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Summary

There is growing worry about the future supply of fossil-fuel-based energy and its environmental consequences. There is call for the globe to switch from fossil fuels to renewable energy sources. (Teles et al., 2015). On the other hand, the speed and scale of this shift remain uncertain and arguable. (Gribkova & Milshina, 2022). The energy transition is inherently risky. (Poudineh et al., 2019). The main objectives of the thesis are to gain improved knowledge of the risks related to the energy transition from fossil fuel to renewables for Norway and India, and contribute to improve the assessment and management of these risks. The energy industry is responsible for nearly three-quarters of the emissions that have already increased world average temperatures by 1.1 degrees Celsius since pre-industrial times, with evident effects on weather and climate extremes. The energy industry must be at the center of the climate change solution. (IEA, 2021b). The thesis performs risk analysis for both nations using Bayesian network, compares and demonstrates the variations in the study's outcomes, as well as the different risk management approaches that they may use. The Bayesian network events and consequences are interlinked, and the sequence of action may or may not be followed as demonstrated as it depends on the various factors and the probability of occurrences of scenarios involving these factors. Factors such as government policies encouraging renewable energy and energy efficiency, technology and innovation, people expectations, Covid-19 will all play a role in the sequence. The thesis further shows that socioeconomic factors influence the risks and the energy transition for both the countries. Risk comparison demonstrates that a same risk problem in two distinct situations (here, two separate nations) is not identical. The risk comparison underlines the importance of conducting a context assessment first in order to have a better understanding of risk. Risk management strategies are suggested in this thesis for the management of risks for Norway and India which contributes to improved risk management of the energy transition risks for Norway and India. Risk informed strategy is used in the thesis wherein risk treatment methods are suggested for the identified risk sources and initiating events. When one wants to choose between several solution alternatives for the energy transition problem then the author suggests that a multi-attribute analysis is a better approach for decision making because there are several factors influencing the decision-making process, including energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, citizen psychology, societal preference, speed of transition, and in general its magnitude. The author believes that the governments must try to strike a balance between the various attributes. These questions have no definitive solutions. The author of this thesis emphasizes that whether precautionary principle be given more or less weight is the choice of the decision maker. Companies should propose alternative uses of oil and gas utilities to successfully tackle the energy transition barrier and enhance the degree of risk acceptability and tolerance in the energy market. For productive operations, organizations should take effective precautions and adopt contemporary risk acceptability models such as ALARP. By performing risk analysis and comparing the risks these countries face in achieving the Paris Climate Agreement and the Sustainable Development Goals using various risk management strategies, this thesis contributes to a better understanding of the energy transition risks and improved risk assessment & risk management for Norway and India.

1 Introduction

1.1 Background of the thesis

Risk analysis methodologies and methods are used all over the globe these days, and they integrate information from statistics, engineering, medicine, psychology, social sciences, and a variety of other disciplines to find solutions to risk challenges. Risk analysis aids in the creation of risk information for real-world activities such as the operation of engineering systems, medicinal treatments, natural events, and many others. It's also a science that generates knowledge in the form of concepts, theories, principles, models, and techniques for analysing, describing, communicating, managing, and controlling risks.(Society for Risk Analysis (SRA), 2018a).

Talking about real-life activities, one of the biggest talking points these days is the ongoing challenges towards a renewable based world. (REN21, 2021). Energy can create transformational opportunities. Clean energy solutions may deliver important services such as improved healthcare, better education, and inexpensive broadband to the 759 million people in the globe who do not have access to electricity, as well as new employment, livelihoods, and long-term economic value to alleviate poverty. Not only is an energy revolution based on renewables and energy efficiency required to speed up economic progress and development, but it is also required to reduce emissions that are fast warming our planet. Currently, the energy sector, which is dominated by fossil fuels, is responsible for 73% of human-caused greenhouse gas emissions. To avoid an increase in the frequency and intensity of severe and catastrophic weather extremes, including as heatwaves, devastating floods and droughts, threats to food and water security, population displacement, and loss of lives and livelihoods, global CO2 emissions must be cut in half by 2030. As nations begin to establish a road out of the COVID-19 crisis, we must now make sure that all countries have the opportunity to participate in an energy transition that greatly enhances people's and planet's well-being. This will be a difficult task. To achieve a fair transition, we must help nations and communities adapt to a green economy through social protection and new skills, ensuring that everyone who needs to be is prepared to take advantage of the 30 million new green employment predicted by 2030. (United Nations & IRENA, 2018)

The International Energy Agency (IEA) is an organization which studies a wide range of energy issues, including supply and demand for oil, gas, and coal, renewable energy technologies, power markets, energy efficiency, energy access, demand side management, and much more. (IEA, 2021b). Natural gas, coal, and power costs have risen to all-time highs in several locations, giving governments ample warning of this threat. The primary causes of these substantial price rises are unrelated to initiatives to shift to sustainable energy. A quick economic recovery from the pandemic-induced slowdown, weather-related problems, and certain supply-side planned and unexpected outages are among them. However, this does not guarantee that renewable energy transitions will be smooth in the next years. (IEA, 2021b).

The process of energy transition is inherently risky. Energy transition risk presents itself in a variety of ways, including market players' investment and operation decisions, as well as changes in the value of organizations' assets. (Poudineh et al., 2019). Risk is almost always a major consideration when trying to tackle real-world problems, such as those relating to technology, health, security, or climate change, and making appropriate judgments. (Aven, 2018). It is critical to emphasize that the energy transition should not be viewed as a global crisis, but rather as a tool for dealing with major challenges. (Gribkova & Milshina, 2022).

An activity, whether real or imagined, that lasts for a certain amount of time has some long-term consequences C, and they are unknown — they are uncertain (U). C and U are the two components that make up risk. A risk analysis' principal goal is to characterize risk, or to produce an informed risk picture. The risk analysis process is an important aspect of risk management, and it follows a similar structure regardless of the application. Risk management frequently necessitates decision-making in situations defined by high risk and substantial uncertainty, and such decision-making provides a challenge in that the implications (outcomes) of such actions are difficult to foresee. (Aven, 2015).

There is an increasing concern about the future availability of the energy based on fossil fuels and the impact that it has on the environment. The increasing demands of energy leads to exploration of oil & gas in difficult areas increasing the related costs. Further, these energy sources have higher emissions of greenhouse gases and hence more dangerous to environment than the renewable energy sources. Therefore, there is a growing call for replacing the fossil fuels with cleaner and renewable energy sources. (Teles et al., 2015). The need for transformation in the global energy system has long been recognized. If there was ever any question, the COVID-19 pandemic has solidified it. The Covid issue has revealed the flaws in the present energy system, as well as the repercussions of energy poverty, which affects billions of people throughout the world. The energy transition is a critical facilitator of climate resilience and sustainable development. Forward-thinking initiatives will result in the creation of new employment, increased economic growth, along with several social and health advantages. The energy transition is not a one-size-fits-all scenario. It entails a combination of competencies, technology, policies, financing, and resources and represents a variety of goals. While the exact journey to the final objective is unique to each nation, the destination is universal. To guarantee that no one is left behind, the process must be fair, inclusive, and systematic. To allow the sharing of experiences and best practices, international and regional collaboration is vital. (United Nations & IRENA, 2018).

To track clean energy transitions successfully, one must first understand what a clean energy transition may look like. Insights into the long-term consequences of today's energy decisions, based on current policy plans and investment decisions, combined with an understanding of what can be done differently to meet climate, energy access, pollution, and other sustainability goals, provide a framework against which indicators can be used to measure progress. (IEA, 2019). The author of this thesis believes that there is a need for risk analysis and comparison of Norway and India in order to determine that even if their destination of meeting climate goals is the same but the path and time to reach the destination may be different. The IEA made efforts previously to demonstrate its commitment to driving clean energy transitions throughout the world by helping governments understand what they need to do to reduce emissions quickly and sustainably. However, it has made it clear that nations' transitions must be safe, affordable, and fair for all populations. Governments risk failing if they do not ensure that these important factors are at the center of their policymaking for energy sector change. (IEA, 2021b). The author aims to fill this gap of risk understanding and show that both the countries need different plans and risk management strategies. Therefore, this thesis contributes to create improved knowledge on the energy transition risks for Norway and India to show exactly how the transition can be safe, fair and affordable by performing risk analysis and making comparison of the risks these nations see to attain the objectives of Paris climate agreement and Sustainable Development Goals by using different risk management strategies.

Government action is a significant factor in determining where the planet goes from here. They do not have absolute ownership; people, communities, civil society, businesses, and investors may all make a significant effect. None, however, have the same ability as governments to define the future of energy by establishing framework conditions that direct investment to energy projects, promoting innovation, sending clear signals about long-term goals, and taking the required actions to achieve them. (IEA, 2021b). The need to address climate change is the primary motivator for a shift from a fossil-fuel-dominated energy industry to one focused on renewable energy sources. Currently, the energy industry is the largest source of greenhouse gas emissions (GHGs). GHG emissions from such industry must be lowered swiftly and eradicated by mid-century to satisfy the Paris Agreement's targets. (United Nations & IRENA, 2018)

When we talk about risk analysis, it is a decision-support tool in which the methodology must be customized to the objectives of the analysis. Risk analyses are conducted to aid decision-making in the selection of solutions and remedies while Risk management is concerned with all actions, situations, and events that may have an impact on the organization's capacity to achieve its goals and vision. To be more particular, consider an enterprise. The enterprise, as well as its goals and vision, will determine which actions, situations, and events are crucial. (Aven, 2015). The author of this thesis, wants to draw an analogy of a country with an enterprise and its government as top management in the enterprise risk management terms.

The risks that Norway and India face as they would move away from fossil fuels and toward renewable energy is the subject of this thesis. Norway and India are two distinct countries with very different challenges and potentials. Population, energy demands, energy supplies, geography, environmental difficulties, financial budget, government regulations, public perception of green energy, and the magnitude of impact if transition is successful do not appear to be identical for the nations. These statements are supported with various evidences and arguments throughout the thesis. The reason why they are chosen for this thesis was because of their unique position in the global energy market as demonstrated in the coming chapters. The thesis aims to conduct risk analysis for both the countries, compare and illustrate the differences in the outcomes of the study as well as the various risk management techniques that they can employ.

1.2 Purpose of the thesis

The main objectives of the thesis are to gain improved knowledge of the risks related to the energy transition from fossil fuel to renewables for Norway and India, and contribute to improve the assessment and management of these risks.

1.3 Content of the thesis

The thesis is organized as follows.

Chapter 2 discusses the current energy situation across the world as well as the energy transition process. It offers context for the current energy situation and serves as a starting point for debate and risk analysis in the thesis. The topic of the chapter further boils down to introducing Norway and India's energy and transition issues.

The risk analysis process is covered in Chapter 3. The risk analysis process for a real-life problem – energy transition – is addressed in this chapter. The planning step begins with problem definition. The situation of energy transition for Norway and India is treated as the 'problem' – subject for risk analysis process and further use. Establishing the context for risk analysis process is important part of the planning step which is followed after problem definition. Based on the problem and context, the next step is selection of analysis method. Risk assessment step consists of the elements of risk analysis and risk evaluation. Risk analysis of energy transition is performed to provide a clear risk picture related to energy transition for Norway and India. The risk picture aims to create an understanding of risk by identifying the risk sources (RS'), events (A'), consequences (C'), measure of uncertainty of occurrence (Q) of RS', A' and C', the likelihood of occurrence of RS', A' and C' and the knowledge aspect on which the likelihood is based on with clear highlight on the strength of knowledge (SoK). The risk evaluation step follows the risk analysis. It aims to evaluate the results from risk analysis with the various risk tolerance criteria of the two countries. Risk comparison in terms of energy demands, energy sources, population, economy, environment, health, infrastructure, public acceptance of the solutions, government policies and regulations are also part of this chapter. Risk treatment consists of suggestions to handle the various risk sources / consequences.

Chapter 4 gives further considerations and insights on application of risk management strategies on the subject. It suggests risk management strategies to handle the energy situation to create a better understanding of solve the energy demands and the shift to renewables.

Discussions are presented in Chapter 5. Here the key findings of the previous chapter are presented and discussed. The results of the analysis are interpreted and the limitations of the study is acknowledged. Recommendation for implementation and future research is presented.

Conclusion makes chapter 6.

Appendix A and B explains some of the fundamentals of the risk analysis process and risk analysis& management respectively. Appendix C contains survey questions on energy transition.

At the end are the references – on which the thesis is based on.

1.4 Methodology

Risk science explains concepts, principles, methods, and models for assessing, characterizing, communicating, and managing (in a broad sense) risk. (Aven, 2020). The thesis employs the method of 'applied risk science'. Risk analysis method of 'Bayesian network' is used in this thesis. The study looks at specific events and specific consequences of interest influencing the governments' principal objectives based on the identified initiating events (threats/hazards). Identifying the most significant risk-influencing factors is also a critical endeavor.

Bayesian network consists of specific initiating event which can lead to a specific consequence affecting the principal objective of the government in question. The risk sources for the event are identified and a complete network is created for the given risk problem.

The author argues that by using a Bayesian network for the given risk problem, it will be feasible to express the relationship between the various variables in a more meaningful manner (energy demand, energy production, new policies, innovation etc.). The method adopted appears to be adequate for the objectives. Because the problem to be addressed is considered critical, a comprehensive analysis that presents an informed risk picture is necessary to provide a solid foundation for the decision to be made. The analysis focuses on qualitative assessment.

2 Present energy situation and transition

2.1 Energy situation of the world and transition

It's difficult to ignore the warning flags. The energy sector is in the limelight since it is responsible for about 75% of global greenhouse gas emissions. In the run-up to the crucial meeting of the United Nations Framework Convention on Climate Change Conference of the Parties (COP26), there were signs of a response, both in the deployment trends for some clean energy technologies and in the increasingly ambitious pledges to reduce emissions made by governments, municipalities, companies, investors, financial institutions, and others. However, recent energy and emissions trends show that we still have a long way to go in terms of how we use and consume energy: the world's partial recovery from the Covid-19 pandemic has raised demand for all fuels and technologies, resulting in a sharp rise in prices and carbon dioxide (CO2) emissions.(IEA, 2021b).

The energy industry is responsible for nearly three-quarters of the emissions that have already increased world average temperatures by 1.1 degrees Celsius since pre-industrial times, with evident effects on weather and climate extremes. The energy industry must be at the center of the climate change solution. At the same time, modern energy is inextricably linked to the livelihoods and aspirations of a global population expected to grow by 2 billion people by 2050, with rising incomes driving up demand for energy services and many developing economies navigating what has traditionally been an energy- and emissions-intensive period of urbanization and industrialization. The current energy system cannot address these challenges; a low-emissions revolution is long awaited. (IEA, 2021b). Norway and India are among the countries who signed Paris agreement. It stated, "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change." (United Nations, 2015).

The energy sector's transformation can lead to long-term economic growth, social inclusion, energy security, improved health, job creation, and other societal advantages. Only if the transition is carried out in a just and inclusive way can such opportunities be realized. Although governments must lead on goal-setting and process, the business sector, cities, and wider civil society, especially youth, must be involved in the creation of a balanced and equitable transition process that is consistent with SDG7 and addresses diverse economic and social concerns.(United Nations & IRENA, 2018).

The energy sector is confronted with a number of interconnected issues: (United Nations & IRENA, 2018)

- As the world's population and economy rise, so does the need for energy services.
- Providing modern electricity to the approximately 700 million people who are now without it would necessitate increased power capacity and infrastructure expansion in nations with limited financial resources.
- The energy sector contributes for over 65 percent of total world GHG emissions; they must be drastically cut, if not abolished, to reach the Paris Agreement's targets.
- Energy systems must become more robust to economic and environmental shocks in the future.

- A significant move away from highly centralized energy production toward increasingly decentralized energy production introduces new parties into the energy value chain, including people, who can both generate and consume energy.
- Increasing the electrification of end-uses such as transportation will result in a large rise in power consumption.

To tackle these hurdles, all countries will need to make large energy sector transitions. To improve energy efficiency and productivity, promote changes in consumption patterns and lifestyle choices, and extend renewable energy for power supply and direct use within and across areas, massive efforts will be required. Simultaneously, the energy sector infrastructure must be changed and expanded to allow for higher use of variable sources, system flexibility, and electrification of new services, primarily for transportation. The good news is that many answers already exist, and transformations are already underway in several nations and areas, and are being developed and scaled up. The pace and magnitude of change, on the other hand, are country-specific, reflecting each country's conditions, especially the financial resources available. Furthermore, to constantly enhance existing choices and fill the gaps for a decarbonized energy system by 2050, increased innovation in technology, business models, and market solutions is required. (United Nations & IRENA, 2018)

SDG7 (Sustainable Development Goals) has a basic definition of energy sector targets for 2030: (United Nations & IRENA, 2018)

- Ensure that everyone has access to cheap, dependable, sustainable, and contemporary energy.
- Significantly increase the proportion of renewable energy in the global energy mix.
- Double the worldwide pace of energy efficiency improvement.

Understanding the underlying baseline and implementation-path assumptions for the three objectives (in SDG7) is critical for assessing how reaching them would help to fulfilling the Paris Agreement's temperature goals. For the energy sector generally, this would require a 25–30% decrease in emissions by 2030 if we want to stay below 2°C, and a 50% drop if we want to stay below 1.5°C. This is in accordance with the Intergovernmental Panel on Climate Change's (IPCC)7 assertion that global net anthropogenic CO2 emissions must fall by around 45 percent from 2010 levels by 2030, and reach net zero around 2050, in order for the 1.5°C target to be met by 2100. (United Nations & IRENA, 2018).

To meet the SDG7 targets and pave the way for strategies to achieve net zero emissions by 2050, there will need to be: urgent and strong political leadership at the local, national, and international levels; clear national targets and timetables; broad stakeholder engagement; and enabling policy frameworks that focus on job creation, economic gains, and environmental benefits, while ensuring that the transition is "just" in the broadest sense. (United Nations & IRENA, 2018).

Even if the majority of the consequences on emissions are not noticed until later, this is another critical gap to be bridged in the 2020s. All of the technologies required to achieve significant emissions reductions by 2030 are now accessible. However, over half of the NZE's (Net Zero Emissions) emissions reductions in 2050 will come from technologies that are now in the demonstration or prototype stage. These are especially crucial for addressing emissions from iron and steel, cement, and other energy-intensive industries, as well as long-distance transportation. The promises made today fall short of important NZE objectives for hydrogen-based and other low-carbon fuel deployment, as well as carbon capture, utilization, and storage (CCUS). (IEA, 2021b).

Changes in climate and energy policy, as well as funding, continuing technical improvement, and fluctuations in energy supply and demand, will all have an impact on the national energy system during the next decade. Renewable technology' fast lowering costs have opened up previously unimagined opportunities all around the world. Many nations' current advances point to a bright future for the security, inclusivity, and sustainability that come with a reformed energy industry. However, in order to fulfill SDG 7 (Sustainable Development Goal) and correspond with the aims of the Paris Agreement on climate change while also implementing the 2030 Agenda for Sustainable Development, the transition must be accelerated and broadened greatly. (United Nations & IRENA, 2018).

As a result, the energy shift can no longer be restricted to little increments. To innovate for the future, it must become a transformative endeavor, a system overhaul, based on rapid upscaling and deployment of all available technologies. This is an excellent time to reconsider long-held preconceptions, perceived restrictions, and default judgments. For a more inclusive and fairer world, the future energy system must encourage resilient economies and societies. To meet the goals of SDG7 and establish a decarbonized energy system by 2050, ambitious and focused efforts are required now and in the next decades. (United Nations & IRENA, 2018).

