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Comparative Analysis of Energy Transition Strategies: Emissions, Resources, Market Dynamics, and Energy Flows in Quebec and Norway

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Executive summary

The importance of energy transition is one of the most important actions in the fight against climate change and environmental degradation, and this comparative analysis assesses how Quebec's and Norway's energy transition strategies differ in their approach to their emissions, resource use, market dynamics and energy flows. This study demonstrates the differences and similarities in their different energy transition strategies, in line with their domestic realities.

The aims of this research are to understand the differences in the domestic emissions of these two states, understand domestic energy generations, energy imports and exports, energy consumption and an analysis of how these differences affect the plans put in place by the national governments of these two states to achieve energy transition. Through a methodology that follows the pragmatist philosophy, a mixed qualitative/quantitative research approach, a case study research design, a document analysis data collection method and a thematic analysis data analysis method, it was possible to carry out this study.

The results obtained from this study on the theme of emissions showed how Quebec's highest-emitting sectors are the manufacturing, household consumption and primary sector, leading to per-capita emissions of 11.3 tonnes of CO_2, while Norway's emissions are dominated by the energy sector, transport and manufacturing, leading to per-capita emissions of 6,515 tonnes of CO_2. The results obtained from the analysis of domestic energy production show the predominance of renewable energies in Quebec, with the vast majority coming from hydroelectricity, followed by wind power, with more minor contributions from biomass, geothermal and solar power. Norway, by contrast, has a greater diversity in its domestic energy production, with the majority coming from natural gas and oil, followed by hydroelectricity and smaller contributions from biofuels, solar, wind, heat, and coal. To complement domestic production, energy imports and exports were essential to understanding the energy present in each territory. Quebec, which produces no fossil fuels on its territory, must import its demand for fossil fuels and import a very low amount of electricity due to the abundance of electricity the province generates. Norway, which already produces fossil fuel energy domestically, imports only a small quantity of energy. Regarding energy exports, Norway's and Quebec's worldwide reputations as energy exporters were confirmed, with significant exports of electricity from Quebec, while Norway exports a very

large quantity of fossil fuels and electricity. Domestic energy consumption across the residential, industrial and transport sectors shows the predominance of renewable energies in Quebec and a more diversified mix in Norway, as well as high energy consumption in the industrial sector through energy-intensive industries and the transformation of the transport sector with increasing electrification.

Finally, an analysis of the differences and similarities between the 4 themes studied has enabled an analysis of the differences in energy transition strategies and demonstrates why Quebec is focusing on expanding its renewable energy production, increasing energy efficiency and continuing electrification through targets set in its master plans. Norway, with a very different domestic reality, puts a lot of emphasis on carbon capture and storage, increased investment in renewable energy generation, and electrification of its economy to reduce dependence on fossil fuels.

Contents

1. Introduction

Increased extreme weather events, deteriorating air quality, negative impacts on biodiversity, exhaustion of natural resources, escalating geopolitical conflicts, growing inequalities, deteriorating energy security, economic losses, increased risk of environmental disasters, and many other consequences. These are some of the potential consequences that humanity will have to overcome if the energy transition does not take place. The transition to sustainable energy is crucial for addressing the pressing challenges of climate change and environmental degradation. Previous generations have stood up for humanity in the face of extreme events that had the potential to radically change the world forever or even threaten human survival. They remained resolute through war, disease, major natural disasters, human crime, famine, drought, and much more. They did what was necessary to ensure our planet's survival through sometimes even ultimate sacrifices. If the world fails to defeat climate change, of which the energy transition is integral, it could lead to the end of humanity. Thousands of years of history, culture, art and humanity, including Chopin's compositions, Rome's Coliseum, the beauty of the Sistine Chapel, the grandeur of the Great Wall of China, Petra, the Taj Mahal, the Pyramids of Giza, Machu Picchu, the writings of Dostoyevsky or Shakespeare, the paintings Da Vinci or Edvard Munch, are at risk of becoming only be traces of a civilization that has disappeared, leaving only lifeless scars on planet earth. We will be the only ones to blame through the inactions of our generations. Unfortunately, it will be very challenging to go back to where it began. However, there is still time to act and do one's part for this common goal of humanity, regardless of the country written on one's passport, gender, skin colour, the number written in one's bank account, values or language spoken. By moving away from fossil fuels and embracing renewable energies, societies can minimize the negative repercussions of global warming, reduce pollution and promote sustainable development. The energy transition is not just a burden, and it is also an outstanding opportunity to advance new technologies and innovation, create new job opportunities, reduce inequalities, have a healthier environment with cleaner air and less polluted rivers, and improve the overall quality of life for humans on every continent of the globe.

This is not the first time humans have had to go through an energy transition, as was the case with the switch from wood or dried dung to coal, then from coal to oil and natural gas, and now to renewable energies. It probably will not be the last time this happens if humans manage to counter the consequences of climate change and mitigate greenhouse gas emissions. For many years, people have stood up and made a rallying cry to denounce the direction where the world is heading, from the climate protests in Montreal to the Greta Thunberg marches. However, it took the planet to experience disastrous consequences such as massive forest fires, major earthquakes, tsunamis, droughts and much more before the international community sat down together and signed the Paris Agreement of 2015, which is to this day one of the most important international documents and commitments emphasizing the need to combat climate change as best as each country and individual can do.

Every country in the world is unique, with its geography, nature, values, mentality, resources, and much more, but some countries and regions share many aspects while being different from others. This is the case between the eastern Canadian province of Quebec and the Scandinavian country of Norway. These two states have many similarities, as both have vast territories and relatively small populations, with a significant proportion of their population living in a single large urban center, the Greater Oslo Region and the Montreal Metropolitan Area. Both places have very cold winters, requiring heating to survive and manage infrastructure in cold climates. Both states have ideal geographies for the development of hydroelectric power, with numerous rivers and non-flat regions, which has enabled these two geographically distant places to both have a very high proportion of hydroelectricity and, therefore, meet a significant proportion of their electricity demand from hydroelectric power. In Norway and Quebec, this clean energy from water power is managed by state-owned companies. In Quebec, it is Hydro-Québec, and in Norway, it is Statkraft. Both places are dedicated to making the energy transition a reality and are signatories to COP21, or the Paris Agreements of 2015. Both places are also committed to the electrification of many sectors of their economies to encourage the energy transition and the development of the infrastructure needed to make this transition a success. There are also several differences, such as the fact that Norway is one of the world's significant producers of oil and natural gas, and the Norwegian economy benefits significantly from it, whereas Quebec does not produce oil on its territory, and its economy has no dependence on the export of oil or natural gas. One of the most significant differences between the two states is their geographical position to the countries and regions that border them. On the American border, Quebec has very different economic partners than Norway, located in northern Europe, surrounded by countries with very different values, mentalities, perceptions of climate change, free trade agreements and free movement than those on the other side of the Atlantic. What is important to a North American may be different from what is important to a European, and even more so to a Scandinavian, the way things are done, how people see work, how they see life, what their ambitions are, what their priorities are, their trust in governments, their perception of state interventionism, the importance of the private car and individual freedoms concerning the collective good, and much more. It is important to make a comparative analysis of the energy transition strategy between Quebec and Norway because there are not many other states in the world that have as many similarities but just as many differences, and to understand how these states consolidate their advantages and disadvantages to do their best to pursue the energy transition with public support. This analysis will show how the approaches to energy transition differ. In contrast, the energy mix, except for oil and natural gas resources in Norway, is very similar, and possibly what could be done better to enable states, companies and individuals to adopt each other's approaches. Quebec and Norway have a common goal: addressing climate change. Understanding the priorities of each, the upcoming transformations, the existing plans, the way supply and production affect strategies, the way each nation's consumption affects strategies, the trade relations of energy imports and exports, and much more, can lead to best practices and mutual support, enabling both nations to optimize their strategies.

I've personally had the privilege of living in Norway and Quebec, and before starting this study, I had a few hypotheses about the results based on my personal experiences during my stays in these two places.

Firstly, in terms of emissions and approaches to emissions reduction, I expected the approaches in Quebec and Norway to be very different. I expected Quebec's emissions to be very high in the transport sector due to the North American mentality, which places great importance on individual cars. In contrast, in Norway, I expected emissions to result mainly from the production of fossil fuels. I expected Quebec's reduction strategy to focus mainly on increasing the production of renewable electricity, particularly hydroelectricity. Given its reputation for fossil fuel production in Norway, I expected a focus on carbon capture and storage and a transition away from the economy's dependence on oil and natural gas. Secondly, in terms of domestic energy production, I expected that in Quebec, hydroelectricity would be produced almost exclusively, whereas I expected Norway to have a greater diversity of energies, including fossil fuels.

Thirdly, in terms of market dynamics, I expected that, since Quebec's neighbours are all less environmentally friendly than they are, especially those south of the border, a large amount of clean electricity would be exported from Quebec, while a substantial amount of fossil fuels would be imported into Quebec. In the case of Norway, I hypothesized that because of its position on the European continent, with neighbours who generally favour a greener approach than on the other side of the Atlantic, I expected Norway to export a large amount of clean electricity, as well as fossil fuels, with very little energy imported into its country.

Fourthly, in terms of energy consumption, I expect that in Quebec, the strategy will once again be based mainly on hydroelectricity, whereas Norway will adopt a more diversified approach with, yes, hydroelectricity, but also wind power in the North Sea, fossil fuels with carbon capture and other investments to reduce emissions from fossil fuel production, combined with investments in various renewable energies. Finally, as Quebec is only one province within Canada, I expected targets to be set only at the federal level for the country as a whole. As Canada is not as advanced as Norway in its energy transition, I expected targets to be not as high in Canada as in Norway.

The situation raises the question of how Quebec's and Norway's energy transition strategies differ in their approach to their emissions, resource use, market dynamics and energy flows. While energy transition strategies are crucial to success in the fight against climate change, and both Norway and Quebec are committed to transitioning from fossil fuels to renewable energies, their two approaches are not quite identical, reflecting their respective realities in terms of trading partners, geography, production, consumption, commercial and environmental priorities, while respecting certain limits to keep society mobilized. This study explores how these differences manifest in emissions, resource use, market dynamics and energy flows. More specifically, this study seeks to identify the distinct ways these two states emit greenhouse gases, manage their energy resources, engage in energy markets and regulate the flow of energy nationally and internationally. Understanding these differences can provide unique insights into how these objectives can be achieved and offer guidance for the development and implementation of environmental policies.

The aim of this study is firstly to demonstrate the importance of the climate crisis and the different scenarios that could arise depending on the success or failure of human efforts to achieve the energy transition objectives and to show the catastrophic impacts and consequences of environmental inaction, or even worse, increased emissions. Then, one objective is to study the realities of each of these states to understand the coherence of the plans defined by governments. In studying these realities, one focus will be understanding where the emissions are coming from. Each of these states' energy production is important to understand how and what kind of energy is available for consumption on the territory. It is also important to understand how and by whom this energy is used, enabling an assessment of which sectors or industries should be prioritized for energy transition. This study also looks at how and what kind of energy is exported or imported to a given territory to see how each state can redirect the energy it needs or what type of energy can be imported to ensure the energy transition. Finally, this study will also allow a comparison of the approaches chosen by these two states to see what differs concerning their realities and if any strategies can be applied outside their own borders. This study will then briefly describe the history of the energy transition and gather the critical points of the 2015 Paris Agreements, to which Norway and Quebec are signatories, explaining the objectives of the energy transition. Following this is an overview of the importance of fossil fuels in global greenhouse gas emissions, the different scenarios for projected emissions, and the consequences of each of these scenarios. Finally, the analysis of the realities of Quebec and Norway in terms of greenhouse gas emissions, production, energy imports and exports, energy consumption and plans for the energy transition. However, this study will not examine the social, cultural, ideological, or current effectiveness of applied measures or strategies after 2050.

2. Literature review

2.1 What is energy transiton?

2.1.1 The history of energy transition

Throughout history, the world has seen many challenges and successes. Despite enduring some of the bloodiest conflicts in history, disease, widespread poverty and much more, humans have consistently demonstrated their ability to innovate and create inventions that reshape the world. Among these innovations are advancements in energy sources and utilization. The current green transition, while not the first, is a significant milestone in the history of energy transitions, underscoring the ongoing quest for new and sustainable energy solutions.

Before the Industrial Revolution, people used wood or dried dung as traditional biomass energy sources to cook and heat their homes. Transportation was mainly by foot and animal. The physical force of water and wind was also used to grind grain. In the 16th and 17th centuries, the world experienced a severe shortage of wood and charcoal, which led to an exponential rise in prices due to the high demand for increasingly sophisticated machines requiring more and more energy and the residential use of these fuels. As a result, countries like Great Britain, in the years of industrialization, began to use a new energy source on a large scale. Today, coal is considered the first energy transition. One of the major inventions of this period, which changed the world forever, the steam engine required a lot of coal to operate, and the use of coal in the home helped to increase coal's share of the total energy consumption from 1.7% in 1800 to 47.2% in 1900 (World Economic Forum, 2022).

Until the end of the Second World War, coal was the main source of energy for transport and residential needs, but the introduction of assembly lines, the growing use of private cars and the widespread introduction of the Bensen burner in the average home meant that the second energy transition was underway. Coal was replaced by natural gas for domestic use (cooking, heating, etc.), and oil took over from coal for transport. This second energy transition saw coal's share of the energy mix fall from 44.2% in 1950 to less than 22.5% in 2000. Natural gas and oil rose from 7.3% and 19.1% respectively in 1940 to 19.7% and 35.1% in 2000 (World Economic Forum, 2022)., and are still among the most essential energy sources today.

The second half of the 20th century was marked by a huge increase in oil and natural gas production and by growing environmental awareness by states, citizens, pressure groups, and companies. Indeed, the most recent energy transition has moved from fossil energies, mainly coal, oil, and natural gas, to renewable energies such as hydroelectricity, solar, wind, hydrogen, and lithium batteries, which can store ecologically produced energy.

2.1.2 The energy transition according to the 2015 Paris Agreement

The 2015 Paris Agreement, also commonly known as COP21, signed by 196 members of the United Nations, is widely regarded as one of the world's leading cooperative agreements on climate change. The revised advanced version of December 13, 2023 presents the ambitious goal of containing global warming to less than 1.5 degrees Celsius above pre-industrial levels. This crucial document to combat global warming requires a transformation of many industries, including the way we produce and consume energy in the countries that have signed up to the agreement. The following extract shows the scale of the efforts the international community will have to undertake to reach the predefined targets (UNFCCC, 2023):

“Further recognizes the need for deep, rapid and sustained reductions in greenhouse gas emissions in line with 1.5 °C pathways and calls on Parties to contribute to the following global efforts, in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances, pathways and approaches:

(a) Tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030;

(b) Accelerating efforts towards the phase-down of unabated coal power;

(c) Accelerating efforts globally towards net zero emission energy systems, utilizing zero- and low-carbon fuels well before or by around mid-century;

(d) Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science;

(e) Accelerating zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production;

(f) Accelerating and substantially reducing non-carbon-dioxide emissions globally, including in particular methane emissions by 2030;

(g) Accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero and low-emission vehicles;

(h) Phasing out inefficient fossil fuel subsidies that do not address energy poverty or just transitions, as soon as possible; “.

2.1.3 Fossil fuels & CO2 emissions

Numerous sectors of human activity produce a significant amount of CO2, which is released into the atmosphere, causing global warming. According to Our World in Data, Oxford University's data platform, the graph from their most recent data titled "CO_2 emissions by sector, World" (Appendix, Table 1) in 2020, the electricity and heating sector emitted 15.11 billion tonnes of CO2 into the atmosphere, the transport sector 7.10 billion tonnes of CO2, the manufacturing and construction sector emitted 6.18 billion tonnes of CO2, the buildings sector emitted 2.71 billion tonnes of CO2, the industry sector emitted 1.63 billion tonnes of CO2, the land-use change and forestry sector emitted 1.17 billion tonnes of CO2, the combustion of other fuels sector will generate 566.79 million tonnes of CO2 and fugitive emissions will generate 268.34 million tonnes of CO2 (Our World in Data, 2023).

The overwhelming majority of emissions in these sectors are a direct consequence of fossil fuel usage, which clearly highlights the importance of the transition to renewable energies as a means of reducing CO2 emissions. Indeed, According to Our World in Data, Oxford University's data platform, the graph from their most recent data titled "CO_2 emissions by fuel or industry, World" (Appendix, Table 2) demonstrates that in 2022 alone, 15.22 billion tonnes of CO_2 were emitted through the use of coal, 11.88 billion tons of CO_2 were emitted through the use of oil, 7.75 billion tons of CO_2 from natural gas, 1.61 billion tons of CO_2 from cement production, 397.45 million from flaring and 301.20 million tons of CO_2 from other industries. The three most common fossil fuels alone (oil, natural gas & coal) emitted at least 34.85 billion tonnes of CO_2 into the atmosphere, representing the vast majority of emissions according to these figures (Our World in Data, 2023). This staggering figure can be reduced if the energy transition to renewable energies proceeds as intended, in line with the 2015 Paris Agreement.

2.1.4 Global warming scenarios

The report of the UN climate panel, published in 2021, defined five possible scenarios for the energy transition in order to analyze progress and forecasts in the fight against climate change (Climate Neutral Group, 2023). These different scenarios are predictions based on a rigorous analysis of how humans can adapt and be proactive in the fight against global warming. These scenarios consider many societal changes, including socio-economic, population, education and more, to provide honest and realistic projections. The different scenarios are: Most optimistic: 1.5C by 2050 - SSP1-1.9, Next Best: 1.8C by 2100 - SSP1-2.6, Middle of the road: 2.7C by 2100 - SSP2-4.5, Dangerous: 3.6C by 2100 - SSP3-7.0 & Avoid at all costs: 4.4C by 2100 - SSP5-8.5. The exact definition of each scenario is in the appendix (Appendix, Table 3).

2.1.5 The consequences of global warming

The consequences of global warming are numerous and severe, posing a threat to human survival, our ecosystem, and all living organisms on land and underwater. Even if global warming is limited to 1.5 degrees Celsius above pre-industrial levels, serious consequences are already being felt worldwide. However, if emissions are not significantly reduced, the situation will escalate into a catastrophe. The world is at a critical point, and the decisions made today will shape tomorrow's world. While some of the consequences are irreversible, a relentless fight against climate change can improve the planet's resilience and attempt to stabilize the curve of consequences (IPCC, 2018).

Firstly, according to the IPCC's "Policy for Policymakers" report, these consequences of global warming affect humans, biodiversity and our ecosystems, one of the primary consequences of global warming will be the increasingly common occurrence of extreme temperatures. Indeed, days of extreme heat in mid-latitude regions will increase, and even if the world succeeds in keeping global warming to 1.5 degrees Celsius above pre-industrial levels, extreme temperatures are projected to rise by more than 3 degrees Celsius. If the world only succeeds in limiting global warming to 2 degrees Celsius above pre-industrial levels, extreme temperatures will rise by more than 4 degrees Celsius. As for high-latitude regions, extreme cold nights are likely to see their temperatures soar by 4.5 degrees Celsius if the world manages to contain warming to 1.5 degrees Celsius or by 6 degrees Celsius if the world achieves only 2 degrees Celsius. The number of annual days with extreme heat events will increase in all world regions, but the tropics will significantly increase (IPCC, 2018).

