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What sectors should the countries' climate policies prioritize? - Conclusions derived from Norway vs Sweden

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Abstract - While each country is making movements to address climate issues, their engagement varies greatly. While countries must take active steps to reach the goals set by the Paris Agreement and other international agreements, some countries seem to be far away from the achievement of the goal. In this paper, the author aimed to determine the direction all country's climate policies must pursue by comparing two countries with similar geographical and economic conditions but different reduction rates in GHG emission: Norway and Sweden. Through analysis of population, climate policies in all sectors (energy, industrial processes and product use, agriculture, and waste), and other events with indirect effects on GHG emissions, it was concluded that the discrepancy in reduction rates is derived from the stringency of energy policies. Thus, this paper claims that countries must focus primarily on the energy sector when implementing policies.

Keywords: Climate policy, Greenhouse gas emissions, Energy sector, Norway, Sweden

Introduction

Since the advent of the Industrial Revolution, the world has changed to a great extent, both positively and negatively. Though the development of technology has allowed human beings to carry on a comfortable and enriched life, aligned with technological advancement has followed extreme climate issues. Climate change is a worldwide issue that must be immediately addressed, but the countries seem unaware of the urgency. Effects are already significant and widespread: glaciers are melting,

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droughts are happening in some countries, and extreme rainfalls are happening in others. Although countries are signing international treaties and setting goals for mitigating climate issues, how they reach those goals highly depends on their national policies, and those policies are still too weak. Countries still prioritize current economic wills rather than considering the long-term. This research aimed to determine which sectors countries' climate policies prioritize to achieve the goals set by international agreements such as the Paris Agreement by comparing countries' GHG emission reduction rates depending on their climate policies.

Methods and Data

By comparing the two countries' climate policies and their consequent GHG emission reduction rates, what is needed to become a strong climate policy can be determined.

Each country's climate policies depend heavily on its economic situation. For example, developed countries are starting to implement stringent climate rules, while developing countries still prioritize their economic development, leaving environmental concerns unresolved. Hence, two high-income countries in the same region with similar economic backgrounds but different GHG emission reduction rates were chosen.

Countries with similar regions and high incomes were found in the World Bank Data Blog country classifications by income level. We sorted countries with high incomes into groups depending on their location, with the same continent in the same group. Then, within the groups, the GHG emission reduction rate from 1990 to 2020 of each country was compared. The data was collected from UNFCCC. When collecting the data, not only the reduction rate but also the amount of GHG emission itself was considered. Of course, the reduction rate is important, but it may not always be an accurate standard point. Countries with high GHG emission rates from 1990, though having a high reduction rate, show extremely high GHG emission rates in 2020 also, even having a higher number than countries with lower reduction rates. Thus, we tried to find two countries that also had similar amounts of GHG emission values in 1990, so that the baseline for the reduction rate is similar. As a result, it was able to drive out two countries appropriate for comparison: Norway and Sweden.

Norway and Sweden are adjacent high-income countries [1]. Though both are implementing climate policies and trying to reduce their GHG emissions, Norway has shown only a 3.57% reduction, while Sweden showed 33.10% (Fig. 1). The interesting point was that with a consistently high reduction rate, Sweden has eventually reached even a lower GHG emission rate than Norway at 2020.

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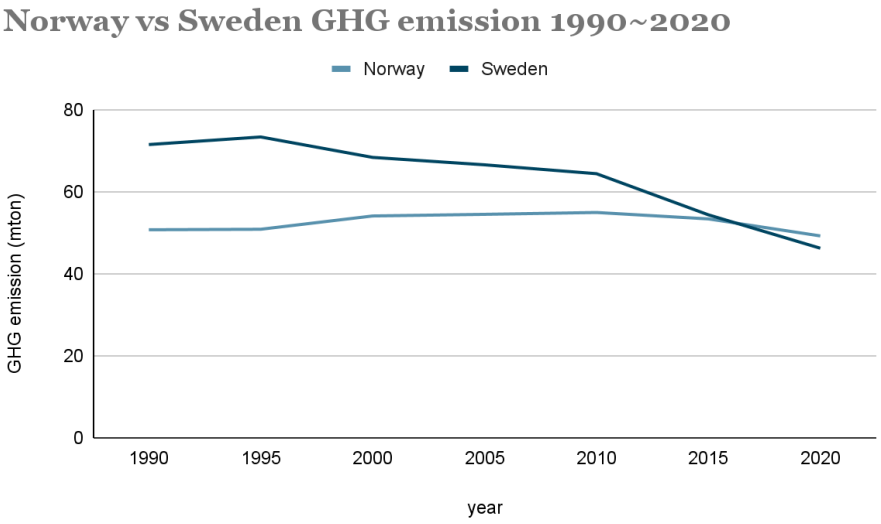

Fig 1. Norway vs Sweden GHG emission from 1990 to 2020 [2]

These GHG emission rates used in the calculation are total amounts of GHG without Land Use-Land Use Change and Forestry (LULUCF).

Various factors might have driven this result. Thus, the author compared the two countries in three areas: population, climate policies, and other major events that may have affected GHG emissions indirectly. Through this analysis, the factor of divergence was driven out.

Population is one of the most basic factors that can affect GHG emissions. Usually, more people mean higher emissions. A larger population requires more resources, leading to higher GHG emissions. Though population won't always be the main factor in GHG emission changes, sometimes it may serve as strong evidence to explain the cause of the status quo. Data on the two countries' populations was gathered from the World Bank Open Data.

While population is also an important factor, the most significant factor than any other areas would be usually climate policies that determine the overall structure and direction of society. This research compared the resulting quantitative data in each of the four sectors of GHG emissions - energy, industrial process and product use, agriculture, and waste - that have appeared due to various interconnected climate policies and may function as intermediate indicators for speculating how GHG emissions rate changes [2]. Only policies that aimed to deal with climate issues were considered in this area; policies that indirectly led to an increase/decrease in GHG emissions were all considered in the third area.

