It needs a significant support. Following this, it is obvious that the government is responsible for this part.

With an outstanding Norwegian energy policy, the policy comes with a slogan that "Power for change". The energy transition has started with the policy on reductions in human emissions of greenhouse gases. As stated by ministry of petroleum and energy on the press release, the main message of Norwegian energy policy is that “security of supply, consequences for climate and economic growth must be considered together to secure an efficient and climate friendly energy supply” (Norwegian Ministry of Petroleum and Energy, 2016).

According to the press release, the policy focuses on the important keys in different area. First, improving the security of supply to find good ways of responding to the growing demand for power. In this area, the new technology and good management system will help to enhance the security of supply. Second, the government is looking for the efficient production of renewables. The wind power can be a new opportunity and may be profitable for Norway in European energy markets. Third, developing new technology and innovation to be more efficient and climate-friendly use of energy. This work is assigned to a national agency, called Enova, in order to reduce greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply. Forth, the focus is on economic growth and value creation through efficient use of profitable renewable resources. They believe that the renewable energy can help to create the value in other industries including competitive advantages in the global market.

5.2.3 SUMMARY

In a nutshell, the energy transition is required certainly the substation concept in order to change in the age of sustainable energy as well as the supportive from government. As the shift requires replacement of energy source as well as the technologies, but just the substitution alone is insufficient for such a whole change.

5.3 FUNDAMENTAL CONCEPTS FOR THE ENERGY TRANSITION

5.3.1 THE NOTION OF PRECAUTION

To avoid the disaster from climate risk, it is noted that we have to be awareness even the future consequences are unclear. So, the precautionary principle is applied in terms of policy and regulation. Some scholars point out that the practical issues with negative consequences from

the failed regulation have been found from the misuse of precautionary principle in the Swedish policy. Therefore, it is important to understand the concept for making the right choice to manage risk.

In this research, it is such a surprise that most participants do not familiar with the notion of precaution. Even so, I can see little hope if compared to the substitution principle. It is because the precautionary principle has been applied a lot in Norway. However, most of interviewees still do not know that much about this concept. In this sense, it is clear that the fundamental concept is overlooked in this sense seem. Due to unfamiliar with this notion, the response to the question of how to implement the precautionary principle is in doubt. Similar to the content analysis of policy documents, there is no specific about the fundamental concept of precaution directly. The expression in those reports implies the concept of precaution towards climate risk. Accordingly, I found that the notion of precaution is ignored even it has been used often in practice.

5.3.2 The Notion of Substitution

As the results of this study, the substitution is unknown principle for all participants. Although the results told that neither students, practitioners, nor the experts have heard the concept called 'substitution principle' before, their response in what a need for the transition is related to the notion of substitution. To illustration, all mentioned about climate change that leads to the energy transition. The participants discussed about the replacement of fossil fuels by the cleaner energy in order to reduce the CO2 emission. This is related to the concept of substitution in general.

With regard to the interviews, the notion of substitution is known in practice in terms of the replacement. All respondent told us that we need to shift to use the renewable energy, which is sustainable instead of the traditional energy source, including develop the technology. It is clear that their explanation is all about the substitution. It seems the fundamental of substitution principle is being neglected. In other cases, I assume that the substitution measure is subset of precautionary principle. I think this point makes sense because even the respondents who have background in risk field, the principle is completely new for them also.

5.3.3 Defining Precautionary and Substitution Principle

According to the result, most of the respondents told us that the precautionary might be we take the actions to reduce risk. Some were stated further that we decide to take an action to mitigate risk even we do not know that much about that risk. For this point, the responses reflect the participants' thought the precautionary is related to lacking knowledge which means scientific uncertainty. I summaries the keyword from the responses on how to define the precautionary principle; (i) being awareness (ii) taking action (iii) scientific uncertainty. Most of the respondents told us that the precautionary might be we take the actions to reduce risk.

While most of them defined the substitution principle, basically, in the way of replacing the old one with the better alternatives. Due to the limited knowledge, so it was hard for the

respondent to define the substitution principle. Some were not be able to respond this question also. I think the substitution principle is easy to assume from how we call it directly, but it seems to be less dimensions in the implementation if we interpret in this way. This issue has been raised by several experts also. However, some respondents mentioned that we can substitute in other terms such as technology and the functions even they were unfamiliar with this concept before. It indicates that a belief to just replacement the fossil fuel with sustainable energy is not fulfill the task. The principle should be able to do more than this view.