Secondly, global warming is also expected to generate numerous natural disasters worldwide, including floods, droughts, cyclones, forest fires and much more. These natural disasters are already common in 2024, but global warming will increase their severity and frequency, putting human lives, farmland and marine life at risk. Entire species of wildlife will be at risk of extinction, and many territories will become very difficult for human or ecosystem survival, with access to drinking water increasingly complex, agriculture and animal farming also challenging, and temperatures that will make life very hard if not impossible. These occurrences will happen if global warming is contained to 1.5 degrees or 2 degrees Celsius above pre-industrial levels. However, the greater the degree of global warming, the greater the occurrence and intensity will be felt in all four corners of the world (IPCC, 2018).

Thirdly, global warming will lead to rising sea levels. Water levels will continue to rise well beyond 2100. However, if global warming is contained between 1.5 degrees and 2 degrees Celsius above pre-industrial levels, water levels are expected to rise by a further 0.1 meters. Global warming will also lead to the melting of many glaciers, which are an essential source and reserve of potable water for humans. The melting of glaciers in Antarctica and Greenland will raise water levels even further, putting many islands, coastal towns, villages and deltas at risk and creating significant risks for the ecosystem and human life, such as saltwater intrusion, flooding and significant damage to infrastructure. As temperatures rise, so do the risks of these phenomena occurring, and a reduction in global warming will enable humans to adapt and reduce the risks and consequences to the best of their ability. In addition, warmer waters will perpetuate higher acidity and lower oxygen levels in oceans, which will seriously impact marine biodiversity, fisheries, the marine ecosystem and the role of water in human services (IPCC, 2018).

Fourthly, the impacts on terrestrial biodiversity and the ecosystem are also facing very significant consequences with global warming. Maintaining global warming at a level that respects the Paris Agreements will help reduce the impact on animal species, drinking waterways and coastal ecosystems and enable humans to continue to extract essential human services from them. If climate warming is contained to 1.5 degrees Celsius compared with pre-industrial levels, of the 105,000 species studied by the IPCC, 6% of insects, 8% of plants and 4% of vertebrates are expected to lose more than 50% of their geographic range. In contrast, if global warming rises to 2 degrees Celsius above pre-industrial levels, 18% of insects, 16% of plants and 8% of vertebrates are expected to suffer a loss of habitat as the planet warms. Furthermore, around 4% of the world's land area is expected to undergo significant ecosystem transformations if global temperatures rise by 1 degree and over 13% if global warming reaches 2 degrees Celsius above pre-industrial levels. Extreme geographies such as tundras and boreal forests will suffer particularly severely (IPCC, 2018).

Finally, global warming will dramatically impact human health, food security, drinking water supplies, economic growth, human security and livelihoods. The impacts will be even more severe for vulnerable and already hard-pressed populations, such as many indigenous communities, who rely heavily on agriculture, hunting and fishing. These regions are mainly those of arctic ecosystems, small developing islands, drylands and emerging nations. The increase in inequality and poverty is projected to rise substantially in many parts of the world that will be most affected by these direct consequences of climate change. In addition, these particularly affected regions are expected to experience an increase in mortality and health problems, including numerous diseases such as malaria, intense fevers and respiratory problems, with air quality continuing to deteriorate. In some of the world's poorest and most challenged regions, particularly sub-Saharan Africa, Southeast Asia and Central and South America, agriculture will be severely affected, even if warming remains within the 1.5

degrees Celsius of the Paris Agreement. However, as temperatures rise, so will the consequences. Serious consequences are also predicted for food security in the Sahel, southern Africa, the Mediterranean, central Europe and the Amazon. The wealthiest and most developed countries are not protected, as they will have the responsibility of helping and welcoming climate refugees, as many places in the world will become uninhabitable. These rich, developed countries such as North America and Europe will have to bear considerable financial costs, but these financial consequences are likely to be highest in the southern and sub-tropical hemispheres due to global warming, and the more severe the warming, the heavier the financial costs (IPCC, 2018).

2.2 Quebec

2.2.1 Quebec emissions

The carbon footprint of Quebec society is calculated by consolidating data from the GHG emissions account and an OECD database that calculates CO_2 emissions from inter-provincial and international trade through one of the most recent analyses by the Institut de la Statistique du Québec. In 2018, Quebec society emitted at least 94.9 million tonnes of carbon, equivalent to 11.3 tonnes of CO_2 per inhabitant yearly. According to the Institut de la Statistique du Québec graph entitled "Empreinte carbone de la société selon les catégories de la demande finale intérieure du Québec et selon le secteur d'activité émetteur, 2018" (Appendix, Table 4), Household consomption emitted 29 601Kt of CO_2, Primary sectors emitted 13 902Kt of CO_2, Utilities which include electricity and natural gas emitted 1606Kt of CO_2, Construction emitted 1 576Kt of CO_2, Manufacturing emitted 32 781Kt of CO_2, Transportation/courier/ warehousing services emitted 7 912Kt of CO_2, Wholesale and retail trade emitted 2 557Kt of CO_2, Other professional and technical services emitted 5 809Kt of CO_2 and finally the Non-commercial sector emitted 2 492Kt of CO_2 (Institut de la statistique du Québec, 2018).

Most of these CO_2 emissions were emitted within the province, with 49895Kt of CO_2 in 2018 (Institut de la statistique du Québec, 2018). However, a significant proportion of Quebec emissions were also emitted outside the province, including 15428Kt of CO_2 in other Canadian provinces and 29601Kt of CO_2 in countries other than Canada. These are CO_2 emissions produced outside of the province of Quebec and generated by the consumption of Quebec society. The countries that emit CO_2 emissions generated by the consumption of Quebec society are dominated by China with 23%, followed closely by the United States with 23%, Europe with 14%, Mexico with 4% and the last 34% distributed by a multitude of other countries around the world as showed in the graph entitled "Répartition des émissions de CO_2 de l’empreinte carbone de la société québécoise, selon le pays d’émission hors Canada, 2018" (Appendix, Table 5).

2.2.2 Energy generated in Quebec

The main reason why Quebec is in such a strong position in the utilities category is that the vast majority of energy generated in the province comes from renewable sources. Indeed, Quebec proudly ranks as one of the world's lowest-carbon energy suppliers, enabling the province to operate without burning vast quantities of coal, natural gas, oil or other fossil fuels. Quebec's geography is ideal for producing hydroelectricity, with its many rivers and streams and its vast territory, the vast majority of which is barely populated, with a land mass of 1.7 millions of square kilometers (Gouvernement du Québec, 2023) and only 8.9 million inhabitants (Institut de la statistique du Québec, 2023), of whom almost half live in the Montreal metropolitan area alone, with a population of 4.3 millions (Statistics Canada, 2021). This ideal geography enabled the provincial government in 1944 to nationalize hydroelectric production and create the state-owned Hydro-Québec (Hydro-Québec, 2023).

Quebec is the Canadian province that produces the most electricity, with a 2019 output of 46,380Mw, 94% of which is hydroelectric. Indeed, more than 40,850Mw of electricity were produced from hydroelectricity in Quebec in 2019 from numerous generating stations across the province, including plants as large as the Robert-Bourassa generating station, which alone has a capacity of 5,616Mw, making it the largest electricity generating station in the country. Another critical power plant that nicely demonstrates the grandeur of Hydro-Québec as the leading energy supplier to the province is the Romaine hydroelectric complex, which has 4 power stations that produce 1,550 MW annually. As of 2024, Hydro-Québec has 61 hydroelectric power stations, 24 thermal power stations, 28 large reservoirs with a storage capacity of over 176 TWh, 681 dams and 91 control structures. Besides hydroelectricity, Quebec supplies electricity from other fuel sources, as shown in the Statistics Canada graph entitled "Electricity generation by fuel type (2019)" (Appendix, Table 6). The chart shows that 94% of total electricity is generated from hydroelectric power, 5% from wind power, 0.7% from biomass and geothermal power, 0.2% from oil, 0.1% from natural gas and less than 0.1% from solar power in 2019 (Canada Energy Regulator, 2023).

The other primary renewable energy sources are wind power, with significant wind farms such as Mont Sainte-Marguerite with a capacity of 143Mw, Nicolas-Riou with a capacity of 225Mw and several others on a smaller scale. Numerous wind energy projects are also under construction. Solar power accounts for only a minimal share of electricity generation, but Hydro-Québec's Robert-A.-Boyd and Gabrielle-Bodis solar power plants produce 9Mw of electricity. Quebec also produces a minimal amount of electricity from natural gas, mainly during periods of very high demand on very cold winter days in eastern Canada, a modest amount from diesel for communities far from urban centers, and biomass, but these quantities are minimal (Canada Energy Regulator, 2023).

Regarding fossil fuels, Quebec does not produce commercial crude oil, but it does have 2 refineries, Suncor and Valero, which together produce a modest 372 million barrels a day. The oil refined in Quebec's refineries comes mainly from the western provinces and the country that shares a common border, the United States. There is no production of natural gas or liquefied natural gas in Quebec, and Quebec's refineries produce only minimal quantities of propane and butane. (Canada Energy Regulator, 2023).

2.2.3 Quebec's energy imports and exports

Quebec's energy import and export activities play a crucial role in its energy landscape. Despite its minimal production of fossil fuels, which are still used for specific purposes like transportation and cooking, Quebec strategically imports natural gas, liquefied natural gas, and oil. Simultaneously, it leverages its abundant hydroelectric power and other energy sources to export electricity, showcasing its energy management prowess (Canada Energy Regulator, 2023).

Quebec receives oil from many national and international sources to meet its demand. Quebec is connected by numerous pipelines, compressor stations, ports and railroads to import these fossil fuels. The province of Quebec receives crude oil through the Enbridge Line 9 pipeline, which transports crude oil from Sarnia, Ontario, to Quebec's largest city, Montreal. The capacity of this pipeline is 300 kb/d, and the oil transported is a blend of Western Canadian and Midwestern American types. Quebec also receives a small amount of oil from the Portand-Montreal pipeline, which averaged only 6.5 kb/d in 2021. There are 3 crude oil terminals in the province, with a total capacity of 123 kb/d, 2 of which are at the province's two refineries. Quebec receives oil from tankers at these two main ports, the two most populous cities, Quebec City and Montreal. 2 major pipelines allow oil to be exported from Quebec to markets in neighbouring Ontario. The first is the Trans-North Pipeline, which supplies the province of Ontario with 124kb/d of petroleum products refined in Quebec, including gasoline, diesel, aviation fuel and heating fuel. The second pipeline that allows petroleum products to be exported from Quebec is Valero's 100 kb/d Saint-Laurent pipeline, which transports petroleum products from Valero, one of only two refineries in the province, to a distribution terminal in the eastern part of the city of Montreal, then on to another location within Canada or abroad (Canada Energy Regulator, 2023).

When it comes to natural gas, since Quebec produces a substantial amount of energy from hydroelectricity and only produces renewable natural gas in its territory, it is entirely logical that the province imports regular natural gas or liquefied natural gas. For regular natural gas imports on its territory, Quebec is connected to TC Energy's leading network in Canada via the Trans-Quebec and Maritimes Pipeline for consumption within the province and also for international export to the U.S. border via an interconnection with the Portland Natural Gas Transmission System at East Hereford, a Quebec municipality on the southern border of the province of Quebec and the U.S. state of New Hampshire. For many years, when federal and provincial governments pursued favourable fossil fuel policies, Quebec historically imported the vast majority of the natural gas consumed on its territory from western Canadian provinces such as Alberta. More recently, with increased natural gas production in the U.S. combined with new connection points between Canada's first and most populous provinces, Quebec and Ontario, more and more natural gas is flowing from the U.S. to Quebec, either directly or via Ontario's networks, and then on to Quebec. The natural gas flowing into Quebec is managed and distributed by Énergir, a government-owned company regulated by the Régie de l'énergie du Québec. This state-owned company distributes natural gas to over 300 municipalities on more than 10,000km of pipelines across the province. However, the Outaouais region, which borders Ontario and is only 1 bridge away from the Canadian capital, Ottawa, is operated by Enbridge Gazifère (Canada Energy Regulator, 2023).

In the field of liquefied natural gas, commonly known as LNG, Quebec state-owned Energir has been operating a liquefaction, storage and regasification plant in its largest urban center, Montreal, for over 50 years. As demand for liquefied natural gas in the marine and road transport sectors is increasing, the government-administered company has expanded the capacity of this plant, located on the east side of Montreal, to help meet demand in regions that are not serviced or connected to its natural gas pipeline network. There have been plans to increase export capacity for liquefied natural gas from the province, but progress is challenging, and expectations are very uncertain. Indeed, in 2015, Stolt LNGaz was granted a 25-year export licence for a maximum volume of 80 MMcf/d by the Régie nationale de l'énergie. However, by 2022, this project, which was also supposed to include a liquefaction terminal near Bécancour, had not progressed and was listed for sale. This is not an isolated case, as in 2016, GNL Québec also obtained a 25-year export permit. However, this project, which was due to come into service in 2026, was rejected by the provincial government in 2021 due to financial and environmental concerns (Canada Energy Regulator, 2023).

Quebec's main energy export is electricity due to its significant hydroelectricity production, resulting in net interprovincial and international electricity exports of 3.4 TWh. Quebec also imports hydroelectricity into its territory from Atlantic Canada's Labrador province through an agreement valid until 2041 that gives Quebec access to almost all the electricity produced from the Churchill Falls hydroelectric station. This access is for almost all 5428 MW produced at this plant. Quebec also exports its energy to markets in the Northeastern U.S., principally to the states of New York and New England. It is the province with the highest electricity exports to the neighbouring U.S. in 2019, with gross exports of 25.9 TWh. Within Québec's 24,804km of transmission lines and 225,304km of distribution lines, there are 15 interconnections between the Québec network and provincial networks such as those of Ontario, New Brunswick and certain American states located mainly in the North-East of the country, such as New York and New England (Canada Energy Regulator, 2023).

2.2.4 Quebec's domestic energy consumption

While greener than many parts of Canada and other countries, Quebec still consume energy. With its 1975 petajoules of end-use energy demand, Quebec ranks 3rd out of the 10 Canadian provinces and 3 territories in terms of total energy demand, and 8th in terms of total per capita consumption, while being the second most populous province in the country, it is second only to neighbouring Ontario. (Canada Energy Regulator, 2023).

In 2019, Quebec's residents exhibited unique energy consumption patterns, particularly in their demand for refined petroleum products, which, are the main fuel consumed. This represented a per capita demand for motor gasoline of 1114 litres within the province, which is nevertheless 12% lower than the average for all Canadian residents, including Quebec. This Canadian average is 1268 litres per capita for motor gasoline demand, but Quebec also stands out positively for diesel demand per capita, which in Quebec is 33% lower than the average demand for the country as a whole. This national demand was 855 litres per capita in Canada and 574 litres per capita in Quebec. Gasoline consumed in Quebec originates mainly from refineries within the province, but exports to meet this demand also come from the Atlantic provinces, the Eastern U.S. and certain European countries (Canada Energy Regulator, 2023).

Natural gas consumption as a fossil fuel in Quebec is also lower than in the rest of Canada because, once again, Quebec produces the vast majority of its electricity from clean energies such as hydroelectricity. Natural gas consumers in Quebec in 2020 together consumed only 5% of total Canadian demand, while Quebec's population at the end of the 4th quarter of 2020 was approximately 8.9 million inhabitants (Statistics Canada, 2021) out of a total Canadian population of 38.03 million (Statistics Canada, 2020)). At the time, Quebec's consumption averaged 587 million cubic feet per day. Most of this consumption came from the industrial sector, which consumed an average of 366 million cubic feet per day, well overtaking the two other sectors that consumed the most: the commercial sector, which consumed an average of 157 million cubic feet per day, and the residential sector, which consumed an average of 65 million cubic feet per day in 2020 (Canada Energy Regulator, 2023).

The province of Quebec is a very large consumer of electricity, and its inhabitants stand out from the rest of the country with their high consumption of electricity, which places them in first place nationwide for electricity consumption, with an average per capita consumption in 2019 of 24 Mwh. This consumption of 24 Mwh is 60% higher than the national average. This very high consumption is largely explained by the presence of numerous industries that require high electricity consumption at an affordable cost to ensure efficient operation, as is the case for aluminum plants and other sectors with high electricity demand. Another explanation for this high consumption is that, as Quebec is a place with very cold temperatures in winter and very hot days in summer, the vast majority of Quebec households heat and air-condition their homes with electricity. The industrial sector consumed the most electricity in 2019, with 93 TWh, followed by the residential sector, with an annual consumption of 71 TWh and the commercial sector, with 40 TWh (Canada Energy Regulator, 2023).