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In the energy sector, climate policies can be sorted into two groups: energy transition and energy conservation [3]. Using alternative fuels to produce energy may avoid GHG emissions from fossil fuel combustion. Additionally, policies for energy conservation, when implemented actively, may have significant effects in reducing GHGs. A unit of energy not consumed equates to a unit of resources saved and a unit of pollution not generated [4]. When the amount of energy needed decreases, the energy demand and quantity of energy consumed diminish, and the quantity of energy produced eventually falls. Considering this logic, the effectiveness of energy conservation policies in reducing GHG emissions in each country was confirmed through the change in ‘energy intensity.’

For sectors other than energy, research proceeded carefully so as not to overlap the components we have already considered in the energy sector. In each sector, only factors that aren’t related to energy but affect greenhouse gases were considered. This might include emissions from processing industrial materials or livestock.

Finally, major events that aren’t correlated with emissions directly but might have led to a decrease in emissions by changing people’s lifestyles, the economy, etc. were considered.

Since the data shows GHG emissions change from 1990 to 2020, the policies and events considered in the research were also limited within that period. All data collected were expressed as a graph or table, using Google spreadsheet and its visualization tools.

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Results

1. Population

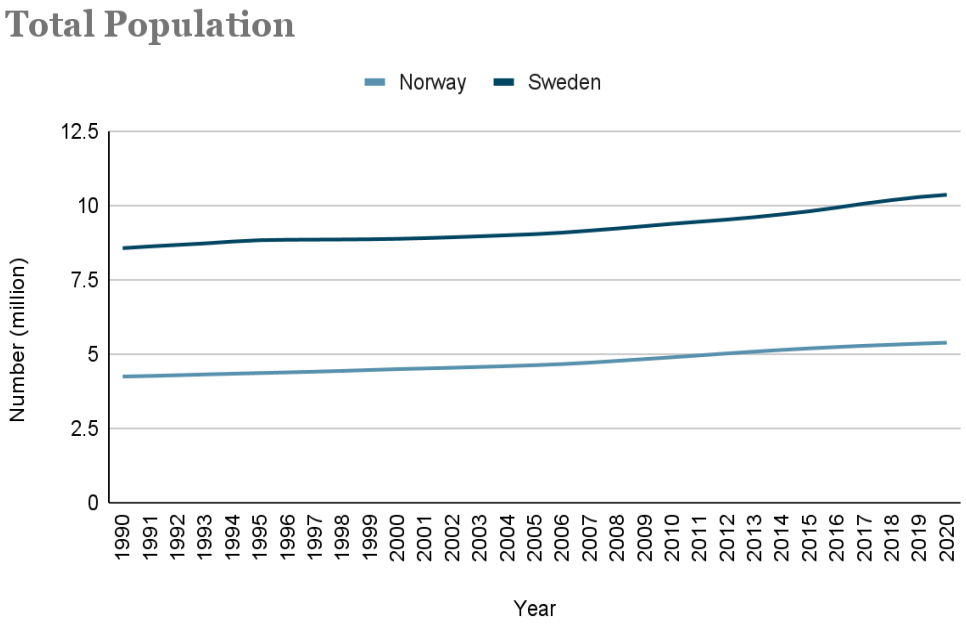

Fig 2. Total Population of Norway and Sweden from 1990~2020 [1]

Sweden has maintained an overall higher population number than Norway, and the population increase rate is also slightly higher in Sweden than in Norway.

The population (Fig. 2) seemed to have no correlation with the GHG emission reduction rate discrepancy between Norway and Sweden. Though Sweden has maintained a higher population rate throughout the period, it rather shows a higher GHG emission reduction rate than Norway. This implies that population is not a major factor in the decrease of GHG emissions.

2. Policies

a. Energy

i. Energy transition: Adoption of low-carbon energy sources & phase-out of fossil fuels

In the early 1990s, the Swedish authorities adopted two measures that have significantly changed the energy balance. The first was the creation of a tax on CO2 emissions, with wood and some waste being exempted. Sweden has imposed one of the most stringent carbon taxes in the world. This promoted the rapid phase-out of fossil fuels. The second measure provided grants to local authorities for work on heating networks powered by bioenergy, and individuals who agreed to connect their homes to these networks. Additionally, for the adoption of renewables other than biofuels

, in May 2003, the Parliament approved an ordinance establishing a system of green certificates. These actions had a significant effect on the energy transition and highly decreased the use of fossil fuels in Sweden's energy consumption. Recogniz ing the risk that nuclear power has, Sweden is trying to replace nuclear power wit h renewables and is imposing taxes on nuclear waste [5].

