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Emissions reduction in the Nordics

Detecting sectoral differences over the three Phases of EU ETS

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Abstract

This thesis investigates the correlation of the emissions and tradable allowances within specific sectors of the European Union's Emission Trading Scheme, in four Nordic countries: Denmark, Finland, Norway and Sweden. The EU ETS is the corner stone of the EU's climate policies; it is a carbon market based on cap-and-trade mechanism. The idea is, that a carbon tonne has a price and one carbon tonne is equivalent of one emitting permit called an allowance. The EU ETS covers approximately 45% of the GHG emissions in EU with over 11,000 energy intensive installations. It has been in use for three Phases now, since 2005. The Phase IV begins in 2021 and ends in 2030. The system has been criticised multiple times over the years, and it has gone through reforms and expansions to new sectors in order to enhance the system.

In this thesis, the relationship of the variables *emissions* and *allowances* is looked in the carbon market in the European Union, by comparing the sectors of *all stationary installations, combustion of fuels* and *refining of mineral oil* in the countries over the 14 years, 2005-2019. Besides the carbon market, the Nordic climate ambitions and policies is researched. Based on this research, the carbon trading does work in theory cost-effectively but as in reality this is not always the case. The system is complex and the differences between the sectors and countries affect the emissions trends, which might disturb the logic behind the scheme. In theory the carbon market is meant to work so that decreasing the cap leads to decrease in emissions. However, in the researched sectors in the four countries, this was not systematically the case.

EU ETS is an interesting and important flagship policy for Europe, and it has been successful in setting a price for carbon after the system has been modified over the 14 years it has been in use. Many possibilities lie within the trading scheme and the future of it as part of the European Union's new Green Deal is crucial in order to achieve the climate goals of the Member States, and the region. EU ETS can be seen as something unique globally, since it is the largest carbon market in the world. If EU ETS is successful, it is possible that other regions can achieve emissions reductions with similar system.

Keywords: *EU ETS, GHG emissions, allowances, carbon market, polluter pays principle, Nordics, climate policies, climate change*

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Abbreviations

CCS – Carbon Capture and Storage

GHG – greenhouse gases

EEA – European Economic Area

EUA – European Union emission allowances

EU – European Union

EU ETS – European Union's Emissions Trading System

LULUCF – Land Use, Land Use Change and Forest

MAC – Marginal Abatement Cost

MB – Marginal Benefit

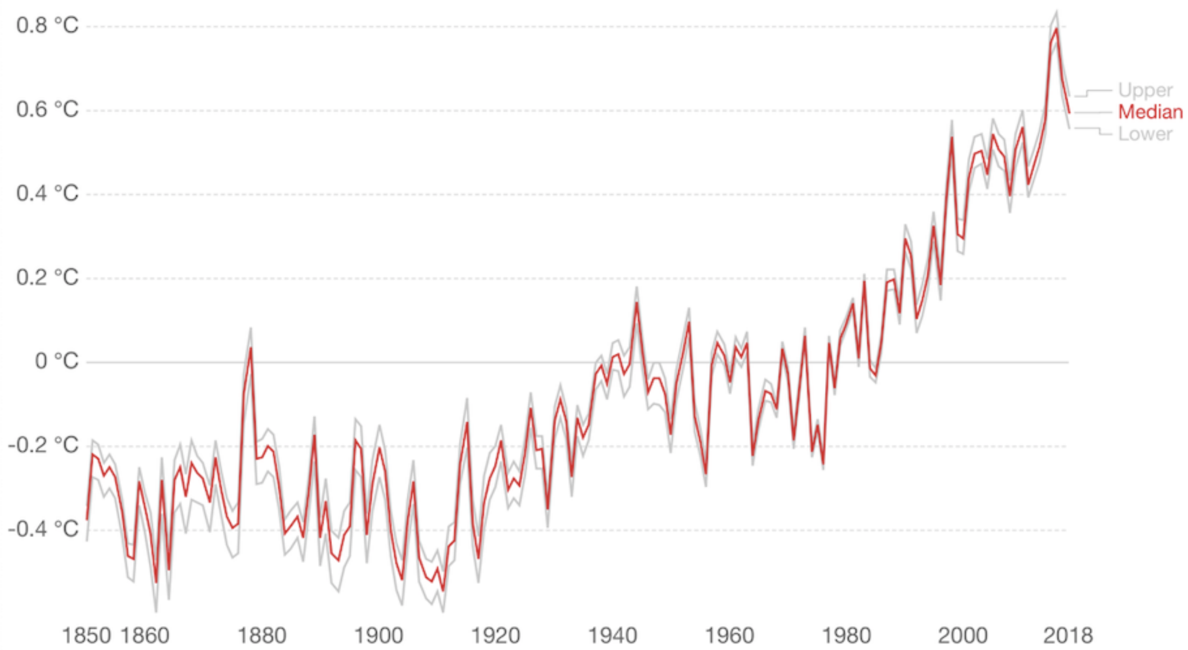
MSR – Market Stability Reserve

1. Introduction

1.1 Research background

The modern world battles with multiple challenges, one of the greatest ones being the increasing amount of greenhouse gases (hereafter abbreviated GHG) and rising temperatures compared to pre-industrial levels. Temperatures and the climate have always been changing, but human actions since the industrialization have been proven to be responsible for accelerating increase in average temperatures. The causality between human actions and rising temperatures has been recognised by many of the world's nations and various treaties have been made globally to reduce the emissions. (Bel and Joseph, 2014) Figure 1 shows the global average temperature relative to the average between 1961 and 1990. Globally humans are emitting over 36 billion tonnes of CO_2 annually and this amount is increasing, despite the heated discussions over the dilemma of climate change. (Ritchie and Roser, 2017)

Figure 1: Global Average Temperature 1850 – 2018, relative to the 1961-1990 average temperatures in Celsius degrees (Hadley Centre, 2020)



However, large differences between countries and regions exists when it comes to the emissions. As in 2019, China alone produced approximately 25% of all the emissions in the world, US 15%, and EU's 28 countries together 10%. (Ritchie & Roser, 2017) All of these and other countries are part of the international climate policy frameworks, but they also have more or less national policies, and in EU's case, also regional.

European Union has been fighting against increasing CO_2 emissions for decades and since 2005 with an emission trading tool called EU ETS, which is a carbon market based on a cap-and-trade logic. This market is explained in detail in chapter 2.2. European Union's Emission Trading System is the oldest, and the largest, emission trading scheme in the world. According to the European Commission, the system is

> "*...a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively".* (European Commission, 2020b)

The trading scheme limits emissions from more than 11,000 energy intensive installations, such as power stations and industrial plants, as well as airlines within the continent. The idea is, that a carbon tonne has a price and one carbon tonne is equivalent of one emitting permit called an allowance. These allowances are tradable between emitting actors. However, as of 2020, this system only covers approximately 45 % of the EU's greenhouse gas emissions. (European Commission, 2020b) The trading scheme has been widely criticised over its existence, but as it seems, no other climate policy solutions as wide as the ETS, have been installed, or even proposed, in Europe.

The scheme started in 2005 and in the year 2020 this carbon market has been active for soon to be full 15 years, over 3 different phases, and the fourth Phase will begin in 2021. These phases are presented in the table 1.

Table 1: Four Phases of EU ETS)

Phase I	2005 - 2007
Phase II	2008 - 2012
Phase III	2013 - 2020
Phase IV	2021 - 2030

Over these phases the EU has been giving out free allowances for the trading, and the Union has been decreasing the amount of allowances over time. This, among other reasons, has affected the amount of emissions over the years. The primary objective of this thesis is to look into the differences in the emissions and allowances within specific industrial sectors over the first three phases of EU ETS in four Nordic countries: Finland, Sweden, Norway and Denmark.

EU states that GHG were reduced in Europe by 23% between 1990 and 2018, while the region's economy grew 61% (European Commission, 2020b). The Commission also states that the most significant decline in emissions was in sectors covered by the EU ETS, especially power plants. Emissions from stationary installations covered by the trading scheme were decreased in 2018 by 4.1%, compared to 2017, when emissions not covered by the scheme, (transport, agriculture, waste and buildings) decreased by 0.9%. However, aviation emissions were increasing in 2018, approximately 19% compared to 2017. Aviation in European Economic Area (EEA) is covered by the ETS, but aviation into or out from EEA is not. (European Commission, 2020b)

After the year 2020 the EU ETS will continue to the Phase IV. Phase IV is connected to the EU's emission reduction target 2030: the sectors covered by the EU ETS must reduce their emissions by 43% compared to the 2005 levels. (European Commission, 2020c) This is an ambitious goal compared to the international climate policies.

1.2 Terminology

The terminology used in the thesis is listed in the key definitions table, Table 1, below.

Table 2: Key definitions from European Union, Directive 2003/87/EC, of the European Parliament and of the council

TERM	*EXPLANATION*
Allowance	*"…an allowance to emit one tonne of carbon dioxide equivalent during a specified period…"*
Emissions	*"…the release of greenhouse gases into the atmosphere from sources in an installation."*

Greenhouse gases	*Gases listed in the Appendix I.*
Installation	*"…a stationary technical unit where one or more activities listed in Annex I are carried out and any other directly associated activities which have a technical connection with the activities carried on that site and which could have an effect on emissions and pollution."*
Tonne of carbon dioxide equivalent	*"…one metric tonne of carbon dioxide (CO_2) or an amount of any other greenhouse gas listed in Annex II* (Appendix I in this research) *with and equivalent global-warming potential."*

1.3 Research gap and the research questions

The EU ETS has been widely researched over the years from multiple perspectives. However, a surprisingly few of the researches have focused on the phase level differences and the comparison of sector level emission reductions within these phases, especially by comparing them between the Nordic countries. The researches that were found focusing on phase level analysis were mainly done in the early 2010 and they were mainly focusing on lessons learnt from Phase I, and advices for Phase II. Now when the third phase is coming to an end, enough data has been collected on all of the phases and the research can be done over the history of EU ETS. However, since the full data on both, the emissions and allowances, was accessible only for the first 14 years, 2005-2019, the research lacks the information from the last year of Phase III, which has to be noticed in the research.

Even though the research is described to be made within *the Nordics,* in this research this term means only four of the five Nordic countries. Data from Iceland is not part of this research because the country is demographically smaller than Finland, Sweden, Norway and Denmark, and the country is also different with its industries and geography. Main reason for excluding Iceland, was to make the comparison between the Nordics simpler.

This research is based on following questions.

1. Are there clear differences between sectors in the emission reductions over the three phases of EU ETS in the four Nordic countries?
    a. What are the main differences within the emission reductions in the stationary installations over the 3 phases of EU ETS within these countries?
    b. Which country has reduced emissions most effectively in the chosen sectors of combustion of fuels and refining of mineral oil?
    c. Is the trend similar in the number of allowances than in the amount of emissions?
2. What are the national policies used in these countries that affect the reductions besides the EU ETS?