2.2.5 Quebec's energy transition plan

The Quebec provincial government has established and made public Quebec's Energy Transition, Innovation and Efficiency Plan. This plan, published in 2018 with updates every few years, is intended to guide present and future governments, as well as private and public stakeholders as well as regular residents, to provide Quebec society as a whole with a clear and precise direction towards sustainable and efficient energy use, and to reduce the province's dependence on fossil fuels, particularly petroleum products. The plan consists of a detailed roadmap including numerous measures in many areas to ensure a fair and efficient energy transition (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

This plan has a series of objectives to be achieved by 2030, according to the document Mise à niveau 2026 - Document en bref (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022) created by the Ministry of Energy and Natural Resources of Quebec. The objectives to be achieved by 2030, translated from French into English, are as follows: "Improve by 15% the energy efficiency with which energy is used, Reduce by 40% the quantity of petroleum products consumed in Quebec, Increase by 25% the total production of renewable energy, Increase by 50% the production of bioenergies, Eliminate the use of thermal coal in Quebec". The Ministry recognizes that the state is not the only essential party that must mobilize to achieve these objectives, and acknowledges the need for a collective effort on the part of ministries and agencies, energy distributors, businesses, citizens, institutions, municipalities and indigenous communities, through a budget of 12 billion Canadian dollars. and 14 action plans aimed at achieving the objectives by 2030 (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The Ministry of Energy and Natural Resources and the Quebec Liberal government, which was in power when the plan was published, have established 6 strategic orientations to be pursued through 2030, which are deemed necessary to ensure Quebec's successful energy transition (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The first direction is the recognition of energy efficiency as a priority source of energy. This implies using less energy to achieve the same levels of service or production of the same outputs, thus increasing the value of each quantity of energy available and used. The means described for the success of this orientation are a more rational use of energy forms for specific needs, the increased use of innovative technologies with high-performance equipment to limit energy losses, the recognition and awareness of energy consumers of the importance of increasing energy efficiency, and finally the application of voluntary and regulatory measures. This first orientation is essential to the success of Quebec's energy transition, as increasing energy efficiency will reduce energy costs, thereby enabling the availability of funds for investment in innovative environmentally-friendly projects. In addition, increased energy efficiency will limit the need for major new investments in energy production and distribution infrastructure, thereby reducing their environmental impact. This efficiency will also make Quebec companies more competitive by reducing their energy bills and enabling them to continue reinvesting in their organization and their environmental approaches. Finally, this energy efficiency will reduce greenhouse gas emissions across the province, helping to limit global warming and provide better air quality, health and well-being for all residents inside and outside the province (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The second objective of the Energy Master Plan is to reduce Quebec's dependence on petroleum products. Quebec has set a target of a 40% reduction by 2030, compared with the amount consumed in 2013. This target is very important for the success of the energy transition, as in 2013, petroleum products accounted for around 40% of the province's energy needs. The transportation sector consumed the vast majority of these petroleum products, with 81.3% of total demand, followed by the industrial sector with 12.9%, the residential sector with 3.3% and finally the commercial and institutional sector with 2.5%. To achieve this goal, Quebec needs to overcome structural, economic and cultural obstacles, which are the result of decades of development focused on very inexpensive petroleum products. However, Quebec does have one major advantage: access to a very large quantity of clean electricity (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The third orientation is to strongly support energy innovation. The countries that signed the Paris Agreement in 2015, including Canada and of course Quebec, are committed to continuous innovation and the development of energy efficiency, green technologies to offset or reduce emissions, and to ensure social and economic development that moves directly towards low-carbon emissions. Quebec, and especially the city of Montreal, is particularly fortunate in having expertise in a number of fields that are directly linked to the achievement of this objective, such as strong hydroelectric and transport electrification engineering, as well as world-renowned expertise in the fields of artificial intelligence, digital technology and aeronautics. A second advantage is the availability and access to vast resources, assets and knowledge enabling the generation of clean electricity, and to preferential tariffs that will enable further innovation and investment in the energy transition. The province's top-quality universities and research centers are and will be increasingly involved in energy innovation, all supported by 21.9 billion Canadian dollars from the federal government. Quebec is also a proud participant in a cap-and-trade carbon credit initiative. Finally, in 2017, Quebec adopted the Quebec Research and Innovation Strategy, which makes energy transition a priority and supports entrepreneurs in the development of new clean technologies (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The fourth direction is to develop the full potential of renewable energies. This plan aims to increase renewable energy production of all sources by 25%, as well as biofuel production by 50% by 2030, with the aim of achieving a total energy consumption of more than 60% from renewable sources by 2030. Quebec has a great potential to increase its production, consumption and export of renewable energies, as its territory is ideal for the continued production of hydroelectric power, as well as wind, solar and biomass. In addition, Quebec is making great efforts and recognizes the need to develop and encourage circular energy business models with industrial heat recovery networks, local geothermal networks and much more, in an attempt to minimize energy losses and enable the use of the outputs of the energy consumed. To ensure the development of a strategic plan for the bioenergy sector in the province, an interministerial committee was set up and the introduction of biofuel quotas in gasoline and diesel was one of the outcomes (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The second-to-last orientation is to reinforce the governance and accountability of the State, which is very important in a context where it is the state that generates and distributes electricity throughout the province, and also ensures the vast majority of natural gas distribution through state-owned companies such as Hydro-Québec and Énergir. To succeed in reducing the consumption of petroleum products in the province, it is essential to review policies, decision-making criteria and regulations in order to achieve the economic, energy and climate objectives needed to continue the fight against climate change. Administrative and regulatory frameworks are not currently adequate in OECD member countries to properly manage the potential for energy efficiency in major economic sectors, and changes within governments are therefore necessary. Short-term objectives need to be aligned with long-term ones, to ensure consistency and coordination between policies and all the players involved. Unfortunately, in Quebec at the moment of the publication of this plan, government actions are perceived as rather ineffective due to this lack of co-ordination between the various players, including the ministries. The capacity of the various levels of decision-making is directly linked to the success of the initiaves essential to reducing the province's carbon footprint and the success of sustainable mobility systems, a low-carbon industrial economy, the operationalization of the circulatory economy, innovations and much more. The next steps will be to integrate energy efficiency and fossil fuel reduction through cross-functional initiatives, with an exemplary state and a proactive policy, management and involvement (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

The final orientation of the province's energy transition plan is to support economic development, which aims to use the energy transition as an important pillar of the province's economic driver. This orientation includes support for numerous energy efficiency and petroleum product substitution projects across the whole of Quebec. This orientation will support major centers for an innovative model of electric mobility, which will lead to the creation of new professions linked to these green technologies as well as increased use of new industrial processes in regions where natural resources are essential for economic development to ensure their long-term viability. More and more Quebec companies will have better tools for integrating into global value chains in fields such as lithium batteries, and will be able to dinstinguish themselves on world markets in the context of the energy transition. This development support will help small and medium-sized enterprises, municipalities and regions to ensure their continued development and viability, as well as enabling them to maintain or acquire a leading role in the energy transition and prepare the ground for a post-petroleum future (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

In the latest update of the Master Plan for Energy Transition, Innovation and Efficiency, Upgrade 2026, published in 2022, the Quebec government developed 14 roadmaps to be followed from the day of publication to 2026 across many industries, areas and sectors essential to ensuring an effective and just transition. The first roadmap focuses on land-use planning, with the aim of optimizing development to reduce energy consumption, make mass transit more favorable and encourage active mobility. Secondly, the second roadmap aims to continue the eco-friendly development of mobility and transport towards an electrified model, with lower consumption of refined petroleum products through significant electrification and infrastructure improvements, as well as preparing the ground to ensure the successful implementation of the law passed in the province which will prohibit the sale of gasoline-powered vehicles on its territory from 2035, while there were close to 100 000 electric vehicules in Quebec (ICCT, 2022). The third roadmap concerns the integration of clean, efficient technologies into industries to help reduce their carbon footprint. Fourthly, improving the energy efficiency of the province's residential buildings through stricter building regulations. The fifth roadmap is to encourage the adoption of energy-efficient practices in the construction and maintenance of commercial and institutional buildings. The sixth roadmap targets the remote networks away of major urban centers, and aims to optimize the use of renewable energies and achieve better energy management. The next roadmap aims to develop the provincial capacities in the production of green hydrogen and bioenergy to diversify the province's renewable energy sources, which is already favored by the vast amount of renewable energy already available that will be needed for the production of green hydrogen. The eighth roadmap aims to support innovation in energy technologies and business models that encourage energy transition. The ninth roadmap highlights the importance of increased collaboration between Quebec and the province's indigenous communities in the development of renewable energy projects. The tenth roadmap seeks to explore new ways of accessing financing for clean energy projects, including collaborative projects between the private and public sectors. The eleventh roadmap prioritizes the acquisition of knowledge through investment in research and development in new technologies and practices that are consistent with the province's plan. The twelfth roadmap will promote awareness among private and public players regarding the importance of energy transitinon and increased efficiency in their use of energy. The thirteenth roadmap will improve access to renewable energy services in the isolated regions and reduce their dependence on fossil fuels. Finally, the state aims to become a role model in the energy transition by implementing sustainable environmental practices in its investments, infrastructures and policies (Ministère de l'Énergie et des Ressources naturelles du Québec, 2022).

2.3 Norway

2.3.1 Norway's emissions

Norwegians emit a large amount of CO_2 equivalent into the atmosphere per capita. According to the table titled “CO_2 emissions per capita, Norway” (Appendix, Table 7) assembled by the IEA, in 2022, Norwegians would have emitted an average of 6.515 tonnes of CO_2 per capita over the year. Even if this represents an 8% decrease in comparison with emissions in 2000, this 6.515 tonnes of CO_2 puts Norwegians in 11th position among the largest CO_2 emitters in Europe, well above the European average of 5.37 tonnes of CO_2 per capita, and in 33rd position worldwide, which is above the global average of 4.26 tonnes of CO_2 (IEA, 2023).

Norway's emission sources are dominated by emissions resulting from fossil fuel combustion, but a significant proportion of emissions are non-energy related. This is the case for heavy industries such as steel production and petrochemicals, which use fossil fuels as feedstock. There are also significant additional CO_2 emissions from calcination processes in cement production and process-based emissions from anodes, which are not directly energy-related. Although CO_2 is the main greenhouse gas, it is not the only greenhouse gas emitted in Norway. Emissions of methane, nitrous oxide, and industrial fluorinated gases (HFCs, PFCs, SF_6) also pose a significant threat to the future of humanity, and these gases, besides CO_2, are considered to be more harmful to the environment than CO_2. In terms of quantity, these gases, even if more harmful than CO_2, have a smaller quantity and when converted into tons of CO_2 equivalent, represent only 16% of Norway's total emissions in 2021, and due to a significant continuing decrease in CO_2 projected in the years to come, it is projected that by 2050, these non-CO_2 greenhouse gases will represent 38% of total emissions in 2050, after being converted into millions of tons of CO_2 equivalent. Norway is making significant efforts to combat climate change and reduce greenhouse gas emissions. Some of the avenues being pursued by this Scandinavian country are a continuation of the electrification of road transport with a reduction in the consumption of refined petroleum products such as gasoline, a reduction in petroleum production, the removal of turbines that run on natural gas and their replacement by electricity from clean sources directly connected to the country's grid, and a modification and optimization of manufacturing processes that are considered heat-intensive. These plans to fight for the planet's future are expected to bring many benefits, and projections for overall emissions of greenhouse gases are set to continue falling over the next several years. In 2021, greenhouse gas emissions were slightly lower than in the 1990 baseline year. However, it is expected that by 2030, emissions will have fallen by 25% and by an imposing 79% by 2050, to stand at 10.8 million tonnes of CO2 equivalent. Unfortunately, this is not enough to reach the net-zero's flagship target for 2050. However, it is still a step in the right direction, as is clearly shown in the graph entitled "Norway greenhouse gas emissions from combustion and non-energy related activities" (Appendix, Table 8), assembled by the Norwegian global quality assurance and risk management company, DNV (DNV, 2023).

When the report was published in 2023, Norway's own-use energy sector accounted for 33% of the country's emissions, including extraction and production activities. Most of the CO2 emissions in this sector were emitted when producing electricity from natural gas on the Norwegian continental shelf. As the Norwegian continental shelf continues to electrify more and more of its energy production, combined with the approaching end-of-life of many non-electrified installations, emissions from the Norwegian energy sector are expected to fall by 40% in 2030 and 77% in 2050, to 3.8 tonnes of CO2 equivalent, with an electrification rate of just over 50% (DNV, 2023).

The manufacturing sector emitted 12 million tonnes of CO2 equivalent, or almost a quarter of Norway's total emissions when this report was published in 2022. Of these 12 million tonnes of CO2 equivalent, almost half come from heavy industry and are therefore not directly related to energy. Emissions from this sector are set to fall by a meagre 6% by 2030, but the most significant reduction will come by 2050, when emissions from this sector are set to fall to 3 million tonnes of CO2 equivalent, a reduction of 76%. The use of clean energy in manufacturing processes and carbon sequestration are the main factors behind this reduction in emissions (DNV, 2023).

The transport sector is also a major emitter of greenhouse gases. In 2021, emissions from this sector represented 27% of the country's emissions, with road transport alone accounting for 8.8 million tonnes of CO2 equivalent. Thanks to the electrification of road transport, a 24% reduction in road transport emissions is forecast by 2030, and a 76% reduction by 2050, representing a greater reduction than off-road transport, such as air, sea or rail. The reduction in off-road transport is expected to achieve a 70% reduction in emissions by 2050.

The agricultural sector emits a considerable amount of methane and not CO2 like other sectors, but the curve towards decarbonization is also present in this sector, where emissions are mainly linked to animal management and landfill activities. Projections for this sector call for a 57% reduction in non-CO2 emissions by 2050 (DNV, 2023).

Finally, in 2023, Statistics Norway published a comprehensive table called “Emissions to air of greenhouse gases, by source” (Appendix, Table 9), which accurately illustrates emissions of the different types of greenhouse gases, as well as an adjustment of the different greenhouse gases in millions of tons of CO2 equivalent from the different sectors of activity in Norway, without however including ocean or air transport. The table shows emissions from government sectors, private and public companies, and private individuals (Statistics Norway, 2023).

2.3.2 Energy generated in Norway

Norwegian energy production is unique when compared with the international energy scene. Indeed, Norway has extensive natural resources and abundant fossil fuels on its territory, including oil, natural gas, coal and much more. From the graph published by the IEA, entitled "Domestic energy production, Norway, 2022" (Appendix, Table 10), we can see that the largest source of energy produced on Norwegian territory is natural gas, with production in 2022 of 4571522 TJ of energy, representing 51% of the total domestic energy production mix. Crude oil follows closely behind natural gas, with production in 2022, according to the same graph, of 3874585 TJ, representing 42.8% of Norway's total energy production. Hydroelectricity is the third most domestically produced energy source ,with 461664 TJ, representing 5.1% of total production. This is followed by biofuels and waste with 73637 TJ or 0.8%. The last three sources of energy production in this Nordic country are solar and wind power, heat and finally coal, respectively producing 54183 TJ or 0.6%, 6534 TJ or 0.07% and 3287 TJ or 0.04% in 2022. Norway's oil and gas resources are significant for the national economy (IEA, 2022). When the U.S. Energy Information Administration published its executive summary of Norway in 2022, crude oil production in Norway represented 2% of world production and 3% of world natural gas production. In addition to the significant quantity of natural gas and oil produced, it represents 50% of Norway's export revenues and more than 20% of its gross domestic product. The development of this industry is set to continue to grow and occupy an important place in the economy, as in 2021, total investments in crude oil and natural gas extraction and pipeline transportation totalled nearly 18 billion U.S. dollars, and also evaluated the possibility of 88 new natural gas and oil project developments. (EIA, 2022)

At the time of this report by the International Energy Agency in 2023, Norway was still producing a small amount of coal, and since 2017, this amount has been considered minimal. Only one coal mine is still active in the country, and its use is mainly to support the local power plant in Longyearbyen. This mine is located in the remote and isolated archipelago of Svalbard in the Arctic Ocean, north of the European mainland and halfway between mainland Norway and the North Pole, and employs a mere 80 people. During COVID-19, production of this coal was once again cut back due to significant water intrusion, reducing output to 63,000 tons (IEA, 2023).

Norway is a significant player in world oil production. As of January 1, 2022, it was estimated that Norway still had reserves of 7.7 billion barrels of crude oil, making it the largest oil reserve in Western Europe. In 2021, more than 1.8 million barrels of oil per day were produced, and according to the Norwegian Petroleum Directorate, 4 new oil fields were developed, contributing to a 5% increase in the country's annual oil production. The table entitled "Norway's top 10 producing crude oil fields, by volume, 2021" (Appendix, Table 11) by the Norwegian Petroleum Directorate shows that out of the 1768 thousand barrels of oil produced daily in 2021, 1112 were produced from the 10 largest fields. The largest field was Johan Sverdrup, with a production of 511 thousand barrels of oil per day, followed by Snorre with 100 thousand barrels of oil per day, Edvard Grieg with 98 thousand barrels of oil per day, Ekofisk with 81 thousand barrels of oil per day, Troll with 70 thousands barrels of oil per day, Oseberg with 57 thousands barrels of oil per day, Heidrun with 55 thousands barrels of oil per day, Grane with 52 thousands barrels of oil per day, Eldfisk with 45 thousands barrels of oil per day and finally Alvheim with 42 thousands barrels of oil per day. Across the country's many oil fields, nearly 95% of total domestic production was produced by 5 companies, including Norwegian oil giant Equinor Energy, which produced the most significant quantity by a considerable margin. According to the graph entitled "Norway crude oil production by operator, 2021" (Appendix, Table 12), Equinor Energy produced the vast majority of oil, with 68% of the country's total production, followed by Asker B.P. with 10%, ConocoPhillips Skandinavia with 8%, Lundin Energy Norway with 6%, Var Energi with 3% and finally the last 5% was produced by other operators. In addition to crude oil fields, Norway also has a crude oil refinery with a distillation capacity of 203,000 barrels of oil per day (EIA, 2022).

Natural gas is the most widely produced energy in Norwegian territory, and the country ranks 8th worldwide for its dry natural gas production globally, with 4.1 Tcf of dry natural gas produced in 2021. As of January 1, 2022, Norway had 51 trillion cubic feet of natural gas reserves. As with oil, most of the production is based in a few main natural gas fields. Indeed, in 2021, 3 natural gas fields in the country generated 50% of total domestic natural gas production. When the production of the 10 largest natural gas fields is put together, these 10 natural gas fields account for 3.27 trillion cubic feet of the country's total production of 4.07 trillion cubic feet. According to the table entitled "Norway's top 10 producing natural gas fields, by volume, 2021" (Appendix, Table 13),the field that produces the most natural gas in the country is the Troll field, with a production of 1.32 trillion cubic feet, followed by Ormen Lange with 0.40 trillion cubic feet, Aasta Hansteen with 0.31 trillion cubic feet, Oseberg with 0.29 trillion cubic feet, Gullfaks Sør with 0. 20 trillion cubic feet, Visund with 0.19 trillion cubic feet, Åsgard with 0.18 trillion cubic feet, Skarv with 0.16 trillion cubic feet, Kvitebjørn with 0.12 trillion cubic feet and finally the tenth most significant natural gas field in the country is Tyrihans with 0.09 trillion cubic feet. This natural gas production significantly increased after the start of the hostilities in Ukraine with the Russian Federation's Special Military Operation, which led the Norwegian government to authorize an increase in natural gas production of 50 billion cubic feet, mainly from the Oseberg and Heidrun fields (EIA, 2021).

As a result of the increase in natural gas production in Norway, the quantity of natural gas liquids recovered in the country has also increased. This production has risen from 203,000 barrels per day of oil equivalent in 2002 to a peak in 2017 of 351,000 barrels per day of oil equivalent, and by 2021 to 249,000 barrels per day of oil equivalent, as shown in the table entitled "Norway natural gas liquids production" (Appendix, Table 14) compiled by the Norwegian Petroleum Directorate. As with regular natural gas and oil, a large proportion of total production is distributed over smaller fields. Indeed, of the more than 50 natural gas liquids fields in Norway, 20% were produced from just 2: the Åsgard and Troll fields. These are the country's two largest fields in quantity produced, and the combined production of the 10 fields that produce the most significant quantity represents 175 thousand barrels per day of oil equivalent out of total domestic production of 249 thousand barrels per day of oil equivalent. After Åsgard and Troll, with production of 31 and 24 thousand barrels per day of oil equivalent, respectively, come the Gullfaks field with 21 thousand barrels per day of oil equivalent, Gjoa with 20 thousand barrels per day of oil equivalent, and Oseberg with 17 thousand barrels per day of oil equivalent, Skarv with 16 thousand barrels per day of oil equivalent, Johan Sverdrup with 15 thousand barrels per day of oil equivalent, Vega with 11 thousand barrels per day of oil equivalent, Tyrihans with 11 thousand barrels per day of oil equivalent and finally Visund with 10 thousand barrels per day of oil equivalent. Norway is also home to Europe's largest processing hub for natural gas liquids, at Kårstø, near Stavanger. This center receives large quantities of natural gas liquids and natural gas from nearly 30 fields and then transports them to mainland Europe or the U.K. The center's operations include the extraction of ethanol, butane and natural gasoline, with the combined capacity of the two propane caverns exceeding 1.6 million barrels of oil equivalent (EIA, 2022).