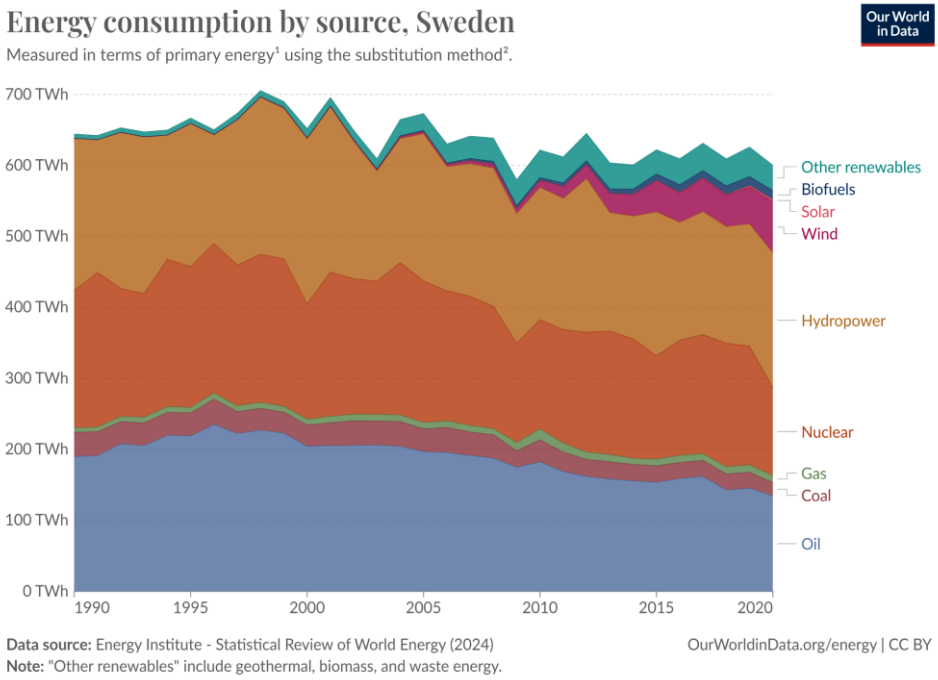

Fig 3. Primary energy consumption by source in Sweden 1990-2020 [6]

As a result, Sweden's energy sources have changed from 1990~2020, with a decrease in the use of fossil fuels and an increase in the use of low-carbon energy sources , especially renewables. (Fig.3) The percentage of renewables in total energy cons umption has increased from 34.25% to 52.20%, with a decrease in the percentage of nuclear power.

Norway has shown ambitions to reach an entirely renewable-based electricity system , with renewable resources accounting for 98% of electricity generation in 2020. I nnovation in Norway's energy sector is spearheaded by Enova, an entity owned by t he Ministry of Climate and Environment. Enova has provided support for the replace ment of fossil fuels with renewable energy. Concentrating mainly on hydro energy, Norway is also on the way to developing wind energy.

Based on the green electricity generation from hydropower, Norway's energy demand is highly electrified: in 2020, electricity covered almost half of the country's total final consumption, the highest share among IEA member countries. The governm

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ent banned the installation of fossil fuel-based heating systems in 2016 and the use of heating oil since 2020. Most buildings nowadays have electric heating systems.

Norway has also shown active adoption of electric vehicles (EVs) for the electrification of transport. By imposing a high registration tax on the purchase of fossil fuel cars in addition to CO2 tax and road use tax and heavily subsidizing zero-emission vehicles, Norway achieved the largest share of EVs in the world [7]. Also, with the support of Enova, Norway invested in the area development of electric vehicle charging infrastructure. Vehicles such as hydrogen infrastructure, zero-emission vehicles, and heavier biogas-powered vehicles are also being adapted in the transport sector for further phase-out of fossil fuels [8].

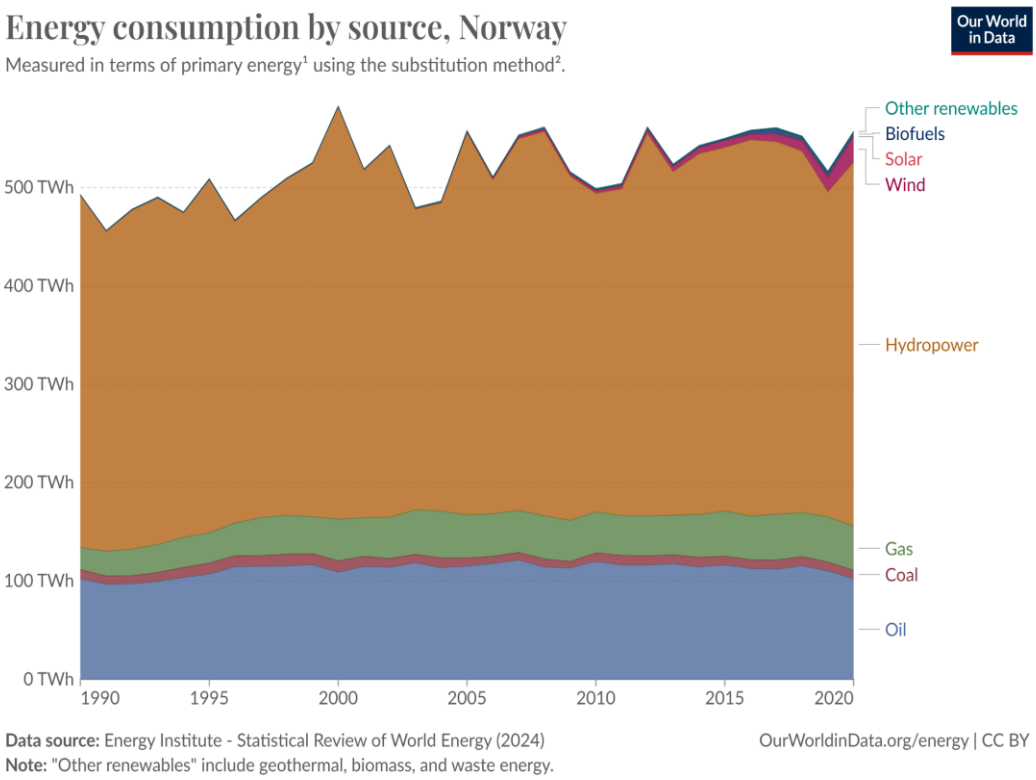

Fig 4. Primary energy consumption by source in Norway 1990-2020 [6]

However, policies seem to be insufficient to bring significant changes from the base line. While the percentage of hydropower usage in Norway was high compared to any other countries in 1990, this percentage has increased slightly since then. Additionally, low-carbon energy sources rather than hydro and wind are utilized nearly at a zero rate. While the adoption rate of renewables has stayed relatively unchanged, fossil fuel usage in Norway has increased due to the increased use of natur

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al gas in the oil and gas industry. Increased oil and gas production and the increase of energy demand in extraction due to the aging infrastructures explain this increased use of natural gas [9]. Consequently, the overall renewables usage rate has decreased slightly from 72.81% to 72.09% while there has been an uptick in fossil fuel usage from 27.19% to 27.95%. The oil usage has remained almost constant throughout the period, while gas usage has increased by 95%.