1.4 Research methdology

This is a quantitative research, and the data used is secondary; the data is not collected by the researcher; it is existing data on emissions and allowances. In this research the data used is from European Environment Agency and the variables *emissions* and *allowances* are looked into with correlational method. The data collection includes data for the complete period of 2005-2019, which means that data for the last year of Phase III is unavailable at this source. However, since the data is well available for the first 14 years of EU ETS, the analysis should not be lacking too much of valuable information, but this limitation of missing data from 2020, should be considered when reading into the results.

The literature used is collected from various sources and it is secondary. Data used in the analysis is from the European Union’s Transaction Log that is collected by the European Environment Agency. Most of the sources used in the analysis of the EU ETS itself comes from the EU’s open sources. The research methodology is described more in detail in chapter 4.

2. Literature review

First part of this chapter is a description of the EU ETS. The history and international frameworks that are behind the development of the trading scheme, the general nature of it, performance, challenges as well as criticism, and pricing of the allowances are presented in the following sub chapters. The second part of this chapter focuses on presenting the countries looked into in this research: Finland, Sweden, Norway and Denmark. The chapter focuses on presenting their economic factors, national climate strategies and the overall emission development.

2.1 History of international frameworks

Leadership is important in climate change mitigation (Lewis, et al. 2019). It could be said that the leadership in climate change mitigation was originated by UN, since the organisation was the first to bring the attention to sustainability and brought the world economies together to discuss it. The first climate convention was held in Geneve in 1979 and it was organised in cooperation with two different sub-departments of UN, the World Meteorological Organisation (WMO) and the World Health Organisation (WHO). Already in this conference the participating scientists recognised the need to take advantage on the knowledge the humankind already had on climate, improve that knowledge and to use the knowledge to prevent human caused changes in climate. (Zillman, 2009) As can be seen today, this convention did not lead to remarkable preventing actions.

In 1992 the world singed the United Nation’s framework for international cooperation to mitigate the climate change, so-called Kyoto protocol, and to support the national policies in achieving cleaner air. These kinds of policies are not, and they cannot be, simple, since the climate change itself is a complex issue resulting from multiple reasons. From this convention and from the protocol started the idea that the developed world should take leadership in climate change mitigation and take responsibility to help the developing world in this task. (Lewis, et al. 2019)

Kyoto protocol was adopted five years after the 192 countries agreed on it and it came into force in 2005. The slow process was because of a complex ratification process, but nevertheless, this is an example of one of the main challenges often facing the international community; the international agreements are challenging to first of all to agree on, because of the large amount of countries involved, and secondly, hard to put into force. (Lewis, et al. 2019) The main idea of the Kyoto protocol is to:

> *"... operationalize the United Nations Framework Convention on Climate Change by committing industrialized countries to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets."* (UNFCCC, 2020)

The Kyoto protocol sets binding emission reduction targets for 36 industrialized countries and the member states of the European Union. With the protocol the countries agreed on reducing their overall emissions at least 5% below 1990 levels by 2012. (UNFCCC, 2008) This goal was not very ambitious, and 28 countries of EU committed to more ambitious goal of 8% during the ratification process. The European countries have committed to more demanding goals by 2020 and even to challenging ones by 2050. (Hildén, 2011) An important element of Kyoto Protocol is that it was the first agreement that established the flexible market mechanism, that makes emissions trading possible. (UNFCCC, 2020) This was an important aspect in the later development of EU ETS.

The world economies come together yearly to discuss and find solutions for the climate issues, and in 2015 they came together in Paris. In that summit the countries agreed on a contract called *The 2015 Paris Agreement on Climate Change* (hereafter abbreviated as the Paris Agreement). This agreement continued from Kyoto protocol, but was intended to be more ambitious and the implementation of it was different. One could say that while Kyoto protocol works like an orchestra, it is guided and controlled by the UN, Paris agreement has a 'bottom-up' approach where UN is simply a facilitator and the parties decide for their own mitigation targets. (Robiou du Pont, et al., 2016) This agreement was created because the previous agreements were not ambitious enough in order to mitigate the climate change.

The main goal of the Paris Agreement, very idealistic one, is to limit the average global temperature rise of the world to 1.5°C, in comparison to pre-industrial time. If this is not reached, the ultimate limit is 2°C. (UNFCCC, 2016) The 0,5°C difference could provide a remarkable difference in reducing the frequency of extreme regional temperatures. (IPCC, 2018) The studies have shown that even though the countries have committed to this goal, none of the major emitters' policies are in line with this reduction goal. Currently existing plans would result in a temperature rise of 2.6°C – 3.0°C. If the average temperature rise is this high, it will cause more accelerating extreme climate events. (Lewis et al. 2019) This means that despite the EU's ambition to be viewed as a global climate change leader, in reality, the Union is not succeeding in reaching its climate change goals.

Some of the recent studies have also shown that even if the major emitters, USA, China, India and EU 28 would create and achieve more ambitious national or regional contributions by 2050, also the rest of the world would need to rapidly change their current behaviour and decrease the emissions so that they would reach somewhat zero emissions by 2050, just to achieve the Paris 2015 goal. However, the rest of the world only accounted 39% of the world CO2 emissions in 2016; this includes the poorest emerging economies who struggle to fulfil basic needs of the citizens, such as food or water, which leads to a result of slow development in emission reduction; simply put, they have more pressing everyday challenges. (Jiang, et al. 2019)

Many famous theorems exist on correlation between the economic growth and environmental degradation, e.g. *Kuznets curve* from 1955, in which the theory argues that the economic growth leads to increase in pollution and only after a certain point, the economy can use resources in investing on green innovations and emissions reductions. Similar arguments are made in other theories: *Brundtland curve,* which investigates the relationship of poverty and environmental problems, and *environmental Daly curve,* which argues on positive correlation between GDP and environmental degradation. (Kortelainen, 2018) Even though these theories have faced also a fair amount of criticism, the unbalance between the developed world and the developing world is a confirmed fact in everyday life and it makes one sceptical about the achievability of the Paris 2015 goals.

It is clear that the climate change has been a concern of the humankind for decades now and the solutions are being searched on a global, regional and national levels. The global agreements are based on global cooperation, policies and political decision-making, and the challenge to find a common ground among the actors who are very different on multiple crucial levels, is enormous.

2.2 EU ETS as a policy

Climate policies cannot merely focus on specific pressures, such as emissions of GHG, they must deal with multiple dimensions of climate change; however the policies themselves have different aspects depending on what are they trying to tackle, e.g. chemical pollution is dealt with different kind of policies than excessive exploitation of natural resources. The process of implementing a national, or regional, or even global policy includes significant amount of learning over the process. (Hildén, 2011). The European Union chose carbon trading as the emission reduction method since it is supported method in the Kyoto Protocol, and it provides a way to reduce emissions in a way that is cost-efficient. (Goers, Wagner and Wegmayr, 2010) The USA was a major party affecting the chosen design of the Kyoto Protocol, since it was a first country to try tradable emission permits: one of the mechanisms in the core of the Kyoto Protocol, was International Emissions Trading, which enabled the international purchase and sale of emission allowances. (Mariotti, 2016)

A common assumption in implementing environmental regulations is that the actors who face increasing costs from policy changes, are the ones who will oppose the change. This would mean that companies are uncooperative in policy reforms. However, this is not always the case; the environmental regulations can also create opportunities and first-mover advantages, even competitive advantages for companies if the costs are lower than competitors' costs. (Genovese and Tvinnereim, 2016) Companies are not the only ones who can achieve first-mover advantages with environmental regulations, especially in a regional system as EU ETS, also the countries can achieve first-mover advantages. The companies who support environmental policies, might also notice an improvement in their relations with governmental organisations. However, a policy reform does not automatically mean that companies are investing more on new materials or adopting to the pressure created by the reform. This indicates that benefits of one reform are difficult to measure. (Genovese and Tvinnereim, 2016)

Tradable emission permits are attractive for regulators in relation to environmental taxes because they are not required to be precisely informed about the production or abatement technology available in different sectors to create a cost-effective equilibrium to the markets. This kind of equilibrium can be achieved in markets through the used market mechanism. (Chaton, Creti and Sanin, 2018) EU ETS can also be attractive to the regulators because of its nature which creates synergies and forces to cooperation among the players; it also creates benefits to the countries.

EU ETS has been supported by companies because of few reasons. First of all, the free allocations of allowances the Union has been giving out over the three phases. (Genovese and Tvinnereim, 2016) However, the idea is to decrease the amount of free allocations over time to reduce the emissions, and it is interesting to look into the change in emissions over the phases when fewer allowances are given out for free. Secondly, EU ETS is supported by the companies because in Europe firms tend to have a culture of sustainable development compared to other economic markets. This kind of culture indicates that the companies have some kind of baseline interest and open attitude towards environmental regulations. These reasons indicate that the opportunity of enhancing performance through cap-and-trade system is real and can generate political support. (Genovese and Tvinnereim, 2016)

Since the beginning of EU ETS, the framework has developed greatly, and the emissions have reduced over the course of the trading scheme. However, some worldwide events, or national events, have to be taken into a consideration when reading into the scale of the reduction. For example, the economic crisis in 2008 and 2009 affected the emissions, and it is unclear how great of reduction of the emissions in EEA during the that time was because of the ETS and what was the impact of the crisis; the economic downfall caused drop in the demand for the electricity, which resulted in an abatement of 150 megatons of CO_2 only within the power sector. (Bel and Joseph, 2014) Similarly, the Corona crisis in Spring 2020 has affected the emissions and the results of the Phase III. The future researches will have to take this unusual event into the consideration when researching the course of development in emissions during the Phase III.