Norway is the country in Europe that produces the largest share of its electricity from renewable sources, and its electricity sector emits the lowest on the continent. With an installed generating capacity of 39,703 MW in 2023, Norway can produce around 156 TWh in a normal year, and it even reached a record in 2021 with an output of 157.1 TWh. One of the main reasons why Norway is the European country with the lowest emissions from its electricity production is that around 88% of Norway's production capacity comes from its 1,769 hydroelectric power stations, as well as 1,240 storage reservoirs with a total storage capacity of 87 TWh and 65 wind farms, which account for 11% of the country's electricity production. There is also electricity production from biofuels, waste, natural gas and other sources, but those quantities are minimal. This high proportion of hydroelectricity production sets Norway apart from the vast majority of Europe because instead of relying on thermal power plants, with fuels available in the energy markets, Norway depends on annual water precipitation, so it is less dependent on high fluctuation in the price of natural gas or other energy sources commonly used to produce electricity. The Norwegian hydroelectric network's storage capacity represents half of Europe's electricity storage capacity and allows Norway to have over 75% of its electricity flexibility. This flexibility in production means that production can be increased when demand is higher than current supply, and the operator can reduce production when demand is lower than supply. This is an essential feature for Norway in its fight against global warming, as it enables better integration of renewable electricity sources such as wind and solar, which tend to be intermittent, so if there's no wind or sun, there'll be no electricity production. The high storage capacity of

Norwegian hydroelectricity brings flexibility to the entire system and limits the consequences of this intermittency. Hydroelectricity is the backbone of the Norwegian electricity system, with a production capacity of 33,391 MW. In a normal year, this hydroelectric network produces around 136.49 TWh of the country's total electricity production of around 156 TWh. A major part of Norway's electricity production is operated by the state-owned Statkraft, which is also Europe's largest generator of renewable energy. Statkraft produces hydroelectricity, electricity from wind, solar, and gas-fired power and supplies district heating with its 6,000 employees across 20 countries. (Statkraft, 2023). In 2023, Norway's 65 wind farms had a production capacity of 5073MW, which corresponds to a production of 16.9 TWh in a normal year. This production naturally fluctuates with weather conditions, as for solar power (Energifakta Norge, 2023).

Regarding solar power, the total capacity installed on Norwegian territory in 2023 was still 299 MW. Many of these installations were to satisfy the personal consumption of individuals and specific industries, often on the roofs of buildings. As of March 31, 2023, there were no dedicated solar power plants on Norwegian territory. In 2022, some 153 MW of new solar power was installed nationwide. Finally, Norway also has thermal power plants, which in 2023 accounted for 1.5% of total electricity generation capacity, many of them in large industrial installations. In 2023, there were 30 thermal power plants with a total energy production capacity of 642 MW (Energifakta Norge, 2023).

2.3.3 Norway's energy imports and exports

In 2022, Norway produced 2510 TWh of energy, but compared to many other parts of the world, Norway exports the vast majority of the energy it produces domestically. In fact, according to the table entitled "Supply and use of energy in Norway, Energy balance. Main figures" (Appendix, Table 15) compiled by Statistics Norway, Norway exported 2335 TWh of the energy it produced, imported 135 TWh, and consumed only 218 TWh (Statistics Norway, 2023).

Norway is one of the world's major producers and exporters of fossil fuels, with production representing 2% of world oil production and 3% of global natural gas production, which together account for 50% of Norway's export revenues and more than 20% of the country's gross domestic product, it is natural to conclude that energy imports and exports are essential to the country's development and continued prosperity. Indeed, even though Norway is not directly linked to the European mainland, it has numerous inter-regional and international connections for exporting and importing energy. There are numerous natural gas pipelines from Norway to many other European countries, such as France, Great Britain, Belgium and Germany, with many pipelines running directly from the fossil fuel production plants in the North Sea to the facilities that import this energy internationally. By the end of 2022, major new pipelines, such as the Baltic Pipe, will connect Norway via Denmark to Poland. According to the table entitled "Norway's crude oil exports by destination, 2021" (Appendix, Table 16) compiled by the International Energy Agency, the vast majority of Norway's oil exports go to European countries. Specifically, European countries will receive 79% of Norway's crude oil exports in 2021, with 30% going to Great Britain, 17% to the Netherlands, 14% to neighbouring Sweden, 4% to Germany, 3% to France and 11% to other European countries. As for exports outside the European continent, the majority went to Asia, which imported 19% of Norway's oil exports, including 14% to China, 3% to India, 2% to South Korea, 1% to other Asian countries, and the final 1% was exported to countries in North, Central and South America. Only 12% of the liquid petroleum produced in Norway was consumed domestically. Some 1.6 million barrels of crude oil are exported from Norway daily, as shown in the table entitled "Norway petroleum and other liquids production and consumption" (Appendix, Table 17) compiled by the International Energy Agency. As for natural gas, Norway ranked third worldwide for the quantity of natural gas exported, after Russia and the United States. The chart entitled "Norway natural gas exports by destination, 2021," (Appendix, Table 18) compiled by Global Trade Tracker, shows that 43% of natural gas exports from Norway went to Germany, followed by Great Britain, which imported 29% of Norway's total exports, and France and Belgium, which imported 15% and 13% respectively of Norway's total natural gas exports. Norway does not just export energy, it also imports a certain quantity of hydrocarbon gas liquids. Some companies, such as Ineos's Rafnes petrochemical cracker, receive ethanol imports from the USA, in this case from Sunoco Logistics's export terminal at Marcus Hook, Pennsylvania or Enterprise Product Partners' terminal in Morgan's Point, Texas, which then crosses the Atlantic Ocean in purpose-built tankers and are finally transformed into various plastics and resins (EIA, 2022).

Another critical component of Norway's energy imports and exports is its electricity market. Norway introduced a market-based power trading system in 1991, giving universal access to its electricity markets from the beginning, unlike many other European countries, which opted for a gradual approach. Stattnett Market AS was then created and later became Nord Pool AS, which today is one of the continent's leading Nominated Electricity Market Operators (NEMO), where electricity is traded on a free-market basis. Nord Pool became the world's first international power exchange in 1996, including Sweden, Denmark, and Finland. Nord Pool's networks are integrated with physical and financial interconnections with other European countries. They serve as the physical power trade exchange mainly in the Nordic countries or the former Soviet countries in the Baltic region and are integrated into the European electricity markets. Norway is expanding into European electricity markets, with recent investments in interconnections such as the Nord Link cable to Germany and the North Sea Link cable to the UK. The Norwegian market is one of the coupled markets, which means it operates through implicit auctions that ensure that electricity moves in line with prices and ensures optimal and harmonious distribution of electricity across the different coupled markets, maximizing benefits for all parties. The graph assembled by NVE entitled "Import, eksport og nettoeksport, 2000-2020" (Appendix, Table 19) in its most recent update to May 2022 shows that Norway exports significantly more electricity than it imports, mainly due to its high proportion of electrcity generated from renewable sources, which are much less dependent on market-driven fossil fuels. In 2021, there were reportedly 25.5 TWh of electricity exported compared with 8.1 TWh imported, and in the first 5 months of 2022, 9.4 TWh were exported compared with 5.5TWh imported (Energifakta Norge, 2023).

2.3.4 Norway's domestic energy consumption

Norway, whether because of its cold winters, its industries, large territory or the high proportion of its electrification, is a vast electricity consumer. In 2022, Norway was one of the biggest electricity consumers on the planet, consuming 23.387 MWh of electricity per capita and 24.117 MWh in 2021. The tables entitled “Electricity consumption per capita, regional ranking, 2021” (Appendix, Table 20) and “Electricity consumption per capita, global ranking, 2021” (Appendix, Table 21), both compiled by IEA Data Services, show how Norway compares with other countries in the world in terms of per capita electricity consumption. Norway is only surpassed by Iceland for per capita consumption in Europe and the world as a whole, making it the second country in the world with the highest per capita electricity consumption. In contrast, the world average is only 3.358 MWh and the European average is 5.924 MWh. This electricity is used principally for heating, air conditioning, lighting, cooking and power devices, appliances and industrial equipment. Further electrification of transport and other sectors will increase this figure. Of all the electricity produced in 2021, only 48% will have been used for final consumption, and many sectors will consume this end-use electricity. According to the graph entitled “Electricity final consumption by sector, Norway, 2021” (Appendix, Table 22) compiled by IEA Data Services, it can be seen that the sector consuming the most of this electricity is the industrial sector, which consumed 179,766 TJ in 2021 or the equivalent of 41.6%, followed by the residential sector with consumption of 143,657 TJ or the equivalent of 33.3%, followed by the public and commercial services sector with a consumption of 83,285 TJ or the equivalent of 21.6%, followed by the transport sector with a consumption of 7,623 TJ or 1.8%, followed by the agriculture and forestry sector, which consumed 6,870 TJ or 1.6% and finally followed by the fisheries sector with a low consumption of 762 TJ or less than 0.2% (IEA, 2023).

Regarding total energy use in the country, there are many differences between electricity consumption and energy in general. Some differences can be seen in the table entitled “Total final energy consumption, Norway, 2021” (Appendix, Table 23) compiled by IEA Data Services. The sector in the country that consumes the most energy is once again the industrial sector. However, its proportion is lower with a consumption in 2021 of 280,208 TJ or 30.8%, followed by the transport sector with a 207,092 TJ or 22 consumption. 8%, followed by the residential sector with 172,631 TJ or 19%, followed by the commercial and public services sector with a consumption of 121,684 TJ or 13.4%, followed by non-energy use with a consumption of 99,191 TJ or 10.9%, followed by order with very small consumptions, the forestry and agriculture sectors, fisheries and finally various unspecified sectors (IEA, 2023). The total energy consumption in Norway in 2019 was 1148 PJ (IEA, 2021) .

The residential sector is a significant energy consumer. Energy is mainly used in this sector for heating and air-conditioning, so a significant proportion is often based on electricity and another on fossil fuels. Usually, air conditioners, appliances, and lights run on electricity, while heating and cooking are powered by fossil fuels, mainly natural gas, oil, coal, and biomass. The graph titled “Residential total final consumption by source, Norway, 2021” (Appendix, Table 24), compiled by IEA Data Services, shows that in this sector, 83.2% of electricity is used, followed by biofuels and waste at 13%, then heat at 3.6%, with minimal quantities of oil, coal and natural gas (IEA, 2023).

The transport sector is also one of the most energy-intensive in the world, and Norway is no exception. Energy is often used mainly to fuel passenger cars, trucks, and airplanes. The vast majority of energy used in this sector is petroleum products. As shown in the table entitled "Transport total final consumption by source, Norway, 2021" (Appendix, Table 25) compiled by IEA Data Services, petroleum products accounted for 86.7% of total energy consumption in this sector in 2021, followed by biofuels and waste with 8.1%, then electricity with 3.7% and finally natural gas with a modest 1.6% (IEA, 2023).

The industrial sector typically uses energy throughout the world for industrial processes such as steelmaking, cement production or chemical production. Depending on the energy source available on a given territory, sources can vary greatly. However, there is still a heavy reliance on fossil fuels for activities that require very high heat or feedstocks. Norway uses much electricity in its industrial sector, as shown in the graph entitled "Industry total final consumption by source, Norway, 2021" (Appendix, Table 26) compiled by IEA Data Services. In 2021, electricity accounted for 64.2% of the total energy consumed in this sector, followed by oil at 13.6%, coal at 9.2%, biofuels and waste at 7.6%, natural gas with 4.4%, and a minimal share of heat (IEA, 2023).

The service sector tends to be much less energy-intensive than the industrial sector, as most energy is used to heat or cool buildings. This sector in Norway is once again dominated by electricity as the main energy consumed, as shown in the graph entitled "Commercial and public services total final consumption by source, Norway, 2021" (Appendix, Table 27) compiled by IEA Data Services. Of the total energy used, 76.7% comes from electricity, followed by heat with 11.6%, then petroleum products, biofuels and waste with 1.8% and minimal amounts of coal and natural gas (IEA, 2023).

2.3.5 Norway's energy transition plan

Norway is heavily involved in the fight for energy transition. As a signatory to the 2015 Paris Agreement, Norway has committed to several transformations to reduce greenhouse gas emissions. The country is committed to reducing its emissions by at least 50%, preferably by 55% by 2030. In addition, the Norwegian government has adopted the Climate Change Act, which legally establishes a nationally determined contribution (NDC) to achieve reductions of around 90% to 95% compared to 1990 levels by 2050. Norway also participates in the European Union's internal energy market. Although Norway is not a member of the European Union, it is an established partner in the European Economic Area. It cooperates closely with EU members on issues of energy, climate and climate change. With its favourable position with EU members, Norway applies many EU policies and initiatives on its territories, such as the cap and trade initiatives known on the continent as the EU Emissions Trading System (EU ETS), the Effort Sharing Regulation (ESR) for non-ETS emissions and even the Land Use, Land-Use Change and Forestry Regulation (LULUCF). The country also plans to continue applying these climate regulations on its territory, even after updating these 3 regulations entitled "Fit for 55" (IEA, 2022).

Norway was one of the first countries in the world to introduce a carbon tax in 1991, covering the combustion of fossil fuels and emissions from the country's domestic oil sector, and this polluter-pays principle is one of the foundations of the country's climate change policy. Around 85% of national emissions are covered by a carbon tax or the Emissions Trading Scheme (ETS), meaning that the country imposes a limit on the total quantity it is prepared to emit. Market participants are then allocated a specific limit of emissions they can trade on the market if they want more or have emitted less than they have been allocated. At the time of publication of this report by the International Energy Agency in 2022, the national CO2 tax was around NOK 766 per tonne of CO2 equivalent emitted for emissions not covered in the carbon cap and trade. The main climate policy instruments in Norway are greenhouse gas taxation, regulatory measures, the availability of information for more environmentally friendly alternatives, environmental requirements in state procurement, subsidies or other financial support for eco-technology innovation projects and incentive initiatives for environmentally-related innovation. When Norwegian emission prices are compared internationally, Norway applies a very high emission tariff. However, even with such a high carbon price, it is unlikely that this will enable the country to achieve its national targets (IEA, 2022).

The International Energy Agency's report "Norway 2022" provides a list of recommendations to the Norwegian government to ensure their energy transformation (IEA, 2022) : "The government of Norway should :

- Establish national emissions reduction strategies for key sectors to 2030 and 2050 that include specific targets and define supporting policy measures.

- Assess various scenarios for future global oil and gas demand as part of a longer-term strategy for transforming from oil and gas revenue dependency to low-carbon energy carriers.

- Consider measures to supplement carbon pricing to achieve harder-to-abate, costlier emissions reductions, especially in the industry sector.

- Prioritise energy efficiency as a policy area, including through sectoral targets, action plans and supporting measures, especially in the buildings and industry sectors.

- Promptly advance a robust regulatory framework that provides long-term investment signals and supports strong deployment of offshore wind generation.

- Increase ambitions to jump-start clean technologies where Norway may have competitive advantages and means, such as hydrogen, green shipping, carbon capture and storage, and offshore wind."

Norway's Climate Action Plan for 2021-2030 aims to reduce Norway's greenhouse gas emissions and adopt a policy that is consistent with the 2015 Paris Accords. The plan's main objectives are to reduce greenhouse gas emissions by at least 50%, preferably 55%, by 2030, compared with 1990 levels. For 2050, the target is a reduction of at least 90% and preferably 95% compared with 1990 emissions, which aligns with the European Union's climate policy objectives. Another critical target is a 45% reduction in 2005 levels for sectors not covered by the European Union Emissions Trading System, such as transport, agriculture, buildings, waste management, and many more. Another objective is the continuation and possible elimination of the use of coal in the Norwegian economy. The main ideas outlined in this document are sector-specific strategies, climate policy instruments, a focus on innovation and technology, cooperation across the European Union, public and private commitment, and improved adaptability and flexibility in the fight against climate change (Norwegian Governement, 2021).

More specifically for specific sectors, the strategy for the transport sector emphasizes zero-emission vehicles, intending to achieve a significant reduction in emissions through a reduction in the number of fossil-fuelled vehicles from 2022 onwards, and all buses will have to run on zero-emissions or biogas by 2025. This strategy should be capable of reducing emissions by 1 million CO2 equivalents. For the maritime sector, the aim is to reduce emissions from domestic and fishing vessels by 50% by 2030, compared with 2005 emission levels, representing a priority sector for the energy transition to low-emission and low-emissions technologies. For the agriculture sector, the strategy is to reduce emissions and increase carbon capture and absorption by 5 million tonnes of CO2 equivalent over the reference period of this document, between 2021 and 2030, through a focus on sustainable practices and technologies. The following important sector in this document is energy production, which accounts for an essential share of the country's total emissions and, therefore, aims to achieve a high level of capture and storage of the carbon emitted during the production of these energies, with growing and ongoing support for the development of renewable energy projects such as wind, solar and hydroelectric power (Norwegian Governement, 2021).

The policy instruments for achieving these objectives are regulatory measures and increased taxation, which will result in a progressive increase in carbon taxes to reach a price on emissions of NOK 2,000 per tonne of CO2 equivalent by 2030. Naturally, this policy instrument will provide incentives, make it less and less advantageous to use fossil fuels that emit emissions, and encourage the adoption of green and carbon-reducing technologies, as with the implementation of the significant Longship project involving the capture, transport and storage of CO2. This project seeks to demonstrate that carbon capture and storage is practical and feasible. Subsidies and some financial support are other necessary policy instruments for the success of the Norwegian plan, such as subsidies for developing new green technologies and focusing on initiatives that contribute to reducing emissions. Finally, another essential instrument is aimed at public procurement and, therefore, the establishment of climate-related requirements for suppliers and sub-contractors in the public procurement area and in transport (Norwegian Governement, 2021).

All these approaches and strategies of the Norwegian government to address greenhouse gas emissions and global warming are directly aligned with the regulations and targets set by the European Union and also include alignment with the internal energy market regulations and rules of the European energy market. Norway is also seeking to mobilize and engage private players in the country's economic sphere by encouraging the use of incentives put in place by the state to lead companies and citizens to align with national climate objectives voluntarily and to foster the competitiveness and adaptability of the business sector and give them the tools to continue prospering in a well-regulated world with a cost attached to their emissions (Norwegian Governement, 2021).