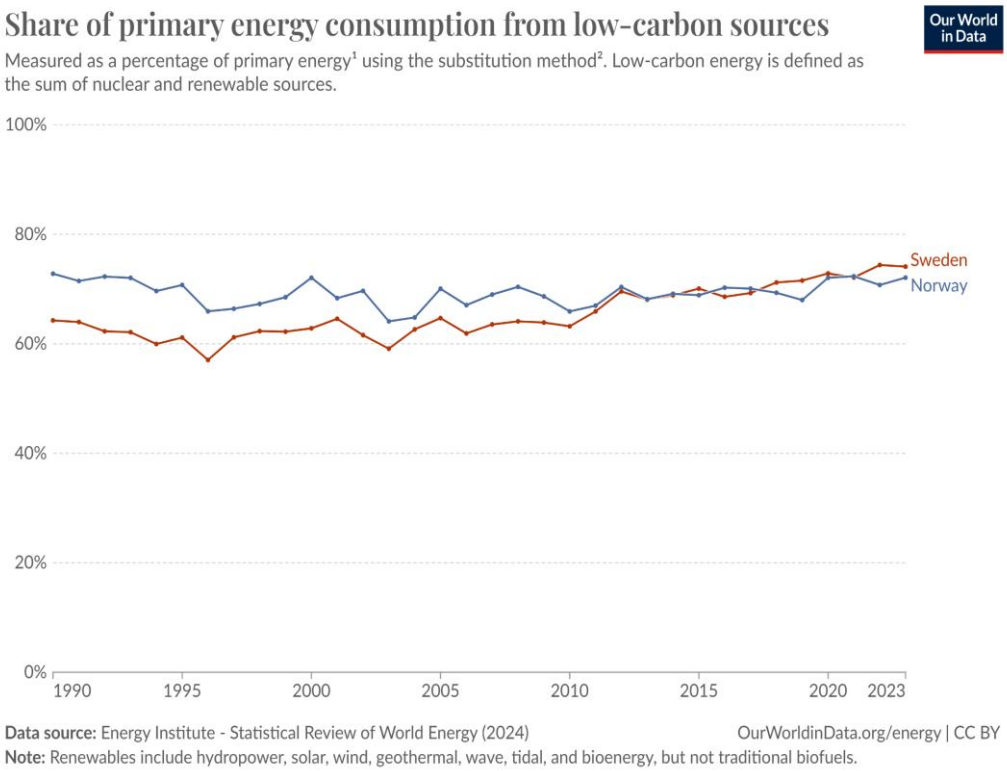

Fig 5. Share of primary energy consumption from low-carbon sources in Norway and Sweden 1990-2020 [6]

Overall, the usage of low-carbon sources in primary energy consumption has increased in Sweden from 64.3% to 74.1% depending highly on renewables, while Norway's usage has decreased slightly from 72.8% to 72.1%.

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ii. Energy conservation

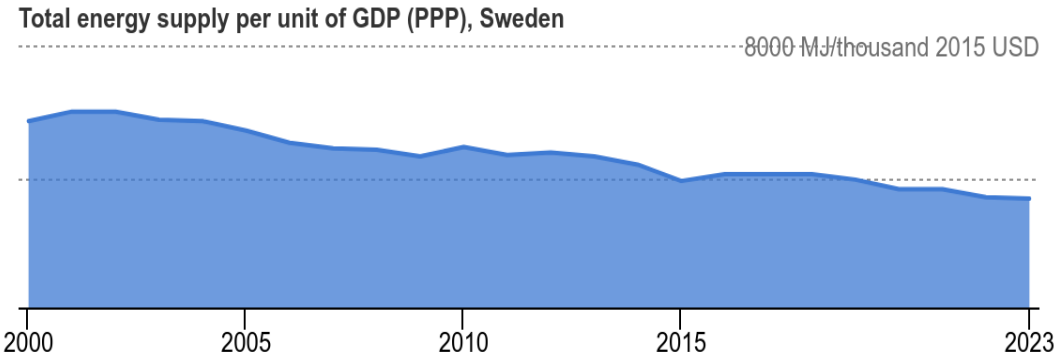

Fig 6. Sweden energy intensity 2000~2023 [10]

The energy intensity in Sweden has decreased constantly throughout the period, reaching a 36.5% decrease from 2000 to 2020. Sweden is a country that primarily focuses its energy policies on the improvement of energy efficiency, even more than renewables. Sweden has implemented various policies targeting energy efficiency in industry, building, and transport. New advances in energy efficiency in building and transport are proven to be expensive and slow. Thus, with minor policies targeting energy efficiency in building and transport, energy conservation efforts in the industry were especially strongly reinforced after 1990. Specific actions have targeted large industrial energy consumers; in return for their commitment to policy, these "energy intensive" businesses were exempted from the energy tax until 2008, or even to 2017 in some cases. Consequently, energy consumption has remained stable while the GDP has grown about 2.6% per year on average [5].

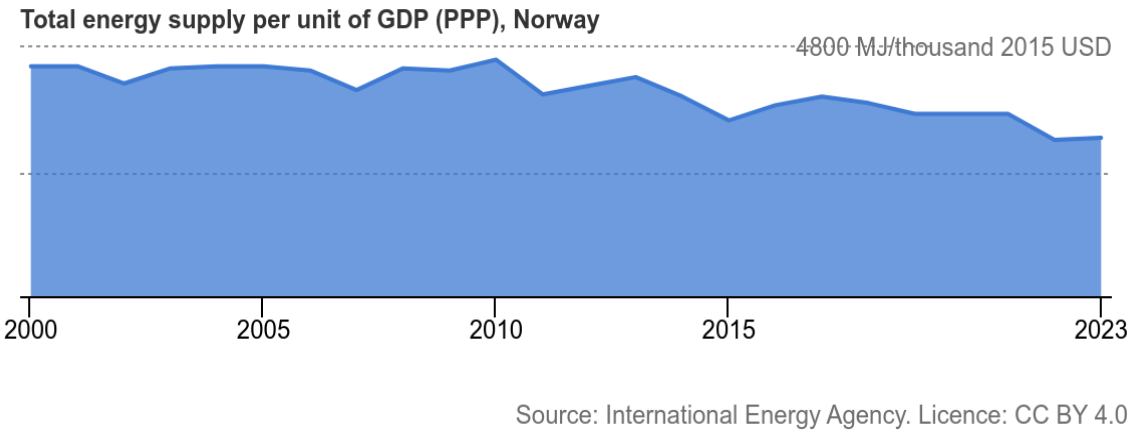

Fig 7. Norway energy intensity 2000~2023 [11]