Despite the benefits of the EU ETS, the system has faced a lot of criticism and as any policy, it has not been implemented without costs. The opportunities of the system were meant to benefit average businesses in Europe, but it has created some fixed emission caps. In other words, if an environmental policy raises the economic concerns among the polluters, they might oppose the system strongly. (Genovese and Tvinnereim, 2016) However, researchers have found that an environmental legislation strengthens the competition and even empowers firms with high market skills; the legislation might support liberal economy. (Fernandez and Rodrik, 1991) This would mean that the greatest beneficiaries of the policy are the large companies, who have the resources to enjoy the new advantages of the market. Large companies are also more likely to be able to lobby the policy makers so that the law can have an expectation that applies only to them. (Genovese and Tvinnereim, 2016)

Milliman and Prince found already in 1989 that direct control methods, such as emission permits, environmental taxes, subsidies, might be economically inefficient from time to time, but they are often supported by politically powerful industries because of lower compliance costs and because they have potential to increase entry barriers in the market. These kinds of policies also increase the innovations within the industries. (Milliman and Prince, 1989) Inoue (2015) argues that corporations that had a strategy or a policy that complies with EU ETS, before they have been regulated with EU ETS, have been more likely to invest in research and development aiming to reduce emissions. Based on a research conducted by the EU's research centre the trading scheme has had an effect on emission reduction, and also limited but positive effect on innovations. (European Parliament, 2014)

The possibility to lobby environmental regulation is different on depending the size of the company, or a sector. It could be argued that sector level lobbying has the higher benefit for all the companies within it, however, large companies might feel that they do not benefit enough, when again small companies might benefit more. However, the size of the sector in a country also affects the process; often larger, economically more important, sectors create higher pressure for the governmental policies, or in the case of EU, for the member states to affect the EU regulations. (Genovese and Tvinnereim, 2016)

2.2.1 How does the carbon market work?

The European Union's Emission Trading Scheme is a cap-and-trade -scheme. This means that the trading scheme

> *"…caps the total volume of GHG emissions from installations and aircraft operators responsible for around 50% of EU GHG emissions. The system allows trading of emission allowances so that the total emissions of the installations and aircraft operators stays within the cap and the least-cost measures can be taken up to reduce emissions."* (European Union, 2015)

The idea behind is to provide cost-effective and economically efficient tool for emission reduction. The scheme covers more than 11,000 power stations and industrial plants all together in 31 countries, and flights between involved countries. The trading scheme has been in use since 2005 and will come to the end of the third phase in the year 2020, and afterwards it will move on to Phase IV for 2021-2030. (European Commission, 2015)

In general, emission trading can be seen as a regulation that sets aggregate limits on the amount of emissions that can be produced by facilities from different industrial sectors. At least in theory cap-and-trade covers the marginal cost of emission reduction caused by the change in environmental regulations which are set by the policymakers. In the cap-and-trade -system the "cap" refers to a cap wide enough to cover the EU's GHG emissions and it is calculated and established by the European Commission. (Bel and Joseph, 2014) This cap has been reduced progressively over the periods the cap is has been monitored and it will be reduced more in the future. The EU ETS is separated to 2 caps; the other one is for fixed installations and the other one is for aviation industry. (European Commission, 2015) Aviation as an industry was included in the carbon market in 2012 and as an industry is the only one in which the emissions are still increasing compared to the fixed installations.

The companies under the cap have to cover their emissions by EU emission allowances which are given out for free or the companies have to buy them through auctions. The allowances can be traded among the companies or countries; the ones that need more allowances can buy them from the ones who have too many within the carbon market. This way the companies or countries who are running short in allowances, can avoid penalties from the EU. One allowance is for one tonne of CO_2 a company emits. (Bel and Joseph, 2014) The price of the allowance is determined by the balance in the supply of those given out for free and those auctioned and weighted against the market demand. The price incentive comes from the scarcity of the allowances; the greater the scarcity, the higher is the price. (European Union, 2015)

Idea of efficient emission trading is believed to be based on the famous Coase theorem, which describes economic efficiency with an assumption of complete competitive markets where transaction costs, income effects, asymmetric information and market power do not exist, but clear establishment of property rights does. In this kind of situation, the parties can trade these rights so that marginal abatement costs are equal among the firms. In the case of EU ETS, Coase theorem predicts that free allocation of allowances has no effect whatsoever in abatement incentives. (Maartens and Venman, 2016) Coase is not the only one arguing that emission trading can help to achieve reduction goals; also, Montgomery published a theory in 1972 that tradable emission permits can help to achieve emission reduction targets cost-effectively. (Haton, Creti and Sanin, 2018)

The free allocation of allowances is done by a method called benchmarking. This means that the performance of each installation is evaluated against the other installations in the sector, and the allowances are rewarded to the best performing ones, the benchmarks are based on the average GHG performance of the 10% best performing installations in the EU in specific sector. (European Commission, 2015, p. 47-50) During the Phases I and II, the free allowances were also handed out by a method called grandfathering. That meant that the allocation was based on each company's historical emission data, but after 2013, benchmarking became the primary method for the allocation of free allowances. (European Commission, 2015, p.40),

Figure 2 visualises the process of allocation of the allowances.

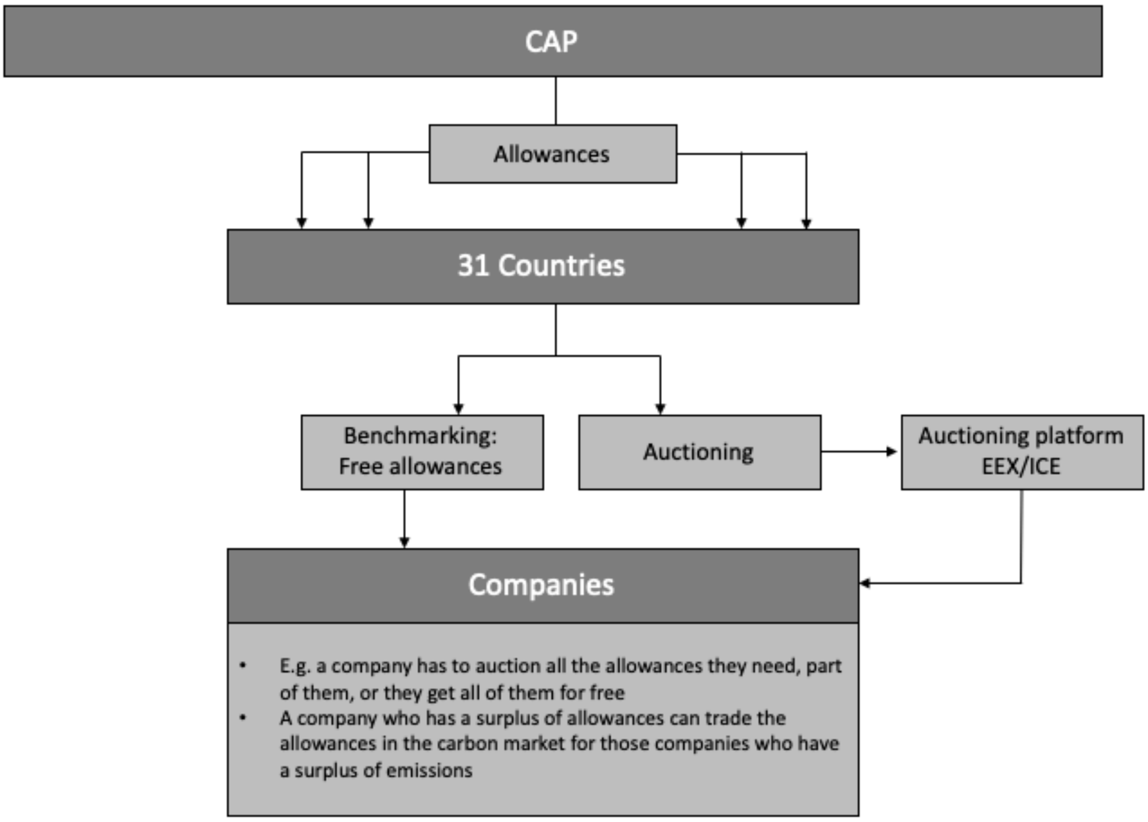


Figure 2: How the EU ETS works. Based on the European Commission's ETS Handbook, 2015.

Auctioning

The importance of the auctioning has been increasing over the time of EU ETS. E.g. the electricity sector has been required to buy all its allowances since 2013; previously the sector was able to pass on the emission costs to the final consumers, even if they received the allowance for free, which meant that they could earn at the expense of the consumers. This was one of the parts of the trading scheme that were under a lot of criticism. (Bel and Joseph, 2014) In other sectors the number of free allowances has decreased from 80% in 2013 to 30% in 2020. During the Phases I and II, most allowances were given out for free, only during the

Phase III, auctioning has become the default method of allocation. (European Commission, 2015)

Allowances are auctioned in the European Energy Exchange (EEX) or ICE Futures Europe (ICE) which is for the trading in UK. (Bel and Joseph, 2014) The method of auctioning ensures the transparency in the carbon market. The auctioning is governed by EU regulation, which covers the timing, administration and all other aspects to ensure that the auctioning is transparent, harmonised and non-discriminatory for the participants. The market generates revenues quite well; in 2013-2015 the auctioning generated approximately €11,8 billion and the Member States were planning to use or had already used approximately 82% of the total revenues for climate or energy purposes, e.g. to support the renewable energy industry or energy efficiency programmes. (Le Den et al. 2017)

Sectors and the firms

All of the 17,367 installations part of the EU ETS in 2018 operate in the sectors presented in the table 3. These installations are operating within over 11,000 entities. The sectors are energy intensive, but not equally in all the Members States of the trading scheme. Some of the sectors are historically and economically more important in other countries than in other. For example, the forest industries, production of paper and cardboard and production of pulp are heavy in emissions in Sweden and in Finland, but not in Norway and Denmark. Reason for this relate to the geography and economic sectors of the countries.

Table 3: Sectors within EU ETS. Information collected from the EEA, 2020

MAIN SECTOR	*NRO & SECTOR*	*NUMBER OF INSTALLATIONS (2017)*	*NUMBER OF ENTITIES (2017)*
Aviation	10 Aviation	1,545	525
Stationary installation Combustion	20 Combustion of fuels	9,697	7,496
Stationary installation Refineries	21 Refining mineral oil	175	139
Stationary installation	22 Production of coke	29	20

Iron & Steel, coke, metal ore			
	23 Metal ore roasting or sintering	12	9
	24 Production of pig iron or steel	294	246
Stationary installation Other metals (including aluminium)	25 Production or processing of ferrous metals	284	250
	26 Production of primary aluminium	40	33
	27 Production of secondary aluminium	35	33
	28 Production or processing of non-ferrous metals	99	91
Stationary installation Cement & Lime	29 Production of cement clinker	331	259
	30 Production of lime, or calcination of dolomite/magnesite	428	299
Stationary installation Other non-metallic minerals	31 Manufacture of glass	463	372
	32 Manufacture of ceramics	1,738	1,087
	33 Manufacture of mineral wool	65	52
	34 Production or processing of gypsum or plasterboard	42	40
Stationary installation Pulp and paper	35 Production of pulp	194	179

	36 Production of paper or cardboard	868	585
Stationary installation Chemicals	37 Production of carbon black	18	18
	38 Production of nitric acid	37	37
	39 Production of adipic acid	3	3
	40 Production of glyoxal and glyoxylic acid	1	1
	41 Production of ammonia	30	29
	42 Production of bulk chemicals	456	364
	43 Production of hydrogen and synthesis gas	46	42
	44 Production of soda ash and sodium bicarbonate	14	14
Stationary installation Other	45 Capture of GHG under Directive 2009/31/EC	2	2
	46 Transport of GHG under Directive 2009/31/EC	1	1
	47 Storage of GHG under Directive 2009/31/EC	0	0
	99 Other activity opted-in under Article 24	420	257
	TOTAL	17,367	11,958

In the trading scheme *entity* refers to a company or organisation, an *installation* is operating facility part of an entity, a stationary technical unit, as described in the table 2.