2.2 Energy situation of Norway and India

Norway's climate ambitions for 2030 are unlikely to be met. Norway has set aggressive climate goals, including a 55 percent reduction in emissions by 2030 compared to 1990 levels, with a further decrease to net zero by 2050. Norway will most likely only achieve a 24 percent decrease by 2030, and a 79 percent reduction by 2050, according to the projections by DNV. Because of its hydropower-dominated electrical grid, Norway's energy usage already has a low carbon intensity. This is a problem because the majority of the remaining emissions come from hard-to-abate industries like oil and gas extraction, heavy transportation, and agriculture, all of which will need to be targeted if Norway is to meet its ambitious climate ambitions. However, it is seen a somewhat effective decarbonization of the road transport industry, particularly for passenger cars. Battery electric vehicles (BEVs) will account for half of the Norwegian passenger vehicle fleet by 2030, resulting in a 25% decrease in overall road sector CO2 emissions compared to 1990 levels. (DNV, 2021a).

Norway's climate goal has been raised to a 55 percent reduction in GHG emissions by 2030 compared to 1990. This translates to a reduction in emissions from over 52 million tonnes in 1990 to around 23 million tonnes in 2030. However, emissions were only marginally lower in 2020 than they were in 1990, making the road ahead exceedingly difficult. Emissions must be reduced by around 29 million tonnes during the coming years upto 2030. In comparison to the relatively flat trends from 1990 to 2020, this is a significant decrease. Norway is far from meeting the carbon objectives established for 2030 and 2050, according to the DNV analysis. As per DNV's projections, it will only reduce emissions by 24%, or 13 million tonnes, by 2030. To meet Norway's pledged commitments, additional 16 million tonnes must be eliminated by 2030. (DNV, 2021a). Norway's energy exports are vital to Europe. Norway's trade balance is favorable due to oil and gas exports. However, due to lower production, oil and gas export values are predicted to drop by almost two-thirds by 2050. This will have a major influence on the labor force as well as the trade balance. To reclaim a positive trade balance, green industry and renewable energy exports must be established. (DNV, 2021a).

Because of its hydropower-dominated electrical grid, Norway already has a low carbon intensity energy system. The hardest-to-abate sectors, such as oil and gas production, heavy transportation, and manufacturing, account for the majority of the emissions must be decreased. Renewable power is a critical tool for decreasing emissions in the transportation, industrial, and oil and gas industries. Everything that is electrifiable should be electrified. Clean power is required for hydrogen production, ammonia production, and carbon capture. New green sectors, such as battery manufacturing, will need a significant quantity of renewable energy. The power supply in 2050 is predicted to be over 250 TWh, or 75% more than it is now. Norway's major tool for increasing power production is floating offshore wind. (DNV, 2021a).

The importance of time cannot be overstated. The world is becoming warmer, and natural disasters are becoming more common. It is critical to accelerate the process of obtaining projects approved by a number of regulatory organizations. Before demand is committed, infrastructure for power and hydrogen must be created. Electrical infrastructure must be built offshore. To meet the rising demand for power, more floating offshore wind farms must be built. Governmental assistance programs are required to get initiatives off the ground and to bring the cost curve for innovative technologies down. It's time to take action; we must make decisions right now. (DNV, 2021a).

Norway will most certainly be required to import power for several years between 2025 and 2035 in order to feed the Norwegian Continental Shelf (NCS) with electricity while also supporting green industrial growth. Importing power can generate price instability as well as remove the competitive advantage of low-cost green electricity, which is required for industrial operations. Since the beginnings of oil and gas production on the continental shelf in the early 1970s, Norway has had tremendous energy abundance, leading to regular budget surpluses and the growth of the sovereign wealth fund. Norway is the world's fourth-largest gas exporter, eleventh-largest oil exporter, and exports nearly all of its petroleum production. However, after 2025, when numerous fields reach the end of their service life and global demand for oil begins to decline, Norwegian oil output will begin to decline; by 2050, exports will be less than 20% of current levels. Gas production and export are expected to stay stable until approximately 2030, when they will begin to drop gradually as European gas consumption falls as a result of strong climate legislation and renewable energy competition. (DNV, 2021a)

In the global energy economy, India is a prominent player. Since 2000, energy consumption has more than quadrupled, fueled by a rapidly rising population – shortly to become the world's biggest – and a time of fast economic expansion. In 2019, about 900 million residents acquired access to electricity, marking the first time in more than two decades that everyone in their home has power. India's energy industry and policymakers will face enormous pressures as the country continues to industrialize and urbanize. Energy consumption per capita is far below the world average, and there are significant disparities in energy consumption and service quality within states and between rural and urban regions. India's customers are concerned about the price and dependability of electricity supplies. (IEA, 2021a).

Three fuels provide about 80% of India's energy needs: coal, oil, and solid biomass. Coal has fueled the growth of power generation and industry, and it continues to be the most important fuel in the energy mix. Because of expanding vehicle ownership and usage of road transportation, oil consumption and imports have increased fast. As a result, oil consumption has more than quadrupled since 2000. Biomass, particularly fuelwood, accounts for a decreasing percentage of total energy use, but it is still commonly utilized as a cooking fuel. 660 million Indians have not entirely shifted to modern, clean cooking fuels or technology, despite recent achievements in extending LPG access in rural areas. (IEA, 2021a). LPG has also contributed to the rise in oil consumption, in part because the government has subsidized and encouraged its use in culinary applications. Due to a lack of indigenous resources, India's reliance on crude oil imports has continuously increased, reaching roughly 75% in 2019. Since 2000, India's industry sector has been the major driver of energy demand increase, with coal accounting for over half of it. Since 2000, transportation energy consumption has increased by 3.5 times, while building energy demand has climbed by 40%, owing to increasing appliance ownership and improved availability to contemporary cooking fuels. (IEA, 2021a)

As urbanization and rising wages force up the usage of domestic appliances, electricity consumption has nearly quadrupled in the last two decades, expanding faster than overall energy demand. The increased usage of electrical motors and other machinery by industry has also contributed to the rise in power demand. On the supply side, coal continues to dominate the power industry, accounting for more than 70% of total generation in 2019. In 2019, solar PV and wind accounted for 18% of total capacity, while their combined generating share was less than 10%. (IEA, 2021a). Because of growing earnings and expanding living standards, India is the world's third largest energy consumer. India will soon overtake China as the world's most populated country, adding the population of a metropolis the size of Los Angeles per year. To fulfill rising energy demand over the next two decades, India will need to expand its current power grid to the size of the European Union. (IEA, 2021a)

India has the highest rise in energy consumption of any nation in all of our scenarios through 2040, because to its growing economy, population, urbanization, and industrialization. India's economic growth has traditionally been fueled by the services sector rather than the more energy-intensive manufacturing sector, and its urbanization rate has been slower than that of other comparable countries. However, even at a moderate anticipated pace of urbanization, India's sheer size means that 270 million people would be added to the country's urban population during the next two decades. As a result, the building stock and associated infrastructure are rapidly expanding. The accompanying spike in demand for a variety of construction materials, particularly steel and cement, exemplifies the global industrial shift to India. India's pace of energy demand increase is three times that of the rest of the world as it expands and urbanizes. (IEA, 2021a)

All roads to successful global clean energy transitions go via India. Despite its low per capita CO2 emissions, India is the world's third highest CO2 emitter. Its electricity industry, in particular, has a carbon intensity that is significantly above the global norm. India is in a great position to pioneer a new paradigm for low-carbon, inclusive prosperity as the world looks for methods to speed up the pace of transition in the energy industry. Many components of such a model may already be seen in India's policy goal, and many more are emphasized in the Sustainable Development Scenario, which shows India's path to net zero emissions. If this can be accomplished, it would pave the way for one of the many energy-hungry developing nations by proving that strong economic growth can coexist with growing carbon reductions and other development goals. India is already a world leader in solar energy, and solar energy paired with batteries will play a significant role in India's energy future. However, to chart this new course, India would require a wide range of technology and policies. India will need to ensure that no one is left behind as new economic sectors emerge and renewable energy employment increase, particularly in places that are now highly reliant on coal. (IEA, 2021a).

3 Risk Analysis process for Energy transition – Norway and India

This thesis will concentrate on the risks that Norway and India face as they go forward with the energy transition from fossil fuels to renewables, in order to acquire a better understanding of the risks. Its goal is to help enhance risk assessment and risk management methods and procedures for the two nations' transition.

Risk analysis process is framed on the below three blocks:

- Planning
- Risk assessment (execution)
- Risk treatment (use)

The questions to answer here are: What is the difference between risk picture of the two countries? Is the threat too high? Is it necessary to put in place risk-reduction measures?

3.1 Planning

In this chapter, we will plan our risk analysis and also include risk evaluation, which together is called risk assessment. We will take into consideration the energy transition situation of Norway and India for the risk analysis. The activity of planning may be broken down into two sub-activities (Aven, 2015).

- Problem definition, information gathering and organisation of work.
- Selection of analysis method.

One must understand that it is significantly easier to make modifications 'on paper' during the planning stages than it is to make adjustments to existing systems during the operational stage (Aven, 2015). As a result, importance of planning in a risk analysis process should not be undermined.

- **Problem definition, information gathering and organisation of work**

The definition of the analysis' objectives is the first stage in a risk analysis. Why should we do the investigation? The goals are frequently based on a problem description. (Aven, 2015). What are the consequences of the energy transition process not being successful? The aim of the energy transition process is to ensure that the countries move towards a greener and more sustainable world. As it has been made clear from chapter 1 and 2 that the energy transition is inevitable but how does the transition stand for the two countries in this study, Norway and India, needs to be investigated. Energy transition is not a one-size-fits-all phenomena (United Nations & IRENA, 2018). Both the countries have different risks and they face different challenges. Hence, what approach needs to be taken by the two countries need to be found out as a result of the analysis. What kind of risk handling and management strategies do they need to make this transition a success?

The objective of the risk analysis is to address the following questions:

- What are the risks seen by Norway and India in the process of energy transition from fossil fuels to renewables?
- What will be the risk handling and management strategies to counter the risks?

The speed and scale at which the transition will occur is studied. The risk analysis' goal is to give a foundation for choosing an alternative (Aven, 2015).

The objective of the analysis is to present a risk picture of the two countries, Norway and India.

Risk description = (C′, Q, K), (or alternatively, (A′, C′, Q, K), where A′ are some specified event A occurrences and C′ are the specific consequences of interest. K is the underlying information (models and data utilized, assumptions, etc.) on which Q and C′ are based. Allowing Q = P, or knowledge-based probability, to describe the uncertainties, is a typical method to risk assessment. (Aven, 2015). We will always keep the specific C′ and A′ in mind while writing a risk description in this thesis.

The analysis builds on

- knowledge concerning the energy situation of both the countries;
- relevant risk data;
- Future plans from both the countries available from credible sources;
- Other reference information available.

Is the transition speed acceptable? What type of measures are required to reach an acceptable level of transition success? In the analysis, risk critical events are identified. The goal is not to quantify the risk level within the region, but rather, to qualitatively list the events in order to find measures which can be implemented to mitigate them and the associated consequences. The objectives have been defined considering time constraints, acknowledging that all the accessible data or information may not be possible to analyze given the magnitude and complexity of the problem in question. Different types of attributes, such as government policies and regulations, population, environment. energy demand, energy sources, public perception, societal safety, economy and infrastructure are analyzed. The results of the analysis can be used in the decision-making process related to the energy transition by both the countries. It gives support in decision making and does not answer the question itself. The relevant audience of this analysis and its results can be any party who find the results applicable and suitable to their situation and roles in the given context of energy transition. Depending on how much weight politicians assign to particular ideals, the ultimate decision might be different.

The author of this thesis, draws an analogy of a country with an enterprise and its government with top management in the enterprise risk management terms. It is important to establish the context in such a scenario. There is a context, an activity, that has certain implications for something that humans value (life and health, environment, economic assets). Enterprise risk is defined as “Risk of an enterprise where the consequences are related to the principal objectives or overall performance judged important for the organization.” (Aven & Thekdi, 2020). In the given context, the author compares the consequences of the failure of energy transition related to the principal objectives laid down by the governments of both the countries for a smooth and successful transition. A common principal objective for the two countries is better environment and climate for their citizens and the citizens around the world.

- **Selection of analysis method**

The governments require a solid decision-making basis since the investment in the move to renewable energy is substantial. (Poudineh et al., 2019). In this thesis, a Bayesian network approach for risk analysis is applied. The risk is considered to be significant, and a complete and extensive study that offers an informed picture of the risk is necessary to provide the politicians with a strong foundation for their decisions. There is a lot of uncertainty about how the transition will go without having a detrimental influence on the society. The world is evolving, and the way energy is generated and consumed is set to alter dramatically in the next years. (IEA, 2021b). As a result, it's critical to highlight the uncertainties rather than relying just on probabilities to create a risk picture. The study looks at specific events and specific consequences of interest influencing the governments' principal objectives based on the identified initiating events (threats/hazards). Identifying the most significant risk-influencing factors is also a critical endeavor.

With Bayesian network it is possible to describe, in a more nuanced manner, the relationship between the various variables (energy demand, energy production, new policies, innovation etc.). The approach used is seen to be adequate for the goals set out. The most important thing is to identify and characterize the key characteristics of the risks and vulnerabilities. A complete and extensive study presenting an informed risk picture is required to offer a sound basis for the choice to be taken since the problem to be handled is regarded critical. The focus of the analysis is on qualitative assessment.

3.2 Risk analysis for Norway

Now, we look closer into the different activities of a risk analysis for Norway, covering identification of initiating events A', cause analysis – risk sources identification (RS') & consequence (C') analysis in this chapter.

A risk analysis' principal goal is to characterize risk, or to give a useful risk picture. The risk analysis will determine the relevant initiating events and construct a cause and consequence picture. (Aven, 2015). The result of risk analysis here will present a risk picture for Norway and India. The primary goal of a risk analysis is to assist in decision-making. The analysis can serve as a useful starting point for determining the best balance between various issues, such as safety and cost. (Aven, 2015). It can be interesting to see how risk analysis results differ for the two countries and then the discussion for risk treatment and risk management is so different for them.

In this thesis, the author aims to strike a balance between the need for precision and the need for decision assistance. Because this is a dynamic subject, the analysis is based on the information available during the time. Situations can alter owing to global variables such as unstable political conditions, COVID spread and its impacts, conflicts among nations, and so on.

- **Identification of (specific) initiating events A'**

The purpose of this section is to identify events which can lead to the failure in the energy transition process for Norway. The identification of initiating events is the first stage in the execution phase of a risk analysis.

Developing energy efficient system is the most cost-effective approach to reduce emissions, therefore it should be first on the list when governments and corporations consider their options for decreasing emissions. If this is not achieved then reduction in emission will not happen. (DNV, 2021a). As a result of which, attempts to realize decarbonization could be in jeopardy.

The power supply in 2050 is predicted to be over 250 TWh, or 75% more than it is now. Norway's major tool for increasing power production is floating offshore wind. Norway's energy exports are vital to Europe. Norway's trade balance is favorable due to oil and gas exports. However, due to lower production, oil and gas export values are predicted to drop by almost two-thirds by 2050. This will have a major influence on the labor force as well as the trade balance. To reclaim a positive trade balance, green industry and renewable energy exports must be established. With rising energy needs, the energy production industry is anticipated to be pressured, necessitating the development of alternative energy sources to meet these demands. (DNV, 2021a).

Before demand is committed, infrastructure for electricity and hydrogen must be created. Electrical infrastructure must be built offshore. To meet the rising demand for power, more floating offshore wind farms must be built. (DNV, 2021a). The future demand for oil and gas will be profoundly affected by a faster energy transition. The question of when world demand will peak is now being debated. What happens after demand has peaked, though, is possibly more important - will there be a prolonged plateau, a gradual drop, or a precipitous collapse? (Froggatt et al., 2020). Failure to scale up renewables production can lead to continual of oil & gas production to fulfill energy demand which in turn will fail the efforts to decarbonize. Another scenario that can take place in case of demand increase and renewable does not ramp up production but due to committed policies, oil & gas production will be required to be tapered down resulting in high demand and low supply situation in Norway leading to unbalancing the energy demand-supply chain.

Decarbonization of heavy industry, which will rely on technologies that have yet to be tried at scale, such as green hydrogen or blue hydrogen with carbon capture and storage (CCS), will be required to meet ambitious climate objectives. The success or failure of these technologies to commercialize will have a significant influence on the usage of fossil fuels in many industries, notably heavy and processing industries, as well as current transportation and production infrastructure. (Froggatt et al., 2020). Because hydro power is Norway's primary source of energy, the majority of the emissions that need to be lowered are in hard-to-abate industries like oil and gas extraction, heavy transportation, and industrial. Renewable power is a critical tool for decreasing emissions in the transportation, industrial, and oil and gas industries. (DNV, 2021a). If alternatives for fossil fuel is not found for these sectors, then it will lead to energy production continuing with fossil fuels and directly or indirectly will fail the efforts to decarbonize.

Industrial development policies will be critical in supporting green industrial growth by unlocking industry prospects. Building a domestic industry will necessitate expanding the policy toolbox to determine the best ways to support industry and technology initiatives at various stages of maturity, as well as to stimulate market and supply-chain creation through projects that have the enthusiastic support of local communities and the country as a whole. (DNV, 2021a). Failure in required policy making will result in innovative products and technology getting into market at a slow rate indirectly reducing the impact of renewable on the system and results in failure in decarbonization.

- ## Cause analysis – identification of threat (risk) sources RS’

We investigate what is required for the initiating events A’ to occur during the cause analysis. What are the variables that cause this? We employ a Bayesian network as our risk analysis approach, which gives us with these causal factors, or risk sources RS’.

Demand growth in Norway began to slow after 2008 due to significant improvements in energy efficiency, as a result of innovations in lighting and heat-pump technology, for example. The next few decades will almost certainly be different. Energy demand growth will eventually trail economic growth due to huge efficiency gains — mostly facilitated by rapid electrification. (DNV, 2021a). The rate of rise in demand for fossil fuels is being slowed by energy efficiency, changing consumption habits, and rising use of non-fossil fuels, especially renewable energy. Large-scale industrial initiatives, such as energy efficiency will be used to meet the 2030 objective; additional reductions will necessitate the development of new technologies and value chains. (Froggatt et al., 2020). Thus, if energy efficient systems are not developed then it can further cause reduction in decarbonization.

The COVID-19 pandemic caused a significant decline in energy consumption in 2020, followed by a rebound in 2021 and continuing increase until 2030. However, after then, energy consumption will progressively decline until 2050. During this period, energy efficiency will be a major driver of the change. It's also generally the most cost-effective way to cut emissions. The electrification of the energy system, as well as the fast-expanding role of renewables in electricity generation, are the key drivers of energy-efficiency gains in many nations, reducing massive heat losses. (DNV, 2021a).

Rapidly growing share of renewable sector advantages are limited for Norway because hydropower provides the majority of Norway's electricity, but electrifying oil and gas production would increase efficiency. Efficiencies may be found not just in the energy supply, but also in how it is utilized. Increasing efficiency through electrifying end-use demand, as shown in the penetration of electric vehicles in the passenger car category. The most significant improvement is projected in road transportation, where electric cars will continue to supplant less-efficient internal combustion engines. Other initiatives to increase demand sector efficiency include appliance switching, improved building insulation, and the use of heat pumps in both residential buildings and low-heat production operations. Efficiency increases and predicted structural changes will have a substantial impact on Norway's energy demand in 2050. (DNV, 2021a)

While the EU and Norway have set goals for increasing energy efficiency, decarbonization of the energy sector is anticipated to lead to progressive electrification of transportation and, more slowly, heat, as well as increased hydrogen usage. This will have a variety of effects on the current electricity industry, including shifting demand, consumption patterns, and demand centers. (Froggatt et al., 2020). Norway is a part of the global energy system, and what occurs in the rest of the globe has an impact on the country's consumption and supply of energy. Similarly, events in Norway can have an impact on other regions of the world. Norwegian energy consumption is based on a supply-and-demand balance, although Norway has historically had enough energy resources to meet local demand as well as export to other areas. (DNV, 2021a). Energy demand has always increased in unison with population expansion and rising living standards. Although Norway's population is declining, it will still reach 6.4 million people by 2050. Increased energy demand is often associated with more people demanding more energy services for transportation, heating, lighting, or consumer goods.