3. Methodology

3.1 Introduction

In order to successfully mitigate climate change, it is essential to complete the energy transition, which both Norway and Quebec are committed to achieving. While there are many similarities in their energy portfolios and ambitions, there are differences in their approaches that reflect their respective realities in terms of domestic emissions, domestic energy production, energy imports and exports, energy consumption and, finally, the plans that guide the direction of the energy transition set by their governments. This study allowed insight into the differences in the strategies of each of these states, what is being done differently, what could be done better and what could be used outside their respective national frontiers, as well as being able to understand the domestic realities of these two states and why specific directions of energy transition strategy are being pursued instead of others. A rigorous methodological approach was used to deliver this study's most relevant and meaningful results. This chapter of the study will outline the approach used to carry out this study and provide a basis for further research into similar topics in the future. In this section of the study, the philosophical research will be described, as well as the research approach and design. Finally, the data collection method, and the data analysis method used will be discussed.

3.2 Research philosophy

The research philosophy used in this study is pragmatism. This approach was chosen because the pragmatist philosophy is the one that most closely matches the primary goal of this research, which is to conduct a comparison of Quebec's and Norway's energy transition strategies in order to gather practical insights and analyze the relevance of the approaches implemented to counter climate change. The pragmatist approach emphasizes practical results and application to the real world. The pragmatist approach also offers flexibility in the methods used to gather information and to make a fair and accurate analysis of the information available on the different aspects studied during the study, such as the different infrastructures, the different strategies pursued, the different possible scenarios, the figures on emissions and much more are excellent examples of the use of both qualitative and quantitative data to achieve research objectives. The climate crisis and the challenge of energy transition are definitely real-world problems, and to achieve relevant results, it is necessary to narrow the gap between theory and practice to find a balance, which the pragmatic philosophy is most suited to achieve.

3.3 Research approach

The research approach chosen for this study is in line with the philosophy used, which is the mixed-methods approach, involving the use of qualitative and quantitative information and data. The subject of energy transition is a multi-faceted one, and to carry out this study, it is essential to provide a qualitative context with information on the consequences of greenhouse gas emissions, the different scenarios, the different types of energy used, market components, measures implemented and to be implemented, and other crucial qualitative information that cannot be adequately represented with purely quantitative data. It is also essential for this study to use numerical data, such as to understand the percentage of certain types of energy used in a sector, the amount of emissions from a particular source, estimates of future emission reduction projections and much more, which require the ability to analyze quantitative data and figures. During this study, a considerable amount of qualitative information was used to explain phenomena, approaches, consequences and provide explanations for results, but the use of quantitative information was also essential to support the qualitative information through tables, graphs, figures on emissions, production, exports and objectives that are defined with percentages and quantitative targets to be able to compare Quebec and Norway.

3.4 Research design

Case study research design can be described as a design that aims to acquire concrete, contextual and in-depth knowledge of a specific real-world subject, enabling the exploration of critical characteristics, subject understandings and case-specific applications. Again, this study seeks to demonstrate this through its research problem and question. Indeed, with this research design, the study can demonstrate a detailed comparison through a comparative analysis between the two regions studied for their different strategies to achieve energy transition. Secondly, the analysis of geography, economic data, and specific public policies is another reason to justify the choice of case study design. One of the main objectives of a case study design is to understand the complexity of a case as comprehensively as possible, which this study seeks to achieve through a multitude of information-gathering methods or digital data.

3.5 Data collection method

The preferred approach to data collection was document analysis. As energy transition is critical for the whole world, many reliable national, international, public and private organizations are doing research, analysis, projections for the future and much more, which is then made public through developed and validated reports. To carry out this study, numerous documents were analyzed, from reports by international organizations on subjects such as energy to other international organizations that issue reports on emissions, energy mix information, future investments and many other crucial information that are capable of pointing out bad practices as well as highlighting positive achievements. To carry out this study, numerous documents and information sites from specific governments were also studied, as these sites and documents offer comprehensive, audited information that demonstrates positions, priorities, future objectives and a variety of relevant information to provide the most accurate information for analyzing the different strategies of their energy transitions. Documents from organizations such as the International Energy Agency, reports from Norwegian, Quebec and Canadian government ministries, statistical information published by governments, reports from state-owned companies and much more demonstrate the appropriate use of the document analysis method.

3.6 Data analysis method

The method selected to analyse the data for this study is the thematic analysis method. In order to be able to make a detailed and contextual comparison of the different strategies that Quebec and Norway have adopted in their different approaches to the energy transition, thematic analysis is particularly appropriate, as the different analyses carried out enabled specific important themes to be defined, providing the information needed to make a complete and detailed analysis. The main themes identified and analyzed were domestic energy production, domestic energy consumption, energy policies, geographical, economic and political context, greenhouse gas emissions, and many other themes. This method of analysis is also highly relevant to the presentation of results, as the approach used is firstly an analysis of the differences in consumption, domestic production, domestic emissions, energy imports and exports and lastly, the master plans for these transitions, to finally be able to make comparisons of these themes for Quebec as well as Norway. This demonstrates the necessity of analyzing data by specific themes to identify and compare data across comparable themes and, therefore, access results that can be compared.

3.7 Conclusion

This chapter begins with a restatement of the research problem and research question and the importance of rigorous use of methodology in achieving meaningful results. Indeed, as in this study, a practical, problem-solving philosophy is needed to find effective solutions and generate relevant knowledge. The philosophy of pragmatism has been chosen as the research philosophy. This pragmatist approach led to the analysis and study of information and data, both quantitative and qualitative, to understand all the details and data relevant to the successful completion of the study through a research approach that integrated the use of different types of data. For the research design, the case study was the most appropriate in terms of the structure and strategy that guided this research project and thus enabled the achievement of concrete, contextual, and in-depth knowledge of a specific real-world subject. As for the methods of data collection and analysis, the document analysis and thematic analysis approaches were chosen, as the availability of numerous reports on the subject of energy transition by national, international, private and public bodies allows for reliable, unbiased data collection and analysis by the most essential themes established.

4. Results

4.1 Introduction

As Norway and Quebec are both highly committed to the energy transition, their approaches are nevertheless very different, reflecting their realities in terms of emissions, domestic energy production, market dynamics for energy imports and exports, and energy consumption, all of which together lead to distinct plans for the direction of the energy transition. This research aims to understand the differences between the realities of the two states, with particular emphasis on their emissions, and, therefore, to understand where emissions come from and which sectors emit the most. Then, to understand what type and how much energy is produced in each respective territory, analyze the different energy imports and exports and measure what type and how much energy is consumed in each territory. All this will enable us to analyze the energy transition plans in each state and answer the research question of how Quebec's and Norway's energy transition strategies differ in their approach to emissions, resource use, market dynamics and energy flows. These results were achieved using a rigorous methodology, including a pragmatist philosophy, a mixed qualitative/quantitative research approach, a case study design, a data collection method and a thematic document analysis method. This results section will display the results of the comparative analysis on the four different topics studied. It will then enable the comparison of the strategies for the energy transition. This results section will compare the results by theme. Starting with their emissions, then their domestic energy production, their market dynamics for energy imports and exports, their domestic consumptions and finally, their distinct plans for the direction of the energy transition.

4.2 Domestic emissions

It is essential to start with each state's theme of domestic emissions to analyze the remaining elements. Firstly, regarding the total emissions of the two states, the most appropriate data is per capita emissions, as Quebec has a much larger population than Norway. Quebec, even though it has positively differentiated itself from the rest of the country, has per capita emissions of 11.3 tonnes of CO_2, while Norway has per capita emissions of 6,515 tonnes of CO_2.

Secondly, in terms of sector emissions, the sectors in Quebec with the highest emissions are the manufacturing sector, household consumption, and the primary sector. For Norway, the sectors with the highest emissions are energy, transport and manufacturing. Thirdly, the geography of emissions in Quebec is relatively diversified, with 49,895 Kt CO2 of emissions coming from within the province, 15,428 Kt CO2 generated in other Canadian provinces, and 29,601 Kt CO2 generated outside Canada's national borders. In the case of Norway, emissions are mainly domestic but have a significant global impact due to exports of natural gas and oil around the world.

4.3 Domestic energy production

Both Quebec and Norway are major energy producers in the world. Quebec predominantly generates renewable energy, particularly hydroelectricity. Quebec also has a very low reliance on fossil fuels for its domestic electricity generation, with significant state involvement in energy production through the state-owned company Hydro-Québec, which manages all aspects of hydroelectricity on its territory. On the other hand, Norway has a highly diversified energy production portfolio, with a significant share of fossil fuels. It is a major global oil and natural gas production player and is steadily increasing its investment in renewable energies, like offshore wind. The primary energy sources in Quebec are hydroelectricity, wind, biomass, geothermal energy, oil, natural gas, and solar energy. Hydroelectricity accounts for 94% of total energy production in the province, thanks to significant facilities such as Robert-Bourassa and the Romaine complex, which generate 5616 MW and 1550 MW of the province's total production capacity of 40,850MW. The wind power sector is also essential for Quebec, accounting for around 5% of the province's total production, with significant wind farms such as Mont Sainte-Marguerite, with a capacity of 143 MW, and Nicolas-Riou, with a capacity of 225 MW. The other sectors are more minimal, such as biomass and geothermal, which produce the equivalent of 0.7% of the province's energy, followed by solar, which produces a minimal 0.1% of the province's energy. In extreme winter conditions, fossil fuels such as natural gas can produce electricity.

On the other hand, Norway produces energy from natural gas, crude oil, hydroelectricity, biofuels and waste, solar and wind power, heat and coal. The country's primary energy source is natural gas, producing 4,571,522 TJ, equivalent to 51% of total domestic production. This is followed by crude oil with a production of 3,874,585 TJ, or 42.8% of total domestic production. This is followed by hydroelectricity, which generated 461,664 TJ or the equivalent of 5.1% of total domestic production, followed by biofuels and waste, which produced 73,637 TJ or the equivalent of 0.8% of total domestic production, followed by combined solar and wind power, which generated 54,183 TJ or the equivalent of 0.8% of total domestic energy, followed by heat and coal, both of which are relatively minimal, with 0.07% and 0.04% respectively of total domestic production.

4.4 Imports and exports of energy

Energy imports and exports are essential for both states' economies and energy mix. Quebec, on their side, focuses mainly on exports of electricity generated by their vast hydroelectricity production network, and significant imports of fossil fuels, like natural gas and oil from the United States or western Canadian provinces such as Alberta. Norway is a significant exporter of oil and natural gas, imports minimal fossil fuels into its territory, and has a growing export of electricity. Firstly, Quebec imports almost all its oil and natural gas needs, producing a minimal quantity of electricity due to its high domestic production capacity. On the other hand, Norway imports a limited quantity of fossil fuels due to its large domestic production capacity or imports a limited quantity in problematic or maintenance situations. Norway also imports limited electricity, mainly to balance its grid with its interconnection to the European electricity market. As for exports, Quebec exports a significant quantity of electricity to its neighbouring markets. It exports a significant volume of electricity to the United States, mainly to the Northeast American markets in New York and New England, with an export volume reaching 25.9 TWh in 2019. Norway, meanwhile, is a significant exporter of natural gas and oil due to its role as a major global exporter of these fossil fuels. The key markets for these exports are mainly European countries, such as Germany, the United Kingdom, the Netherlands and many others. The volume of exports was approximately 4 million barrels of oil per day and 120 billion cubic meters of natural gas annually. Norway also exports a significant amount of electricity, most of which is produced from renewable sources. The main markets for these exports are neighbouring countries connected to the Norwegian grid, such as the Scandinavian countries, Germany and the Netherlands, with increasing volumes.

4.5 Domestic energy consumption

Energy consumption within the respective states is also noticeably different when comparing Quebec and Norway. Quebec has a very high reliance on renewable energy sources for electricity, with a very high electricity consumption generated from its hydroelectric plants. Quebec also consumes a wide range of energy sources, including electricity, oil and natural gas for heating and transportation. Norway has a reasonably diverse energy consumption profile, with a high proportion of fossil fuel use, high per capita electricity consumption, mainly due to weather conditions, and a growing share of renewable energies in the Norwegian energy mix, particularly in the transport and heating sectors. The total final energy consumption in Quebec was 1600 PJ in 2018, with most of it generated by renewable energy sources, including hydroelectric power. On the other hand, Norway had a total final energy consumption of 1148 PJ in 2019, of which diversified sources were used. The energy-intensive sectors in both states were mainly residential, industrial and transport.

Firstly, energy consumption in Quebec's residential sector is driven by heating, which uses much electricity from its abundant hydroelectric resources. Other heating sources are natural gas and oil, but the amount is much lower than that of electricity. Moreover, in rural areas, minimal use of wood and biomass can also be used to meet residential demand. Electricity consumption in this sector is very high, and programs are in place to improve home insulation and promote energy-efficient applications. In the same sector, but in Norway, heating in the residential sector is mainly provided by a mix of electric heating, mainly from clean sources, district heating, some use of natural gas and oil, and increasing use of heat pumps. Electricity use is also abundant, and because of the extensive use of electric heating, per capita electricity consumption is high. as in Quebec, efficiency initiatives are being applied to make homes more efficient in their consumption and encourage better-insulated homes. District heating systems use a mix of biomass, waste heat and fossil fuels. However, electricity is the dominant source, with a continuous reduction in the use of natural gas and oil.

Secondly, Quebec's industrial sector is characterized by high energy consumption in energy-intensive industries such as aluminum smelting, mining, and pulp and paper. Other than electricity, natural gas is also used for heating and industrial operations, while oil is used in specific processes, but to a lower extent. In the same sector, but in Norway, energy-intensive industries are mainly aluminum production, oil refining, and chemical manufacturing.

Significant electricity is consumed in industrial processes, including aluminum production with a considerable share of fossile fuels used. Fossil fuels, mainly natural gas, are also used in the oil refining and petrochemical industries. Oil is also used in industrial applications but is not as abundant as natural gas. A growing share of renewable energies continues to be used in many of the country's industrial processes.

Thirdly, energy consumption in Quebec's transport sector is dominated by gasoline and diesel, with a constant increase in electricity and a certain amount of biofuels in the transport sector. The increasingly widespread use of electric cars is leading to a rise in the proportion of electricity used to power cars, with significant investments in incentives to buy these vehicles and a growing infrastructure to enable their use. By 2020, there were around 100,000 electric cars on Quebec roads. Investment in the electrification of public transport is also one of the reasons for the increase in electricity's share of the province's energy mix for the transport sector. In the same sector, Norway also uses a high proportion of gasoline and diesel, but electricity is already a significant part of the mix, and this proportion is growing continuously. Hydrofuels are also being used increasingly in this sector. Norway is one of the world leaders in terms of its share of electric cars on the road, supported by powerful incentives and excellent infrastructure, enabling Norway to have more than 400,000 electric cars on the road by 2020. Even in public transport, electrification, including ferries and buses, is very high.

4.6 Energy transition plans

The Quebec government has published a report called "Energy Transition, Innovation and Efficiency Plan." The Norwegian government has published a "Climate Action Plan 2021-2030" to guide their national fight against climate change, including their energy transition, which has distinctions about their national emissions, domestic energy production, energy imports and exports, and energy consumption. The main aim of Quebec's plan is to guide the province towards sustainability and efficient use of energy on its territory by reducing the use of fossil fuels and making the transition from mainly petroleum products to green energies through targets such as reducing greenhouse gas emissions by 40% by 2030, compared with 2013 emissions, an increase in energy efficiency of 15% by 2030, a reduction in the use of petroleum products of 40% by 2030, an increase in renewable energy production of 25% and bioenergy production of 50% by 2030, and the complete elimination of thermal coal. For Norway, the objectives are to reduce greenhouse gas emissions by 50% to 55% by 2030, concerning 1990 levels, and to achieve near-carbon neutrality by 2050. They also plan to improve energy efficiency across multiple sectors, wasting less energy and doing more with the same amount of energy, increasing carbon capture and storage, and electrifying transport even more significantly, thereby reducing dependence on fossil fuels for transport. Quebec's strategy for achieving these goals includes expanding hydroelectric projects, increasing wind farm production, programs that provide incentives for increased energy efficiency, and incentives for the continued development of transportation electrification projects, such as financial incentives for the purchase of new electric vehicles, new recharging infrastructures for these electric vehicles, electrification of public transport and a law banning the sale of gasoline-powered combustion cars from 2035. Initiatives and project strategies to achieve Norway's targets include significant investments in offshore wind farms, innovation and increased implementation of carbon capture and storage projects, green hydrogen production and export initiatives, and electrification of natural gas and oil production platforms to allow emission reductions in this highly polluting sector.

4.7 Conclusion

To conclude this results chapter and introduce the discussion chapter, the critical data for these two states are very different. Quebec's per capita emissions are much higher than Norway's, at 11.3 tonnes of CO2 per capita, while Norway's is at 6.515 tonnes of CO2 per capita. Quebec's emissions are mainly in the manufacturing, household consumption and primary sectors, whereas Norway emits the most greenhouse gases in the energy production, transport and manufacturing sectors. Secondly, Quebec's energy production revolves mainly around renewable energies, mainly hydroelectricity, which accounts for 94% of its national production, with smaller contributions from wind, biomass, geothermal, minimal solar and fossil fuel refining, without directly producing any. Norway's energy mix is more diversified, with the vast majority of energy produced from fossil fuels, mainly oil and natural gas. However, there is some production of hydroelectricity, biofuels, solar, wind, heat and coal. Quebec's imports and exports are mainly electricity exports to the Northeast of the U.S., fossil fuel imports, and a smaller amount of electricity imports. As a significant energy exporter, Norway exports large quantities of fossil fuels, mainly natural gas and oil, as well as electricity, mainly to its European neighbours. The country's energy consumption is dominated by renewable energies in sectors such as industry, housing and transport, with some use of fossil fuels. In Norway, renewable energy consumption is also high in the same sectors, and the use of renewable energies is increasing. Finally, Quebec's energy transition plan focuses on increasing renewable energies, improving energy efficiency, electrifying transport and reducing the use of fossil fuels to make way for more renewable energies. The Norwegian plan reflects the realities of their country, with an emphasis on reducing greenhouse gas emissions through carbon capture and storage for high-emission industries and fossil fuel production, electrification of transport and offshore oil platforms, and increasing energy efficiency. More details and explanations will be presented in the discussion chapter.

5. Discussion

5.1 Introduction

To fully measure how Quebec's and Norway's energy transition strategies differ in their approach to their emissions, resource use, market dynamics and energy flows, and to understand the fundamental differences in emissions, domestic production, imports and exports, energy consumption and finally, the differences that are reflected in the energy transition strategies, it is necessary to interpret the results obtained and presented in the results chapter, which demonstrated the differences between the two states. This discussion chapter will attempt to explain the differences observed in the results chapter. At the start of the study, based on my observations and experiences, specific hypotheses were established, including that emissions in Quebec would be mainly in the transport sector due to the North American car culture. In contrast, in Norway, emissions would be mainly in the energy production sector. The second assumption was that Quebec's energy production would be almost entirely hydroelectric, whereas Norway's energy mix would be largely fossil-fuel-based. The assumption for Quebec's imports and exports was that it would export electricity and import fossil fuels, whereas Norway would mainly export energy from all sources to its European neighbours. The assumption for energy consumption in Quebec is that most of the energy consumed on its territory will still be hydroelectric, whereas, in Norway, it is a more diversified mix with high use of fossil fuels and renewables. Then I hypothesized that, as Quebec is only one province in a country, the plan would be less ambitious, as the objectives would be defined at the federal level.