2.2.2 The challenges of the trading scheme

As a complex, massive scheme, EU ETS has been, is constantly and will be up against many challenges, starting from the integrity of the scheme to the execution and the results. The scheme has developed over the 15 years of its existence, and the Union is aware of the challenges the scheme has. The European Court of Auditors looked into the challenges in the trading scheme in 2015 and found out that overall both the Commission and the Member States are not managing the EU ETS adequately in all terms. The Court argues that there are certain issues when it comes to regulation and overseeing the market; EU level oversight does not exist, and some amount of insufficient regulatory cooperation exists. The definition of an "emission allowance" is not legally clear, and some amount of unclearness exists in regard of security interests in allowances. The security of the finances and data across the wide range of account holders in the market is too weak and should be further developed. (Cardiff, Fésüs, den Engelsen and Friel, 2015)

Fundamental problems with EU ETS can refer to problems in the implementation of policies economists see efficiency-enhancing, but the governments nevertheless fail to implement. Example of this kind of problem is the division between the ones who gain and the ones who lose after an implementation of a new policy. Often those who gain, are politically in a better position, than those who lose. This can lead to resistance from the losing side. (Fernandez and Rodrik, 1991) In EU ETS, this might lead to an unfair distribution of gains when it comes to allowances, but also, into resistance from smaller players if they feel like they are losing.

One of the challenges in EU ETS is the allocation of the allowances: in some cases, the companies have too many allowances and in some cases too few compared to the emissions. In theory the free allocation of allowances could lead to a situation where installations are trying to get more allowances for free by trying to emit more. However, proof to this kind of behaviour would be basically impossible to find. The installations are supposed to reduce the emissions when they have less and less allowances, or they have to buy more allowances from other players at the market.

Maarten and Venmans (2015) made a study with managers whose companies are part of EU ETS, and one the results they found was that some of the companies who have extra allowances, do not sell the extra ones in the market. These companies had internal issues related to the matter, e.g. the people responsible for the carbon trading were in accounting department, instead of production. This made the manager feel the whole trading scheme too abstract. The Coase theorem predicts that no matter if the allocation is above or below the emissions, for a given carbon price, it creates the same incentive for investments. In their study Maarten and Venmans found that this view was only supported by two companies out of 16 companies. Majority of the companies taught that allocation below emissions creates better incentive to invest. (Maarten and Venmans, 2015) Their research was based on only Belgian companies and the number of the companies interviewed was small, so it should not be used as a proof that this is how all the participating companies think of the ETS, but it is an interesting insight on the matter.

EU ETS has suffered from relatively low prices in the past; the system suffered from chronic oversupply of allowances when prices stayed in low in the beginning of 2010. This led to questioning of the credibility of the whole system. (Lewis, 2018) One can imagine that this would be problematic not only for the system itself, but also because EU ETS is the largest cap-and-trade -system in the world; if it suffers from credibility issues, smaller systems will also suffer from the effect of disbelief on the carbon markets. When the price of an allowance is low, the carbon market is not working as it has been intended to work; in that kind of situation it does not support the transformation away from fossil fuels.

This challenge made EU to create Market Stability Reserve (hereafter abbreviated as MSR), by the Decision (EU) 2015/1814 of the European Parliament and of the Council. The MSR is a flexibility mechanism, with the main idea of being able to react market changes, e.g. to economic shocks in the markets. Basically, the European Commission places 12% of the allowances to a reserve, if the total number of the allowances in the annual circulation is higher or equal than 833 million. From this reserve the allowances are released if less than 400 million allowances are in the circulation, or if the price is 3 times higher for 6 months, than average carbon price over the two following years. (Chaton, Creti and Sanin, 2018)

Challenges related to pricing of EUAs may lead to also one serious dilemma called carbon leakage. This refers to a situation where high pricing of emission allowance makes the companies transfer their production to other countries outside of EU, where the carbon emissions do not have prices; this makes it possible for the company to produce their products and not to focus on emission reduction. The risk of carbon leakage is not equally high to all the sectors, certain energy-intensive industries are in a higher risk of committing to carbon leakage. The European Commission has been publishing a list with the sectors in high risk of carbon leakage for each of the Phases. (European Commission, 2020a) However, the matter of carbon leakage and the question if the EU ETS is causing it or not, is widely debated and not always agreed on in the academic researches. E.g. Naegele and Zaklan (2017) argue that they did not find evidence of EU ETS causing carbon leakage in the manufacturing industry. They rather argue that EU ETS helps the manufacturers to incentive green innovations and so it increases the competition. The competition effect of the climate policies was analysed in the chapter 2.2 in this research.

2.2.3 Critisism towards the trading scheme

The EU ETS has been criticised over the years for many different reasons, but the main topics for the criticism are the distribution of the free allowances and the volatile price development of the EUAs. Milliman and Prince (1989) argue that industry innovators do gain more benefits from tradable permits or emission taxes, than from free permits. This is based on the idea that positive price and the price development may entice the innovation process and greater investments in low-carbon technologies. Even though their study was made decades before the development of EU ETS, it is reasonable to bear their findings in mind. Free allocation and its insignificant effect on competitiveness of the companies has been also criticised by many others, e.g. Joltreau and Sommerfeld in 2017, and Goers, Wagner and Wegmayr in 2010.

Goers et al. (2010) argue that the best policy is not only one policy like emission tax or permit trading, they believe that the best is a combined policy of these two. They state that the problem of the first Phase of EU ETS was clearly that too many free allowances were handed out. According to their research this led to too high emissions in the sectors when the companies wanted to get more allowances for free. They believed that hybrid policies would lead to more efficient abatement and not too high abatement costs with more scarce allocations. Abrell, Faye and Zachmann (2011) also believe that transforming the system to full auctioning of allowances could even cause losses on profits for the participating companies, but also, it would increase the emissions reduction. Abrell, et al. even questioned the relevance of the Coase theorem when it comes to EU ETS; they argue against the logic of initial allocation on allowances being irrelevant.

The price issue of the EUAs has been criticised by many. For example, Perino and Willner (2016) argue that when an excess of supply of EUAs exists in a way that it can be seen systematic, the whole trading scheme does not provide price signals to increase investments in low-carbon technologies. They criticise the EU's attempt to fix the trading scheme with the MSR, by arguing that the MSR only affects prices and emissions, if it causes also other temporary scarcity, since e.g. the prices might increase fast because of the MSR, but then again fall under the baseline. This kind of effect can again negatively affect the innovation process of the companies. (Perino and Willner, 2016) As it is seen in the Spring 2020, the prices of allowances did increase fast in 2018, and the fall has been rapid because of the Corona crisis. This drop can be seen in figure 3. Because of the global pandemic and the economic crisis caused by it, the long-term effect of MSR is difficult to estimate in the upcoming years. Creti and Joëts (2017) mention in their research that it is unsure if the price is right when it comes to the marginal abatement costs, or if e.g. price manipulation or other inefficiency issues affect the price of EUAs.

One of the challenges with EU ETS that it has been proven that some of the sectors manage to abate more emissions than others. E.g. Abrell et al. (2011) state in their research that during the first Phase and the beginning of the second Phase of the trading scheme, *non-metallic minerals and basic metals* reduced more emissions than any other sectors. During that time *electricity and heat* sectors did not reduce their emissions at all. However, e.g. Kortelainen (2018) argues in her research that when looked into the sectoral abatement differences over the 3 Phases, it can be concluded that the *power and heat* have reduced their emissions more and the changes in their industry have been massive; this is partly because since 2013 this sector has been only able to trade their allowances, the EU is not allocating free allowances to the *power and heat* sector anymore.

2.2.4 Price volatility

The carbon trading scheme may be a result of international agreements and emission reduction goals, but one attribute of it affects the whole market more than any other, and that is the price of the allowances. This is because of the cost-effectiveness requirement states that the marginal abatement cost, MAC, has to be the same for all the parties involved.

As stated in the chapter 2.2.3, a great deal of the criticism and disbelief on EU ETS is based on the price volatility of the EUAs. The price volatility has been a valid concern especially in the past, since the price of a EUA has been very low and it has been changing radically over the years. Based on their research on the first Phase of EU ETS performance, Kettner, Köppl and Schleicher (2009) argue that price stability is crucial for environmental effectiveness of a trading scheme. Low prices of EUAs can be historically linked to over-allocation of the allowances, the price of EUA was very volatile especially during the first phases of the trading scheme, and it could be at least partly linked to the uncertainty of the industries and the companies with their environmental policies. (Kettner, et. al, 2009) However, it can be seen that the environmental policy development has not changed the volatility of the prices since the beginning of the trading scheme.

The price volatility in the EU ETS since the beginning is a result of multiple things. Besides the over-allocation, the price drivers of EUAs have been the global economic activity, energy prices and even weather conditions. (Kettner, et. al, 2009) The carbon pricing also affects the competitiveness of the companies. To increase the price of allowances, it is required that some of the allowances are permanently removed from the circulation. To place allowances to MSR and postponing their release date that way, can increase the scarcity of allowances in short-term, but only if the prices are lower in the future. (Perino and Willner, 2017) Figure 3 shows the price development of the EUAs during last 12 years in euros, price/tCO_2. This chart describes how the prices were relatively low for major time of the existence of EU ETS. The prices started to rise during 2018 because of the update and the expected release date of the MSR in 2019. Since 2019, the price did not go under 20 €/tCO_2, until, the price dropped when the Corona crisis hit the economic markets in February 2020.

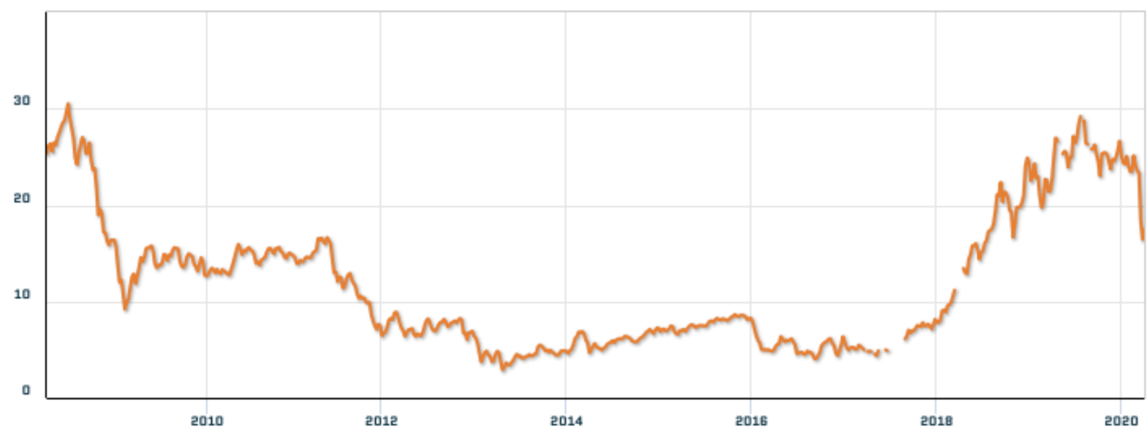


Figure 3: ECX EUA Futures, 2008-2020. (Quandl, 2020)

In this figure the vertical side represents the euros and horizontal years. It can also be seen that the price fell from 30€/tCO_2 in mid-2008 to less than 5€/ tCO_2 in mid-2013. Koch, Fuss, Grosjean and Edenhofer (2014) look into the explanations to this drop in their research and argue that the most often identified reasons for this drop are the economic recession which began in 2008, changes in renewable energy policies and increased use of international credits.