(DNV, 2021a). Increasing energy demand is one of the root factors that can hamper the campaign of decarbonization.

Because of its hydropower-dominated electrical grid, Norway already has a low carbon intensity energy system. This is a problem because the majority of the remaining emissions come from hard-to-abate industries like oil and gas extraction, heavy transportation, and agriculture, all of which will need to be targeted if Norway is to meet its ambitious climate ambitions. (DNV, 2021a). How Norway deals with the hard-to-abate sectors will be a deciding factor in its success and failure.

Norway's energy system is inextricably linked to that of Europe and the rest of the world. Grids, pipelines, shipping, technology, economic links, and policy development are all examples of interconnections. Norway has a strong foundation for developing green export-oriented sectors, but it needs supportive policies. Targeted policies and their successful execution, such as public investments in further R&D and funding for real-world initiatives to trigger technological readiness and scale-up, will be critical in achieving emissions-reduction goals. Such regulations become much more necessary and crucial if Norway raises its aim to achieve net zero emissions by 2050. (DNV, 2021a). Norway's policies and investment decisions, as the world's biggest sovereign wealth fund, may have a meaningful influence at domestically and globally, assisting in a smooth transition by effectively managing climate-related financial risk and investing in low-carbon businesses. (Froggatt et al., 2020). If Norway doesn't manage to make policies and regulations that suit the further mission of emission reduction and are not in sync with what the industry needs then it faces a serious threat to accomplishing its objectives.

- **Consequence analysis – C'**

An analysis is carried out for each initiating event A', considering the potential consequences C' of the event occurring. As discussed before, the consequences of interest are the one judged important by the governments or which affects the principal objectives of the governments in the given context. From the identification of initiating events and cause analysis, there comes three different consequence scenarios.

- Supply and demand mismatch domestically and then mixed up with export requirements can potentially lead to collapse of Norwegian energy system if due care is not taken to cater the increasing energy demands with time under the situation that energy via fossil fuel production is declining while renewable energy does not ramp up its production situation. Norway, as a major exporter of fossil fuels, face major systemic risks if it does not adapt to the energy transition. (Froggatt et al., 2020). The impact of additional power consumption on transmission grid capacity is determined by factors such as geographical distribution, demand profile over time, price sensitivity, and the speed with which the development occurs. (Holmefjord, 2019)

- Norway has signed the Paris agreement and if the events A' consisting of failure to decarbonize occurs then it can eventually lead to Norway not being able to meet the climate goals that it has set for itself.

- The ultimate consequence that can lead from failure to meet the climate targets is the negative impact on climate and weather conditions. (United Nations, 2015).

Refer the Bayesian network of Risk Analysis for Norway in Figure 1 which shows the specific risk sources RS’, specific events A’ of interest and specific consequences C’ which affect the principal objectives of the Norwegian government for the energy transition process in picture.

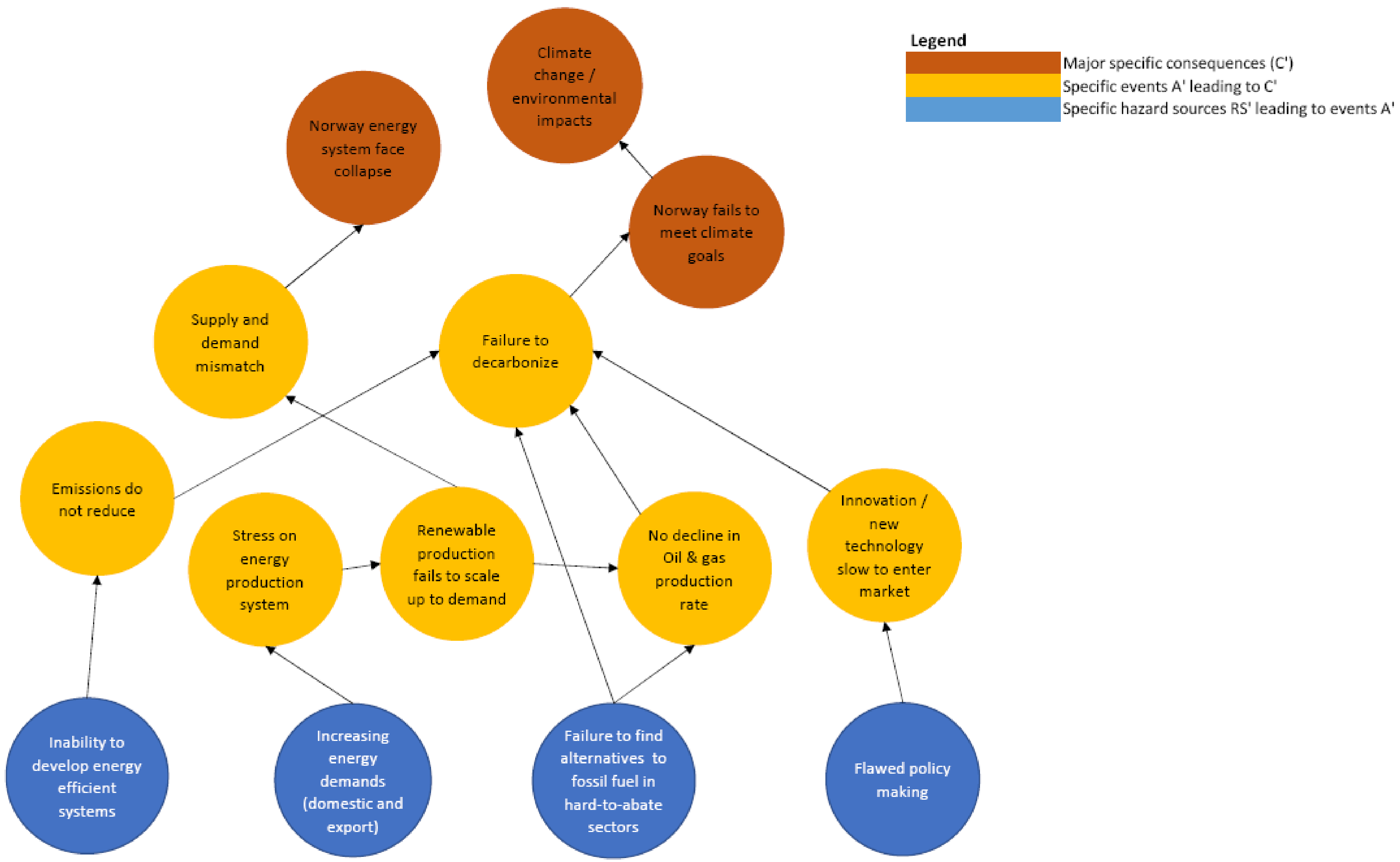


Figure 1 : Bayesian network of Risk Analysis for Norway

3.3 Risk analysis for India

In this chapter, we look closer into the different activities of a risk analysis for India, covering identification of initiating events A', cause analysis – risk sources identification (RS') & consequence (C') analysis in this chapter.

- ### Identification of (specific) initiating events A'

The purpose of this section is to identify events which can lead to the failure in the energy transition process for India. The identification of initiating events is the first stage in the execution phase of a risk analysis.

India's energy choices will primarily influence the region's transition speed. Fossil fuels now provide more than 70% of energy. (DNV, 2021c). In the stated policies scenario (STEPS), as per IEA, India's cumulative import bill for fossil fuels triples over the next two decades, with oil being by far the largest component, indicating that India's energy security would remain at jeopardy. Domestic oil and gas production continues to lag behind demand trends, resulting in a net reliance on imported oil of more than 90% by 2040, up from 75% currently. This continuous reliance on imported fuels exposes the country to price cycles and volatility, as well as the risk of supply interruptions. (IEA, 2021a). India's dependence on fossil fuels is quite evident in the coming future. In the authors viewpoint, with the given tapper down in the production of oil worldwide while rising India's demands it can result in an unstable energy situation in India if its dependence on oil is not replaced by an alternative fuel.

In India, transportation has changed dramatically during the previous three decades. The early 1990s economic reforms created the framework for a massive growth of transportation and communication activity. Since then, tremendous expansion in practically all forms of transportation infrastructure has fueled economic growth, resulting in an increase in demand for both passenger and freight mobility. Over the previous three decades, these developments have resulted in a fivefold increase in both energy usage and emissions in the transportation sector. (IEA, 2021a). It implied that the increased use of fossil fuel, especially oil, in the transport industry will result in reliance on fossil fuels giving rise to more emissions. This may lead to failure in decarbonization efforts of India.

According to STEPS, India will add capacity to its installed base equal to that of the European Union over the next two decades, with solar PV and wind accounting for nearly three-quarters of the capacity increases as their costs decline. Solar PV, whether alone or in combination with battery storage, will be competitive with existing coal-fired electricity by 2030. By 2040, installed solar capacity will have surpassed 700 GW, enough to provide about a third of India's electricity needs. The widespread deployment of batteries contributes to this rate of expansion. (IEA, 2021a). A failure in solar and battery infrastructure and plans would make India rely more on the fossil fuels putting its goal to decarbonize in jeopardy.

The government of India offers a variety of subsidies, including direct subsidies in the form of budgetary assistance and indirect subsidies through policies such as tax breaks, credit support, service offered below market value, and price support incentives for renewable energy projects. They are available throughout the renewable energy value chain, from R&D through entrepreneurship, manufacturing, project development, and end-consumption. (GSI, 2017). A move toward a "gas-based economy," cleaner use of fossil fuels, greater use of biofuels, rapid scaling up of renewables, a focus on electric mobility, a shift toward emerging fuels such as hydrogen, and digital innovation across energy systems are among the seven focus areas articulated by India's prime minister. Clean technology markets may boost their added value through innovation. India may position itself as a centre for research expertise and a home for the accompanying intellectual property, with 15-30% of worldwide markets for certain of these items. Regardless of the time horizon, the value of innovation soars for nations and enterprises aiming towards net-zero GHG emissions. According to an IEA analysis, technologies in the prototype or demonstration phase account for roughly 35% of the total CO2 emissions reductions required to transition to a sustainable route. Furthermore, many clean energy technologies that are already well-established in some sections of the market require further adjustments in order to keep costs down and extend into new applications. As a consequence, there is a lot of room for increased innovation initiatives in areas like solar PV and battery systems, which are likely to develop quickly; sectors that tap into India's talents, such digital know-how; and areas crucial to addressing future emissions concerns that now lack answers. (IEA, 2021a). It is evident that India needs to focus on its innovation and new technology which can enter the market and help it towards its goal of decarbonization else it risks failure.

- **Cause analysis – identification of threat (risk) sources RS'**

We will now investigate what is required for the initiating events A' to occur during the cause analysis. What are the variables that cause this? We employ a Bayesian network as our risk analysis approach, which gives us with these causal factors, or risk sources RS'.

Because of growing earnings and expanding living standards, India is the world's third largest energy consumer. India has the highest rise in energy consumption of any country in all of our scenarios through 2040, because to its growing economy, population, urbanization, and industrialization. Because of its sheer size, India's urban population is expected to grow by 270 million people over the next two decades. As a result, the building stock and associated infrastructure are rapidly expanding. The accompanying spike in demand for a variety of construction materials, particularly steel and cement, exemplifies the global industrial shift to India. India's pace of energy demand growth is three times the world average as it grows and modernizes as per future assessment. (IEA, 2021a). The rise in population and the urbanization in India is going to make energy demands increasing in the upcoming years. This risk source is the single most source which could possibly derail India's ambitions to target the committed climate goals.

The shift will be aided by major reforms such as a real-time power market and future fixed-minimum percentages for renewables. Green hydrogen will be encouraged as a means of decarbonizing transportation and industry as a result of climate policies. (DNV, 2021c). India's Nationally Determined Contribution (NDC) under the Paris Agreement is a key reference point for energy and climate policy. India has pledged under the NDC to reduce its economy's emissions intensity by 33-35% by 2030, relative to 2005 levels, and to reach a 40% share of non-fossil fuels in electricity production capacity by 2030. In the stated policies scenarios (STEPS), solar power would surpass coal's portion of India's power generating mix within two decades, or even sooner in the Sustainable Development Scenario. Solar now contributes for less than 4% of India's electrical output, whereas coal accounts for about 70%. In the STEPS, they converge in the low 30%s by 2040, and in some scenarios, the changeover is much faster. India's governmental objectives, particularly the target of 450 GW of renewable capacity by 2030, and the incredible cost competitiveness of solar, which outcompetes current coal-fired power by 2030 even when combined with battery storage, are driving this abrupt reversal. The expansion of utility-scale renewable projects is aided by several novel regulatory measures that promote solar to be combined with other production technologies, as well as storage, to provide "round the clock" power. (IEA, 2021a). India's renewable energy industry has grown rapidly, and the country is poised to dominate the globe in sectors such as solar power and batteries in the future decades. India's policies seem to be going in the right direction with the targets in mind. (IEA, 2021a). All this means that India has high hopes on solar and batteries. The renewables should grow in this sector for India to move in the right direction. However, one needs to analyze to what extend would this be followed in future given the various uncertainties in its the energy market.

By 2040, India's roadways will be home to an additional 25 million trucks as road freight activity triples, and the country's fleet will have grown to 300 million vehicles of all sorts. In recent years, transportation has been the fastest-growing end-use sector, and India is poised for a massive development of transportation infrastructure, including highways, trains, and metro lines, as well as airports and ports. India's oil demand would climb by over 4 million barrels per day (mb/d) by 2040, the highest increase of any country. (IEA, 2021a). Thus, there is no reduction in the oil consumption of India for the transport sector as per this assessment.

According to the Council on Energy, Environment, and Water in Delhi, in order to attain net zero by 2070, India's coal use for electricity production would have to peak in 2040 and then decline by 99 percent by 2060. (Farand, 2021). Coal is the most carbon-intensive fossil fuel, and eliminating it is a critical step toward meeting the Paris Agreement's goal of limiting global warming to 1.5 degrees Celsius. India's coal phase-out program should seek to achieve net-zero greenhouse gas emissions by 2050. India's power firms have traditionally relied on coal, resulting in large-scale GHG emissions and other issues. A coal phase-out strategy should strive to reduce coal-related emissions by up to 35% per year, with renewable energy replacing coal. (Pandey, 2021). Failure in coal phase down is an important threat to the decarbonization efforts of India.

- **Consequence analysis – C'**

An analysis is carried out for each initiating event A', considering the potential consequences C' of the event occurring. As discussed before, the consequences of interest are the one judged important by the governments or which affects the principal objectives of the governments in the given context. From the identification of initiating events and cause analysis, there comes three different consequence scenarios:

- Given the price cycles and volatility due to reliance on import of fossil fuels, if the required flexibility in power system operation does not materialize, energy security risks might occur in India's domestic market, particularly in the electrical sector. The poor financial health of many electrical distribution companies poses an additional systemic danger to the dependability of electricity delivery. (IEA, 2021a).

- India has signed the Paris agreement and if the events A' consisting of failure to decarbonize will eventually lead to India not being able to meet the climate goals that it has set for itself.

- The ultimate consequence that can lead from failure to meet the climate targets is the negative impact on climate and weather conditions. (United Nations, 2015).

Refer the Bayesian network of Risk Analysis for India in Figure 2 which shows the specific risk identification factors RS', specific events A' of interest and specific consequences C' which affect the principal objectives of the Indian government for the energy transition process in picture.

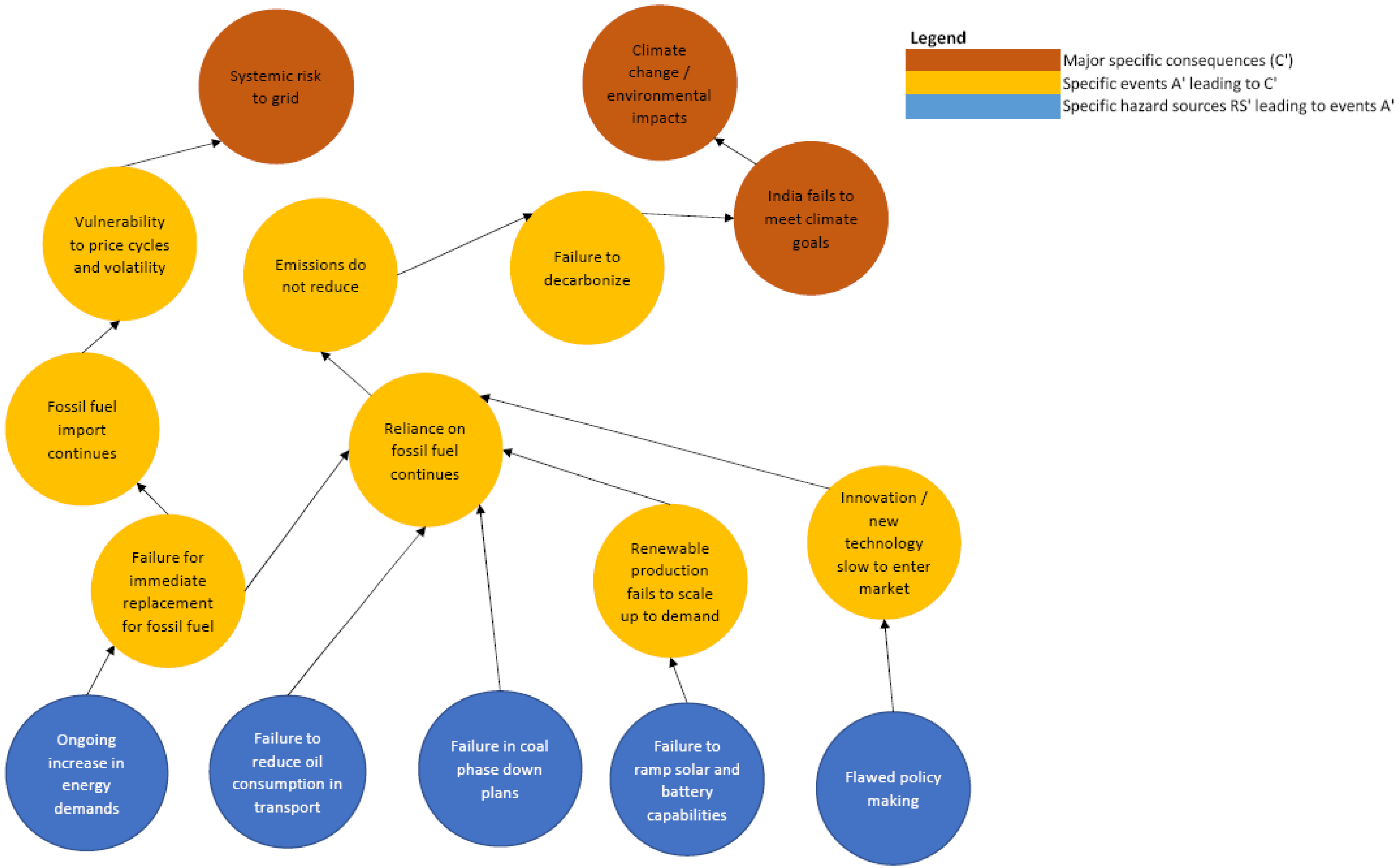


Figure 2 : Bayesian network of Risk Analysis for India

3.4 Uncertainties in energy transition for Norway and India

Energy transition risk is typically considered as a long-term threat whose impacts will not be realized for decades. However, this perspective is a skewed depiction of reality. This is because, while the shift may take decades to complete, the heightened uncertainty around the transition has a considerably shorter time scale than the transition itself. This, along with the uncertainties surrounding climate change and emission reduction plans, may result in an underestimating of the problem and its impact on growth prospects, cash flows, and asset payoffs. (Poudineh et al., 2019).