5.3.4 Distinguishing Between Precautionary and Substitution Principle

Most scholars totally agree that there is a link between precautionary and substitution principle. During the interview, the question has been raised about the relationship between the precautionary and substitution principle. One point that I can see also is that the respondent obviously noticed the link between precautionary and substitution principle. Some said that they were not sure whether it divides into two principle. The way of response to the question indicates that most of them believe that there is no much difference between these two principles. Somehow, the respondents presumed that the substitution principle is one part of the precaution as I observed from their responses. Even the respondents are not clearly understood these principles, they still can see this relationship. I agree with this point because I also think that the substitution is considered as a precautionary measure. We are looking for the alternative as we want to confront the potential risk. The participant's perception fits well with the what is mentioned in several literatures. To be clear, the substitution strategy can be seen as one measure for the use of precautionary principle.

5.3.5 Summary

In conclusion, most of the respondents acknowledge that there are exist the precautionary and substitution principle in practice. They just do not know how it is called which may contribute to fundamental issues. Unfortunately, none respondents were absolutely understanding these concepts. In spite of unclear on the basis, the respondents can see the relationship between the precautionary and substitution principle in some extent. Thus, the substation as we require in the energy transition can be counted as the measure under the use of precautionary principle to confront risk when we are lacking scientific uncertainty.

5.4 Precautionary and Substitution Principle in practice

5.4.1 Implementing the Precaution and Substitution

As we all known that the precautionary and substitution principle are required to deal with the main target risk in climate change. There is still a question that in what level should we implement these principles. Certainly, we would not want to end up with the failed regulation like some prohibit cases in the Swedish policy.

According to the result, all respondents agreed that we need the radically measures to make the transition moving forward fast enough. It appeared that these approaches are the way to either promote or give force to substitution (see e.g. Hansson, Molander, and Rudén 2011).

5.4.2 THE PATHWAY TO ACHIEVE ITS ENERGY GOAL

Becoming a low-emission society by 2050 which is Norway's long-term target on energy transition policy requires several instruments to meet the target, while Norway is one of the world's important exporter of oil and gas production. Crude oil and natural gas are the main export products of more than 50% of the total. An economic growth including financing of the Norwegian welfare state in Norway has largely relied on the petroleum activities (Norwegian Ministry of Petroleum and Energy, 2013). It is clear that the Norwegian economy largely depends on the oil and gas industry.

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According to the press release, the policy focuses on the important keys in different area. First, improving the security of supply to find good ways of responding to the growing demand for power. In this area, the new technology and good management system will help to enhance the security of supply. Second, the government is looking for the efficient production of renewables. The wind power can be a new opportunity and may be profitable for Norway in European energy markets. Third, developing new technology and innovation to be more efficient and climate-friendly use of energy. This work is assigned to a national agency, called Enova, in order to reduce greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply. Forth, the focus is on economic growth and value creation through efficient use of profitable renewable resources. They believe that the renewable energy can help to create the value in other industries including competitive advantages in the global market.

In order to limiting CO2 emissions, the use of traditional energy resources will be restricted or phase-out by replacing with the alternative energy such as electricity, sunlight, hydropower, wind and so forth. These will affect more or less on Norwegian oil and gas industry in the long-term. Even the Norwegian government have realized that there is a significant challenge to achieve the goal, but they put forward their intention to enhanced the target to reduce greenhouse gas emission at least 50% until the maximum at 55% by 2030 in according to the intended nationally determined contribution (NDC) submission to the Declaratory Action of Constitutionality (ADC) under the Paris Agreement. The incremental target is step up compared to the last submission for 10%. According to Jan Tore Sanner who is the Minister of Finance, he said "[c]limate change is the biggest challenge of our time, and Norway will take on a leading role in cutting emissions both nationally and internationally. The fact that Norway

now steps up and strengthens its climate target for 2030 can pave the way for other countries to do the same" (Norwegian Ministry of Climate and Environment, 2020b). After the new target submission, the policy instruments will be added and more stringent to meet its goal.

As a result of my research, most respondents had an optimistic opinion that it is possible to achieve the goal by 2050. However, they supposed we need more ambition towards the policy strategy to reach its goal on the target year. I think it means that the current instrument and policy we have today is not enough. Still, the respondents did not want to lose the hope. That is why they had a strong belief that the development would keep going one until reaching the target.