Based on their research they argue that the marginal abatement cost theory cannot solely explain the price dynamics of the EUAs; only 10% of the variations relate to abatement related reasons, the rest remains unexplanatory by abatement related fundamentals.

The high volatility of the prices led to the installation of MSR in the trading scheme. Since MSR is the EU's response to the oversupply of the allowances, the investors assumed correctly that from the beginning of January 2019, the surplus of allowances will disappear. The MSR is believed to cause a drop from 1,776 million to 496 million allowances over the years 2019-2023, which in percentage is a decrease of 70%. (Lewis, 2018) Creti and Joëts (2017) argue that overall, EU ETS has been a successful scheme in setting a price for carbon, with clear price drivers, such as abatement potential and the effect of extreme temperatures. They also argue that the price volatility on supply and demand as well as to energy and environmental policy measures, does not seem to distract the market efficiency.

2.3 Previous research on EU ETS

Several researchers have studied the EU ETS over the last 14 years. The approaches have been various depending on the research teams; some of them have focus on country specific data, and some on EU wide data, often on a firm level. The analyses have also often focused on the first or second Phase of the trading scheme. These researchers have found positive and negative outcomes in EU ETS, and the ways it has changed industrial sectors in Europe. Martin, Muûls and Wagner (2015) point out in their research that most of the studies in EU ETS focus on the *direct effect* of the ETS on power plants and industrial plants, and not on *indirect effects* such as an impact because of higher electricity prices.

2.3.1 Performance analysis

It is crucial to constantly analyse the performance of EU ETS; however, it is somewhat challenging to estimate to what extent the emissions reductions have been because of ETS, and to what extent because of something else.

As stated in the introduction chapter, the emissions have been reduced over the years in the EU states; greenhouse gas emissions were reduced by 23% between 1990 and 2018, while the region's economy grew 61% (European Commission, 2020b). Since the Commission also states that the most significant decline in emissions was in sectors covered by the EU ETS, e.g. the emissions from stationary installations decreased 4.1% in 2018 compared to 2017 and emissions not covered by the scheme, (transport, agriculture, waste and buildings) decreased by 0.9%, one can argue that the trading scheme has an effect on the emissions. However, the causality in this case cannot be explained without looking into it closely; it can be that the difference is because of ETS, or it might be caused by something else.

Velten, Duwe, Zelljadt, Evans and Hasenheit (2016) state that the Member States earned close to €12 billion from the ETS during 2013-2015. Most of the revenues (20%) were received by Germany, which is the biggest emitter in the EU. Member States had agreed among themselves that over half of the revenues made through EU ETS should be used in climate purposes, and in the period 2013-2015 85% of the revenues were used for climate purposes in the Member States, both to national and international purposes. However, there are differences among the states, some, like Denmark and Ireland, used almost all the revenues on climate purposes, half to international climate actions and half to domestic ones. Finland was the only member state over the period 2013-2015 who used 100% of the revenues on international climate actions. Italy and Hungary used both less than 50% of the revenues on climate actions. Climate actions meant in this chapter are development of renewable energy sources, increase of energy efficiency and other projects that increase sustainability internationally and domestically. The carbon trading is a good way for reaching revenue increases.

Some of the researchers have presented ways to reform the EU ETS. Graichen, Graichen and Healy presented three ways to strengthen the EU ETS in their research in 2019. These ways are the following: strengthening the cap, enhancing the resilience of the system and introducing a carbon price floor. The idea behind strengthening the cap is to apply a higher linear reduction factor (LRF), which would decrease the cap and so the emissions faster. The other, enhancing the resilience of the system, basically means that the MSR would be improved. Since MSR reacts to unexpected events on the markets, it is a safety mechanism that can react fast to imbalances in the markets, but it should be used to solve also underlying structural imbalances.

Lastly, Graichen et. al, (2019) present the idea of introducing a carbon price floor. This would mean that the European Commission would introduce a minimum price for carbon, which would then ensure that there would be sufficient cost for emitting the GHG. The price floor would increase the price of carbon in the market for all the sectors in all the countries, when again a surrender charge could be targeted to different sectors or countries. Graichen et. al, also mention the possibility to increase the scope to include more sectors and activities or by applying a layered approach when benchmarking allowances.

2.3.2 The achievability of the EU goals

European Union aims to become the first climate neutral economy, and 2030 is an important year for EU in the combat against climate change. EU's most ambitious goals are set on the year 2030, or at least the ones that will set a path for future improvements.

In 2018 the GHG emissions were 23.2% below the 1990 levels in Europe, which was a positive note since it was already more than the 20% target for 2020. However, development is not fast enough for the 2030 target; at the moment the member states have policies and planned actions that would provide 30% reduction in GHG emissions by 2030. Proposed additional actions would improve the reduction to 36% compared to 1990's level, but this implies that reaching the 40% target is difficult. The problem lies within certain sectors; the reduction should be sustained yearly, and it should be consistent over all the sectors. (EEA, 2019)

European Environment Agency argued in 2019 that the sectors covered by EU ETS are reducing GHG emissions as expected. However, the most problematic sector within the EU ETS is the only sector where emissions keep on rising: in aviation. GHG emissions from aviation is expected to keep on increasing by 2030. (EEA, 2019, p.7-13, 26) This sector is also a challenging one since not all the emissions in it are not included in the carbon trading scheme. The aviation industry has taken a serious economic hit because of the Corona crisis in the Spring 2020, and at least the near future development of the industry is unknown

The problem is not only in the EU ETS, it seems to be the trend in all the sectors, no matter if they are part of trading scheme, or if they are part of some other climate policy. Part of the problem is also the member states; some of them are more advanced and some of them are lacking behind in the development; the projections submitted in 2019 by the Member States reveal that only three of the states are on track in achieving the Efforts Sharing Targets by 2030: Sweden, Portugal and Greece. Effort Sharing Target is a legislation that establishes annual binding targets set for the Member States to reach the climate goals until 2030. Seven states plan to establish additional policies and actions to reach their Effort Sharing Targets. Rest of the states, 18 of them, have not indicated yet, what they plan to do in order to reach their targets. Effort Sharing Targets are not part of the EU ETS, they are another policy EU uses to tackle the climate change. (EEA, 2019, p.7-13, 28)

EU's climate strategy has two important areas, which do not have binding Effort Sharing Targets for the Member States: renewable energy development and energy efficiency. The development in these areas are part of the national objectives of the Member States and the development on either of these areas is not fast enough to reach the 2030 targets. At the moment the proportion of renewable energy in the gross final energy consumption in Europe has been growing on an average rate of 0.7 percentage points annually. To meet the renewable energy target for 2030, the increase should be 1.1 percentage points per year over the next ten years. This can be achieved, but it needs dedicated actions to further develop the renewable energy generation and to reduce the energy consumption from fossil sources; lately the total energy consumption in Europe has been increasing faster than the consumption from renewable energy sources. (EEA, 2019, p.7-13) This is problematic when trying to reach the targets of 2030; if this does not change, the goals will not be reached.

The renewable energy target is also challenged by one of the non-ETS sectors; transportation. This sector is in risk of not even reaching the target of 2020; the target is that 10% of the energy in transport would come from renewable source in 2020, but in 2017, only 7,6% was achieved. When it comes to the energy efficiency, the targets seem to be far and difficult to meet; for example, the final energy consumption has been increasing in the Member States for the period of 2015-2018. The greatest increase has been in the buildings, which was 8,3% between 2014-2017, and in transport which was 5,8% during the same period. (EEA, 2019, p.7-13) Number of factors affect the energy consumption in general, but these are both significant changes when the EU is trying to achieve reductions in energy consumption. These sectors are not part of EU ETS and an important tool to achieve emission reduction within them is the EU's Efforts Sharing Targets.

The Land Use, Land Use Change and the Forest (hereafter abbreviated LULUCF) -sector represents the net carbon sink of the EU. It will be included to the EU's climate strategy in 2021, when also the Phase IV of EU ETS begins. LULUCF plays and important role in all the scenarios EU has and it is a central sector when it comes to the carbon capture and negative emission development. (EEA, 2019, p.31) However, it is not part of EU ETS, which is why it is not looked into in more detail in this research.

One of the issues with EU's climate strategy are the changing governments of the Member States, as in all the policies. When some of the countries are historically more interested in the climate change mitigation, some of the countries are less. Changing governments might also change the policies of the Member States, if they see something more important than emission reduction, e.g. if economic development is seen as conflicting with the climate issues. One could estimate that this is the reason why legally binding goals are important for EU.

2.4 The Nordics

The Nordic countries are Denmark, Finland, Iceland, Norway and Sweden, but the region includes also the islands with autonomy, Åland, Faroe Islands and Greenland. All the countries involved are small open-economy countries. In this research the focus is in the countries of Finland, Sweden, Norway and Denmark. The region is known for its high development and low inequality. All the Nordic countries are democratic countries with high welfare based on high levels of education and long-life expectancy, and the countries also invest in research and innovations. The region is peaceful, and the power distance is low. The main challenges include aging population which puts pressure on the welfare model and the labour markets. The Nordic region is also known for its high cooperation among the countries; the shared practicalities help the countries to learn from each other and accumulate knowledge about best practices. (Lehtomäki, 2020)

Together the Nordics form the EU's 6th largest economy and the region has the highest GDP per capita, €52,600, in Europe. When discussing about the climate issues, it is important to notice that the Nordic regions has more forest of the land than other parts of EU, in the Nordics forests account 56 percent of the land when in EU the average is 37 percent. (Nordic Council of Ministers, 2018)

The energy mix in the Nordic countries has similarities but also some differences. The energy mix of the Nordics in percentages of the total consumption in 2015 is seen in the table 4. The numbers presented in the table are based on Nordic Energy Research from 2018. The total number of the energy consumption in the table based on the research is above 99%. This table presents the differences and similarities in the Nordic energy mix.

Table 4: Energy mix of the Nordics in 2015.