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The energy intensity of Norway in 2020 was 20.8% lower than in 2000. Again, Enova is Norway's main provider of financial support for energy efficiency projects. From 2003 to 2018, Enova focused on energy efficiency projects in the industry sector, contributing to reducing technological risk and costs of new technology [8]. In 2018, this scheme was replaced by measures more specifically targeting emissions reductions rather than energy efficiency. Between 2012 and 2018, Enova also provided support for industry to implement energy management systems.

The main energy efficiency measure in the building sector is the adoption of building codes. Since 2010, energy performance certificates have been required when buildings are built, leased, or sold [7].

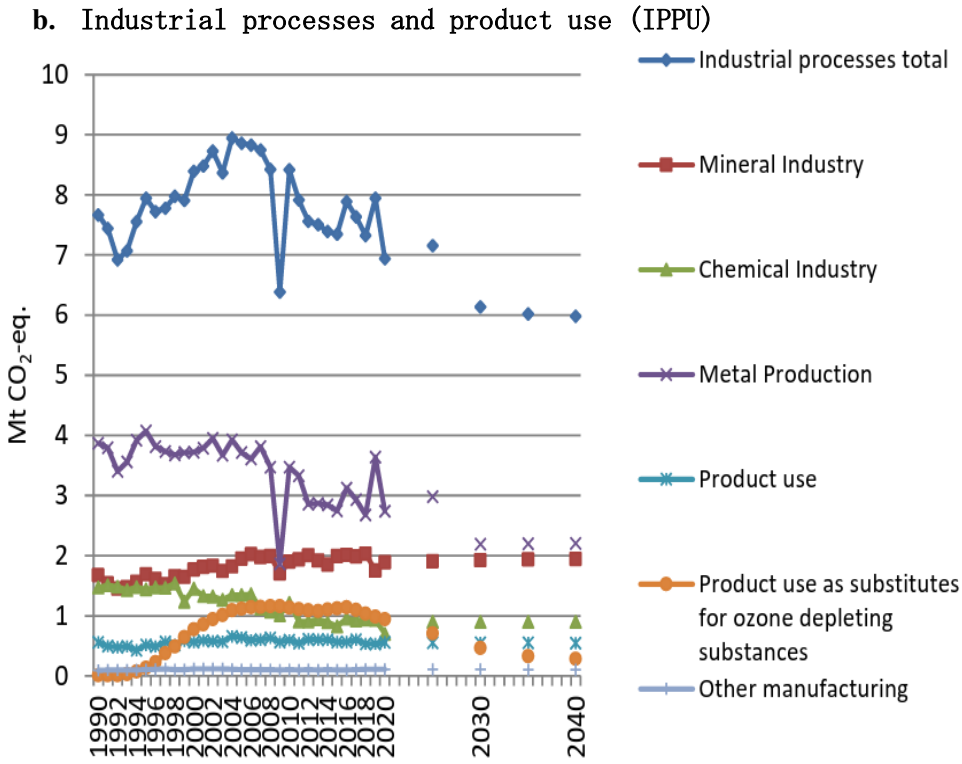

Fig 8. Decrease in GHG emissions from IPPU by subsector in Sweden [12]

GHG emissions in the IPPU sector of Sweden had only a slight decrease in metal production. Sweden's primary GHG-emitting industry is the iron and steel industry [13], and policies aiming to shift to a fossil-free technology in the iron and steel industry were implemented [12]. Sweden has promoted hydrogen technology for iron ore reductions and bio-coal as a reducing agent or an alloying element.

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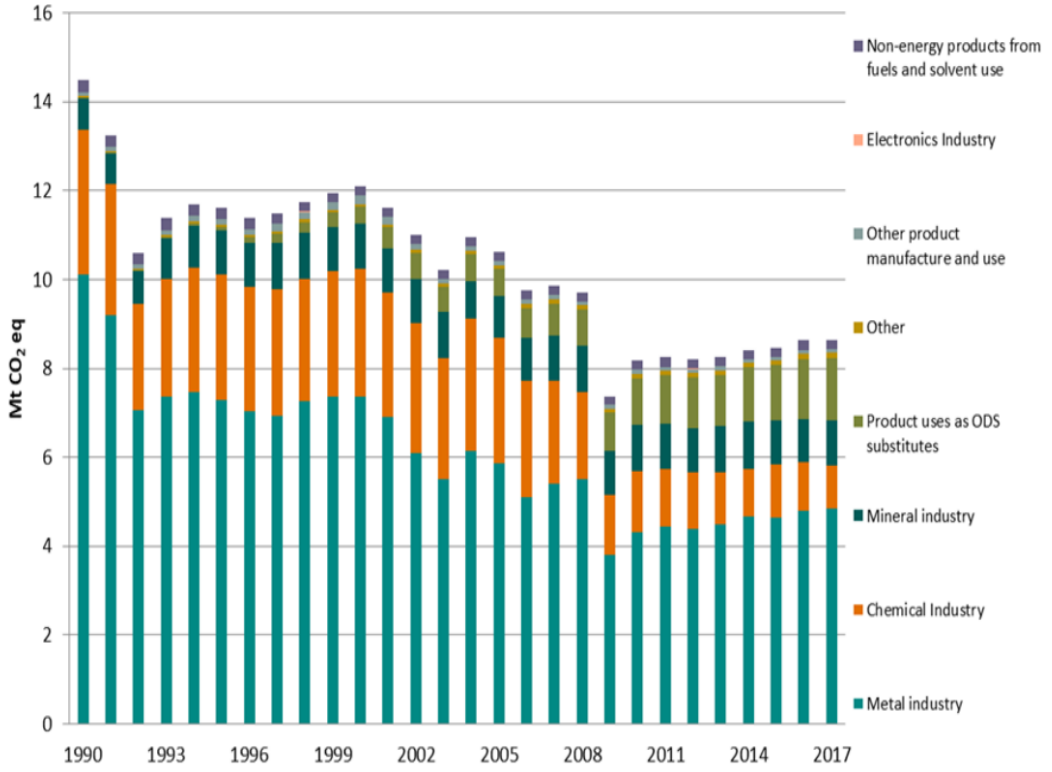