Because of severe economic effects and the conundrum between future advantages of sustainable development and today's issues of delivering energy to the population, the COVID-19 pandemic has a substantial impact on short-term demand and might continue to do so in the long run. Uncertainties regarding the actual spread of COVID-19 variations continue to pose a threat to global economic growth. COVID-19, for example, might be both a motivator and a barrier to widespread renewable energy use. It might be due to a drop in global energy consumption; this drop in demand could become long-term if remote working becomes a permanent phenomenon and worldwide demand for office space falls. The slowing of international climate discussions might be interpreted as a signal of a reorientation of national priorities. (Gribkova & Milshina, 2022).

Covid-19 has thrown India's growth trajectory into disarray; the extent to which alterations induce fundamental shifts or transitory disruption is a major uncertainty. Nonetheless, the pandemic has expressed uncertainties about India's capacity to recruit a broad pool of private capital in order to reach aggressive deployment objectives in the coming years. Furthermore, growth in other technologies like distributed solar PV and biofuels is slow, and new finance issues are arising. Another major uncertainty is the Indian government's and others' policy responses to today's difficulties. This includes how well they integrate energy and sustainability into their recovery plans, as well as how well they address structural challenges that plagued the economy even before the Covid19 outbreak. (IEA, 2021a). Furthermore, given the lack of adequate pricing signals that would allow batteries to arbitrage between periods of shortage and ample supply, the economic model for utility-scale battery storage in India remains uncertain. (IEA, 2021a).

Renewable energy investment is critical, especially in light of climate change. Despite the fact that numerous research have looked at the drivers of renewable energy, little is known about how risk or uncertainty influences renewable energy distribution. (Ivanovski & Marinucci, 2021). Due to the uncertainty, countries are prioritizing "market risks" in their policy and planning—economic stimulus and job creation are and will continue to be a top government priority; international energy companies will rely more on approaches that improve investment resilience, including climate-related risks. Different scenarios are determined by future uncertainty and a range of elements. (Bradley & Lahn, 2020).

There are several uncertainties which can dictate how the energy transition will shape and the speed with which it can go ahead. The following are a few such key issues – Whether COVID-19 will be brought under control – whether the global economy reverts to pre-crisis levels – whether renewables will supply a bulk of global energy demand increase by 2030 – whether Coal's proportion of the energy mix in 2040 falls below acceptable levels – whether oil consumption levels go down. (Gribkova & Milshina, 2022). The energy transition is seen as a solution to many of the difficulties that modern nations confront, not only in the energy sector. Changes in the energy sector and other realms of human activity have an impact on economic and social spheres, and this scenario dictates how nations choose individual policies. Due to changes in national economic or technical progress, geoeconomics and geopolitical transitions, or unexpected occurrences, these plans may need to be revised. As a result, examining national energy policies and other relevant action plans might help to provide a more realistic picture of the global energy sector's future. (Gribkova & Milshina, 2022). The energy transition is a unique process that will be determined by national plans in each country. Several significant players in the production and consumption of energy resources are strongly reliant on the global energy environment. In-depth case study analysis can aid in examining existing techniques to implementing the energy transition in a given nation, in order to evaluate proclaimed energy objectives and how they connect to tactics in related fields. (Gribkova & Milshina, 2022). Thus, the uncertainties in energy transition related to Norway and India are not isolated to them, it is connected with the uncertainties in the global scenario.

The world is moving away from fossil fuels and toward renewable energy sources. The speed and magnitude of this transformation, on the other hand, are uncertain and debatable. This will have enormous repercussions for Norway, which is one of the world's top energy and capital exporters. Many of the uncertainties of the energy transition, such as the rate of change and the prices of technologies like renewable energy and electric cars, would be exacerbated by more difficult climate objectives (EVs). While market conditions will have a significant impact on the rate of adoption of these technologies, regulatory interventions and investments in essential infrastructure will be critical to their expansion. (Froggatt et al., 2020).

The primary question is whether the voluntary and involuntary shifts in consumer behavior witnessed during the pandemic are an outlier, and whether daily life will return to anything resembling business as normal if the virus is handled by distance measures and vaccination. Alternatively, these developments might signal a major shift in cultural behavior that has ramifications for future energy markets. The speed and form of the transition, which we say may occur quicker than the 'energy establishment' believes, is a crucial uncertainty. The speed and scope of the shift internationally, as well as in areas and nations that are significantly reliant on fossil fuels, particularly those that rely on Norwegian oil and gas is of significance. (Froggatt et al., 2020).

In Norway, there are apprehensions about onshore wind power expansion, a lack of hydrogen infrastructure, legal-administrative impediments, an uncertain financial case for CCS, societal acceptability, and lingering technological problems related to hydrogen storage and delivery. (Damman et al., 2021). If hydrogen is to become extensively utilized, the creation of blue or green gas is plainly required to satisfy emissions reduction goals; however, none is now economically viable, and both are subject to technological uncertainty. Large infrastructure projects, such as the installation of interconnectors between nations for grid flexibility, may be delayed due to uncertainty over technological prices and perhaps political and regulatory concerns, such as Brexit. Meeting ambitious climate goals and reforming industry would require the adoption of new technologies that have yet to be tried at scale, such as carbon capture and storage (CCS or CCU) and hydrogen utilization. (Froggatt et al., 2020). The commercialization success or failure of these technologies will have a significant influence on the usage of fossil fuels in all sectors, as well as the destiny of current transportation and production infrastructure. Despite these uncertainties, it is apparent that all aspects of the fossil fuel business, as well as the industries that rely on it, will be severely disrupted. (Froggatt et al., 2020).

Before the Russia-Ukraine conflict of February 2022, global inflation was already at multi-decade highs. This was especially true in the case of energy pricing. Given that Russia produces a large portion of the world's oil (c.12%) and gas (c.17%), the conflict scenario poses considerable dangers to energy flows. As a result of this uncertainty, oil, gas, and electricity prices in Europe have continued to climb sharply in recent months. The second danger is that inflation might have negative economic consequences. Tighter financial conditions, increasing energy prices, and anticipated pay rises are among them — as well as the implications for economic development. Energy shortages and wars that result in increased energy prices have slowed economies greatly in the past. (Monk et al., 2022).

None of the scenarios presented in next sub-chapters are predictions for what will happen in the next years; there is no singular vision of the future. The author wants to express here that the risk analysis process and its results in this thesis acknowledge these uncertainties, however, the goal of the analysis is to demonstrate a more practical, likely and perhaps more useful scenarios which can emphasize the spectrum of conceivable futures, as well as the actions and situations that may lead to them.

3.4.1 Qualitative probabilities for risks – Norway

Norway has a strong foundation for developing green export-oriented sectors, but it needs supportive legislation. When it comes to the global energy shift, there are a few areas where experts at DNV anticipate considerable growth: Solar PV capacity increase by 20-fold, while wind capacity increase by 10-fold. Offshore wind will expand from a current proportion of less than 1% to about 15% of global power output by 2050. The number of electric vehicles and the batteries that power them is expected to increase at a 19 percent yearly compound growth rate. (DNV, 2021a). As a result, the failure to scale-up of renewable energy will be viewed with a LOW probability.

Despite the rapid expansion of these green businesses, the climate crisis will worsen, and the experts at DNV predict average world temperature to rise by 2.3°C over pre-industrial levels by 2050. (DNV, 2021a). Climate change and environmental effect will be rated as having a MEDIUM probability based on this. As a result, the writers of DNV report anticipate increased pressure to further decarbonize the so-called hard-to-decarbonize sectors (e.g., industrial heat, aviation, trucking, and shipping) via options such as carbon capture and storage (CCS), hydrogen, and biofuels. Norway is already at the forefront of these decarbonization technology development. (DNV, 2021a). Decarbonization appears to be difficult for Norway, resulting in a HIGH likelihood rating for "failure to decarbonize."

Norway is far from meeting the emission objectives established for 2030 and 2050, according to the DNV report (DNV, 2021a). According to the projections, Norway will only reduce emissions by 24%, or 13 million tonnes, by 2030. To meet Norway's pledged commitments, additional 16 million tonnes must be eliminated by 2030. The goal is to be a zero-emission country by 2050, but the projection indicates just a 79 percent reduction (DNV, 2021a). The author rates the likelihood of consequence Norway failing to reach its climate targets as HIGH.

On a national, regional, or global scale, it is far from certain that energy or climate objectives and targets will be realized. As a result, it is not expected of Norway to meet its national aim of lowering greenhouse gas emissions by 55 percent by 2030 compared to 1990 levels. Targets and ambition levels may or may not be converted into actual policy, and there are countless examples of objectives and targets not being realized in the Norwegian context. Ambitious objectives, on the other hand, are frequently followed by specific policy actions that translate intentions into reality, affecting the emissions trajectory. However, DNV analysis show that GHG emissions will continue to fall throughout the projected period till 2050. Emissions were somewhat lower in 2020 than in 1990, and by 2030, they will have decreased by 24% compared to 1990 levels. By 2050, we predict emissions to be 79 percent lower than they were in 1990, at 11 million tCO2e, falling short of both the 2030 (55 percent reduction) and 2050 net zero targets.. (DNV, 2021a). Thus, emissions will be reduced in the coming future however, the targeted emission decline will not be met. This puts the 'Emissions does not reduce' into a LOW probability level but further strengthening the probability that Norway fails to meet climate targets.

Norwegian energy consumption is based on a supply-and-demand balance, although Norway has historically had enough energy resources to meet local demand as well as export to other areas. It is critical to increase renewable power production in order to support green industrial growth and meet decarbonization ambitions. Norway's energy output has traditionally been nearly completely focused on hydropower, although in recent years onshore wind has contributed roughly 10% of generation capacity. In addition to local production, energy is continually imported and sold to Germany and the United Kingdom via a Nordic grid and interconnector connections. Hydropower and onshore wind capacity increases in recent years have contributed some variable renewable capacity, resulting in an almost 10-year string of yearly net-electricity exports. (DNV, 2021a).

It is anticipated that a considerable rise in power demand will occur over the next decade, but slower growth in production. The present Norwegian electricity surplus will be consumed by households, service industries, and transportation electrification. This would result in a domestic electrical supply shortage, limiting future decarbonization ambitions as well as new industrial growth in areas like battery manufacturing, green steel, alumina, and electrolysis-based hydrogen generation. Norway will most certainly be required to import power for several years between 2025 and 2035 in order to feed the Norwegian Continental Shelf (NCS) with electricity while also supporting green industrial growth. (DNV, 2021a). This is a clear indicator of a possible supply-demand mismatch scenario and stress on the energy production system, but the consequences of this situation may not be concerning as per the author because Norway has sufficient options to meet rising energy demands through a combination of imports and domestic production as discussed in previous sections.

Importing power might result in price instability and perhaps higher costs, reducing the competitive advantage of low-cost green electricity, which is required for industrial operations. The DNV report (DNV, 2021a) indicates that achieving power surpluses, decreasing emissions, and sustaining industrial growth without adding significant new capacity would be difficult. When offshore wind capacity begins to be built out about 2030, the situation improves slightly, and by the mid-2030s, Norway will be able to leverage a yearly power surplus once more. (DNV, 2021a). This means that power system collapse for Norway has a low probability of occurring.

The Climate Change Act was passed by the Norwegian Parliament in June 2017, establishing by law Norway's emission reduction objectives for 2030 and 2050. The act's goal is to encourage Norway's climate objectives to be met as part of the country's transition to a low-emissions society by 2050. (Norwegian Ministry of Climate and Environment, 2019). Industrialization policies will be critical in supporting green industrial growth by unlocking industry prospects. Building a domestic economy will necessitate expanding the policy framework to determine the best ways to support technological and business initiatives at various stages of this process, as well as to energize market and supply-chain creation through initiatives that have the optimistic support from the local communities and the country as a whole. The Norwegian climate objectives are in line with the EU's, and policymakers must create and implement policies to accelerate emission reductions in line with them. Technological innovation, resource availability, and rules and incentives all influence the energy mix of Norwegian manufacturing. (DNV, 2021a). The policies by Norway seem to be going in the right direction hence new technologies should not be seeing problems to enter the markets.

Because of its hydropower-dominated electrical grid, Norway's energy usage already has a low carbon intensity. This is a problem since the majority of the remaining emissions come from industries that are hard to enforce, such as oil and gas extraction, heavy transportation, and agricultural. (DNV, 2021a). The likelihood of reduction in oil & gas production due to hard to abate sectors is considered MEDIUM based on the available information.

3.4.2 Qualitative probabilities for risks – India

In the predicted scenarios as per International Energy Agency (IEA, 2021a), India's cumulative import for fossil fuels becomes three times in next 20 years, with oil being by far the most significant component, India's energy security is still in peril. According to this research, the likelihood of fossil fuel import is huge. India relies heavily on imported oil. The domestic oil & gas production falls way short of the consumption. The same will continue till 2040 where the oil imports will make 90% of the consumption figures which is currently 75%. (IEA, 2021a). As far as India is concerned, fossil fuels will not be replaced immediately. As a result, the likelihood of failure for immediate replacement & continuation of fossil fuel import is HIGH.

This ongoing reliance on imported fuels exposes the country to price fluctuations and supply interruptions. India could face energy security risks. The domestic electrical sector would face outages in case the power grid does not provide flexibility. The distribution boards are not financially strong and resilient to absorb the shock of electrical grid failure. This poses a systemic danger to reliability of power. The aim to revamping this sector is to improve the cost-reflectiveness of tariffs, billing and collection efficiency, and technical and commercial losses. (IEA, 2021a). Based on past experience, India's power industry is better prepared to deal with the issue of grid failure. Due to the availability of high-resolution data and numerical weather prediction models for forecasting, there has been a significant improvement in recent years. (Soonee et al., 2018). According to the author, the systemic risk on the electricity grid has a LOW chance because of ongoing development in the electrical system’s robustness. The risk of grid failure appears to be challenging, but with a low likelihood of success.

Road transport energy demand is expected to more than double in the predicted scenarios, during the next two decades, while this rise is drastically reduced in the Sustainable Development Scenario. Diesel-powered freight transport accounts for more over half of the STEPS' expansion. By 2040, India's roadways will be home to an additional 25 million trucks as road freight activity triples, and the country's fleet will have grown to 300 million vehicles of all sorts. In recent years, transportation has been the fastest-growing end-use sector, and India is poised for a massive development of transportation infrastructure, including highways, trains, and metro lines, as well as airports and ports.

The policy settings in place now are enough to avoid a runaway increase in transportation energy consumption. And other areas of the system are fast shifting to less energy-intensive solutions, with a significant growth in the usage of two- or three-wheeled vehicles for road transportation as an example. (IEA, 2021a). There will be no net expansion in India's coal fleet once the coal-fired power units now under construction are completed during the next few years. The coal-fired generation was the most vulnerable to the drop in energy demand in 2020. Because renewables do not meet all of the predicted rise in power consumption, it increases up significantly in the STEPS as demand rebounds. (IEA, 2021a). In the STEPS, coal's contribution of the entire energy mix slowly drops, from 44% in 2019 to 34% in 2040, and even faster in various scenarios. (IEA, 2021a).

India's electricity consumption is expected to grow at a significantly faster rate than the country's entire energy demand. However, a dramatic increase in unpredictability – both in power generation from solar PV and wind, and in daily demand – is a distinguishing characteristic of the prognosis. On the supply side, renewable energy generation in several Indian states is expected to regularly surpass demand (usually in the middle of the day) by 2030. (IEA, 2021a). Although the extraordinary expansion of renewables has slowed the growth of India's power sector emissions in the STEPS, the coal-fired fleet remains a major CO2 emitter, accounting for the sixth largest single category of emissions globally today. (IEA, 2021a). Electrification, efficiency, and fuel switching, as well as a concerted effort to create more sustainable transportation infrastructure and transfer more freight onto India's soon-to-be electrified railways, are the major instruments for the transportation industry. These transitions need creativity, collaboration, and finance. (IEA, 2021a). Government measures aimed at speeding up India's renewable energy transition can help the country achieve long-term development and energy security. (IEA, 2021a).

A move toward a "gas-based economy," cleaner use of fossil fuels, greater use of biofuels, rapid scaling up of renewables, a focus on electric mobility, a shift toward emerging fuels such as hydrogen, and digital innovation across energy systems are among the seven focus areas articulated by India's prime minister. (IEA, 2021a). Thus, as seen from the evidence available, on one hand, transportation will be reliant on oil, while on the other, a mix of renewable energy expansion and supportive legislation will pave the way for more decarbonization efforts. Hence, Innovation / new technology slow to enter markets & Reliance on fossil fuels both has a MEDIUM likelihood occurrence based on the data and knowledge available. Based on the available information and evidence, the events Emissions do not reduce and Failure to decarbonize sums up to overall LOW probability of occurrence.

As per Urmi Goswami (2021), India is on pace to meet its existing NDC's 2030 objectives for reducing emission intensity and increasing the percentage of non-fossil fuel based energy producing capacity. As per Rogelj, director of research at the Grantham Institute for climate science at Imperial College London, in the report from Gayatri Vaidyanathan (Vaidyanathan, 2021), if India's 2070 objective includes all greenhouse gas emissions then it will aid the world in meeting the 1.5°C goal. He further believes that given India's current development position and the pressing need to bring significant segments of its population out of poverty and this would be a highly ambitious net-zero aim for India. Thus, given the number of variables affecting this situation being huge and the so India meeting its climate goals and Climate change / environmental impacts needs to be put with MEDIUM probability.

3.5 Strength of knowledge (SoK) supporting the assigned qualitative probabilities

The author has utilized qualitative probability to explain the risk in this energy transition scenario. The probability levels are dependent on background knowledge, and it is necessary to understand how strong this knowledge is in order to apply the levels correctly in risk management. The following factors must be taken into account as per Aven (Aven, 2015):

How reliable are the facts and models that back up the probability estimates? What about the expert viewpoints that were incorporated? And how reasonable are all of the assumptions made?

As per (Aven & Thekdi, 2020), in order to assess the strength of knowledge, we must consider salient points such as:

- "The reasonability of the assumptions made.
- The amount and relevancy of data/information.
- The degree of agreement among experts.
- The degree to which the phenomena involved are understood and accurate models exist.
- The degree to which the knowledge K has been thoroughly examined (for example with respect to unknown knowns; i.e., others have the knowledge, but not the analysis group)."

Based on the above criteria, as per the author's analysis, below table shows the strength of knowledge for the assigned probabilities of risks – events and consequences for energy transition of Norway.

Table 1 : Qualitative probability and SoK - Norway

Risk	Qualitative probability	Strength of knowledge (SoK)
Supply and demand mismatch	MEDIUM	MEDIUM
Stress on energy production system	MEDIUM	WEAK
Failure to decarbonize	HIGH	STRONG
Renewable production fails to scale up to demand	LOW	STRONG
Emissions do not reduce	LOW	MEDIUM
Innovation / new technology slow to enter market	LOW	STRONG
Norway fails to meet the climate goals	HIGH	STRONG
No decline in oil & gas production rate	MEDIUM	STRONG
Norway energy system face collapse	LOW	MEDIUM
Climate change / environmental impacts	MEDIUM	MEDIUM

Below table shows the strength of knowledge for the assigned probabilities of risks – events and consequences for energy transition of India.