POWER SOURCE	*DENMARK*	*FINLAND*	*NORWAY*	*SWEDEN*
Fossils (oil, coal, gas)	63%	47%	48%	35%
Biomass & waste	24%	33%	6%	33%
Wind	8%	0.8%	0.8%	3%
Hydro	0%	5%	44%	15%
Nuclear	0%	8%	0%	12%
Other (solar, geothermal, imported electricity)	4%	5.9%	0.8%	1.3%
Total	99%	99.7%	99.6%	99.3%

As seen in this table, all the Nordics have had fossil fuel consumption in 2015, Sweden had the lowest percentage of the end consumption. However, all the four countries are high in renewables; this highlights the ambition in the region and the possible benefits in the cooperation. Finland and Sweden have a high amount of biomass energy production, because of the forestry industry. In 2015, Denmark was clearly the frontrunner in wind power, and Norway in hydropower. Sweden and Finland are the only countries of the four, who are using nuclear power.

The carbon intensity of Nordic electricity is 60 gCO_2/kWh, which is very low compared to the global average of 500 gCO_2/kWh. The region has developed steadily in climate policies over the years, and this could work as a steppingstone for implementing climate friendly policies in transportation and other challenging sectors such as buildings. (Nordic Energy Research, 2018)

2.4.1 Climate policies in the Nordics

The Nordic countries are using a number of instruments to tackle the climate change, and the instruments are not unified within the countries. The Nordics are more ambitious in reducing the emissions e.g. in the transport sector, than the other EU countries. (Calmfors and Hassler, 2019) Denmark wants to decarbonate the energy supply, Finland aims for carbon neutrality by 2035, Norway and Sweden target to carbon neutrality by 2050 and 2045. (Carlén and Kriström, 2019) However, if looked to the emissions per capita, the Nordics are all above the OECD average. (Nordic Council of Ministers, 2014) If believed the estimations made by the European Environment Agency in 2019, in the Nordics only Sweden is on track in achieving the 2030 Effort Sharing Targets.

An important question is that why the Nordics, which are all small countries, have chosen more ambitious climate policies than other EU countries. The Nordics have relatively modest direct effects on the global GHG emissions. (Calmfors and Hassler, 2019) Golombek, Greaker and Hoel (2019) argue that this is because of two reasons: the ones that are about national self-interest and the welfare of the own citizens, and to those concerns that are also about the welfare of the citizens in other countries. The first category supports motivation on strategy of developing national businesses and green technology, and the second category supports the moral obligation and direct altruism.

Carlén and Kriström (2019) argue that significant marginal cost disparities exist in the non-ETS sectors between the Nordics. They also recognise that marginal abatement costs, MAC, are higher in the Nordics compared to international average. This is because energy-intensive industries are important in the Nordics. Carlén and Kriström argue that the EU regulation should be used to create trading between the countries also in the non-ETS sectors, since it could be cost-effective and that could lead to higher emission reductions. However, Golombek et al., (2019) argue that more effective way to reduce emissions would be in the development of clean technologies, than emissions trading. This could be beneficial in the Nordics where countries have expertise in producing wind power (e.g Denmark) or offshore technologies (Norway). Nordic cooperation within the technology development can lead to innovation in carbon capture and storage, which could be of benefit in the global battle against climate change. Golombek et al. argue that at the moment Nordic governments have had a too much of a country focus and they have subsidized technological innovations, which have led to situation where the innovations have stayed secrets and they have not been useful globally.

They recommend that the Nordic countries should do more cooperation with the climate policies to actually achieve higher impact.

Calmfors and Hassler (2019) argue that the Nordics should strengthen their cooperation but also with other ambitious countries to achieve the goals of the Paris Agreement. After the reform of the EU ETS, it can support the national policies and actions to reduce emissions so that the countries can save some of the EUAs, which decreases the need for allowances in the future. National policies and stronger cooperation together with the development of clean technologies can lead to important reductions within the Nordic region, but also globally.

2.4.2 The subsidies used in the Nordics

Support to renewable energy is often provided through two methods: direct, and indirect subsidies. The direct subsidies used in Europe are two different types, the feed-in tariffs, and market-based mechanisms, such as tradable green certificates. Out of these, Denmark and Finland use feed-in tariffs and Norway and Sweden tradable green certificates. Examples on indirect subsidies are e.g. tax exemptions that renewable energy sources receive in CO_2 taxes. (Næss-Schmidt, 2013)

Denmark’s feed-in tariffs are financed through taxing electricity consumers, and Finland’s subsidies come from state budget. Denmark has fixed feed-in tariffs and premium feed-in tariffs, difference being that the fixed ones are granted for off-shore wind producers, solar and wave solutions, and premium ones are given for on-shore wind producers, as well as biomass and biogas producers. Finland uses sliding premium feed-in tariff for biogas, wood and wind; this kind of tariff compensates directly the difference between target price and the average spot price on electricity. In Finland the wood chips are specifically subsidised with the premium feed-in tariff which works so that when the ETS price is low, this tariff is high, and the other way around. (Næss-Schmidt, 2013)

Norway and Sweden use common green certificates. In their scheme, the renewable energy producers receive a green certificate, when they produce one MWh of electricity with renewable methods. The energy producers need to buy or surrender green certificate responding the energy consumption of their own. This system creates a price to the market and as it is common to Norway and Sweden, the certificates issued in one country can be surrendered in the other one. (Næss-Schmidt, 2013)

Since all the Nordics use taxes on fossil fuel producers, the biogas and biofuel producers are indirectly subsidised in the countries; the size of the subsidy depends on the tax rate. (Næss-Schmidt, 2014) All the subsidies, the indirect and direct ones support the transition to renewables.

2.4.3 National climate policies and the ETS in the Nordics

In 2013 ETS covered about 44% of the emissions in the Nordics, which is close to the EU's coverage, 45%. Some differences between countries are present, in 2013 35% of emissions in Sweden were covered with ETS, and 50% in Finland and in Norway. (Bragadóttir, Magnusson, Seppänen, Sundén and Yliheljo, 2015)

Even though the Nordics are part of the EU ETS and support the trading scheme, strong cooperation within the region has also created other options for emissions reduction if the EU ETS is not working accordingly. For example, in 2017, the Nordics announced that they are considering introducing a carbon price floor, if the reform of the trading scheme with MSR does not work as it was planned. This, as many other signals from the region imply that the Nordics are motivated to reduce emissions ambitiously, with or without EU. (Kirk, 2017) Beside the EU ETS the Nordics use additional carbon taxes or national subsidies to support the development and use of renewable energy. These actions reduce the demand for ETS emission allowances in a member state. (Silbye and Sørensen, 2019)

From the energy production point many opportunities lie in the north; while Norway produces oil and gas, Norway has also, as Sweden, focused on developing and producing hydropower. Denmark is strong in wind energy, and Finland and Sweden both still have nuclear plants, but are pushing for bio-fuels. Already 20 years ago, these countries connected their national electricity grids, so that the hydropower could be used in the region when there is less wind, for example. This kind of cooperation has created significant benefits for the countries, and it has been managed well. However, to complete the transition towards clean energy, also the Nordics have to become greener. This is one of the reasons why the Nordics have followed the ETS development closely; if the ETS is not efficient enough, the Nordic region might need to develop approach of their own to support the emission reduction. (Kirk, 2017)

Besides the energy production, the Nordics have common interest in many other issues, and related to carbon emission reduction, the LULUFC -sector is important in the north. Nordics are the richest region in forests in Europe and the LULUFC is important sector for net emissions in the Nordics, and in Europe. (Nordic Council of Ministers, 2014) The LULUFC sector is not part of the EU ETS, neither are agriculture or transportation. These are the sectors the Nordics could cooperate even more to reduce the emissions. In the Nordics the GHG emission structure is typically quite similar, and the sectors outside of EU ETS are remarkable in the north. This is problematic when looked into the trading scheme more closely, as described in the chapter 2.4.7.

2.4.4 Denmark

Denmark is a member state of EU and the country has 5,8 million inhabitants. The main exports of the country are machinery, transport equipment, chemicals and related products, food and live animals. These sectors are also high on energy-intensity. Renewables covered 34,9 % of the primary energy supply per capita in 2017. (OECD, 2019) The country is aiming for massive increase in the use of renewables and trying to achieve 43,6% out of total energy consumption by 2021. However, without new initiatives, this number is expected to decrease by 2030 under 40%. (Danish Energy Agency, 2018) This indicates that the country should focus on supporting the innovations and new initiative in order to keep on increasing the share of renewables in final energy consumption. Denmark has a political consensus towards the increasing the cost-efficiency of the climate policies. The country wants to transit towards technology-neutral scheme; this supports low-price and green technology development. (OECD, 2019a)

Newest Danish climate strategy is from December 2019, when the government reached an agreement for a new Climate Act. This new act has several key objectives:

1. Legally binding target to reduce GHG emissions by 70% by 2030 compared to 1990.
2. Denmark will work towards net zero emissions in the EU and in Denmark by 2050 at the latest.
3. To limit non-ETS GHG emissions in 2030 at least by 39% compared to 2005.
4. Transport sector transition; to stop the sales of all new diesel and petrol cars in 2030.
5. Make sure that the emissions do not exceed removals as accounted in the LULUCF sector.

Denmark's strategy is in line with the five dimensions of the EU; decarbonisation, both removals and renewable energy, energy efficiency, energy security and research, innovation and competitiveness. Denmark aims to be known as a country of green entrepreneurialism, the government wants to support their entrepreneurs and innovators so that the goals of the Climate Act are achievable. (Danish Ministry of Climate Energy and Utilities, 2019)

National Climate policies of Denmark

Historically Denmark started to look for wind energy after the oil crisis in 1973, this led to the first commercial wind turbine 1979. The development and success of onshore wind energy led to the development of offshore wind energy. (Ministry of Foreign Affairs of Denmark, 2020) The Danish Energy Agency has been active in making projections and analyses on climate issues since 1984. (Danish Energy Agency, 2018)

In 2002 the largest offshore wind farm of the time was established at the North Sea, approximately 20 kilometres from the coast of Denmark. Next wind farms followed in 2009 and 2019. Surprisingly, wind energy is still not the main renewable used in Denmark, around 12% of electricity comes from wind power. Other renewable sources are bioenergy, which is the biggest renewable source in Denmark, then solar and geothermal energy. (Ministry of Foreign Affairs of Denmark, 2020) As described in the 2.4.3, Danish government subsidises the renewable energy production directly and indirectly.

The Danish Parliament created Energy Agreement in 2012, for the period of 2012-2020. (Danish Ministry of Climate Energy and Utilities, 2019) In this the legal ambitions and first ambitious goals for climate strategy were defined. The GHG emissions in Denmark are formed especially in three sectors: energy, agriculture and transportation. From these three, only energy is part of EU ETS, agriculture and transportation are non-ETS sectors. The emissions in energy sector primarily come from combustion of fossil fuels, such as coal, oil and natural gas. (Danish Energy Agency, 2020)

Danish government has provided subsidies and tax exemptions for zero emissions vehicles, and the government is aiming to end all the sale of new gas or diesel cars by 2030. This is very ambitious goal when still in 2018, 99.5% of all cars were fossil fuel powered cars in Denmark. The government is aiming to achieve the goal with taxes on private transport, both through fuel and purchase of new vehicles. The other problematic sector in Denmark is the agriculture, which was in 2016 responsible for 20% of the GHG emissions, but not a subject to any emission regulation tax. (OECD, 2019a)

Overall, Denmark is one of the frontrunner countries in the emissions reduction in EU. This will be seen in this research on the analysis on the stationary installations sectors. Based on the literature reviewed in this part, Denmark wants to ensure a market-driven transition to the greener future, and has used different kinds of instruments for a long time.