In contrast, the Norwegian plan would be ambitious and adapted to the demanding European standards. This chapter aims to explain the results obtained in the results chapter and the figures obtained in a more detailed way. This chapter will further evaluate the four established themes and the energy transition plans.

5.2 Domestic emissions

The per capita emissions figures for the two states could be better for Quebec or Norway. Even though Norway emits far less per capita than Quebec, it ranks 11th in Europe, suggesting that both states can improve their per capita emissions. As indicated in the results chapter, Quebec's per-capita emissions are 11.3 tonnes of CO2, while Norway's per-capita emissions are 6,515 tonnes of CO2. There are many reasons for the high emissions in these two states, and the fact that both are some of the coldest places on the planet is an essential indicator of these high emissions.

For Quebec, an important reason for these high per capita emissions is the presence of high-emission manufactures and industries, such as aluminum smelting and many others, in this province, which is recognized as an essential industrial base for the whole of Canada. Household consumption, such as heating and air-conditioning of residential spaces, is also one of the reasons for these emissions even if a significant par of the enery used for those activities are from electricity. Even if Quebec has a very green electricity supply, this high per capita emissions figure indicates that it is not enough to compensate entirely for the emissions from its industries with its generation of electricity from renewable sources. Furthermore, the primary sector, which includes emissions-intensive activities such as agriculture and mining, is a significant contributor to these high emissions.

Even though Norway produces and uses a significant proportion of its electricity from renewable sources, it is still one of the world's leading producers of fossil fuels, which has a significant impact on its per capita emissions. The energy sector dominates the country's emissions, mainly from oil and natural gas production and export. Norway's size and climate make many domestic and international transport activities essential to the country's functioning, and combined with emissions from energy exports, this contributes to the country's high per capita emissions. As in Quebec, many high-emission industries are present in the country, and once again, this impacts the country's per-capita emissions. As Norway is one of the world's major exporters of fossil fuels, the impact of Norwegian emissions is often distributed across many countries. However, this impact, even if not taken into account when compiling per-capita emissions data, has a considerable impact on the success of this energy transition, which is a global objective with consequences that know no borders.

Quebec is seeking solutions that balance economic growth with a reduction in environmental impact, and this is leading to strategies tailored to its domestic realities, with policies aimed at increasing the use of renewable energy sources in the manufacturing and transport sectors, including incentives and programs to improve energy efficiency on its territory, the adoption of green technologies, and the promotion of public transport and incentives for the selection of electric cars.

Norway, meanwhile, has an approach that aims to reduce emissions in its energy sector while maintaining the economic benefits of oil exports to the country, as well as ensuring an energy transition without compromising its energy security. One of the most essential activities on which Norway focuses is its ongoing innovation and investment in carbon capture and storage, which will give them the tools to continue producing fossil fuels, which are very important to the Norwegian economy while reducing emissions from this sector. This is combined with investments in renewable sources, a strong promotion of transport electrification, and reduced dependence on fossil fuels.

5.3 Domestic energy production

By analysing the different types and volumes of energy produced in Norway and Quebec, it is possible to understand the energy production profiles and evaluate the respective strategies for increasing the share of renewable energies and reducing the share of fossil fuels. As indicated in the results chapter, Quebec produces the vast majority of its energy from its numerous hydroelectric plants, which account for 94% of the province's energy generation, followed by solar power, which accounts for 5% of total energy generation. This is followed by biomass and thermal, which contribute 0.7% of the province's energy production and are mainly used in specific industries and residential applications. There is also a minimal amount of solar power, which is limited by the province's climatic conditions and northern latitude. Finally, there is a minimal amount of fossil fuel used almost exclusively in periods of very high winter demand. Energy production in Quebec is almost entirely renewable, with a heavy reliance on hydroelectricity.

Norway, compared to Quebec, produces a wide variety of energy sources on its territory, including many fossil and renewable sources. As mentioned in the results chapter, 51% of the energy produced in Norway is natural gas, positioning Norway as a world leader in the export of natural gas, which is essential for domestic and international demand. This is also the case for petroleum products since almost 43% of the total energy produced in Norway is petroleum products, making Norway once again one of the world's leading producers of this type of energy. However, the vast majority of petroleum is exported due to the relatively low demand for this energy compared to the quantity produced. Hydropower accounts for 5.1% of total domestic production, followed by biofuels and waste at 0.8%, solar and wind power at 0.6% and heat and coal with minimal quantities, which is an excellent example of the presence of the energy transition in this country. Compared with Quebec, where the vast majority of energy comes from a single source, and the main production facilities are large hydroelectric power stations, Norway has a highly diversified energy portfolio, with its numerous offshore oil and gas facilities, numerous hydroelectric dams across the country and a steady increase in offshore wind farm projects. Domestic priorities and the different availabilities of resources on each territory lead these two states to face different challenges and, therefore, different strategies. In Quebec, this lack of diversity in energy generation, which is dominated by hydroelectricity and wind power, can pose a significant risk, as almost all the energy produced within the province comes from a single source and can pose risks to water availability and environmental and ecosystem impacts. To address this reality, the Quebec government is continuing to invest in its hydroelectric capacity while ensuring that water is managed ecologically. Investments in the expansion of wind farms are also one of the strategies pursued by Quebec to continue developing renewable energies that are not just hydroelectric dams. Norway's domestic energy production faces similar challenges to the reduction of emissions, as the country's economy depends on exports of natural gas and oil, so the Norwegian government is seeking to find a balance that will allow it to benefit from the revenues from its fossil fuel exports, but with minimal emissions from its offshore extraction activities. Strategies include increased use of carbon storage and capture and the expansion of wind power projects and other renewable energy sources to prepare for the fossil-free future.

5.4 Energy import and export

By analyzing the differences between energy imports and exports, it is possible to understand how energy trading dynamics influence energy policies and markets. The focus of this analysis allows an understanding of the volumes and types of energy entering and leaving the country, which, when combined with domestic production, provides a more accurate insight into the energies present on the respective territories of these two states, as well as their dependencies. Quebec imports almost all the fossil fuels it needs. These imports of natural gas and petroleum come mainly from western Canada, from provinces that produce a lot of this energy, such as Alberta, and from the United States. These imports represent a dependence on other states for the supply of these types of energy, which are still necessary for the province's functioning. Quebec also imports a minimal amount of electricity due to the abundance of clean energy production capacity in its territory. Norway is quite different from Quebec when it comes to energy imports, which are measured in terms of imported fossil fuels due to its large domestic production of oil and natural gas. However, there are still imports that ensure the balance of domestic production during periods of strong imbalance. Norway also imports a limited amount of electricity, as its domestic production is already very high and can largely ensure the supply of domestic energy demand. However, the coupled interconnection of Norway's electricity grid with the European grid naturally routes electricity in the most efficient way to maximize the benefits of all the countries participating in this European grid. So some foreign electricity is also routed to Norway. Quebec and Norway both have key roles in supplying their regions with energy and in international markets, but of course, because of the availability of fossil fuels in Norway, the impact of Norwegian energy exports is more considerable. Quebec is a major exporter of electricity to the northeastern U.S., mainly to the New England and New York markets, with an export volume of 25.9 TWh in 2019. These exports clearly demonstrate Quebec's ability to supply its neighbours with renewable energies. Quebec also re-exports some fossil fuels. Quebec does not produce fossil fuels on its own territory. However, its refining facilities and connections to natural gas and oil pipelines, its favourable geographic position with a major port in Montreal, and its position in eastern Canada with direct access to the St. Lawrence River, which provides a route to the Atlantic and therefore an efficient interconnection with the rest of the world, make this province a valuable exporter of these energies. Unsurprisingly, Norway is a major world exporter of oil and natural gas, and these significant exports enable these energies to be supplied throughout Europe and the rest of the world. Norway's exports of 4 million barrels of oil a day and 120 billion cubic meters of natural gas annually underline Norway's role in the global energy scene and provide essential revenues for the country. Norway is best known for its exports of fossil fuels. However, the country is also a major producer of renewable energies, mainly from its hydroelectric power stations, making it a major exporter of electricity. These exports are more regional than oil exports due to the difficulty of exporting electricity over very long distances without direct connections. The approach of energy availability within Quebec can lead to certain challenges, such as Quebec's great dependence on fossil fuel exports and places Quebec at risk of market volatility and geopolitical risks, but these risks can be mitigated due to the abundance of fossil fuels in other Canadian provinces, so these energies are available in the country and these risks can easily be minimized. In addition, Canada's excellent relations with the U.S. also help to mitigate these risks, as the U.S. is considered Canada's closest ally, and free trade and trade facilitation agreements make these imports more stable. Quebec seeks to balance its strategy between clean electricity exports and fossil fuel demand to achieve its transition objectives. The strategies pursued by Quebec are therefore directed at improving the province's self-sufficiency by continuing to electrify its economy and reducing its dependence on fossil fuels, which will naturally also reduce its dependence on fossil fuel exports. A second strategy involves improving interconnections for electricity trade with its neighbours, enabling it to continue exporting clean energy that will help the global energy transition and provide revenue for the province. Norway still faces challenges similar to those of its domestic emissions and production as it seeks to achieve a balance between continuing to export fossil fuels, which are essential to its economy, with an approach to reducing emissions and encouraging the transition from fossil fuels to renewable energies. Once again, a strong emphasis is placed on carbon capture and storage operations, enabling the country to maintain its income from fossil fuel exports while reducing the carbon footprint of the production and transport of these energies to consumers. A strong emphasis is also placed on increasing the production of renewable energies in Norway, which will further enable the country to make the transition from fossil fuels to clean energy and diversify its energy mix. It is also important to consider the ongoing improvement of Norway's electricity grid interconnections with its European neighbours, enabling Norwegian electricity to be more easily exported to Europe to balance markets. This strategy also has an important impact on a global level, as Norwegian electricity, which is mainly from renewable sources, can contribute to reducing the dependence of its neighbours on fossil fuels, such as natural gas or coal, to produce electricity, thereby reducing global greenhouse gas emissions.

5.5 Domestic energy consumption

The differences in energy consumption between Norway and Quebec are influenced to a great extent by the availability of energy resources on their territory, both through domestic production and through imports and exports. The analysis of energy consumption enables an assessment of the consumption profiles in these two states, as well as an understanding of the types and volumes of energy consumed, in order to evaluate strategies for transitioning consumption from fossil fuels to renewable energies. Quebec consumes much more total energy on its territory, and its consumption in 2018 was 1600 PJ, compared to Norway, which consumed a little less than 3/4 of Quebec's with 1148 PJ in the same year. The predominant source of energy consumed in Quebec is from renewable energies, so the vast majority comes from hydroelectric sources. In contrast, Norway has a much more diversified mix with consumption from fossil fuels, hydroelectricity and other renewable sources. Naturally, given the overwhelming predominance of renewable energies in Quebec, this greater quantity consumed does not have the same impact on emissions as a lesser quantity, but a certain proportion is fossil-based. The three main sectors to be analyzed reflect the differences between these two states: the residential, industrial, and transportation sectors. Firstly, in the residential sector in places like Quebec and Norway, which experience freezing winters every year, the majority of energy consumption is dedicated to heating homes, and Quebec has a high reliance on electricity for heating, again due to its abundant supply of hydroelectricity. Natural gas, firewood and biomass are also used in periods of extreme cold in regions not well connected to the main Hydro-Québec network, but this quantity is minimal. Norway also has a predominantly renewable consumption for residential heating, with more diversified heating sources that include a combination of electric heating, district heating, and heat pumps, mainly from clean sources. A minimal amount of natural gas and oil can also be used, but this is a rare occurrence, which Norway is trying to eliminate. Secondly, Quebec's industrial sector is characterized by many energy-intensive industries, which consume high energy to keep them running. Much electricity is used, but a significant proportion of fossil fuels, especially natural gas, are used for specific industrial and heating operations. Norway also has energy-intensive industries such as aluminum production, oil refining, and chemical manufacturing. Norway also uses much electricity, but much natural gas is still needed for the oil refining and petrochemical industries, as well as a smaller quantity of petroleum products. A growing share of renewable energies in more and more industrial processes is being applied through technological innovations and the electrification of more and more processes. Thirdly, the transport sector in Quebec is unfortunately dominated by gasoline and diesel, but a growing share of electricity use is also present. By 2020, Quebec had 100,000 electric cars on its roads, and incentives and policies are in place, such as the law that will ban the sale of fossil-fuelled cars from 2035 in Quebec, combined with major investments in the electrification of public transport, which is not just limited to buses, but also to maritime and rail transport. Norway is recognized worldwide as a leader in terms of the proportion of electric cars used, and more than 400,000 electric cars were on Norwegian roads in 2020, with ongoing investment in infrastructure to facilitate the transition from fossil-fuel vehicles to electric vehicles. There is still a significant use of petrol and diesel. Quebec's main challenge in the transition of its energy consumption is to reduce the province's dependence on fossil fuels for transportation, and the abundant use of personal transport and fossil-fuelled vehicles on its territory makes this task all the more complex. In addition, the very high energy consumption for heating and industrial use requires rigorous supply management to avoid penalizing these industries, which are an essential part of the Quebec economy, especially in areas of Quebec outside of Montreal, enabling these smaller communities to continue to exist and prosper. The strategy Quebec is trying to adopt is to improve energy efficiency across all sectors, which means using less energy to achieve an equivalent, if not greater, output. Promoting incentives and infrastructure, as well as legislation to increase the share of electric cars, is very important for Quebec because instead of having vehicles and public transport that consume polluting energies that are imported into the province, the abundance of renewable energies in the province makes the transition to electric vehicles even more interesting. Norway faces the challenge of managing high per-capita electricity consumption, particularly in its residential heating activities. Another challenge that Norway faces, but for which its approach is often seen as an international model, is the continued reduction in the use of fossil fuels in transport on its territory. Norway's strategies are aimed at continuing the electrification of its transport system through incentives and the development of more and more infrastructure to enable this transition, increased use and production of renewable energies in all sectors, but especially in its industrial sector, and improving its energy efficiency in all sectors, but particularly in the residential sector to have less heat loss in residences and consequently enable the same heating, with less energy.

5.6 Energy transition strategy and conclusion

The analysis of the energy transition master plans in Norway and Quebec enables us to analyze the different priorities, objectives, initiatives, strategies and understanding of the different strategies put in place with respect to the different realities in domestic emissions, domestic energy production, imports and exports and energy consumption in these studied states. The analysis of these plans acts as a conclusion to the various themes analyzed in this study. It enables an assessment of how each of these states addresses their specific challenges and plans to complete their energy transitions. The approaches pursued by Quebec in its master plan focus primarily on reducing emissions, improving energy efficiency, increasing renewable energy production and reducing the use of fossil fuels. These objectives are strongly correlated with the realities observed in analyzing the four themes studied. Norway, which has a very different energy reality, also aims to reduce emissions, increase energy efficiency, increase the use of carbon capture and storage operations and increase the electrification of its economy. Quebec is aiming to achieve these goals through expansions of its hydroelectric and wind farm production, programs that encourage and provide incentives to do more with the same amount of energy in all its sectors of activity, and continued electrification of its transportation sector with an approach that aims to electrify both personal and public transport. As for Norway, this will involve further development of renewable energy production such as hydroelectricity and wind power, implementation of carbon capture and storage projects on a broad scale, exploration of new ways of producing renewable energy, and electrification of its natural gas and oil production platforms. It is becoming clear that some approaches are similar and can be applied equally well in both countries, while others are industry-specific, and the desire to reduce emissions at all costs is not exactly unanimous. Both states are looking for a balance between continuing to prosper in their economies and in the satisfaction of their citizens while at the same time attempting to reduce emissions at the lowest possible cost, which appears to be an optimization of energy use and production, meaning doing as much if not more in the respective states, but with a reduction in emissions. Quebec has an exemplary dominance of renewable energies on its territory, but it still struggles to have low emissions per capita, whether for its climate, which requires much energy to stay warm, or its energy-intensive industries. Quebec's approach is to keep jobs in these energies, which are important to the economy, allow people to keep their homes warm, and reduce its dependence on imported fossil fuels, and their approaches, which once again consist of increasing efficiency, increasing fossil fuel production and reducing the use of fossil fuels in the economy and transport. These approaches have been carefully chosen to avoid too many negative impacts and deliver significant societal benefits. Indeed, the energy transition will enable Quebec to create more jobs within the province instead of paying other provinces or American neighbours for their energy, will enable the province to export more clean energy and thus generate revenues, have cleaner air quality, reduce the costs to citizens and businesses of purchasing fossil fuels for their transportation and other needs in favour of energy generated within the province, and achieve greater energy independence. Norway is also seen globally as a leader in energy transition, even with its role as one of the world's major producers of fossil fuels. This unique position is not very common when analyzing the world's other major fossil fuel producers. Their approach has been carefully chosen to continue to benefit from these fossil fuels on its territory, as the loss of these revenues and jobs would be very difficult for the Norwegian economy. It is no secret that fossil fuels are not eternal, and Norway understands this well, so they are seeking to diversify their energy production to produce more renewable energies on their territory and to enable them to continue producing fossil fuels with minimal emissions and also to position themselves as one of the greenest fossil fuel producers in the world. The electrification of its economic sectors also correlates with its reality, as this electrification will enable Norwegian consumers and businesses to be supplied with domestically-produced energy where revenues remain in Norway and Norwegian workers receive a salary and pay taxes in Norway. These investments in renewable energies, even though renewable energy is already abundant in this country with a small population, will enable them to continue to be a major energy exporter, even after the world is in an advanced phase of the energy transition, and Norway will continue to accumulate revenues from energy exports.

6. Conclusion

After analyzing how Quebec's and Norway's energy transition strategies differ in their approach to their emissions, resource use, market dynamics and energy flows, this concluding chapter will begin with a brief summary of the results obtained during the execution of this study, describe the limitations of the study carried out, make recommendations for future research and analyze how this study contributes to the field of energy transition research.

Quebec and Norway have high per capita emissions, so Quebec has 11.3 tonnes of CO2 per capita, while Norway has 6.515 tonnes of CO2 per capita. Quebec's emissions are highest in the manufacturing, household consumption, and primary sectors, while Norway's are highest in the energy, transport, and manufacturing sectors. Both states are large energy producers, but the difference is that Quebec produces almost all of its energy from renewable sources, such as hydroelectricity and wind power. At the same time, Norway has a broader energy mix with significant production of oil, natural gas, hydroelectricity, wind power, biofuels and many others at more minor levels. To compensate for the non-existence of fossil fuels on its territory, Quebec imports this energy from its neighbours. With its abundance of electricity, Quebec is a major exporter of electricity. On the other hand, Norway is recognized as a major exporter of fossil fuels and renewable energies, with less significant energy imports. Additionally, these two states consume much energy in their residential, industrial and transport sectors. To conclude this brief summary, Quebec is applying a strategy to achieve its energy transition, which is geared primarily towards electrification, improving energy efficiency, reducing dependence on fossil fuels and continuing to develop renewable energy projects. Considering the importance of its fossil fuel exports, Norway aims to reduce emissions from this sector through carbon capture and storage, improved energy efficiency, increased renewable energy production and continued electrification.