Table 2 : Qualitative probability and SoK - India

Risk	Qualitative probability	Strength of knowledge (SoK)
Failure for immediate replacement of fossil fuels	HIGH	STRONG

Risk	Qualitative probability	Strength of knowledge (SoK)
Fossil fuel import continues	HIGH	STRONG
Vulnerability to price cycles and volatility	MEDIUM	MEDIUM
Systemic risk to grid	LOW	WEAK
Reliance on fossil fuel continues	MEDIUM	STRONG
Innovation / new technology slow to enter market	MEDIUM	STRONG
Emissions do not reduce	LOW	STRONG
Failure to decarbonize	LOW	MEDIUM
India fails to meet the climate goals	MEDIUM	MEDIUM
Climate change / environmental impacts	MEDIUM	MEDIUM

3.6 Risk picture

Risk can be described as (RS', A', C', Q, K) where RS' are specific risk sources affecting specific events A' leading to specific consequences C' of the activity. Q is a measure of uncertainty related to RS', A' and C' occurrence. K is the knowledge that support RS', A', C' and Q. The occurrence of a particular set of events is described as A'. (Aven, 2014). Uncertainty Q is characterized by (P, SoK, K) where P is a subjective knowledge-based probability, SoK is a judgement of the strength of the knowledge K supporting the probabilities. Probability P is defined as: Experts' degree of belief in specific events occurrence P (A' | RS', K). (Aven, 2014), (Aven, 2015).

3.6.1 Norway

Figure 1 gives us a clear risk analysis of the given problem in question – energy transition for Norway. The risk sources RS', the specific events A' and the specific consequences C' of interest for the Norwegian government are presented in the Bayesian network. The events and consequences are interlinked and based on various scenarios & probability of occurrence they may follow the suggested sequence of events. The speed and pattern of the transition, which we say may occur quicker than the 'energy establishment' believes, is a crucial uncertainty as showed in the previous chapter. Government policies to promote the use of renewables and energy efficiency, relative energy pricing impacted by technology and innovation, and consumer expectations will all play a role. COVID-19 may have an effect on each of them in turn. (Froggatt et al., 2020). We have discussed on the uncertainties and probability aspect of the risks as well as assessed the strength of knowledge on which these probabilities are based on. Thus, all these elements constitute a risk picture for Norway for the given problem: Risk Sources RS', events A', consequences C', probabilities P, the strength of knowledge SoK of the knowledge base supporting the probabilities.

3.6.2 India

Figure 2 gives us a clear risk analysis of the given problem in question – energy transition for India. The risk sources RS', the specific events A' and the specific consequences C' of interest for the Indian government are presented in the Bayesian network. The events and consequences are interlinked and based on various scenarios & probability of occurrence they may follow the suggested sequence of events. The speed and pattern of the transition, which we say may occur quicker than the 'energy establishment' believes, is a crucial uncertainty as showed in the previous chapter. Also as discussed earlier, the government policies to promote the use of renewables and energy efficiency, relative energy pricing impacted by technology and innovation, and consumer expectations will all play a vital role. We have discussed on the uncertainties and probability aspect of the risks as well as assessed the strength of knowledge on which these probabilities are based on. Thus, all these elements constitute a risk picture for India for the given problem: Risk Sources RS', events A', consequences C', probabilities P, the strength of knowledge SoK of the knowledge base supporting the probabilities.

3.7 Risk evaluation and comparison

As per Aven & Thekdi (2020), risk evaluation is defined as "Process of comparing the result of risk analysis against risk (and often benefit) criteria to determine the significance and acceptability of the risk." As per ISO (2018), "The purpose of risk evaluation is to support decisions. Risk evaluation involves comparing the results of the risk analysis with the established risk criteria to determine where additional action is required." Risk tolerance is defined as – An attitude expressing that the risk is judged tolerable. (Aven & Thekdi, 2020).

3.7.1 Risk tolerance criteria for energy transition risks

Due to a fierce rivalry in the corporate world, firms who do not estimate risk probability will not be able to continue in business for long. Risk is an unavoidable component of company operations, but it is also a critical component of organizational growth and development, particularly in the energy transition. (Rafiq et al., 2022). Risks are involved in almost every human activity. Risk analysis may assist identify the degree of risk in a scenario and whether the risk is acceptable, tolerable, or unacceptable. Individual or social considerations become increasingly relevant in the decision-making process about the acceptability or tolerance of a risk at this step. (Tchiehe & Gauthier, 2017).

Many relevant elements influence risk acceptance, in addition to concepts and methodologies such as ALARP, cost benefits, and equity-based criterion. (Tchiehe & Gauthier, 2017). There are various elements, or criteria, that are used to determine whether a risk is acceptable or manageable. These variables might vary based on geographies, social and organizational cultures, and industries. Lind (Lind, 2002a) proposes a list of relevant criteria to consider when assessing whether or not a risk is acceptable. Ethical, economic, political, and psychological variables all have a role. Lind (Lind, 2002b) recommends that the risk acceptance process also considers the financial advantages created, as well as social, environmental, and cultural issues, as well as the capacity to minimize the number of accidents. Moral, emotional, and social judgements can be linked to this, and they can impact it in a variety of ways. Finally, the risk tolerance process is influenced by time and specific circumstances, as well as the related costs and rewards. Identifying the risk acceptance parameters for a certain business is difficult (Tchiehe & Gauthier, 2017) (Wenping & Xia, 2012). The type of risk, the safety objectives to be met, and the data available on different events involving this risk are all aspects to consider when identifying these factors. It also relies on the risk's personal, social, economic, and environmental consequences. (Tchiehe & Gauthier, 2017).

Moseman (Moseman, 2012) proposes two ways for determining risk acceptance criteria in a particular situation. They can be calculated speculatively based on present, historical, or predicted levels of risk in similar situations. They can also be determined by comparing them to other types of social dangers. The basis of those two techniques has been explored in the context of this study to discover and categorize risk acceptability significant elements in energy transition and therefore, according to the author of this thesis, imposing risk acceptance criteria or risk tolerance limitations makes very little sense in the context of energy transition.

There are unmistakable signals that things are changing. Even as economies fell under the weight of Covid-19 lockdowns, renewable energy additions like as wind and solar PV grew at their quickest rate in two decades in 2020, while electric car sales established new highs. Policy action, technological innovation, and the growing urgency of the need to address climate change are ushering in a new energy economy. There is no assurance that the transition to this new energy economy will be easy, and it is not happening fast enough to avert severe climate damage. However, it is already evident that the energy economy of the future will be very different from the one we have now. (IEA, 2021b). Based on such claims from IEA, the author thinks that there is no doubt that the energy transition is taking place, and it will continue to be a topic of debate for years to come. The application of risk tolerance criteria for a process that is already underway is not rational in the context of this thesis. The risk tolerance criteria assist in determining whether the risks are acceptable or require treatment. Events such as COP26, the Paris Agreement summit, and various nations' energy transition initiatives, have made it clear that a shift to green energy is inevitable, and the costs of failure of the energy transition can be catastrophic as highlighted in Paris agreement. As a result, this chapter aims to underline that the risks of energy transition failure have already been identified as being severe, and that risk tolerance criteria aren't really required in this thesis. The author here recommends that all the risks identified through the use of a Bayesian network in the process of risk analysis must be treated.

It could be argued that there are uncertainties for various RS' (risk sources), A' (specific events), and C' (specific consequences) to occur, which the author respectfully acknowledges, but by including all risks into the risk treatment phase, the author is able to provide viable risk handling measures. It is up to governments (higher management) to decide which areas of the energy transition they want to focus on and where they want to invest in order to reduce the probability of failure and/or the severity of the consequences. The goal is to facilitate a seamless energy transition, and the risks are interconnected, with the worst consequence of having a climate catastrophe. As a result, risk treatment must consider each cause, initiating event, and consequence. Because it is a network, and events cannot be studied in isolation, providing a consequence level for each risk source / event makes very little rationale. The consequences of the Bayesian network for both the countries are catastrophic hence treatment of the whole network is justified.

3.7.2 Risk comparison of Norway and India

In this chapter, first we will see how the risks of Norway and India as found in the earlier chapters fare against each other and then we will see the socioeconomic influence on the risks and the energy transition. The objective of risk comparison here is to demonstrate how a same risk problem in real life in two different contexts (here two different countries) are not exactly same. There can be similarities but there can also be contrasts. Hence, by comparing the risks here we can showcase that solving risk problems is not a copy paste exercise and needs thorough analysis and investigation in order to reach required solutions.

For effective society and individual decision-making, risk comparison is necessary. Effective risk communication may be enabled by evaluating the usefulness of risk comparison information. Graunt developed the risk comparison approach in the 1660s, and it has shown to be useful for both individual and community decision-making. These risk comparisons are helpful in deciding which initiatives to prioritize as part of societal decision-making. In order to minimize hazards in society, a risk trade-off analysis is necessary. (Murakami, 2018). Risk management in relation to technology systems has always been a challenging problem. For politicians and risk-decision makers, this job is getting increasingly difficult. Various causes contribute to this condition, including the technological system's ever-increasing complexity. (Krausmann et al., 2006). Decision makers are faced with a wide range of approaches for assessing and managing a specific risk, which makes comparing risk studies conducted by different analysts or for different end users difficult and, as a result, has hampered the widespread use of risk assessment for certain decision-making purposes. (Krausmann et al., 2006).

Because the idea of risk is regarded as the most challenging ability among all numeracy factors, risk comparison is also utilized to provide information to the public as part of risk communication. The use of numerous heuristics by laypeople and even experts when interpreting risk information is dependent on the communication style. Low-probability risk, in particular, is commonly overstated, and comparison data is required to appropriately measure the differences between low-probability risks. People are known to overestimate one specific risk due to a lack of risk comparison information. (Murakami, 2018). One possibly plausible objective of risk comparison, according to Fischhoff (Fischhoff, 2006), is to provide recipients an intuitive sense of how significant a risk is by comparing it to another, otherwise similar risk that they do comprehend. The second potential use of risk comparisons is to make it easier to make consistent judgments concerning different threats. (Fischhoff, 2006). The decision of prioritizing countermeasures in societal decision making is based on the civil authority, the targeted population, and the breadth of the countermeasures, therefore the target population is an essential consideration. (Murakami, 2018).

Let us see how to risks for Norway and India compare with each other for the risk analysis performed here. The risk sources RS’, events A’ and consequences C’ which are similar in nature (wherever possible) are presented in the table by writing them side by side.

Table 3 : Risk comparison - Norway and India

	Norway	**India**
Risk sources RS’	Inability to develop energy efficient systems	-
	Increasing energy demands (domestic and export)	Ongoing increase in energy demands
	Failure to find alternatives to fossil fuel in hard-to-abate sectors	Failure to reduce oil consumption in transport
	Flawed policy making	Flawed policy making
	-	Failure to ramp solar and battery capabilities
	-	Failure in coal phase down plans
Events A’	Emissions do not reduce	Emissions do not reduce
	Supply and demand mismatch	-
	Stress on energy production system	Vulnerability to price cycles and volatility

	Norway	India
	Renewable production fails to scale up to demand	Renewable production fails to scale up to demand
	No decline in Oil & gas production rate	Fossil fuel import continues
		Reliance on fossil fuel continues
	Innovation / new technology slow to enter market	Innovation / new technology slow to enter market
	-	Failure for immediate replacement for fossil fuel
	Failure to decarbonize	Failure to decarbonize
Consequences C'	Norway energy system face collapse	Systemic risk to grid
	Norway fails to meet climate goals	India fails to meet climate goals
	Climate change / environmental impacts	Climate change / environmental impacts

As it can be seen that there are similar RS', A' and C' for Norway and India. Does that mean that the risks are similar? Of course, some RS' and A' do not have similarities while all the C' have similarities. What does that suggest? A careful investigation of the both the context is necessary to come up to some conclusions.

- For Norway, energy efficiency, changing consumption patterns and the increasing use of non-fossil fuels, primarily renewable energy, is slowing the rate of increase in demand for fossil fuels. (Froggatt et al., 2020). Thus, Norway is already thinking of making energy efficient systems while on the other hand for India a more immediate challenge is to cater the increasing power demand which is evident from International Energy Agency's report (IEA, 2021a) which states that to meet growth in electricity demand over the next twenty years, India will need to add a power system the size of the European Union to what it has now. The author here would like to express that in the context of risk comparison it is also important to understand the priorities of both the parties.

- In the next years, millions of Indian households are anticipated to acquire new appliances, air conditioners, and vehicles. India will soon overtake China as the world's most populous country, gaining the equivalent of a city the size of Los Angeles to its population each year. (IEA, 2021a). Energy demands are going to increase for both the countries but one thing to consider is: Is the scale of increase in demand for both the countries similar too? In addition to domestic production in Norway, energy is continually imported and sold to Germany and the United Kingdom by Norway via a Nordic grid and interconnector connections. (DNV, 2021a). As per the author, if Norway faces energy deficit domestically then it can stop export for the given time and cater to its own energy demand. This is not possible for India to do because India imports energy and it will have to import energy to cater its needs. A huge contrast can be seen here. Increasing energy demands may be a risk source for both the countries but the capabilities of both the countries to handle this problem is completely different. This is an example of how same risk source in two different contexts can have two different action paths. On the same lines, supply demand mismatch is an event for Norway to consider which could end up with possible grid failure as shown in risk picture earlier while India being an energy import-oriented country need has different challenges. The author wants to convey that infrastructural needs and financial budget are the factors that needs to be taken into account to compare the risks and the context.

- As explained in earlier chapters with increasing demand in energy and the given current scenario for India, there is no immediate replacement for oil & gas. Since 2000, energy consumption has increased, with coal, oil, and solid biomass still meeting 80% of demand.(IEA, 2021a). As per the author, the scale of demand is so high that it will need radical renewable energy production and integration which cannot be done in a span of just few years for India. Norway's energy exports, which include oil and gas, are crucial to Europe. Norway's energy output has traditionally been nearly completely focused on hydropower, although in recent years onshore wind has contributed roughly 10% of generation capacity. (DNV, 2021a). Thus, while dealing with similar risk problems one needs to understand the scale of problem, the time at hand and in this case the energy sources need to be taken into account. This is an example of how different scale problems can be for different countries even if the problem statement is the same.

- India will continue to use oil in its transport sector in coming years as discussed in previous chapters. In India, the electric vehicle sector is far behind, accounting for less than 1% of total vehicle sales. Currently, conventional vehicles predominate on Indian roadways, with barely 0.4 million electric two-wheelers and a few thousand electric cars. Due to many hurdles, the Indian EV sector has taken a back seat. (Bureau of Energy Efficiency (Govt of India), 2022). Thus, India’s consumption of oil is not seen to decline. While on the other hand, The Norwegian Parliament has set a national aim for all new cars sold in Norway to be zero-emission by 2025. (Electric or hydrogen). By February 2022, Norway had over 470.000 registered battery electric vehicles (BEVs). In 2021, battery electric vehicles had a market share of 64%. The speed of the transition is influenced by a variety of policy tools and incentives. (Norsk-elbilforening, 2021). The problem for Norway to reduce fossil fuel is in hard to abate sectors. Thus, both the countries risk failure of energy transition in different sectors.

- When comparing policies and plans, India's statement that it wants to achieve net zero emissions by 2070 and fulfil half of its electricity needs with renewables by 2030 represents a pivotal point in the global battle against climate change. India is pioneering a new economic growth strategy that might sidestep the carbon-intensive paths taken by many countries in the past — and serve as a model for other emerging economies. Prime Minister Narendra Modi has set more ambitious objectives for 2030, including the installation of 500 gigawatts of renewable energy capacity, a 45 percent reduction in the economy's emissions intensity, and a billion tonnes of CO_2 reduction.(Birol & Kant, 2022). Norway has set aggressive climate goals, including a 55 percent reduction in emissions by 2030 compared to 1990 levels, with a further decrease to net zero by 2050. According to DNV projections (DNV, 2021b), Norway will only achieve a 24 percent decrease by 2030 and a 79 percent reduction by 2050. Policy making is a common risk source for both the countries. It is undeniably one of the important risk sources which is directly in the hands of the government.

- Renewable energy expansion is a theme that both countries should be engaged in. The basic spatial idea of place is the starting point for thinking about the geographies of energy transition. The term 'location' relates to both an absolute (latitude and longitude) and a relative feature (the relational closeness of one system element to another). (Bridge et al., 2012). As per the author, the geographical locations of Norway and India play an important role as to what kind of renewable energy they can focus on. The Indian Ministry of New and Renewable Energy (MNRE) has been working on Solar, Wind, Tidal and Geothermal energy. (Government of India, 2022). Landscape presents prospects for the production of "green electricity," which can have new sources and can be developed commercially. Remote rural locations, such as uplands (for wind) and narrow sea passageways (for tidal stream), as well as metropolitan surroundings, are examples (for building mounted photovoltaics and energy from waste).(Bridge et al., 2012). The majority of Norway's electricity is generated by flexible hydropower, although wind and thermal energy also play a role in the country's electrical generation. (Norwegian Government, 2022).

- Ultimately all the risk events lead to failure in CO2 emissions reduce and to what extent decarbonization happens. The consequence of failure of the energy transition is environmental changes and climate disasters which is common result for both the countries.

- **Socio-economic risk influential factors comparison:**

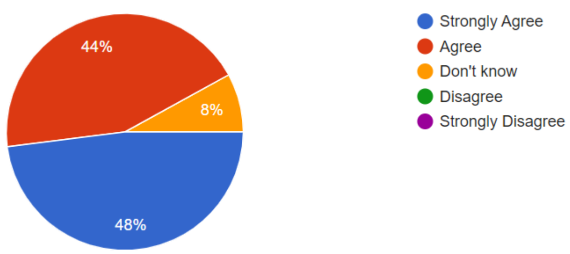
Many energy systems models have attempted to suggest routes for the global energy system's profound decarbonization. Most of the time, these paths aim to reduce system costs or greenhouse gas emissions; with few exceptions, they overlook the political, social, and economic limitations that stymie transitions, resulting in unrealistic decarbonization pathways. (Cotterman et al., 2021). There is a gap between scientifically possible and socially practical global decarbonization approaches, with the latter reflecting the behavioral, political, and economic restrictions that hamper transitions. It is critical to develop more realistic global decarbonization strategies, which require industry, politicians, and the general public to account both social and technological limits to technology deployment, allowing for more sustainable energy transition planning. To promote efficient integration with growing economic and energy systems, a quick socio-technical transition to a low-carbon future will necessitate the creation and deployment of new physical infrastructure. A sociotechnical transition would also take into account larger social, behavioral, and political aspects that influence people', families', communities', businesses', and nations' lifestyle, purchasing, production, marketing, regulatory, and related decisions. (Cotterman et al., 2021).