2.4.5 Finland

Finland has approximately 5,5 million inhabitants, and historically important industries for Finland are forestry, agriculture, mining and electronics. One of the peculiarities in the industries in Finland is the production of peat, which is not done in any other Nordic country. Peat production is high in emission intensity, since it causes alterations in the forest land and in mires. Because of the importance of the energy intensive industries to the country, in 2016 Finland had the third highest GHG intensity of the OECD countries. However, in 2014 Finland used the highest percentage of the GDP in OECD countries, 0.12%, on research and development of new energy technologies. (OECD, 2016)

The key industries are all energy intensive industries and the national climate policies are somewhat controversial and the needed actions in decreasing the emissions have been heavily debated over the years. As the Ministry of Economic Affairs and Employment states in the strategy (2019), currently Finland has a government that has created a new climate strategy with three ambitious objectives:

1. To achieve carbon neutrality by 2035,
2. To be the world's first fossil-free welfare society,
3. To strengthen carbon sinks and stocks in the short and long term.

Additionally, the government also wants to make the electricity and heat production nearly emissions-free by the end of 2030s. (Työ- ja elinkeinoministeriö, 2019) The newest climate and energy strategy builds upon the past policies and is aiming for more radical and long-term effects than the previous ones.

National climate policies of Finland

In Finland the UNFCCC was adopted by the Parliament 1994 and the Kyoto protocol in 1997. The first national climate policy came into force in 2001, and few strategies have followed it. (Hildén, 2011) The newest strategy was made in 2019. (Työ- ja elinkeinoministeriö, 2019) In the Finnish system the government submits the strategies in the form of reports to the Parliament, which then debates over the reports in its permanent committees and may demand specific actions to improve the proposed strategy. (Hildén, 2011) The first climate policy in

2001 focused on the objectives set in the Kyoto protocol, which meant that the emissions were supposed to stay on the same level than in 1990, and not increase from there. However, already this strategy recognised the fact that the emissions will increase, if the government does not act efficiently and set determined objectives, such as support economically development of energy efficient technologies, use environmental taxation to guide the markets towards emission reduction and support renewable energy. (Valtioneuvosto, 2001)

The second climate strategy was made because the government recognised the change in the global energy and climate economics. The government stated in 2005 that the most important change in the markets is the European Union's new climate change programme and the carbon trading market. The second strategy also aimed to answer better to the goals set in the Kyoto agreement. In 2005 the strategy stated that in theory, other taxes and market support mechanisms are not needed anymore after the EU ETS started. In reality, environmental taxes and control mechanisms are still used in Finland besides the EU ETS; in 2005 the government was relatively optimistic about the effect the emission trading scheme will have on the energy markets. Even though one of the most important industries for Finland, agriculture, is not part of the EU ETS, the price development in the fuel markets affects it, nevertheless. (Valtioneuvosto, 2005) One interesting feature of Finnish energy markets and governmental strategies have been over the years the belief in nuclear energy. When other countries in the Nordics, except for Sweden, have shifted the focus completely towards renewables, Finland has focused on nuclear energy beside the renewables.

In 2008 the government shifted the perspective of national climate policies to long-term goals. The new strategy had main objective towards 2020 and set visions to 2050 as well. In 2008 European Commission set an obligation to Finland to increase the renewables into 38% by 2020. In 2008 the government estimated that the renewables would cover only 31% of the energy production by 2020, if national policies would not be fixed and new measures would not be done. The government also recognized that without the measurements and the energy consumption increasing, the GHG emissions would increase over 30% by 2050. The strategy in 2008 was the first strategy that set an objective to stop the increase in energy consumption. (Valtioneuvosto, 2008)

In 2008 the government also stated that the objective to have 38% of the energy production from the renewables was challenging and it would require actions both in the reduction of energy consumption, but also to produce renewables from water, wind, solar and ground sources. In the renewable electricity demand, cooperation with Norway and Sweden was a key for Finland. (Valtioneuvosto, 2008) In 2013 new government updated the strategy from 2008 and this time the government argued that the long-term goal is to build carbon neutral welfare society. One of the challenging parts of any climate strategy in Finland has been the LULUCF -sector, since it relates essentially to almost all the main economic sectors of the country, forestry, agriculture and mining, and the reductions in forest land decreases the carbon capture. (Työ- ja elinkeinoministeriö, 2013)

2.4.6 Norway

Even though Norway is not member of the EU, it has been part of the EU ETS since 2008 through the EEA agreement and the cooperation with EU is important for Norway in many issues, also in climate matters. About half of the emissions in Norway are part of EU ETS. (Norway and the EU, 2020) Norway has 5,3 million inhabitants and economically it differs from other Nordic countries with the production of oil and gas. The oil production is one of the reasons why the country is one of the wealthiest among the OECD countries. Norway also has extensive resources to produce hydropower, which reduces the baseline emissions of the country. (OECD, 2019b)

Norway has quite ambitious climate policy to reduce the emissions within the country's borders. However, the country is somewhat controversial in the matters, since an important part of the national income comes from the fossil fuel production and sale. (Silbye and Sørensen, 2019) In February 2020, Norway announced that the new enhanced climate target is to reduce emissions at least 50-55% by 2030 compared to 1990 emission levels. (Ministry of Climate and Environment, 2019)

In the climate strategy made in 2017, Norway defined the main goals of the strategy as follow:

1. Norway will reduce the GHG emissions by 30% by 2020 in comparison to 1990.
2. Norway has conditionally undertaken a commitment to reduce its emissions by at least 40% by 2030 compared to 1990.
3. Norway will be climate neutral by 2030.
4. Norway has adopted legally binding target of being low-emission society by 2050.
5. Greenhouse gas emissions from deforestation and forest degradation in developing countries will be reduced in ways that contribute to sustainable development.
6. As a political goal, Norwegian society will prepare for and adapt to climate change.

The 2020 target was under the Kyoto Protocol, and the 2030 target was part of the Paris Agreement. Norway made the latter legally binding by Climate Change Act, as well as the target of being a low-emission society by 2050. (Ministry of Climate and Environment, 2017)

National Climate policies of Norway

Norway ratified the UNFCCC in 1993, and the Kyoto Protocol in 2002, and the Paris agreement in 2016. Norway's main policy tool is a carbon tax, which is quite high compared to many other countries. In 2017, the Norwegian Parliament adopted the Climate Change Act, which is a law on emission reduction targets by 2030 and 2050. Norwegian authorities argue that the *polluter pays* -principle is the cornerstone of the Norwegian policy on the climate change mitigation; Norway introduced the first CO_2-tax on mineral oil and petrol already in 1991. (Ministry of Climate and Environment, 2019) This was recognised as a possibility to cost-effectively limit the GHG emissions from the oil production. The tax has been evaluated a policy tool since then. Norwegian emissions of CO_2 increased 19% between 1990 and 1999, while the economy grew 35%. Bruvoll and Larsen (2002) argue that the effect of the carbon tax during that time on the emissions reduction was small, only 2,3%, the effect was strongly dominated by the Norwegian petroleum sector.

The paradox of Norway's most important industry and climate policies has been noted internationally. The challenges in demand-side climate policy and the position as a global supplier of fossil fuels introduces very different type of situation in Norway than in other Nordic countries. Holtsmark (2019) argues that increasing both, the supply side and demand side marginal abatement cost leads to optimal policy, which means lower oil extraction and carbon pricing leads to cost-effective combination. However, considerable uncertainty on the effects exists. Optimal combination of the supply and demand side policies in Norway is determined by the costs of the domestic emissions reductions together with percentage of the carbon leakage.

In 2020, the standard rate of CO_2-taxes is approximately NOK 545 (appr. €55)/tonne of CO_2. This is a tax for petrol, diesel, mineral oil, natural gas and LPG (liquefied petroleum gas). Over 80% of domestic emissions in Norway are subject to compulsory emissions trading, carbon tax or both. The polluter pays principle is used to also ensure that the costs for the society as a whole are the lowest possible. When the polluter pays, it creates cross-sectional economic policy instruments, the tax and the trading system, and has a basis of decentralised, cost-effective and informed actions. (Ministry of Climate and Environment, 2019)

OECD estimated in 2019 that Norway needs to reduce the GHG emissions from transport to achieve their targets. Around half of the emissions in Norway are non-ETS emissions, and large share of that is within the transport sector. Some inefficiencies are created through differences in carbon pricing policies. Norway's economy is less CO_2 intensive than the average among OECD countries, because of the hydropower production, and the energy intensity is not too high, but the emissions from production have not decreased progressively. (OECD, 2019b) Among all the things to be considered in Norwegian climate policies, the effect of the policies on technological development, political processes and international institutions should be considered. (Holtsmark, 2019)

Norway is the one country out of the four, who also has an official carbon capture and storage (hereafter abbreviated as CCS) program. This program has an objective on promoting the possibilities and the technology globally. CCS would have possibilities on larger cooperation among the Nordic countries. (Greaker, Golombek and Hoel, 2019)

2.4.7 Sweden

Sweden is the biggest country of the four analysed in this research; Sweden has approximately 10 million inhabitants. According to OECD (2019) Sweden had one of the highest employment rates in the EU last year, which indicates that the economy is strong, and both genders are well presented in the labour markets. Some of the main industries in Sweden are industrial machinery, road vehicles and electronics. (OECD, 2019c)

Sweden's newest climate strategy, the climate policy framework, is from 2017, and it can already be described as ambitious. The newest climate policy framework is based on three pillars: Climate act, climate goals and climate policy council. The four goals are:

1. The main goal in the strategy is for Sweden to have zero net emissions of GHG by 2045.
2. The emissions from domestic transport, excluding domestic aviation, will be reduced by at least 70% compared with 2010 by 2030.
3. The emissions that are covered by EU ETS, should be at least 63% lower than in 1990 by 2030.
4. The emissions that are covered by EU ETS should be at least 75% lower than in 1990 by 2030.