During this study, several limitations were encountered. The first of these limitations was the absence of comparable data, with some data not being as comparable in one state as in the other, which would have created a wider spread between the data analyzed and the actual reality of the data. The second limitation was that each of these states consolidates its data in a way that is specific to itself, and this can, unfortunately, create variations in what is included in a sector, in what is considered for data accounting purposes, and can make the task of comparisons slightly more complex. The third limitation was that the scope that has been studied may only consider some sectors and therefore not everything that affects the energy transition, and may not include all the more minor innovations, components or sub-sectors that may slightly affect the results. The fourth limitation was methodological constraints were also observed when carrying out this analysis, and the constraints in analyzing a comparison of two states with unique environments, distinct economic factors, different mentalities, social and cultural aspects and lifestyles are all distinctions that can affect the approaches, but which were not analyzed in this study. The fifth limitation of this study is the difficulty of completely covering such a large and complex subject within a limited timeframe and scope. Given the extensive nature of energy transition strategies, a full comprehensive analysis could easily extend to a thousand pages, and even then, it would only capture some of the relevant details. For this reason, this study has selectively focused on key themes and critical points in order to provide the best analysis with respect to the limitations. Finally, a temporal limitation has also been observed because these documents, plans, advances and progressions are not always included as soon as they occurred or occurred during this study. Therefore, it was impossible to conduct an analysis with perfect real-time information and data.

Many recommendations for future research can be made about this study:

- It would be relevant to make a more extensive comparison with more than only two states, which between them represent only a tiny percentage of the planet's total emissions and could offer a more global perspective, as the fight against climate change is not only limited to Quebec and Norway.

- It would be interesting to analyze studies using a long-term temporal approach to measure the success or failure of policies or strategies implemented to make the energy transition.

- As this study has focused on many different sectors, it would be valuable to carry out more in-depth studies of specific sectors and analyze each sector's components and not just the most critical points of these multiple sectors and themes.

- As technologies and innovations are essential steps in the energy transition, studies on the impacts and difficulties encountered when implementing them would be useful.

- A study of the social, cultural, and economic aspects would be instrumental in understanding how local populations see it, how important it is, and how far they are willing to go to achieve the energy transition.

This study makes an essential contribution to the field of energy transition research. Firstly, it provides a structured analysis of energy transition comparisons in two regions on two different continents, enabling evaluation standards and benchmarking to be established. Secondly, this study also highlights the essential contribution of hydroelectric resources in the province of Quebec and how hydroelectricity is helping to reduce states' dependence on fossil fuels, demonstrating that a society can sustain and continue to innovate with a predominantly renewable energy mix, and encourage other states to increase their renewable energy production capacity. Thirdly, this study also demonstrates to the world's major fossil fuel producers that they can continue to benefit from oil production and export revenues while continuing their domestic energy transition, producing fossil fuels with reduced emissions and consider carbon capture and storage approaches. Fourthly, this study allows the international community to study the approaches and policies implemented in these two states and analyze how these approaches apply to the realities of the different states in their domestic energy situations and their respective industries and economic sectors. Finally, this study can serve as a model for other similar states, and these states can learn from the approaches of Quebec and Norway, both of which are recognized internationally as leaders in the energy transition.

It is essential to understand how Quebec's and Norway's energy transition strategies differ in their approach to their emissions, resource use, market dynamics, and energy flows. This chapter concludes the study by highlighting key differences in the two states' domestic emissions, domestic energy production, energy imports and exports, domestic energy consumption and energy transition master plans. This study has demonstrated where the emissions generated in Quebec come from and why these emissions are significantly higher than in Norway. The sectors that emit the most emissions in Quebec are manufacturing, household consumption and primary sector, while Norway's are highest in the energy, transport and manufacturing sectors. The study also demonstrated the predominance of renewable energies generated in Quebec, with almost all coming from hydroelectricity and wind power.

In contrast, in Norway, the mix is much more diversified, with a lot of oil and natural gas and renewable energies dominated by hydroelectricity and wind power. This study also demonstrated the differences between the two countries' energy imports and exports, enabling Quebec to compensate for the absence of fossil fuel production and to export and benefit from the electricity surpluses generated on its territory. At the same time, Norway is primarily an exporter of fossil fuels and renewable energies. Secondly, the study also demonstrated the high energy consumption from different sources in the sectors that consume the most, namely residential, industrial and transport. Finally, after analyzing the differences between the various themes studied, the last analysis was a comparison of the energy transition master plans of the two states, demonstrating the different approaches chosen by these two states. Quebec has favored an approach that is very much in line with its reality, with increased production of renewable energies, improved energy efficiency, and increased electrification of its transport system. Norway, which relies heavily on fossil fuels, has adopted an approach that reduces emissions while continuing to produce fossil fuels, including carbon capture and storage, increased electrification and production of renewable energies. This chapter concludes with a description of the limitations encountered throughout this analysis, as well as recommendations for future research in this topic and how this study contributes to this field of research.

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Appendix

Table 1: CO_2 emissions by sector, World

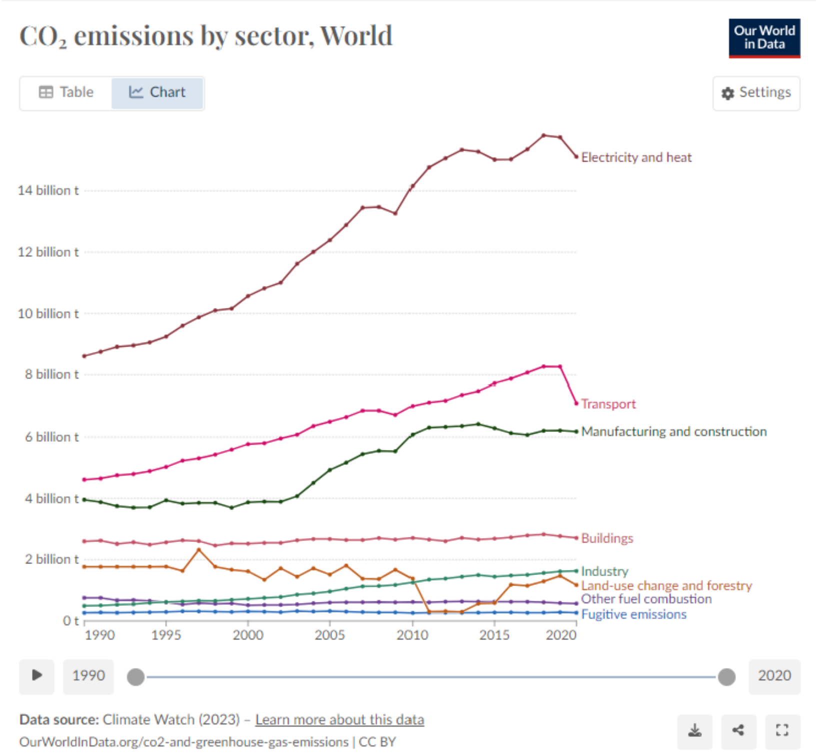

Table 2: CO_2 emissions by fuel or industry type, World

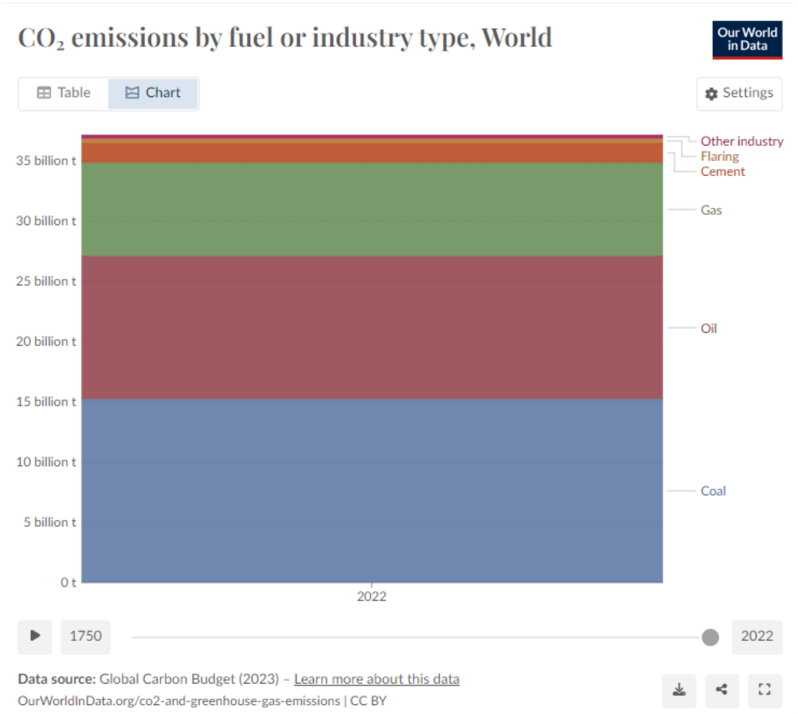

Table 3: Five future scenarios' Climate Report AR6 IPCC 2021

"Scenario 1 – Most optimistic: 1.5C by 2050

SSP1-1.9:

The IPCC's most optimistic scenario, this describes a world where global CO2 emissions are cut to net zero around 2050. Societies switch to more sustainable practices, with focus shifting from economic growth to overall well-being. Investments in education and health go up. Inequality falls. Extreme weather is more common, but the world has dodged the worst impacts of climate change.

This first scenario is the only one that meets the Paris Agreement's goal of keeping global warming to around 1.5 degrees Celsius above preindustrial temperatures, with warming hitting 1.5C but then dipping back down and stabilizing around 1.4C by the end of the century.

Scenario 2 – Next Best: 1.8C by 2100

SSP1-2.6:

In the next-best scenario, global CO2 emissions are cut severely, but not as fast, reaching net-zero after 2050. It imagines the same socioeconomic shifts towards sustainability as SSP1-1.9. But temperatures stabilize around 1.8C higher by the end of the century.

Scenario 3 – Middle of the road: 2.7C by 2100

SSP2-4.5:

This is a "middle of the road" scenario. CO2 emissions hover around current levels before starting to fall mid-century, but do not reach net-zero by 2100. Socioeconomic factors follow their historic trends, with no notable shifts. Progress toward sustainability is slow, with development and income growing unevenly. In this scenario, temperatures rise 2.7C by the end of the century.

Scenario 4 – Dangerous: 3.6C by 2100

SSP3-7.0:

On this path, emissions and temperatures rise steadily and CO2 emissions roughly double from current levels by 2100. Countries become more competitive with one another, shifting toward national security and ensuring their own food supplies. By the end of the century, average temperatures have risen by 3.6C.

Scenario 5 – Avoid at all costs: 4.4C by 2100

SSP5-8.5:

This is a future to avoid at all costs. Current CO2 emissions levels roughly double by 2050. The global economy grows quickly, but this growth is *fuelled by exploiting fossil fuels and energy-intensive lifestyles. By 2100, the average global temperature is a scorching 4.4C higher. "*

Table 4 : Empreinte carbone de la société selon les catégories de la demande finale intérieure du Québec et selon le secteur d'activité émetteur, 2018 (*Carbon footprint of society by categories of final domestic demand in Quebec and by emitting activity sector, 2018*)

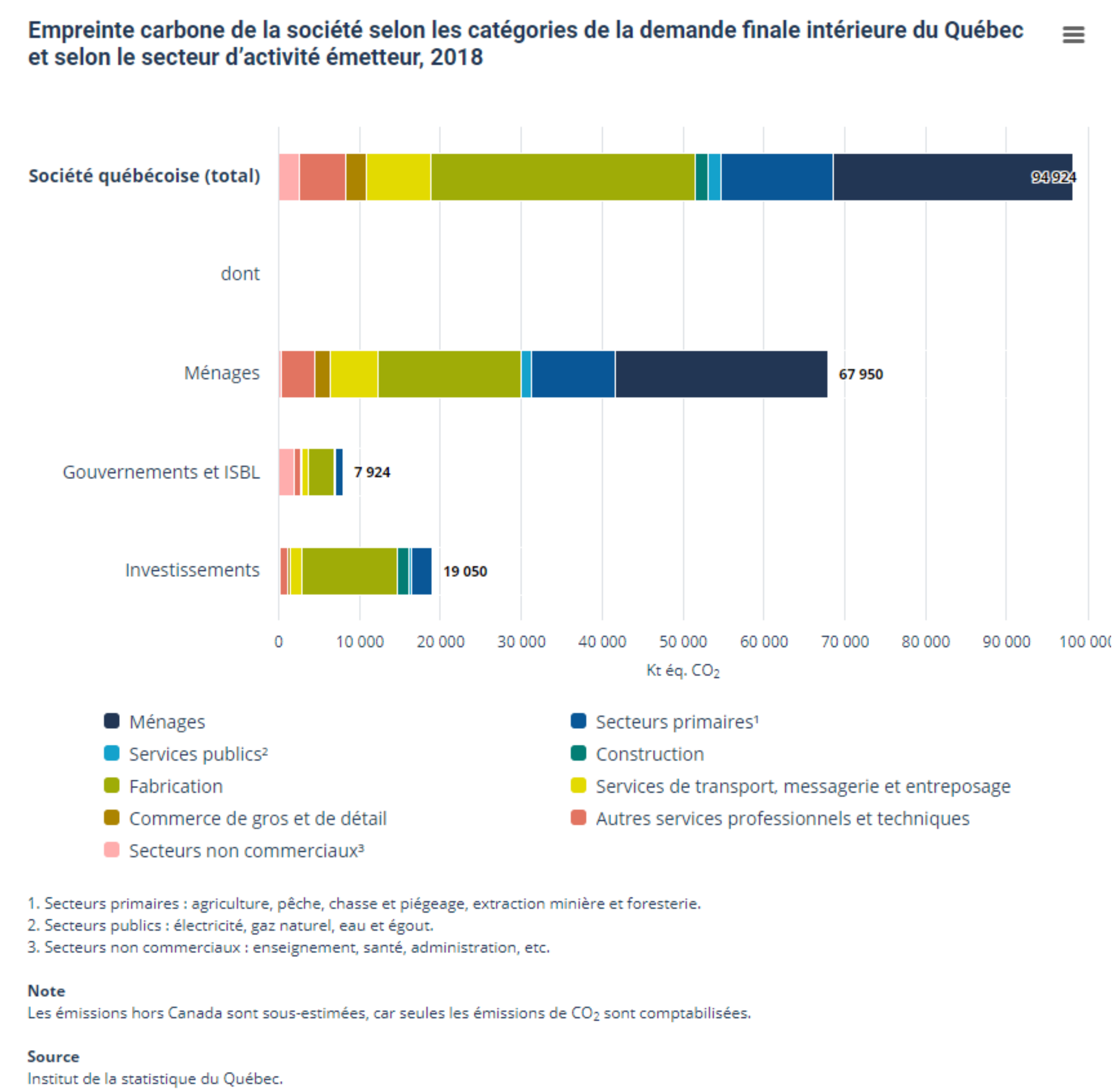

Table 5: Répartition des émissions de CO2 de l'empreinte carbone de la société québécoise, selon le pays d'émission hors Canada, 2018 (*Distribution of CO2 Emissions from the Carbon Footprint of Quebec Society, by Country of Emission Outside Canada, 2018*)

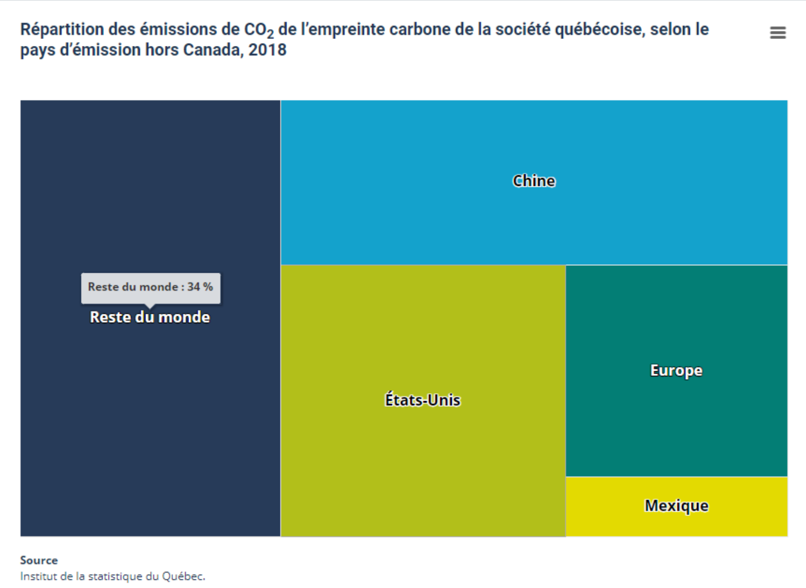

Table 6: Electricity Generation by Fuel Type (2019)

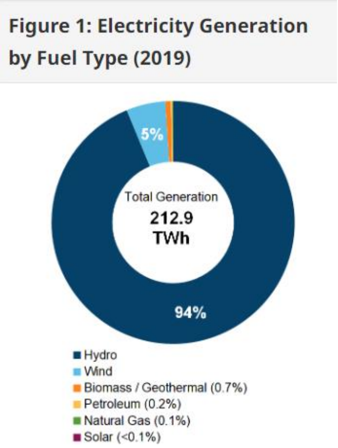

Table 7: CO2 emissions per capita, Norway

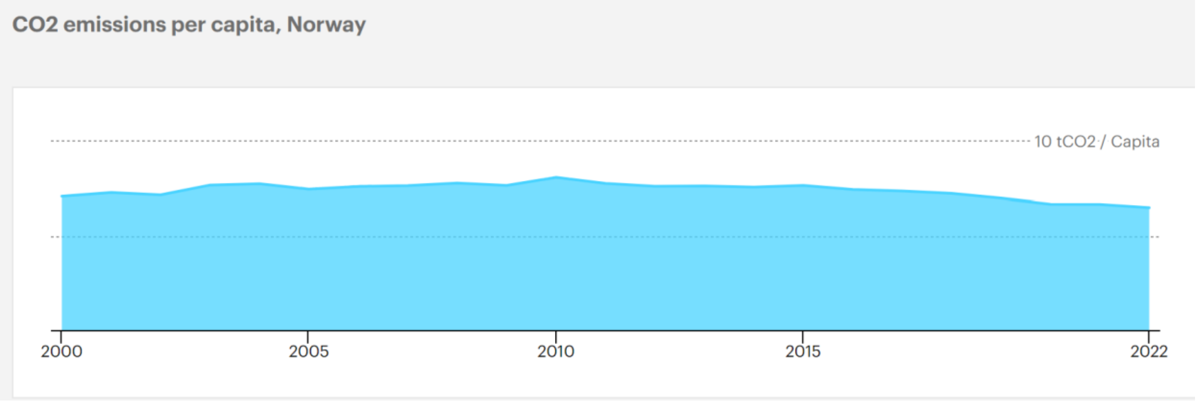

Table 8: Norway greenhouse gas emissions from combustion and non-energy related activities