Fig 9. Change in GHG emissions from IPPU by subsector in Norway [9]

In Norway, metals such as aluminum and ferrosilicon, and chemicals (mainly petrochemicals) are the main product groups [13]. Norway has adopted advanced technologies to decrease the emissions from industries. Emissions of PFCs from aluminum production decreased by 96.6 percent in 2017 compared to 1990. Also, in the chemical industry subsector, technological development led to declining emissions from the production of nitric acid, ammonia, and carbides [9].

c. Agriculture

In Sweden, the decrease in emissions of greenhouse gases from agriculture is largely due to the reduced number of cattle [12]. The decline of cattle will be discussed in part 3.

In Norway, the main reason for the decreasing trend in GHG emissions is the reduction of nitrogen content in the synthetic fertilizers used [9]. However, the decrease in GHG emissions is still a slight value of 6.02% despite the low baseline.

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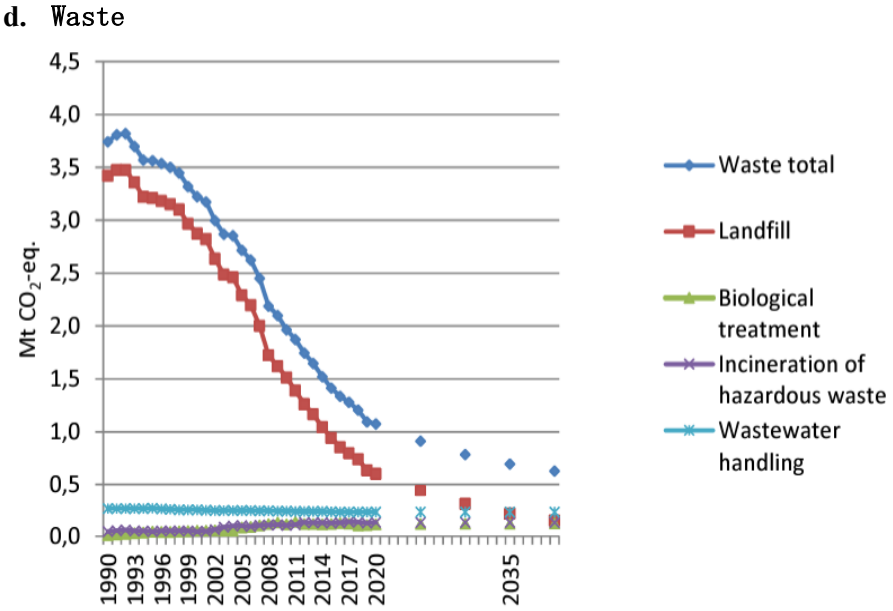

Fig 10. GHG emissions in Sweden from the waste sub-sectors [12]

The main cause for the decrease of GHG emissions in the waste sector in Sweden is the regulation of landfills. The ban on depositing combustible materials in landfills (2002), and the ban on depositing organic materials in landfills (2005). Furthermore, a tax on depositing waste in landfills was introduced in 2000. [12].

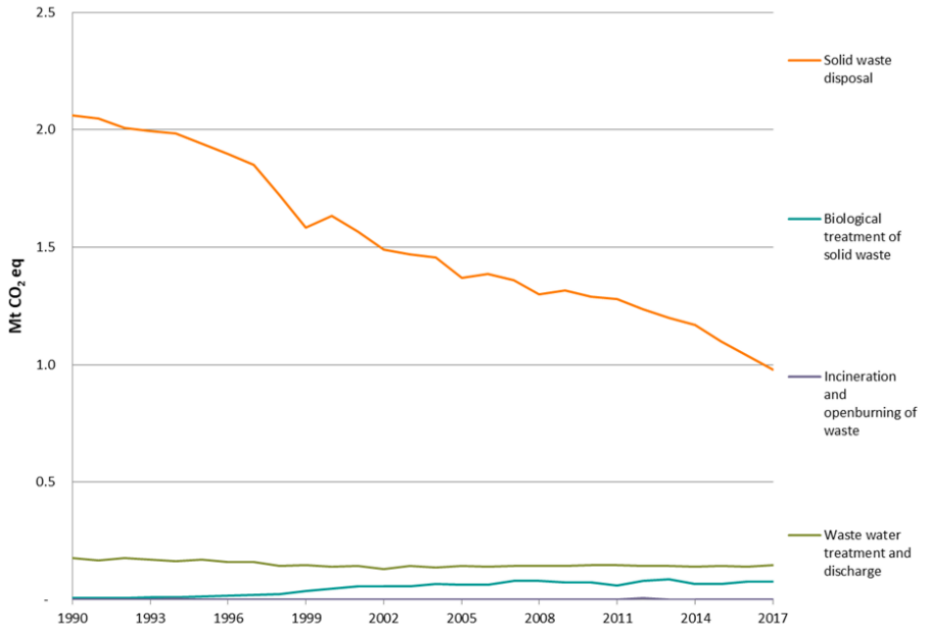

Fig 11. GHG emissions in Norway from the waste sub-sectors [9]

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GHG emissions from the waste sector in Norway have generally decreased by 42.3% since 1990. While the total amount of waste generated increased by more than 60.4 percent from 1995 to 2016, due to the increase in material recycling and a ban against disposing of biodegradable waste to landfills, methane emissions have decreased leading to a decrease in total emissions of greenhouse gases from the waste sector [9].