Hence, the results present in the same direction. To achieve the target for transition, it truly needs; (i) policy instruments and institutions, (ii) energy transition will not be delivered by fast without government support, (iii) the government support for R&D and mandates; funding, (iv) the relative costs of new energy technologies, and (v) Technology development and new innovation

5.4.3 SUMMARY

Obviously, it cannot be denied that there has a change to reaching the target to become a low car bon society. With the current situations, achieving the target seems to be far away from the realistic. Yet, we still have a little hope to reach the goal if we could build up the ambition of the policy strategy that contributes to the strict law and regulation, including the better policy.

Chapter 6 – Conclusion and Recommendation

6.1 CONCLUSION

This research aimed to study how the precautionary and substitution principle would work to impel the energy transition in Norway towards a low emission society. There are several findings with respect to the discussions and results as following:

1) The substitution principle is a core pillar of the energy transition. It can be seen as a subset of the precautionary principle. It appeared that the doctrine of the substitution is not limited in the replacement of fossil fuels with renewable energy sources, but also includes technology development to promote the substitution. So, the government has an important role to launch the effective policy pushing forward to the goal of climate neutrality and be able to accelerate the speed of the energy shift.

2) It is clear that the energy transition requires the concept of substitution, but the fundamental principle of substitution is remarkably neglected. While the fate of the precautionary principle is not much different. The fundamental concept of the precautionary principle still has also received minimal attention even though a principle has been widely used throughout European regulation in addressing risk. As a consequence, it probably leads to practical issues.

3) The goal setting is a key in policy-making. In this context, it is rather difficult to predict the future outcomes in order to deal with climate risk. Reducing carbon emissions to mitigating climate risk can contribute to countervailing risk, and thereby decisionmakers have to take into account all concerned aspects to consider the overall risk picture. Therefore, there is a need for risk-based decision-making to make a better decision.

4) In a comparison between a content analysis of policy documents and interviews, the finding indicates that scientific-based and risk-informed analysis are essential for policy-making. Thus, decision makers should pay more attention to the role of scientific evidence and risk-informed analysis for better decisions.

5) As an optimistic view on a long-term policy, it would say that Norway has the opportunity to reach the 2050 goal of becoming a low-emission society with the conditions that if the policy strategy is enhanced to even more ambitious, including having more progressive on the future technology development. However, it is found that the pathway to reaching the target is still in doubt because the current measures and instrument now are still insufficient.

6.2 RECOMMENDATION

1) In order to achieve the 2050 goal, the available instruments need to enhance radically enforcement and providing more incentives. The government should get involved throughout the transition process. Accordingly, the precautionary instruments should be implemented intensively to promote the substitution.

2) Even the substitution principle is not a perfect tool, it is essential for the energy transition. It could help to accelerate the transformation to be faster if strengthen the fundamental knowledge of these principles. Common sense tells that a complete understanding of the basic concept could contribute to proper implementation, and also avoid any fundamental issues.

3) As policy-making involves risk perception to some extent, the policymakers should be able to distinguish between real and possible risks. Also, the policymakers should consider risks associated with the energy transition and other concerns. Thus, it is vital to note that the decision should be made based on scientific evidence and risk-informed analysis more than subjective judgement.

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Appendix A: Research Protocol

The interview questions were categorized into three main topics. Firstly, the general questions were asked about the participant's educational background and the current work, see as follow:

1. Tell me about your background and experience?
2. What is your current work about?
    - What are your responsibilities at work?

The next part was questioned about the energy shift in Norwegian context. These questions described how the participants understand the energy transition.

3. How is energy transition important?
4. In your opinion, what will be the most potential source for future energy?
5. What are the main challenges in terms of legal, economic, costs and benefits to health, and environmental impact for the energy transition in Norway?
    - What are the risks we may confront?
    - What are the benefits of the energy transition?
6. What is required for the energy transition in Norway to achieve its goal?
7. What is your expectation on the future of fossil fuels in a low-carbon society in terms of the risks and benefits?

The rest were designed to query the questions in terms of Norwegian energy policy and the concept of precautionary and substitution principle. The following shows questions in the last part of interview:

8. How familiar are you with the notion of precautionary principle and substitution principle?
9. How do you define the precautionary principle and the substitution principle?
10. How the precautionary and substitution principles are applicable to the energy transition?
    - What are the pros and cons of using these principles?
11. To what extent precautionary and substitution principles should be implemented in Norwegian climate policy?
    - Do we need to completely ban or phase-out the fossil energy?
    - Is it possible to completely replace fossil fuels with alternative resources?

12. As the transition goal to become a low-carbon society by 2050, whether the implementation of current instruments in Norway according to these principles are sufficient for the energy transition? If not, what will be further requirements?