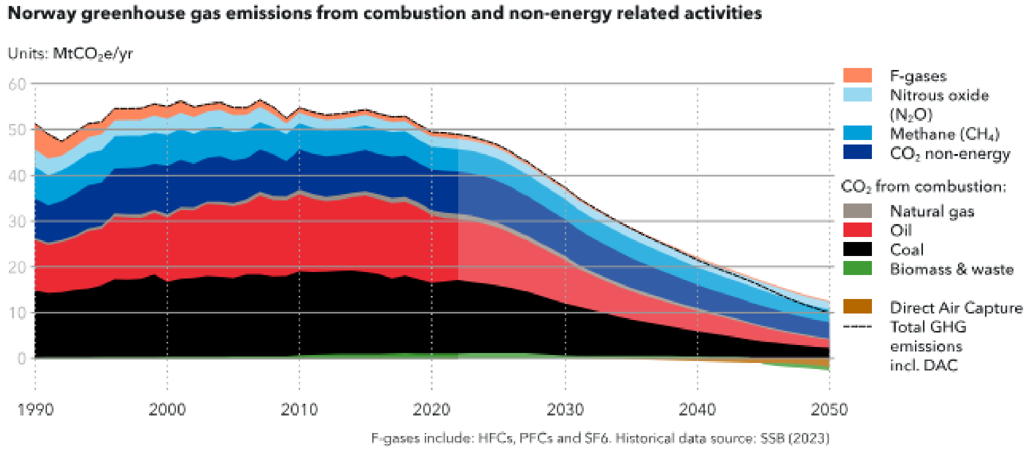

Table 9: Emissions to air of greenhouse gases, by source

Emissions to air of greenhouse gases, by source[1]

	2022						
	Million tonnes CO_2 equivalents[2 3]	Million tonnes	1000 tonnes		Tonnes		
	Greenhouse gases total	Carbon dioxide (CO2)	Methane (CH4)	Nitrous oxide (N2O)	Hydrofluorocarbons (HFK)	Perfluorocarbons (PFK)	Sulphurhexafluoride (SF6)
All sources	**48.9**	**40.8**	**175.8**	**8.3**	**468.2**	**17.3**	**3.0**
Oil and gas extraction - stationary combustion	11.6	11.5	2.5	0.0	0.0	0.0	0.0
Oil and gas extraction - process emissions	0.4	0.1	10.9	0.0	0.0	0.0	0.0
Manufacturing industries and mining - stationary combustion	2.3	2.3	0.6	0.1	0.0	0.0	0.0
Manufacturing industries and mining - process emissions	9.2	8.7	3.6	0.9	0.0	17.3	0.0
Energy supply	1.5	1.5	0.9	0.1	0.0	0.0	0.0
Heating in other industries	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Heating in households	0.3	0.0	9.2	0.0	0.0	0.0	0.0
Passenger cars	4.0	4.0	0.2	0.1	0.0	0.0	0.0
Light duty vehicles	1.5	1.5	0.1	0.1	0.0	0.0	0.0
Heavy duty vehicles	3.0	3.0	0.0	0.1	0.0	0.0	0.0
Motorcycles and mopeds	0.1	0.1	0.2	0.0	0.0	0.0	0.0
Railways	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Domestic aviation	1.2	1.1	0.0	0.0	0.0	0.0	0.0
Costal navigation	3.8	3.7	4.3	0.1	0.0	0.0	0.0
Motorized equipment etc.	2.7	2.6	0.6	0.1	0.0	0.0	0.0
Agriculture - enteric fermentation and manure	3.2	0.0	100.5	1.3	0.0	0.0	0.0
Agriculture - fertilizer and other	1.5	0.1	0.1	5.1	0.0	0.0	0.0
Landfill gas	0.9	0.0	31.3	0.0	0.0	0.0	0.0
Road, tyre and brake wear and abrasion of railway contact wires	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Products containing fluorinated gases, solvents etc.	0.9	0.1	..	0.0	468.2	0.0	3.0
Other	0.4	0.1	10.8	0.3	0.0	0.0	0.0

[1] Does not include ocean transport and international air transport.

[2] Greenhouse gas emissions expresses in CO_2-equivalents show how much warming effect a greenhouse gas has, converted to the amount of CO_2.

[3] In June of 2023 the GWP-values were changed. The table contains CO_2 equivalents (GWP-values) according to AR5, the IPCCs Fifth Assessment Report, which are used in the Paris Agreement.

Table 10: Domestic energy production, Norway, 2022

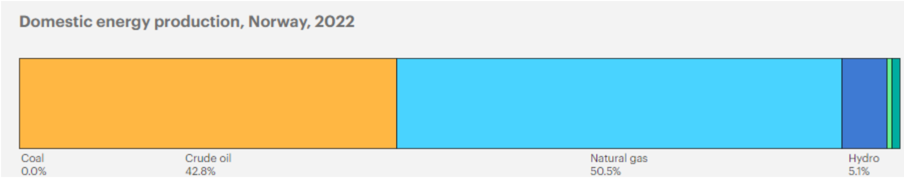

Table 11: Norway's top 10 producing natural gas liquids fields, by volume, 2021

Table 3. Norway's top 10 producing natural gas liquids fields, by volume, 2021

Field	Thousand barrels per day of oil equivalent
Åsgard	31
Troll	24
Gullfaks	21
Gjoa	20
Oseberg	17
Skarv	16
Johan Sverdrup	15
Vega	11
Tyrihans	11
Visund	10
Total volume, top 10 fields	175
Total volume, Norway	249

Data source: Norwegian Petroleum Directorate

Table 12: Norway crude oil production by operator, 2021

Figure 1. Norway crude oil production by operator, 2021

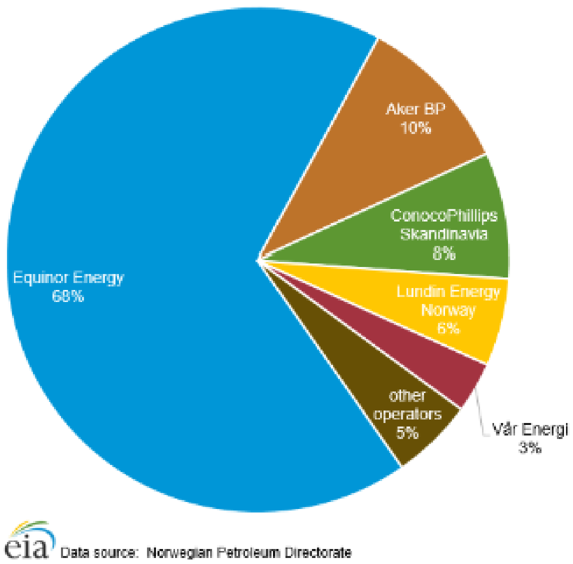

Table 13: Norway's top 10 producing natural gas fields, by volume, 2021

Table 2. Norway's top 10 producing natural gas fields, by volume, 2021

Field	Trillion cubic feet
Troll	1.32
Ormen Lange	0.40
Aasta Hansteen	0.31
Oseberg	0.29
Gullfaks Sør	0.20
Visund	0.19
Åsgard	0.18
Skarv	0.16
Kvitebjørn	0.12
Tyrihans	0.09
Total volume, top 10 fields	**3.27**
Total volume, Norway	**4.07**

Data source: Norwegian Petroleum Directorate

Table 14: Norway natural gas liquids production

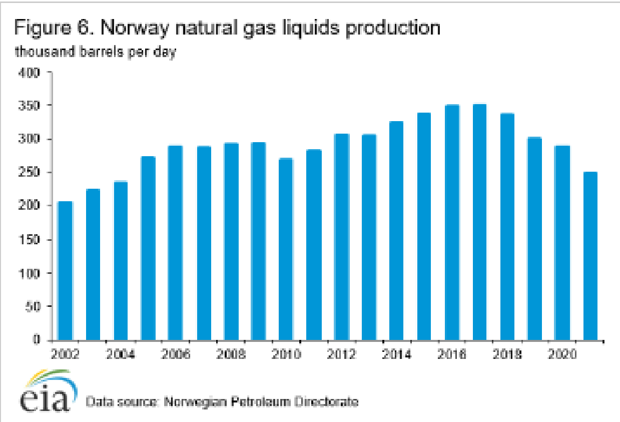

Table 15: Supply and use of energy in Norway, Energy balance. Main figures.

Supply and use of energy in Norway, Energy balance. Main figures.

	TWh	Change in percent	
	2022	2021 - 2022	1990 - 2022
Production[1]	2 510	1.0	82.3
Imports	135	6.0	72.5
Exports[2]	2 335	2.0	96.5
Consumption[3]	**218**	**-3.8**	**17.9**
Manufacturing and mining	76	-3.5	3.1
Transport	56	3.6	41.0
Households	45	-9.9	10.6
Other[4]	42	-6.6	32.9

[1] Production of primary energy products such as crude oil, natural gas, hydropower etc.

[2] The figures for export of natural gas 2021 and 2022 was corrected 15 September 2023.

[3] Final energy consumption

[4] Commerce and public services, agriculture and fishing

Table 16: Norway natural gas exports by destination, 202120

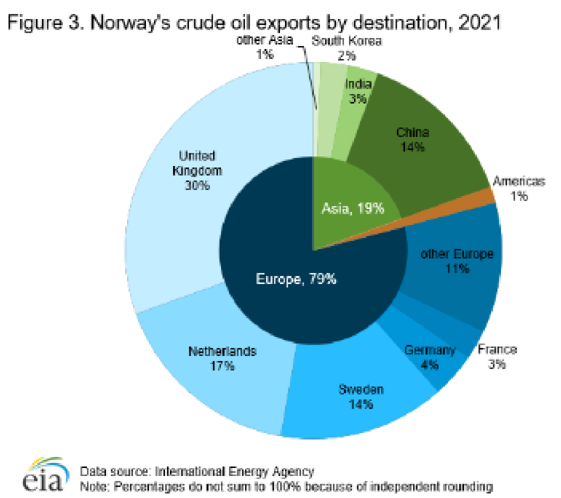

Table 17: Norway petroleum and other liquids production and consumption

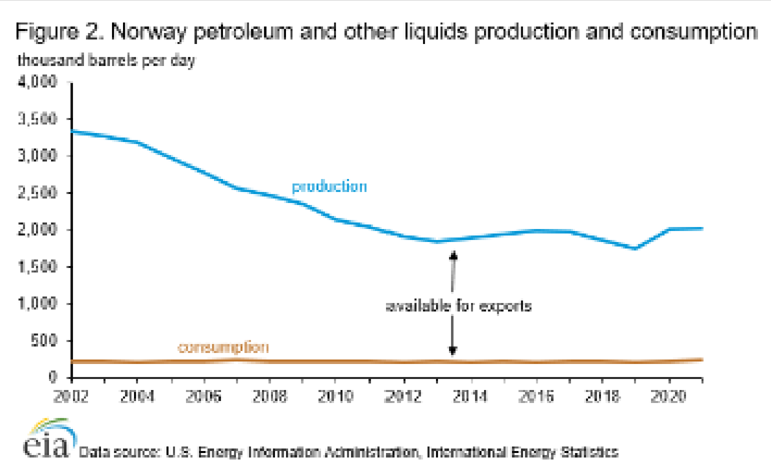

Table 18: Norway natural gas exports by destination, 2021

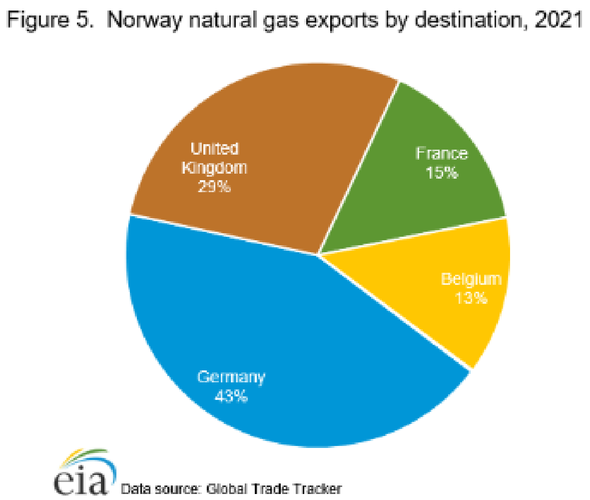

Table 19: Import, eksport og nettoeksport, 2000-2020

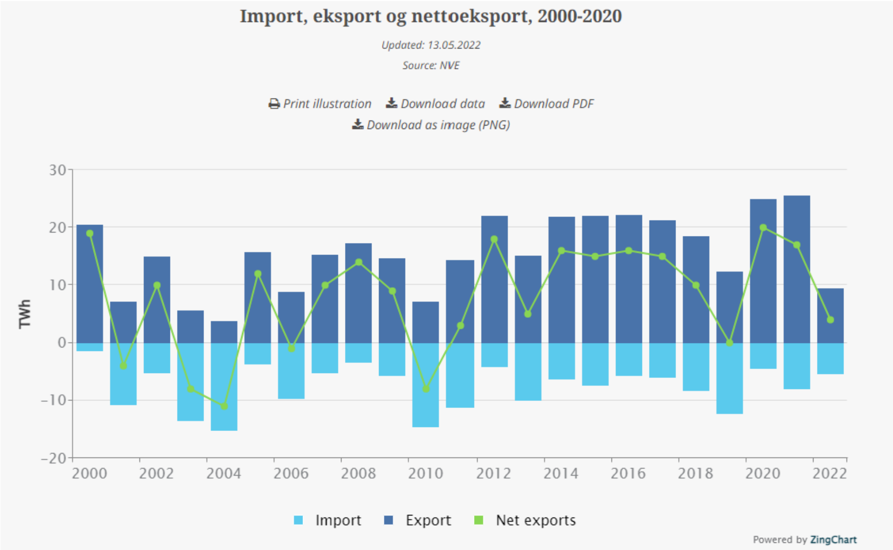

Table 20: Electricity consumption per capita, regional ranking, 2021

Electricity consumption per capita, regional ranking, 2021 — Regional ranking | Global ranking

Rank	Country/Region	MWh / Capita
-	**Europe**	**5.924**
1	Iceland	51.07
2	**Norway**	**24.177**
3	Finland	15.644
4	Sweden	13.015
5	Luxembourg	12.135

Table 21: Electricity consumption per capita, global ranking, 2021

Electricity consumption per capita, global ranking, 2021 — Regional ranking | Global ranking

Rank	Country/Region	MWh / Capita
-	**World**	**3.358**
1	Iceland	51.07
2	**Norway**	**24.177**
3	Qatar	18.124
4	Kuwait	17.308
5	Finland	15.644

Table 22: Electricity final consumption by sector, Norway, 2021

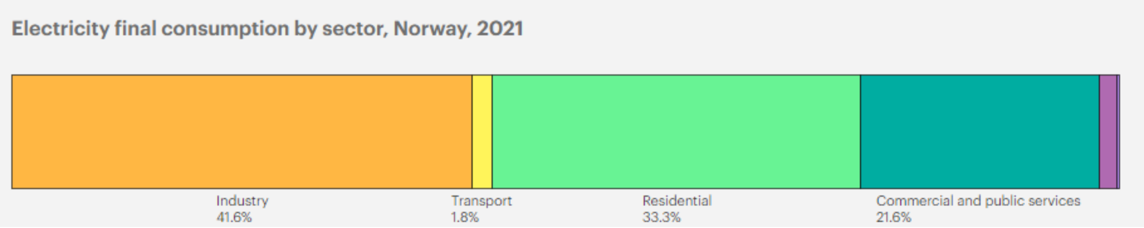

Table 23: Total final energy consumption, Norway, 2021

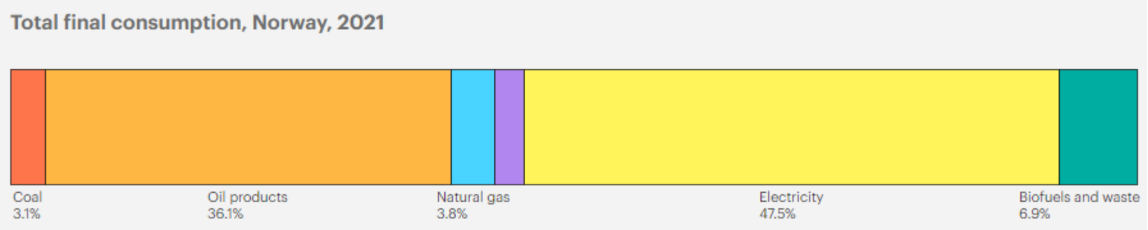

Table 24: Residential total final consumption by source, Norway, 2021

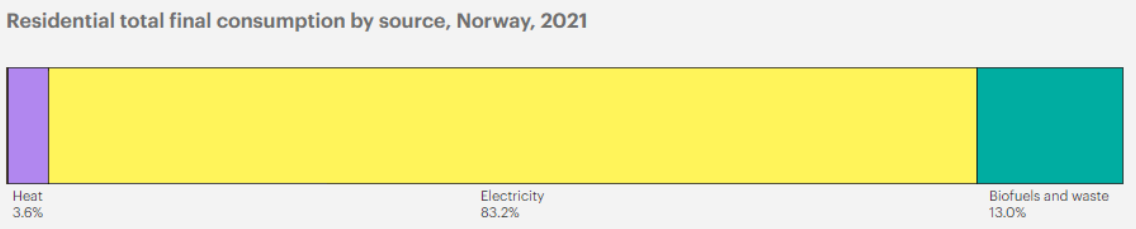

Table 25: Transport total final consumption by source, Norway, 2021

Table 26: Industry total final consumption by source, Norway, 2021

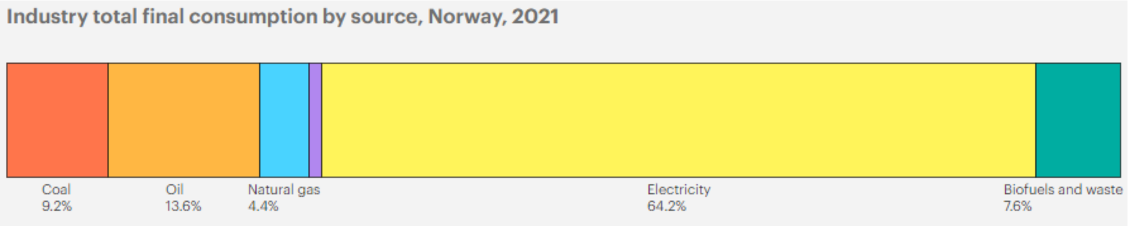

Table 27: Commercial and public services total final consumption by source, Norway, 2021