3. Major events that may have an indirect effect on GHG emissions

a. Reduced number of cattle in Sweden

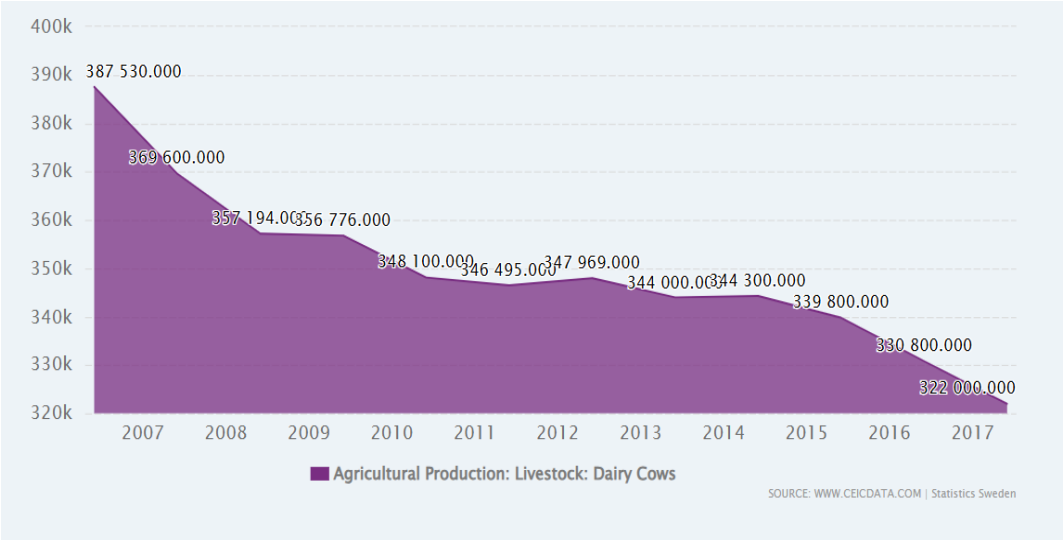

Fig 12. The number of dairy cows in Sweden 2006-2017 [14]

As mentioned in part 2-c, the reduced number of cattle has been one of the two top factors to lead to a reduced rate of GHG emissions in agriculture (Fig. 12). This decline in the number of cattle is driven by the monopolization of the dairy and meat economy by a few huge farms. Just over 26 % of the agricultural holdings that keep cattle for the production of milk and/or meat have disappeared from the Swedish countryside during this period with only a few large crews left in cattle holdings [15].

This in turn has led to lower methane emissions from the digestion process in ruminant animals and to reduced emissions of methane and nitrous oxide from manure (Fig.13).

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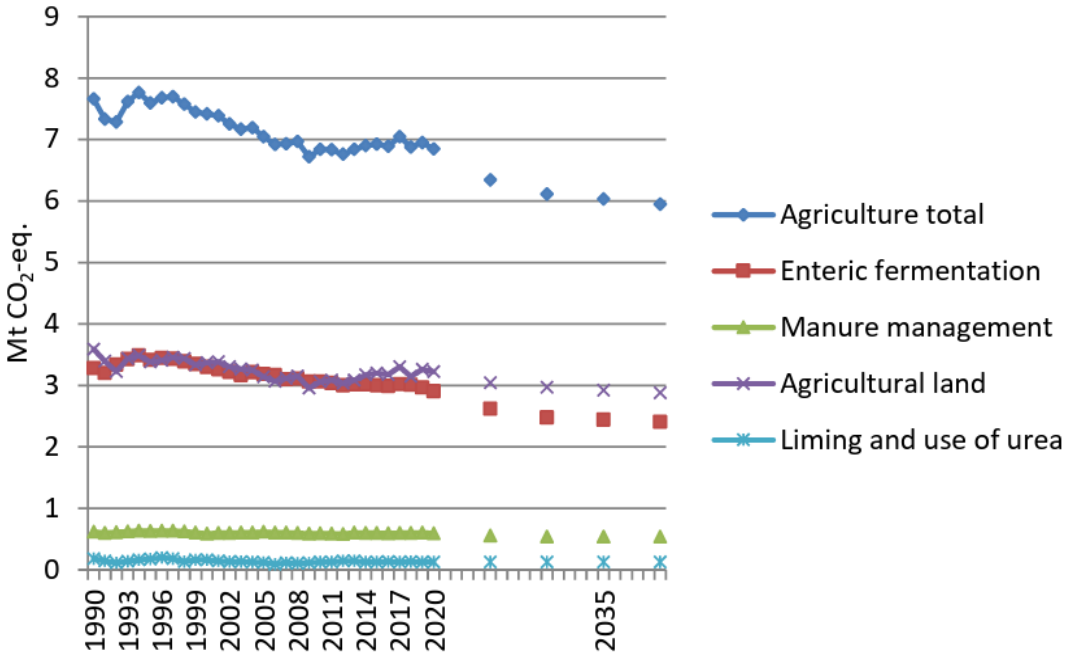

Fig 13. GHG emissions in Sweden from the agriculture sector [12]

b. COVID-19

In 2020, major emission reductions were brought to both countries due to the restrictions to mitigate the spread of COVID-19. As a result, domestic transport and industrial activities and highly decreased, eventually avoiding GHG emissions. Daily carbon dioxide emissions of the world were 17% below the average in recent years [16]. As COVID-19 affected both countries, the reduction effect may be offset.

c. Cease of magnesium production in Norway

The steadily increasing export from China of low-cost magnesium has led to a dramatic downturn in magnesium prices, particularly in the European market [17]. As a result, the supply of magnesium in Norway has decreased significantly. (Sweden wasn't a country producing magnesium, thus wasn't affected by the market change.) While reductions in SF6 emissions over the period are, in the early 90s, mainly due to improvements in the production processes, starting from 2002, the reduction is highly due to the closing down of production of cast magnesium, and in 2006, due to the closing down of secondary magnesium production [9].