Even if every attempt was made to differentiate the influential factors, there would always be some overlap between the various criteria and variables. These variables can have an effect on one another to some extent. Beliefs and personal values criteria, for example, might be based on the same personality qualities. However, these characteristics undoubtedly account for a sizable fraction of the elements that influence the risk acceptance process. These findings imply that accepting a risk is a highly subjective decision. Indeed, the bulk of the significant components discovered in the risk management process are qualitative and rely on the persons participating or in charge's own perceptions, attitudes, and traits (workers, company managers, health and safety officers, production managers, etc.). (Tchiehe & Gauthier, 2017). These socio-technical issues might lead to a lack of accessible finance, disincentives to technical innovation, regulatory delays, public resistance to facility siting, and obstacles in the availability of materials and personnel needed to help overcome inertia in the low-carbon transition. Only when these impacts are acknowledged and expected can efforts to address them be effective. (Cotterman et al., 2021). A greater understanding of these elements might lead to improved decision-making process when it comes to taking risks in the workplace. In consequence, these findings may have an impact on policy and communication strategies at all levels. Even while additional study is needed to determine the proportional impact of all of these aspects, the findings imply that, when considering the many variables linked with them, the economic and personal dimensions are the most relevant. (Tchiehe & Gauthier, 2017).

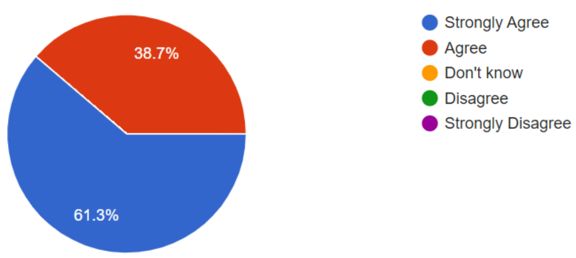
It's crucial to compare the impact of socioeconomic factors on the energy system to see how it affects the optimal energy generating mix. The author of this thesis performed a small survey for this purpose. Two surveys were prepared on Google Forms – one for Norwegian population and one for Indian population. The online survey links was published across various social media for people to take part in it. There was no specific set of population which was targeted for the survey. 25 Norwegians and 31 Indians took part in this survey. The survey was anonymous and no personal data from respondents was collected. The survey meant for Norwegian population had 11 questions related to energy transition with a Norwegian context, whereas the Indian population had 11 questions with an Indian context on energy transition. The aim of the survey is not to show the exact behaviour of people of both the countries, neither it claims that a similar result can be anticipated if larger number of people take part in it. The survey aims to show that behavioural similarities and contrast can exist even for a small group of people of both the countries, so it is even more important to consider the people's behaviours and mentality when making decisions on energy transition affecting the whole population of the country. The results may be different than this or may be similar. The point is that the author recommends that behavioural choices and priorities of the respective population would assist in making better decisions on energy transition. The survey further aims to solidify how people's personal and ethical choices can impact the energy transition process from a societal point of view and can make the transition a success or failure especially when whole population of both the countries is considered. In the appendix, you'll find the list of questions. The below results are snapshots from the results in Google Forms. Let us see how the results are:

1. **Climate change is due to human activities.**

Norway:



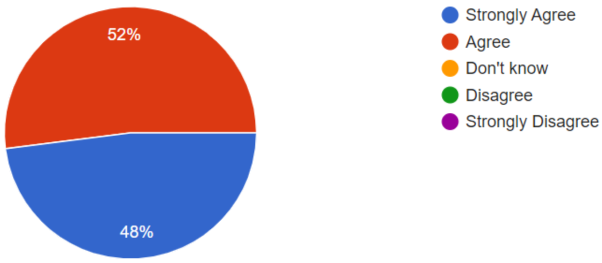
India:



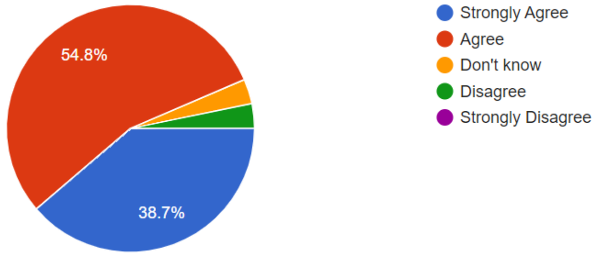
The respondents of both the countries in general agree that the climate change is due to human activities.

2. **Energy transition to green energy from fossil fuels is necessary to save the Earth from climate disasters.**

Norway:



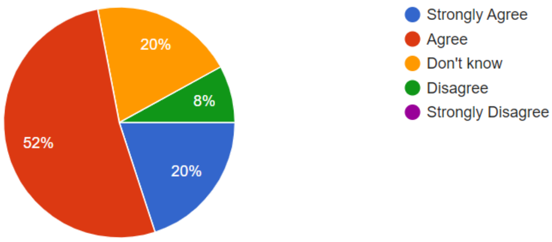
India:



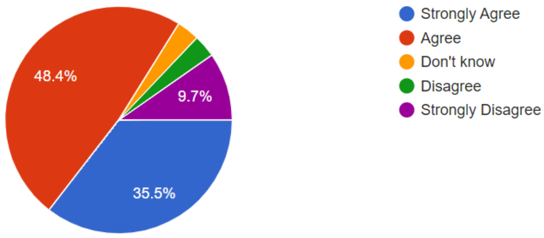
The respondents of both the countries in general agree that energy transition is a necessary step to be taken in order to save this planet.

3. **In Norway, climate change and the environment is at a higher priority as a national issue (for Norwegian context).**
   In India, climate change and the environment is at a higher priority as a national issue. (for Indian context).

Norway:



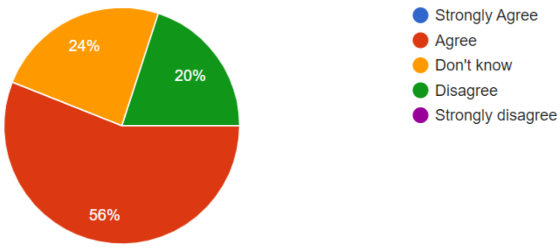
India:



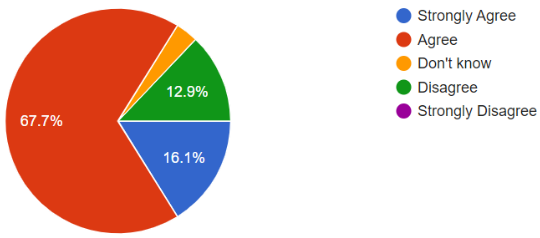
Although, a majority of the respondents of Norway and India believe that climate and environment is a higher priority issue in their countries but it is not to be ignored that 20% of respondents in Norway do not know about the priority.

4. **The Norwegian government policies and strategies are shaped towards successful energy transition. (for Norwegian context).**
   The Indian government policies and strategies are shaped towards successful energy transition. (for Indian context).

Norway:



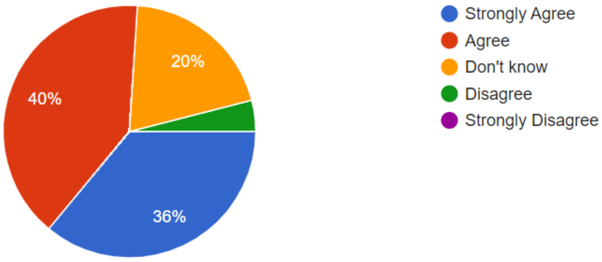
India:



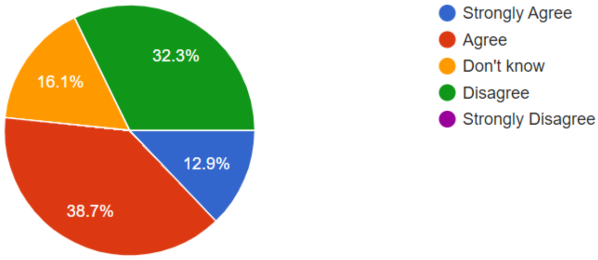
The results of the Norwegian respondents are mixed to a large extent with majority of them agreeing that the Norwegian government policies and strategies are in the right direction but alarming enough that almost 1/4th of them do not know if it's right or not. On the other hand, almost 84% of Indian respondents think that the Indian government policies and strategies are moving in the right direction. In this regard, the government of India receive face smooth cooperation from people for the transition process.

5. **Norway has enough infrastructure and/or finance to carry out a successful energy transition. (for Norwegian context).**
   India has enough infrastructure and/or finance to carry out a successful energy transition. (for Indian context).

Norway:



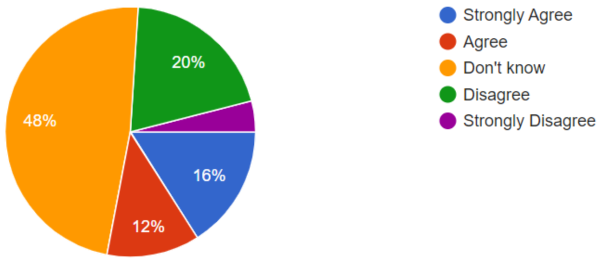
India:



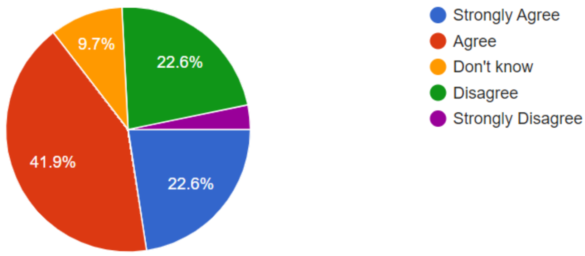
A significant finding here is that almost 1/3rd of Indian respondents does not feel that India has enough infrastructure/ finance to carry out the transition process while the percentage of people from Norway saying this is far less. Almost 3/4th Norwegian respondents think that Norway has enough infrastructure / finance to successfully carry energy transition.

6. **A Norwegian citizen's contribution towards energy transition is equal to that of the Norwegian government. (for Norwegian context).**
   An Indian citizen's contribution towards energy transition is equal to that of the Indian government. (for Indian context).

Norway:



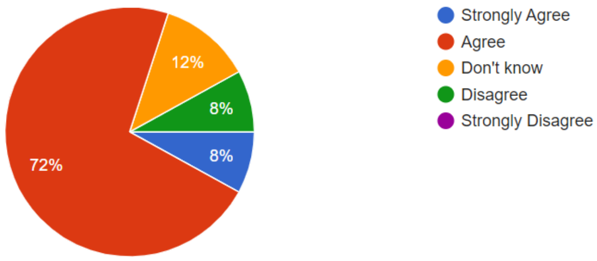
India:

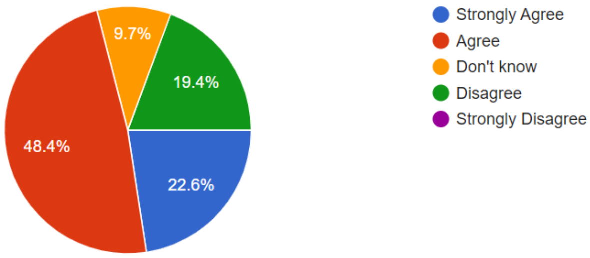


Almost half of the Norwegian respondents do not know if their role in energy transition as important as the government and only about 1/4th of them think that their role is as important as the government. This is an alarming situation. On the other hand, there is a completely contrasting picture of India. Almost 2/3rd of Indian respondents think that their role is as important as the Indian government.

7. **You are willing to change your lifestyle to support energy transition by utilizing more renewable energy even if it increases your living costs.**

Norway:

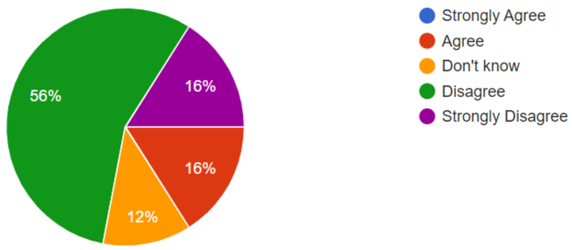




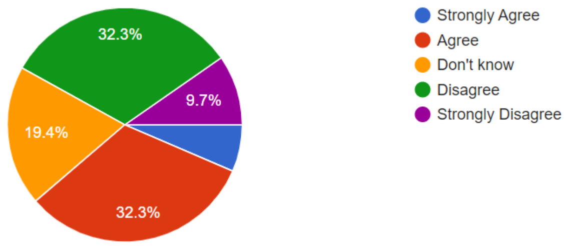
80% of Norwegian respondents are in agreement that they are willing to change their lifestyle to encourage renewable energy even if their living cost increase and this number is slightly less for Indian case – almost 70%. That is a very positive sign that people are willing to accept the green energy in Norway as well as India.

8. **Imagine that you work in a sector that contributes to greenhouse emissions (e.g., oil & gas). You think, personally, it is unethical to work in this sector.**

Norway:



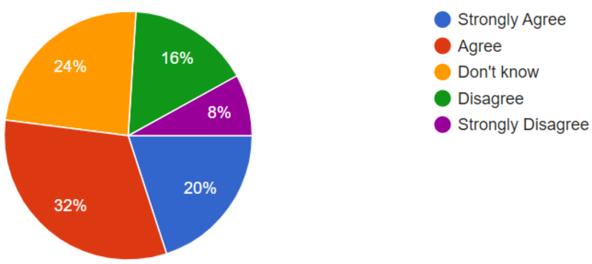
India:



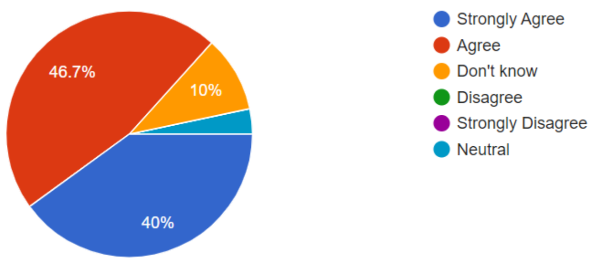
72% of Norwegian respondents do not agree that that it is unethical to work in sectors emitting greenhouse gases while this number is 42% on the Indian case. This ethical question has quite contrasting result. Almost 39% Indian respondents think that it is unethical to work in the sector while those who agree in case of Norwegian respondents is just 16%. This result, as per the author, is strongly dependent on the fact that oil & gas provides more employment (in terms of percentage jobs) in Norway than in India.

9. **From a societal point of view, Norway should take the larger share of the total global bill of energy transition than the less developed countries.**

Norway:



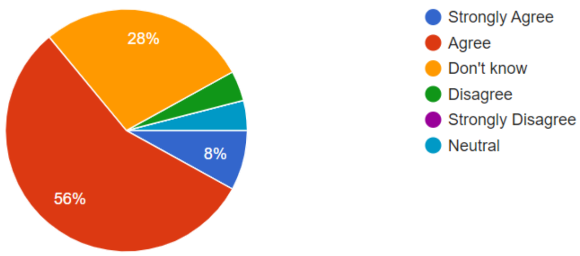
India:



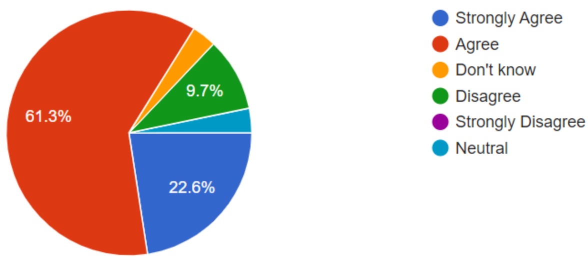
Almost half of the respondents think that Norway should take a larger share of the total bill of energy transition than the less developed countries and almost ¼ Norwegian respondents think otherwise. On the other hand, more than 86% Indian respondents, which is a huge quantum, think that the developed countries should take the larger share than India which indicates that they have high expectations from the developing countries to make energy transition a balanced game.

10. **Energy transition will be successful in Norway (for Norwegian context).**
    Energy transition will be successful in India (for Indian context).

Norway:



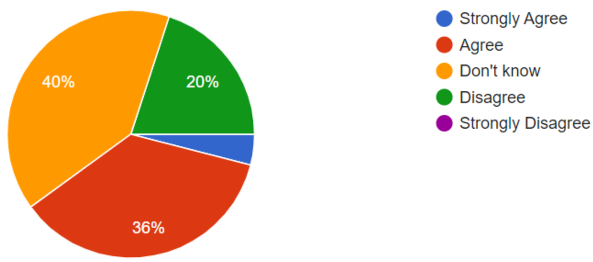
India:



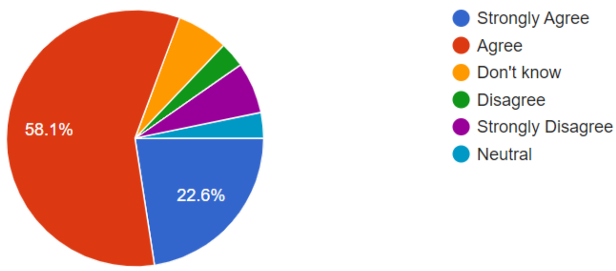
64% of Norwegian respondents are optimistic that the energy transition will be successful in Norway while this number is almost 84% in Indian case which is a huge number. Very interestingly 28% Norwegian respondents don't know about if it would be successful in Norway or not. The results show highly optimistic expectations of Indian respondents about India's success.

11. **Energy transition will be successful globally.**

Norway:



India:



The main result to see is that 40% of Norwegian respondents do not know if the transition will be successful globally. 40% think positively it will be a success while more than 80% Indian respondents think that the transition will be success globally which is again a big number and says once again about how optimistic Indian respondents are about this situation.

In this chapter, we made comparisons of risks for Norway and India with a detailed look into the influential factors such as energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, psychology of citizens, societal preference, speed of transition and in general magnitude of impact. It should be highlighted that the risk comparison emphasizes the significance of doing a context assessment first in order to have a better knowledge of risk. Because of its reliance on a number of linked elements, the energy transition has uncertainties. The risk comparison between Norway and India gives useful information for improved societal decision-making. Overall, a comprehensive understanding of the multi-faceted energy transition problem can be achieved with comparisons of risks and their consequences for effective risk management and communication.

3.8 Risk treatment

Risk treatment refers to the process and execution of risk mitigation techniques, such as strategies for avoiding, reducing, optimizing, transferring, and retaining risk. The term "risk transfer" refers to sharing the rewards or possible losses associated with a risk with another entity. (Aven, 2015). In the given context, risk treatment is carried out in combination of each risk source along with the relevant initiating event. Events A' cannot be treated in isolation because it is a network and all the events are interconnected in some way or the other as shown in the Bayesian network earlier. Hence, risk treatment for risk sources and events in combination makes more sense as per the author. It is important that in such scenarios the risk treatment should be done taking into consideration the whole risk picture.

3.8.1 Selection of risk treatment options

The choice of the most suitable risk treatment alternatives involves balancing costs against benefits, constraints, and consequences. (ISO, 2018).

The below risk treatment options can be used in case of Threats / Hazards:

- Escalate - Escalation applies when there is consensus that the threat is outside the scope of the project and the proposed response is beyond the project managers power or responsibility. In the context of energy transition, it project refers to the country's campaign of energy transition and the project manager refers to the leader of the country. (PMI, 2017).
- Avoid – "Process of actions to avoid risk, for example, not be involved in, or withdraw from an activity in order not to be exposed to any risk source". (Society for Risk Analysis (SRA), 2018b).
- Transfer – "Sharing with another party the benefit of gain, or burden of loss, from the risk. Passing a risk to another party." (Society for Risk Analysis (SRA), 2018b).
- Mitigate – "Process of actions to reduce risk. (Society for Risk Analysis (SRA), 2018b)." Risk mitigation involves actions that minimizes the likelihood of occurrence and/or consequences of a threat. (PMI, 2017).
- Accept – "An attitude expressing that the risk is judged acceptable by a particular individual or group." (Society for Risk Analysis (SRA), 2018b). Risk acceptance acknowledges that a threat exists, however no proactive action is taken. It may be suitable for threats with low-priority, and it may also be considered in situations where it is not possible or cost-effective to deal with a threat in any other method. (PMI, 2017).