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Discussion

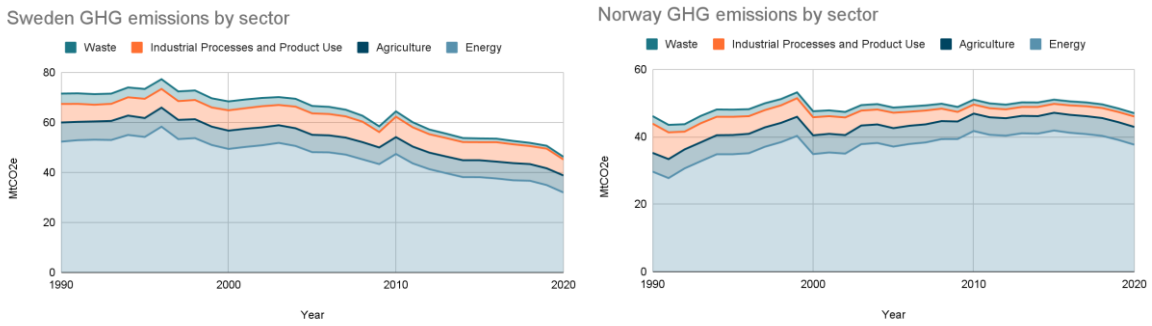

Fig . GHG emissions 1990~2020 by sector [2]
(a) Sweden / (b) Norway

In the energy sector, Norway showed a 19.81% increase in GHG emissions while Swede n showed a 38.85% decrease. Though Norway started with a lower GHG emission rate i n the energy sector in 1990, Sweden eventually reached a value even lower than Nor way's start line, while Norway's GHG emissions increased from the value in 1990. This is due to Norway's increased use of natural gas with no additional adoption of renewables and relatively weak improvements in energy efficiency. While Sweden eventually implemented active climate policies for energy transition, Norway's ad option rate stayed almost constant. As a result, Sweden has overtaken Norway's po sition. Also, the energy efficiency was also higher in Sweden than in Norway. Sinc e the gap between the statistics of adoption rate and energy intensity becomes hug e when applied to reality, it has resulted in huge differences in GHG emissions. T his gap seems hard to overcome though Norway has the carbon capture and storage (C CS) technology that Sweden lacks.

In the sector of industrial processes and product use, Norway showed a much higher reduction rate in emissions than Sweden: Norway -38.7% and Sweden -14.14%. This di fference seems to be partly due to Norway's active steps in advancing technology but also attributed to the closedown of the magnesium industry.

In the agriculture sector, though Sweden showed a higher reduction rate, the overa ll percentage of reduction was quite similar between Norway (-6.02%) and Sweden (- 11.11%), with similar numerical values in final emissions. Also, since Sweden's r eduction rate was highly due to the decline of cattle, it was concluded that there aren't significant differences made through climate policies in agriculture.

Lastly, in the waste sector, Norway showed a decrease of 42.3%, while Sweden showe d a decrease of 73.94%. Though Sweden had a higher reduction rate, as Norway had s

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tarted with a lower emission baseline in 1990, the final emission itself was similar between the two countries with 1541.37 in Norway and 1076.81 in Sweden.

Summing up this information, the discrepancy between the two countries' GHG emission reduction rates seems to have been driven by the energy sector. The slight weakness in Norway's energy policies has resulted in Sweden even showing a lower total GHG emission in 2020. Hence, energy is where the country's stringency in policies may bring a huge gap in reduction rates, and this is why energy must be prioritized over any other sectors when implementing climate policies.

A similar situation has appeared between Austria and Finland. Though they are both high-income countries located in Europe, Austria showed only a 1.92% decrease in GHG emissions from 1990 to 2021 while Finland showed a 32.76% decrease in their GHG emissions throughout the same period. The gap in the reduction rate seemed to be highly derived from the energy sector (Table 1). This provides additional evidence for the conclusion derived from the case study of comparing Norway vs Sweden.

Category	Austria			Finland		
	Base year	2020	Difference	Base year	2020	Difference
Total GHG emissions without LULUCF	79,047.23	73,910.84	-6.50%	71,087.75	47,756.28	-32.82%
1. Energy	52,664.96	49,930.23	-5.19%	53,420.15	34,396.60	-35.61%
2. Industrial Processes and Product Use	13,615.38	15,523.86	14.02%	5,216.20	5,030.20	-3.57%
3. Agriculture	8,399.71	7,197.46	-14.31%	7,243.80	6,414.59	-11.45%
5. Waste	4,367.18	1,259.29	-71.16%	5,207.61	1,914.89	-63.23%

Table 1. Austria vs Finland GHG emissions by sector [2]

Conclusion

To conclude, energy policy is where one country can be distinguished from another in GHG emission reduction rates. Without taking active steps in energy policy, it is difficult to reduce GHG emissions until the numbers are set by international agreements. Logically thinking, since the energy sector takes up over a third-quarter of each country's and the world's GHG emissions, mitigation and adaption in the energy sector would have the most impact on the GHG emissions rate compared to other countries. While this fact might be evident, this paper shows evidence from reality through the case study comparing Norway and Sweden. Thus, countries must implement rigorous energy policies, as weaker policies would lead to an irretrievable increase in GHG emissions. On the other hand, even slightly stronger policies would bring high reductions, pushing the country one step closer toward a green society.

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