3.8.3 Norway

Table 4 : Risk treatment - Norway

Risk Source	Initiating events A'	Risk treatment method	Suggested solution	Execution
Inability to develop energy efficient systems	• Emissions do not reduce • Failure to decarbonize	Mitigate	Generation of renewable electricity	• Energy efficiency will be a major driver of the change. It's also generally the most cost-effective way to cut emissions, therefore it should be at the top of the list when governments and businesses assess their alternatives for reducing emissions. (DNV, 2021a). • It is critical to increase renewable power production in order to support green industrial growth and meet decarbonization goals.(DNV, 2021a). • Renewable electricity is a vital resource for decreasing emissions in the transportation, industrial, and oil and gas industries. Everything that is electrifiable should be electrified.(DNV, 2021a).
Increasing energy demands (domestic and export)	• Stress on energy production system • Supply & demand mismatch	Mitigate	Generation of renewable electricity	• To meet the rising demand for power, more floating offshore wind farms must be built. (DNV, 2021a). • Norway is particularly well positioned to play a leadership role in the development of floating offshore wind (FOW) electricity. Norway's major tool for increasing power production is floating offshore wind. (DNV, 2021a).

Risk Source	Initiating events A’	Risk treatment method	Suggested solution	Execution
	• Renewable production fails to scale up to demand			• Capacity constraints for offshore wind (bottom-fixed and floating) are not foreseen, and capacity will be increased when it is viable, even for export. (DNV, 2021a). • Onshore wind, solar PV (on a limited scale), and (eventually) offshore wind, all encouraged by policy, will promote increase in demand for power in Norway as well as for export, which will account for a greater percentage of demand. (DNV, 2021a). • To reclaim a positive trade balance, green industry and renewable energy exports must be established. (DNV, 2021a). • Norwegian industry is prepared to work side by side with Norwegian government to address the climate problem and expand its export capability in the future. It was expected to have a projected 1.4GW increase of transmission capacity to Europe to be installed by 2021 for exporting power. During the 2030s, additional transmission capacity of 5GW is expected to be gradually installed. (DNV, 2021a).
Failure to find alternatives to fossil fuel in hard-to-abate sectors	• No decline in oil & gas production rate • Failure to decarbonize	• Accept • Mitigate	• CCUS (Carbon capture, use & storage) • Use of Hydrogen as fuel	• As the term itself is self-explanatory – hard-to-abate – then government must be ready to accept that cutting down emissions in these sectors may not be that easy or feasible. • However, there could be some possible solutions as suggested below:

Risk Source	Initiating events A'	Risk treatment method	Suggested solution	Execution
				• Investment in capital-intensive technologies like CCUS and hydrogen to enable emissions reductions in "hard-to-abate" sectors like heavy industries. CCS's prospects look to be dependent on industry rather than the electricity sector, at least in the short term, and there is a belief that it will be critical in hard-to-abate industrial sectors.(Froggatt et al., 2020). • While shipping is a harder to abate sector, it is critical to move to hydrogen and batteries in coastal and short-distance routes.(Froggatt et al., 2020).
Flawed policy making	• Innovation / new technology slow to enter market • Failure to decarbonize	Mitigate	• Greater awareness in regulatory bodies • Better policy management	• It is critical to accelerate the process of obtaining projects approved by a number of regulatory organizations. (Froggatt et al., 2020). • Governmental assistance programs are required to get initiatives off the ground and to bring the cost curve for innovative technologies down. (Froggatt et al., 2020). • Targeted policies and their successful execution, such as public investments in further R&D and funding for real-world initiatives to trigger technological readiness and scale-up, will be critical in achieving emissions-reduction goals. (Froggatt et al., 2020).

Risk Source	Initiating events A’	Risk treatment method	Suggested solution	Execution
				• Climate goals, air quality, health, job development, and energy security are just a few of the policy objectives that will drive policy changes, which will affect the energy system. (Froggatt et al., 2020).

3.8.4 India

Table 5 : Risk treatment - India

Risk Source	Initiating events A’	Risk treatment method	Suggested solution	Execution
Ongoing increase in energy demands	• Failure for immediate replacement for fossil fuel • Fossil Fuel import continues	Accept	Immediate replacement for fossil fuel is not likely and not feasible as described in the earlier chapters. This risk needs to be accepted.	-
	• Vulnerability to price cycles and volatility	Mitigation	• Regional integration makes resilient system	• Establish regional energy markets to aid renewable energy integration, encourage cross-border power grid connectivity and commerce, and lower prices through economies of scale. Through increased and smarter grid infrastructure, regional approaches to energy transition may save costs and improve access to dependable and cheap electricity. (United Nations & IRENA, 2018). • Resource diversity should be used to ensure supply security. (United Nations & IRENA, 2018).
Failure to reduce oil consumption in transport	• Reliance of fossil fuel continues • Emissions do not reduce • Failure to decarbonize	Mitigation	• Develop sustainable transport roadmaps	• Time-bound roadmaps for all means of transportation should be included in urban planning, with full consideration of mobility demands, efficiency, and renewable possibilities. • Electrification, sustainable bioenergy or green hydrogen, improved public transportation and

Risk Source	Initiating events A’	Risk treatment method	Suggested solution	Execution
			• Electrification, efficiency and fuel switching	shared mobility, and promotion of regional and international collaboration and action are all answers that must be included in plans across all areas.(United Nations & IRENA, 2018). • Moving to electric scooters and tuk tuks would be more preferable, since the country could easily transition to tiny electric vehicles. (Froggatt et al., 2020). • To create more sustainable transportation infrastructure and transfer more freight onto India's soon-to-be electrified railways.(IEA, 2021a).
Flawed policy making	• Innovation / new technology slow to enter market	Mitigation	• Time bound strategy making	• Develop medium- and long-term integrated energy management plans, set decarbonization goals, and adjust policies and regulations to build energy systems that support long-term development. (United Nations & IRENA, 2018). • Solar power facilities are less expensive to develop than coal power plants because of consistent policy encouragement and a thriving private sector.(Birol & Kant, 2022)
Failure to ramp solar and battery capabilities	• Renewable production fails to scale up to demand	Mitigation	• Strategic use of solar and battery by proper planning	• Battery storage is especially well adapted to the short-term flexibility that India requires to align its solar-powered output peak in the middle of the day with the country's early evening consumption peak. (IEA, 2021a).

Risk Source	Initiating events A'	Risk treatment method	Suggested solution	Execution
				• Local battery storage systems can be utilized to store excess generation and limit solar power system feed-in power. (Zeh & Witzmann, 2014).
Failure in coal phase down plans	• Reliance of fossil fuel continues	• Accept (to extent) • Mitigate	• Coal phase down will take time but slowly it can be done.	• Non-OECD nations should phase out coal by 2040, with many requiring assistance to do so. (United Nations & IRENA, 2018).
	• Emissions do not reduce • Failure to decarbonize	• Mitigation	• Carbon Capture, Use and Storage (CCUS)	• Putting the industrial sector on a comparable new road through more widespread electrification, material and energy efficiency, technologies like CCUS, and a move to increasingly lower carbon fuels is a critical – and much more difficult – challenge ahead. (IEA, 2021a). • CCS implementation in the Indian economy under net-zero scenarios dramatically reduces the rate of transition required across progress variables. (Malyan & Chaturvedi, 2021).

4 Further considerations on application of risk management strategies

Risk management is concerned with all actions, situations, and events that may have an impact on the organization's capacity to achieve its goals and vision. (Aven, 2015). In this context, the goal and vision of countries is to curb the emissions, reach the targets set in Paris agreement, meet Sustainable Development Goals and in general prevent climate disasters. Risk informed strategy was used in the previous chapter wherein risk treatment methods were suggested for the identified risk sources and initiating events. In this chapter we will further see how we can use various risk management strategies for energy transition problem in picture.

4.1 Use of risk informed strategies

The risk assessment generates a risk description that includes recognized events and effects, assigned probability, uncertainty ranges, and strength of knowledge judgments using the suggested risk methodology. (Aven, 2014). This is exactly done in the previous chapters for the given risk problem of energy transition. The assessment and its findings give information that decision-makers and other stakeholders may use to help them make decisions and express their opinions on important problems including deciding between options, implementing risk-reduction measures, and so on. (Aven, 2014).

In this thesis, a high standard of quality is aimed which is evident that all the assessment stages can be traced, all assumptions are recorded, and all analytical concepts and methodologies are justified. These judgments are of interest to the decision-makers of both the countries and potentially other stakeholders – not as a prescription for what to do, but as an input to a broader process, namely managerial review and judgement i.e., governmental review and judgement in this context. The author wants to highlight that the decision-makers and maybe other stakeholders should consider the assessment's conclusions in light of its limitations, as well as any concerns and issues that were not addressed by the assessment but are nonetheless relevant to the decision-making process. There may be benefits connected to the activity under consideration, as well as strategic and political considerations for both the countries and it varies on case-to-case basis we saw in previous chapters. Such factors may be critical in making a choice, but they may not be completely reflected by the evaluation.[1]

The outcomes of the risk assessments are also fed into more comprehensive decision-making methods including cost–benefit analysis, cost–effectiveness analysis, and multi-attribute analysis. All of these methods have in common that they are systematic procedures for arranging the advantages and disadvantages of a choice option, but they differ in terms of the analyst's willingness to clearly compare the components in the situation. (Aven, 2014).

Cost benefit analysis: CBA (cost-benefit analysis) is an analytical method for evaluating investments and supporting policy decisions that benefit society. CBA may be used to estimate costs and corresponding social benefits in a variety of industries (energy, transport and household). (Sofia et al., 2019). Sofia et al. have used CBA for the decarbonization scenario for Italy in 2030 and verified it in terms of environmental and socioeconomic benefits. (Sofia et al., 2019). However, the author of this thesis does not recommend such an approach of converting all the traits into a single unit (money).

[1] Interpreted & adapted from (Aven, 2014) for the energy transition context.

Many economists prefer to use a traditional cost–benefit analysis to convert all of the qualities to a single equivalent unit (E. B. Abrahamsen et al., 2011) but it is not recommended but the author here in the case of energy transition.

A cost-effectiveness analysis is a decision-making method that has been found to be successful in comparing competing safety solutions. The cost-effectiveness can be defined quantitatively and more accurately as a cost-effectiveness ratio: the ratio of change in expected costs to change in expected effects. This sort of ratio (index) is frequently used to communicate cost-effectiveness to analysts and other stakeholders. (Aven, 2014). As per the author of thesis, a cost effectiveness analysis may not be an appropriate method for decision making. A more suitable option can be multi attribute analysis.

A multi-attribute analysis is a decision-making technique that examines the outcomes of various decision possibilities for each attribute independently. Attributes such as investment expenses, operations costs, safety, environmental hazards, and so on are considered for each option alternative. Quantitative studies are frequent for some features, whereas qualitative assessments are common for others, such as political and social elements. A multi-attribute analysis is the sum of all of these studies. (Aven, 2014). The author here recommends that in the energy transition risk problem, a multi-attribute analysis is more suited approach for decision making as there are several factors influencing the decision-making process such as energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, psychology of citizens, societal preference, speed of transition and in general magnitude of impact. The governments must balance the various qualities to make suitable decisions.

4.2 Use of precautionary principle

When developing transition paths in the face of uncertainty, it is suggested that by using the precautionary principle to ensure that potentially severe and irreversible dangers be avoided. In many fields, society has grown risk averse as a result of significant uncertainty and possibly harmful repercussions. For example, boarding an airplane in the 1940s was an extremely dangerous activity. It eventually evolved into today's safest mode of transportation, thanks to a 'trial and error' technique and progressively stringent rules over time. This technique is ineffective in addressing the climate catastrophe since there is no Planet B. Instead, we may study climate-friendly transition paths using the precautionary principle, which has been created, implemented, and accepted for dealing with uncertainty in other fields. The risks of anthropogenic climate change exceeding 1.5 degrees Celsius are existential for the environment and civilization. (Desing & Widmer, 2021).

Growing knowledge of the Earth system implies that peak warming of more than 1.5 degrees Celsius may pose an existential threat to the biosphere, and so civilization. Transitions that, with a high probability, transcend this critical threshold expose future generations to significant dangers without their permission. Desing & Widmet advocate for the precautionary principle and investigate the energy requirements for minimizing climate hazards using a minimum energy transition model. (Desing & Widmer, 2021).

Despite the controversy over scientific uncertainty about the relationships between solar activity, greenhouse gas concentrations, and climate, the precautionary principle is proposed for use in dealing with energy decisions as a way to account for future climate change implications by de Carvalho et al. (2010). However, it is also acknowledged that in the actual world, the precautionary principle does not appear to be widely applied to energy decisions. The precautionary principle is a moral and political principle that states that in the lack of scientific consensus that an action or policy will not cause significant or irreversible harm to the public or the environment, those who urge performing the action have the burden of proof. It implies a responsibility to intervene and protect the public from damage when scientific study uncovers a probable danger after other possible sources have been eliminated. (de Carvalho et al., 2010).

Given the precautionary principle, the debate between those who attribute the rise in average biosphere temperature solely to variations in solar activity, which increases the amount of heat received by the Earth, and those who attribute it solely to human factors, particularly the use of fossil fuels, is a sterile one. There is no doubt that rising GHG levels in the atmosphere resulted in sensitive rises in average temperature, with major effects for almost all biotic habitats and the exacerbation of phenomena such as cyclones and floods in lowland areas. Thus, even in the absence of scientific knowledge to establish an exact and precise quantitative link between atmospheric GHG content and these disasters, the precautionary principle should be seriously considered when evaluating energy choices, production and consumption patterns, and their social consequences and impacts on asymmetry within and among societies. The social and economic consequences of these impacts can be devastating, and the only way to avoid or mitigate them is to develop new economic and energy models that balance GHG in the atmosphere while also allowing for a more equitable distribution of social product within societies and across countries and regions of the planet. Less access to basic materials, the use of renewable energy sources, likely less consumption, better distribution, reduced productivity and surplus output, and therefore more labour and capital are all part of the precautionary strategy. (de Carvalho et al., 2010).

These questions have no definitive solutions. Different persons and political groups might have different perspectives on these concerns. There are no hard and fast rules that say a certain amount is unacceptable and that the precautionary approach must be followed. (Aven, 2014). The author of this thesis emphasizes that whether precautionary principle be given more or less weight is the choice of the decision maker.

4.3 Use of ALARP principle

The evaluation standard for risk acceptability criterion is based on risk acceptance decisions made during risk analysis and risk appraisal. Certainly, comparing the findings of risk analysis to risk criteria as a result of risk assessment in order to establish if the degree of risk is acceptable or manageable. Companies should propose alternative uses of oil and gas utilities to successfully tackle the energy transition barrier and enhance the degree of risk acceptability and tolerance in the energy market. Furthermore, businesses should employ cutting-edge technology that minimize resource waste while maximizing productivity. For productive operations, organizations should take effective precautions and adopt contemporary risk acceptability models such as ALARP. (Rafiq et al., 2022).

The ALARP principle places a high emphasis on the cautionary principle, which is a fundamental safety management philosophy that states that in the face of uncertainty, caution should be the guiding principle. (H. B. Abrahamsen & Abrahamsen, 2015). The author of this thesis would emphasis here that in the context of energy transition, both the countries should consider using the ALARP principle but as explained by Abrahamsen & Abrahamsen (H. B. Abrahamsen & Abrahamsen, 2015), the ALARP concept should be construed in a way that allows it to vary from one extreme, where decisions are made based on expected values in some decision settings, to the other, where the cautionary principle is applied without regard for cost-benefit evaluations in others. The grossly disproportionate criteria should not be interpreted in a static way. According to this principle, risks and environmental impacts should be reduced to "as low as reasonably practicable," which means that measures to prevent equipment failures and loss of containment, as well as measures to mitigate the consequences of potential accidental scenarios, have been implemented, as long as the costs are not shown to be grossly disproportionate to the benefits obtained. (E. B. Abrahamsen et al., 2017).

There is a wide scope of applying ALARP principle for Norway and India and most of the safety experts would back such a solution. However, economists may have a different viewpoint where some might argue for India that given the economic situation and the fact that it is a developing country, some weight needs to be given the costs and how the safety measures can add value to the existing system.

4.4 Use of robust and resilient strategies

Risk management has a role to play if it is well planned and implemented, but only if it follows key concepts like robustness, resilience, and antifragility, which enable us to survive stress and improve over time. (Aven, 2014). For a more inclusive and fairer world, the future energy system must encourage resilient economies and societies. To meet the goals of SDG7 and establish a decarbonized energy system by 2050, ambitious and focused efforts are required now and in the next decades. Regional integration may help improve energy system resilience to extreme weather patterns, climate variability and change, and carbon emissions reduction, as well as promote green economic growth and employment in general. Future economic and environmental shocks will need energy systems to become more robust. (United Nations & IRENA, 2018).

Significant investments in an energy system that prioritizes renewables, electrification, efficiency, and related energy infrastructure are required to achieve a sustainable, climate-safe, and more resilient future. Because there are so many various energy sources across geographies, there is more connection that can provide stable and affordable energy throughout the year, as well as reducing power rates in the home nation while generating export money. The number of new links between states is developing. These measures will boost renewable energy integration and resilience. (United Nations & IRENA, 2018). To construct the most resilient and economic systems, countries must analyze all choices and plan long-term, while adjusting to technological, financial, and demand changes. In diverse environments, factors like resilience and cost-competitiveness will play a big role in selecting which low-carbon solutions will win. To deal with an increase in power demand coming from increased access to and electrification of end-use sectors such as transportation, heating, and cooling, adequate transmission and distribution networks are required. (United Nations & IRENA, 2018). The world's energy infrastructure is already experiencing rising physical dangers as a result of climate change, emphasizing the urgent need to improve energy system resilience. (IEA, 2021b).

5 Discussion

This chapter aims to list the key findings of the thesis and discuss it – interpret & explain the results along with highlighting the significance, limitations, implications and recommendation for further implementation of the findings.

- The thesis performed risk analysis for both nations, compared and demonstrated the variations in the study's outcomes, as well as the different risk management approaches that they may use. A clear risk picture of the given problem in question – energy transition for Norway and India is derived in chapter 3.6. Risk picture consists of Risk Sources RS’, events A’, consequences C’, probabilities P, the strength of knowledge SoK of the knowledge base supporting the probabilities. The risk sources RS’, the specific events A’ and the specific consequences C’ of interest for the Norwegian government and Indian government are presented in the Bayesian networks in chapters 3.2 and 3.3 respectively. The purpose is not to quantify the amount of risk in the region, but to subjectively list the incidents in order to identify steps that may be taken to minimize the occurrence of the events and their consequences. Given the enormity and complexity of the challenge, the objectives have been specified with time limits in mind, admitting that it may not be feasible to examine all of the available data or information. The events and their consequences are interrelated, and they may occur in the order specified based on numerous scenarios and probabilities of occurrence. The speed and pattern of the transition, which we predict may happen sooner than later is a major uncertainty. Government policies promoting renewable energy and energy efficiency, relative energy cost influenced by technology and innovation, and consumer expectations will all play a part as demonstrated by the Bayesian network. COVID-19 might have an impact on each of them separately.

- The main purpose of the analysis is to examine the path towards energy transition for Norway and India. Because the research is constrained by the most important players in the global energy landscape, the results cannot be immediately applied to other economies. Depending on the national energy scenario, the results of analysis can vary if the policies and governmental framework change. The findings may be used to better understand energy transition alternatives because the scenarios analyzed differed in terms of development goals, economic, technological, and governmental elements. Instead of depending just on probabilities to generate a risk picture, it's vital to emphasize the uncertainties. Based on the specified initiating events (threats/hazards), the analysis looks at individual occurrences and specific outcomes of interest impacting the governments' primary objectives.

- This thesis examined the hazards that Norway and India face as they transition away from fossil fuels and toward renewable energy. Norway and India are two massively different countries with varied problems and opportunities. Population, energy demands, energy supply, topography, environmental challenges, financial budget, government laws, public image of green energy, and the amount of effect if the transition is successful do not appear to be the same for the countries. The thesis bridges the risk understanding gap for Norway and India, demonstrating that both countries require distinct planning and risk management tactics. As a result, this thesis contributes to better understanding of the energy transition risks for Norway and India by performing risk analysis and comparing the risks these countries face in achieving the goals of the Paris Climate Agreement and the Sustainable Development Goals using various risk management strategies.

- Socioeconomic factors influence the risks and the energy transition for both the countries. Risk comparison shows that a same risk problem in two distinct situations (here, two separate nations) is not identical. There may be analogies, but there may also be differences. As a result, by comparing the risks, we can demonstrate that tackling risk problems is not a copy-paste activity, but rather requires in-depth research and inquiry to arrive at the essential answers.

- Risk comparison is also used to deliver information to the public as part of risk communication. The communication style influences the adoption of multiple heuristics by laypeople and even specialists when assessing risk information. The thesis provides risk comparison for Norway and India with a detailed look into the influential factors such as energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, psychology of citizens, societal preference, speed of transition and in general magnitude of impact. The risk comparison underlines the importance of conducting a context assessment first in order to have a better understanding of risk. The energy transition is fraught with uncertainty due to its reliance on a number of interconnected variables. The risk comparison of Norway and India provides essential data for better societal decision-making. Overall, comparisons of risks and their repercussions for good risk management and communication can help to gain a thorough knowledge of the multifaceted energy transition challenge.

- There are various uncertainties that might influence how the energy transition takes shape and how quickly it proceeds. Whether COVID-19 will be brought under control – whether the global economy will return to pre-crisis levels – whether renewables will supply the majority of global energy demand by 2030 – whether coal's proportion of the energy mix in 2040 will fall below acceptable levels – whether oil consumption levels will fall are just a few of the key issues. Many of the problems that modern nations face, not just in the energy sector, are viewed as solutions by the energy transition process. Changes in the energy sector and other areas of human activity have an influence on the economy and social spheres, and this situation affects how countries adopt their policies. These plans may need to be altered as a result of changes in national economic or technological advancement, geoeconomics and geopolitical shifts, or unanticipated events. Examining national energy policies and other pertinent action plans, as a consequence, may assist in providing a more accurate picture of the global energy sector's future. The energy transition is a one-of-a-kind process that will be decided by each country's national goals and priorities. The global energy ecosystem is heavily reliant on many major participants in the production and consumption of energy resources. As a result, the energy transition risks in Norway and India are not unique to them; they are linked to the global scenario's uncertainties.

- The risk treatment step is of importance to decision-makers in both nations and maybe other stakeholders – not as a prescription for what to do, but as an input to a bigger process, namely management review and judgement, or, in this case, governmental review and judgement. The author emphasizes that decision-makers and maybe other stakeholders should analyse the assessment's conclusions in light of its limitations, as well as any concerns or issues that the assessment did not cover but are nonetheless important to the decision-making process. Benefits associated with the activity under review, as well as strategic and political issues for both nations, may exist, and this varies on a case-by-case basis, as we saw in earlier chapters. Such elements may be important in making a decision, but the evaluation may not fully represent them.

- This risk informed strategy is used in the thesis wherein risk treatment methods are suggested for the identified risk sources and initiating events. When one wants to choose between several solution alternatives for the energy transition problem then the author suggests that a multi-attribute analysis is a better approach for decision making because there are several factors influencing the decision-making process, including energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, citizen psychology, societal preference, speed of transition, and in general magnitude. The author thinks that governments must try to strike a balance between the various attributes. As per the author, turning all of the characteristics into a single quantity is not a good technique to deal with risk issues since expected values have constraints and often neglect 'uncertainties.' These questions have no definitive solutions. The author of this thesis emphasizes that whether precautionary principle be given more or less weight is the choice of the decision maker. Companies should propose alternative uses of oil and gas utilities to successfully tackle the energy transition barrier and enhance the degree of risk acceptability and tolerance in the energy market. For productive operations, organizations should take effective precautions and adopt contemporary risk acceptability models such as ALARP.

- Risk management has a place if it is well-planned and implemented, and it adheres to important ideas like robustness, resilience, and antifragility. The future energy system must foster resilient economies and societies for a more inclusive and equitable society. Ambitious and concentrated efforts are necessary now and in the next decades to accomplish SDG7 targets and develop a decarbonized energy system by 2050. Regional integration has the potential to increase energy system resilience to extreme weather patterns, climate variability and change, and carbon emission reduction, as well as boost green economic growth and employment in general. Energy systems will need to become more resilient in the face of future economic and environmental crises.

6 Conclusion

There is growing worry about the future supply of fossil-fuel-based energy and its environmental consequences. The globe is switching from fossil fuels to renewable energy sources. On the other hand, the speed and scale of this shift remain uncertain and arguable. The energy transition is inherently risky. Market actors' investment and operating decisions, as well as changes in the value of companies' assets, are all examples of energy transition risk. Government action will have a huge impact on where the world goes next. They do not have complete control; individuals, communities, civil society, corporations, and investors may all have an impact. None, however, have the same power to shape the future of energy as governments.

The thesis analyzed risk for both countries, compared and highlighted the differences in the study's outcomes, as well as the various risk management options that they may employ. A clear risk picture is created of the challenge at hand — Norway and India's energy transition. This provides improved knowledge on the risks related to the energy transition from fossil fuel to renewables for Norway and India. The goal of the thesis is not to quantify the level of risk for the countries, but to subjectively list the incidences in order to identify actions that may be made to reduce the likelihood of these events and their repercussions. It is an enormous and complex risk problem; hence the objectives have been set with time constraints in mind, acknowledging that it may not be possible to review all of the data or information available. The Bayesian network events and consequences are interlinked, and the sequence may be followed as demonstrated or may not be followed as it depends on the various scenarios and the probability of occurrences of such scenarios. Factors such as government policies encouraging renewable energy and energy efficiency, technology and innovation, and people expectations, Covid-19 will all play a role in the sequence.

The thesis bridged the risk understanding gap between Norway and India by proving that both countries require unique risk management and planning strategies. As a result, by performing risk analysis and comparing the risks these countries face in achieving the Paris Climate Agreement and the Sustainable Development Goals using various risk management strategies, this thesis contributes to a better understanding of the energy transition risks and improved risk assessment for Norway and India. Norway and India are two vastly different countries, each with its own set of challenges and possibilities. Population, energy demands, energy supply, geography, environmental difficulties, financial budget, government rules, public perception of green energy, and the amount of effect if the transition is successful appear to be different for each country.

Both nations' risks and energy transition are influenced by socioeconomic considerations. A risk comparison reveals that the same risk problem in two different contexts (here, two different countries) is not the same. There may be parallels, but there may also be distinctions. As a consequence of comparing the risks, we can show that addressing risk issues is not a copy-and-paste exercise, but rather necessitates in-depth risk investigation and inquiry to arrive at the necessary answers.

There are a number of unknowns that might affect how the energy transition develops and how swiftly it moves forward. COVID-19's spread, the global economy will recover to pre-crisis levels, conflicts amongst nations, supply of energy from renewables to global energy demand, coal's share of the energy mix will decrease below tolerable levels, and oil consumption levels will diminish, to name a few significant concerns.

The thesis strives to attain a high degree of quality by identifying all assessment phases, recording all assumptions, and supporting all analytical ideas and techniques. These decisions matter to decision-makers in both countries, as well as maybe other stakeholders — not as a prescription for what to do, but as an input to a larger process, such as management review and judgement, or, in this case, governmental review and judgement. The author underlines that decision-makers and maybe other stakeholders should consider the assessment's results in light of the assessment's limitations, as well as any concerns or issues that the assessment did not address but are nonetheless relevant to the decision-making process. Benefits linked with the activity under consideration, as well as strategic and political difficulties for both countries, may exist, and this varies by situation, as we saw in previous chapters. Such factors may be crucial in making a decision, but they may not be totally represented in the evaluation. The thesis employs risk-informed technique, with risk treatment options proposed for the identified risk sources and initiating events. Because there are several factors influencing the decision-making process, such as energy sources, energy demands, population, economy, geography, political goals and strategies, ethical factors, social factors, personal factors, infrastructure needs, citizen psychology, and society, the author suggests that a multi-attribute analysis is a better approach to choose between alternatives for decision-making. These questions have no definitive solutions. The author of this thesis emphasizes that whether precautionary principle be given more or less weight is the choice of the decision maker. Companies should propose alternative uses of oil and gas utilities to successfully tackle the energy transition barrier and enhance the degree of risk acceptability and tolerance in the energy market. For productive operations, organizations should take effective precautions and adopt contemporary risk acceptability models such as ALARP. The thesis, in this way, contributes to improved risk management of the energy transition risks for Norway and India.

Risk analysis and risk management strategies gives the governments a clear picture of the problem they are dealing with along with the uncertainties and knowledge base which supports the probabilities. The discipline of risk analysis is important when it comes to tackling real-world problems, and it is frequently employed for solutions throughout the world. The thesis explained to the readers the need and goal of a risk analysis science for a better future globally.

Appendix A: Risk analysis process

There are numerous challenges and issues associated with integrating theories and methods from risk assessment, risk perception, risk communication, and risk management, as well as from other fields/disciplines, to solve real-world risk problems (which are typically multidisciplinary and interdisciplinary in nature).(Society for Risk Analysis (SRA), 2018a). Risk analysis concepts and methods are integrated with information from statistics, psychology, social sciences, engineering, medicine, and a variety of other disciplines and domains to tackle risk challenges. The issues necessitate multidisciplinary and interdisciplinary solutions. Climate change, business, medicine, and other topics are highlighted, with risk analysis backing the effort.(Society for Risk Analysis (SRA), 2018a).

In practice, successful risk analysis entails, among other things: (Society for Risk Analysis (SRA), 2018a):

- The risk assessment is successfully included into the risk management decision-making process
- The risk characterization is presented in a format that is appropriate for the decision-making scenario
- The true purpose of the analysis, such as advise vs. defend, is disclosed
- Assumptions and caveats, as well as the ramifications of these for decision-making, are expressed.
- Potential surprises are handled, and suitable management measures are applied.
- All legal criteria are fulfilled.

The word 'risk analysis process' in this thesis refers to the three main phases: planning, risk assessment, and risk treatment. The words risk analysis, risk evaluation, and risk assessment have a distinct meaning in the thesis. Risk assessment is the result of risk analysis and risk evaluation. The risk analysis findings are evaluated.

The word 'risk analysis process' in this thesis refers to the three main phases: planning, risk assessment, and risk treatment. The words risk analysis, risk evaluation, and risk assessment have a distinct meaning in the thesis. Risk assessment is the result of risk analysis and risk evaluation. The risk analysis findings are evaluated. The questions to answer are: What is the difference between alternative I and alternative II? Is the threat too high? Is it necessary to put in place risk-reduction measures? The assessment of risk is followed by the treatment of risk. This refers to the process and execution of risk mitigation strategies, such as tools for avoiding, reducing, optimizing, transferring, and retaining risk. (Aven, 2015).

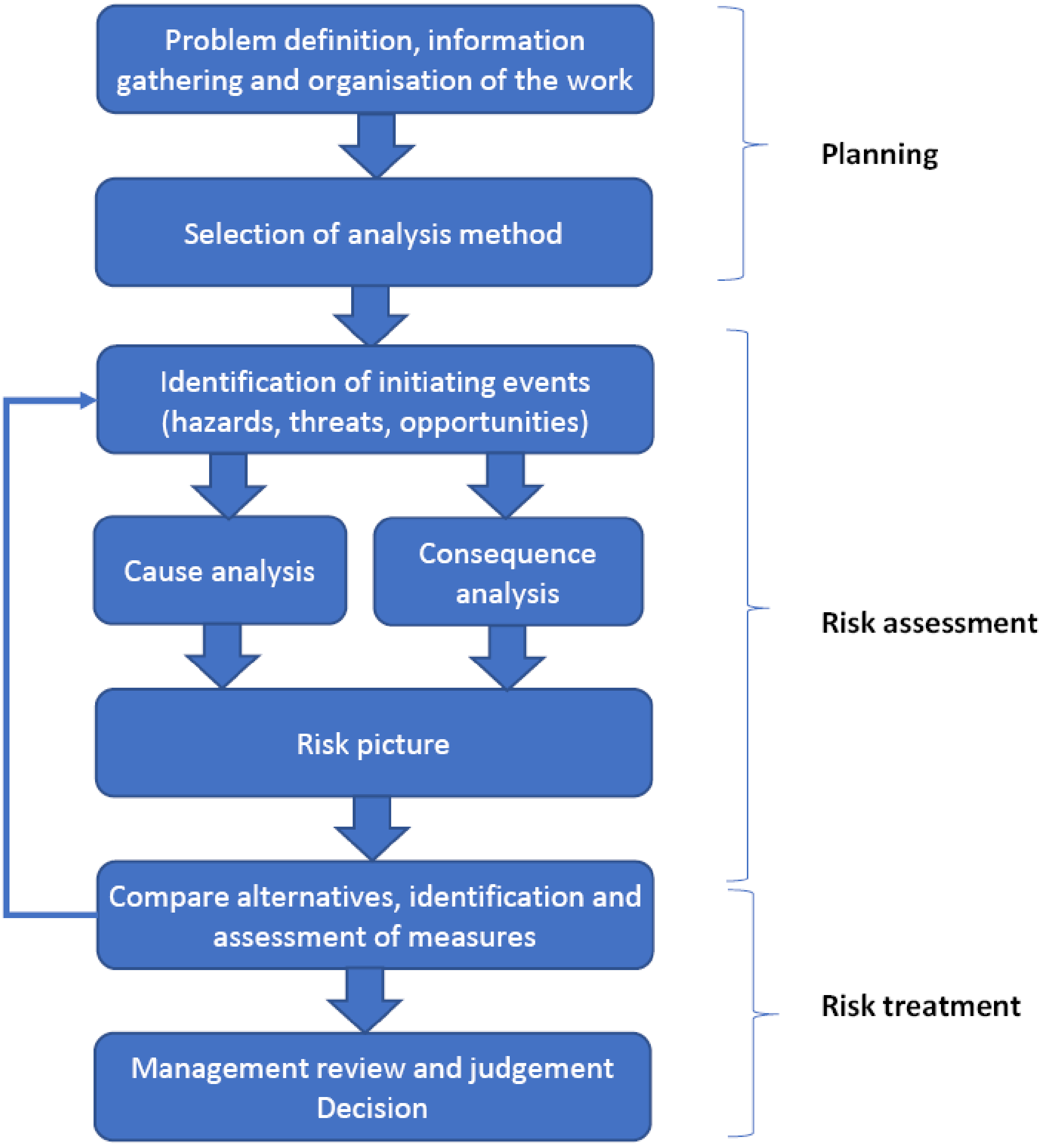


Figure 3 : Main steps of risk analysis process (Aven, 2015)

Appendix B: Risk analysis & risk management

A risk analysis can be used to: establish a risk picture; compare different alternatives and solutions in terms of risk; identify factors, conditions, activities, systems, components, and other factors that are important (critical) in terms of risk; and demonstrate the effect of various risk measures. (Aven, 2015).

The results provide the basis for making following decisions: (Aven, 2015)

- Choosing amongst a variety of different solutions and activities during the system's planning phase.
- Choosing between alternate solution or measure designs. What actions may be taken to make the system less susceptible, allowing it to withstand more loads and stresses?
- Determining if other solutions and measures fit the given requirements.
- Establishing requirements for a variety of solutions and metrics, such as the performance of readiness systems.
- Establishing an acceptable level of risk and safety.

Identification of hazards, threats and opportunities is the process of identifying, recognizing and describing risks that may aid or hinder an organization’s objectives. (ISO, 2018). When we talk about risks (threats), we're talking about hazard identification (threat identification). It's commonly claimed that "you can't deal with something you haven't identified." It's tough to avoid or mitigate the consequences of events that haven't been discovered. As a result, identifying initiating events is an important part of the investigation. It is therefore important that identification of initiating events be carried out in a structured and systematic manner. (Aven, 2015).

When we talk about risk analysis, we're talking about a decision-making tool in which the technique must be tailored to the analysis' goals. Risk assessments are carried out to assist in the selection of solutions and cures. All actions, situations, and events that may have an influence on the organization's ability to fulfill its goals and vision are dealt with through risk management. (Aven, 2015). ‘Risk management' is defined as any actions and activities used to manage risk, such as identifying threats/hazards, assessing risk, and making risk-informed decisions.(Aven, 2014). Risk management is concerned with resolving the challenges that arise from pursuing opportunities while also preventing losses, accidents, and disasters. (Aven, 2015). Risk management generally employs three key strategies: risk-informed, cautionary/precautionary, and discursive. In most circumstances, a combination of these three tactics would be the best course of action. The risk-informed approach refers to the use of risk assessments to treat risk – avoidance, reduction, transfer, and retention. (Aven, 2014).

To be effective in implementing risk management, an organization's senior management must be involved, and actions must be implemented at several levels. The following are some critical considerations for success: (Aven, 2015)

1. Establishment of a risk management plan i.e. the principles by which the company defines and manages risk. The company should decide if it wants to just adhere to the statutory standards (minimum criteria) or strive to be the best player in the industry.
2. the development of an enterprise risk management process, that is, formal processes and routines that the organization must adhere to.

3. defining management structures, including roles and duties, so that the risk analysis process is incorporated into the organization.
4. Implementation of analyses and support systems, such as risk analysis tools and recording systems for various sorts of incidents.
5. to improve the level of expertise, understanding, and motivation inside the organization through communicating, training, and developing a risk management culture.

Appendix C: Survey on energy transition (Questions)

Norway:

1. Climate change is due to human activities.
2. Energy transition to green energy from fossil fuels is necessary to save the Earth from climate disasters.
3. In Norway, climate change and the environment should be a higher priority as a national issue.
4. The Norwegian government policies and strategies are shaped towards successful energy transition.
5. Norway has enough infrastructure and/or finance to fund a successful energy transition.
6. A Norwegian citizen's contribution towards energy transition is equal to that of the Norwegian government.
7. You are willing to change your lifestyle to support energy transition by utilizing more renewable energy even if it increases your living costs.
8. Imagine that you work in a sector that contributes to greenhouse emissions (e.g., oil & gas). You think, personally, it is unethical to work in this sector.
9. From a societal point of view, Norway should take the larger share of the total global bill of energy transition compared to less developed countries.
10. Energy transition will be successful in Norway.
11. Energy transition will be successful globally.

India:

1. Climate change is due to human activities.
2. Energy transition to green energy from fossil fuels is necessary to save the Earth from climate disasters.
3. In India, climate change and the environment should be a higher priority as a national issue.
4. The India government policies and strategies are shaped towards successful energy transition.
5. India has enough infrastructure and/or finance to fund a successful energy transition.
6. An Indian citizen's contribution towards energy transition is equal to that of the Indian government.
7. You are willing to change your lifestyle to support energy transition by utilizing more renewable energy even if it increases your living costs.
8. Imagine that you work in a sector that contributes to greenhouse emissions (e.g., oil & gas). You think, personally, it is unethical to work in this sector.
9. From a societal point of view, developed countries should take the larger share of the total global bill of energy transition compared to India.
10. Energy transition will be successful in India.
11. Energy transition will be successful globally.

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