In this climate framework Sweden is arguing that the country is trying to achieve international climate leadership and wants to for further beyond that EU is requiring. Sweden has a special Climate policy council, that's job is to support the government in policy making by providing assessment on how the overall policy is compatible with the climate goals. (Ministry of the Environment and Energy, 2017a)

National climate policies of Sweden

Sweden was the first country in the world to pass a national environmental protection act, in 1972. Since then the country has not changed its consensus, rather they have tried to grow the economy in a sustainable way. Currently over half of the national energy supply in Sweden comes from sustainable sources. Even though Sweden is on the top of many indexes when it comes to pollution mitigation and sustainable development, a lot is still needed to be done. As in all the Nordics, carbon footprint of Swedish individuals is very high. (Sweden.se, 2020)

In 2001 Sweden created an extensive climate strategy. By that time the goals were more modest than they are in the new strategy: the main goal was reducing the GHG emissions by 4% by 2010 compared to 1990. In this strategy Sweden already recognised the need for international actions and they were ambitious to be an active player in international field. In this strategy the sectorial responsibility was recognised; the energy intensive industries should reduce their emissions most. The strategy also argued for actions to raise the knowledge about the climate issue, to recognise the climate measures in local investment programmes, promote for alternative fuels and for renewable power production. (Ministry of the Environment, 2001) This strategy can be seen as setting the direction to the increase in renewable energy production, and currently Sweden is one of the top countries in the renewable energy production.

In Sweden the parliament deicides on the introduction of the climate strategies and was also the party that decided to form the Climate policy council. Even though Sweden has had climate policies since 1972, the Ministry of the Environment believes that the new Climate policy framework from 2017 is historically the most important climate reform. This is because it provides long-term conditions for business and the society to act on to achieve the transition needed to tackle climate change. It is also the first act, that sets an obligation to each government to pursue a climate policy based on the climate goals set by the parliament. (Ministry of the Environment, 2017b)

Sweden, as also Finland and Norway, is aiming to build more biofuels factories for producing biofuels from forestry residues. Forestry is an important industry in Sweden and any development on the sector is useful in the carbon reduction. The ambition to develop the biofuels relate to the Sweden's ambition to reduce the emissions in transportation sector. (Greaker, Golombek and Hoel, 2019)

2.4.8 Challenges of the Nordic climate policies

The Nordic countries have not made empty promises when it comes to the attempt to achieve the climate goals set in the Paris Agreement. Their promised total GHG reductions exceed those made by comparable industrialized countries, they have relatively high carbon taxes, and higher GHG emissions reduction activities than comparable countries, and they have multiple measures in introducing new technologies and specific climate policies for different sectors. The total amount of emissions in Nordics contribute only 0,5% in global emissions. (Greaker, Golombek and Hoel, 2019) However, as recognised earlier; the individuals are some of the most emitting ones in the OECD countries; the changes in individual behaviour should be supported more strongly by the governments.

Even though the Nordics are seen as leading countries in climate politics, and they are more advanced than many others, and the countries themselves want to achieve a leadership in tackling the climate change, their policies can be improved. Currently all of the countries, the four presented in this research, have overlapping policies with the EU ETS. This indicates that some of them are inefficient, or that the EU ETS is inefficient for them. The cost-efficiency of the policies can be improved e.g. by making cooperation agreements with the EU Member States within sectors that are not part of EU ETS. (Carlèn and Kriström, 2018)

Greaker et al. (2019), argue that the Nordics should take full advantage of the EU mechanisms. Næss-Schmidt (2013) states that especially for the power sector, the future of the ETS is the driving force of the emissions reduction, and that the mitigation efforts used in the Nordics besides the ETS do not have effect on the national compliance or the overall emissions. This is because the cap in the market is EU wide and the reforms of the EU ETS affect the countries involved.

The Nordics have also policies that are more efficient on some of the sectors, but not on all of them. This is one of the difficulties in global and national climate policies; how to create policies that can boost the economic growth while decreasing the emissions. In the Nordics the most important industries are quite energy intensive, which has in the past resulted in high emissions. The LULUFC sector is not part of the EU ETS, neither are agriculture or transportation, and the emissions reductions in these sectors have to be supported with other methods than with EU ETS.

3. Theory and hypothesis

When analysing the EU ETS, reasons for its existence should be looked into. The trading scheme was built to respond to the problem of climate change, and it can be seen as an action to divide the responsibility and costs of the emissions mitigation between the member states, as well as the polluting industries. Climate, or clean air, is here described as a *public good;* public good means goods that are non-rivalrous and non-excludable, and air is consumed by all; no one can prevent an individual from consuming it. (Encyclopaedia Britannica, 2020) Further on, clean air can be described as Global Public Good, (GPG), since it does not know the boarders or countries and no country can stock it behind their boarders. This is why the carbon emissions of one country, may and often do, significantly harm other countries as well. (Woodward and Smith, 2020) Public goods have beneficiaries, the ones who benefit from them; when it comes to clean air, beneficiaries are all those who are breathing it, in Europe the Europeans, citizens of the Member States, or tourists visiting the region.

EU ETS and emission trading in general can be traced to the Coase theorem from 1969 and it is a market-based instrument. Market-based instruments can be appealing to policy makers, since the basic idea is to achieve environmental objectives with the lowest possible cost for the society. (Mariotti, 2016) The Coase theorem created a frame for the pollution control with terms of rights, it assumes that the property rights are assigned with single payments and they do not depend on pollution abatement. (Maarten and Venmans, 2015) Coase theorem has an approach that identifying the rights and making them tradable, private markets will eventually achieve an optimal environmental quality by achieving optimal allocation of resources. (Mariotti, 2016)

Basically, Coase theorem argues that the initial allocation of allowances does not make a difference for the allocations of the allowances in later trading periods. (Abrell, Faye and Zachmann, 2011) As a theory, Coase predicts that the price of a tradable permit should reflect on the market issues related to the marginal costs of emissions abatement (Koch, et. al, 2014). However, Maarten and Venmans (2015) argue that the assumption of the unimportance of the initial allocation of allowances does not hold when a new plant has free allocation of allowances that are dependent on the investments. This would mean that investments in a new industrial plant are not taken into consideration when looked into the effect of initial free allocation.

Now if EU ETS is arguably cost-effective as a scheme; a requirement is that MAC are the same for all the actors in the markets. From a very simple, economic perspective, an answer to a question of economic efficiency and emission reduction is that it is ideal to reduce the emissions to the point where marginal benefits of the reduction equal the marginal costs: *MB = MAC*. In other words, equal willingness to pay across the emitters, ensures equal marginal abatement costs, which ensures the efficient abatement in the market of tradable permits. If the MAC is different between two emitters, the abatement should be shifted towards the one who has lower MAC.

3.1 The polluter pays principle

The polluter pays principle is one aspect to notice in the discussion of emission trading. This concept was first introduced in 1972, by the OECD council. It aims to a situation where polluter is responsible for the emissions produced in the operations, and pays for them, so pays for the harm the emissions are causing. This principle is also part of the Article 191(2) of the EU. It is fairly clear that this principle should be looked into when talking about emission trading since that aims for internalising the cost of pollution. This was defined in 1992 in Rio Declaration on Environment and Development. (Schultén, 2012)

Polluter pays principle has two forms, which have to do with the internalising the cost of pollution. The weak form of the principle prohibits the use of governmental subsidies as a control mechanism, so that the prices actually reflect the real cost of the pollution abatement. The strong form of the principle provides that the governments should make sure that the internalisation of the costs happens. Both of these are aiming for the internalising of the costs, the weak form requires passive actions from the government, and the strong form wants governments to act more aggressively. The internalising of the costs is more about the efficiency of the polluter pays -principle; it assumes that the polluters pay for the pollution because of the economic efficiency. (Schultén, 2012) This can be linked back to the efficiency idea of market-based instruments, such as the EU ETS.

3.2 Justifications for the hypothesis

EU ETS is a market where the polluters pay the same cost for the abatement of emissions. As described above, in theory this leads to efficient abatement of emissions in the market. The logic behind the EU ETS is that when the cap is reduced, the emissions are reducing. This makes it reasonable to assume that while the tradable permits, the allowances, are decreasing, the emissions are also decreasing. This would mean that over the years the EU ETS has caused a reduction of emissions through reduction of allowances. The analysis and discussion chapter 5, discusses the following hypothesis:

H0: *When the number of the allowances is decreased, the emissions are decreasing.*

4. Methodology

This thesis is a quantitative analysis on emissions reductions within stationary installations included in EU ETS and the comparison is made between four Nordic countries, Denmark, Finland, Norway and Sweden. The countries were chosen purely because of the interest of the researcher; the background of living in two of the countries and visits in all of them provided an understanding about the cultural issues and the ambition towards the climate leadership in the Nordics. This sparked the interest towards making a research on the effectivity of the EU ETS in general, but also in these countries; for seeing if the countries have actually reduced emissions in selected sectors. The countries being relatively similar environmentally, economically, politically and socially, provided an opportunity to make a comparison between the countries, which the researcher believed to be an interesting one.

The research methodology used in the research is secondary; the data is not collected by the researcher; it is existing data of emissions. Saunders et al. (2016) describe secondary data something that has been collected for some other purpose. The purpose of the data used in this research, is for the EU to follow the emissions and allowances within the EU ETS from the member states.

In this research the data used is from European Environment Agency. The literature used was collected from various sources and it is secondary. Data used in the analysis is stored in the European Union’s Transaction Log that is collected by the European Environment Agency. Most of the sources used in the analysis of the EU ETS itself comes from the EU’s open sources. EUTL dataset includes data on EU ETS: the emissions and allowances by country, sector and year. The exact date of importing data was 26.05.2020, and it includes the information from the years 2005 to 2019. All the following figures are based on the same dataset. The data tables are provided in the Appendix II.

4.1 Research design

The research design used can be described as correlational research or as descriptive type of research; which means that there is a change in one variable, that leads to a change in another variable, but it is not clear which has caused the other to change. (Saunders et al., 2016) The research describes the relationship of the emissions and the allowances in certain countries and within the specific sectors, as well as the disturbances in the data, but it does not try to explain the causal factors of them. The research recognises trends and patterns in the data, but it does not seek for causal interpretation. This is because the variables are affected by multiple factors, not only the distribution of allowances is a reason to emissions reduction, the issue is more complex as described in the chapter 2.

The descriptive element comes also from the qualitative side of the study; large part of it is focused on the national policies of the chosen countries, and the effect of those is not measured, rather looked into in order to understand the complete picture of the climate policies used in these countries, beside the EU ETS.

4.2 Data Collection Strategy

The data was collected from the EU's since the researcher wanted to use the data delivered by the Member States and the participating installations to the EU. The database was open for the public and so made the collection possible through the site. The researcher downloaded the data on emissions and on both, freely allocated and auctioned allowances for the sectors of *all stationary installations, combustion of fuels* and *refining of mineral oil* through the years 2005-2019.

Firstly, the data on all the stationary installations was selected since the researcher believed it to be important in order to see the complete picture on the development in the emissions and allowances over the 14 years. Secondly, researcher looked through the data in this source to see the sectors in which all of the countries had operations. This was important for the aim of the research; one could argue that to compare sector specific differences among the countries requires the countries to have emissions on the chosen sectors. This is why, *all the stationary installations, combustion of fuels* and *refining of mineral oil* were selected; all the four countries had emissions in them. The two sectors looked into more specifically, *combustion of fuels* and *refining of mineral oil* are some of the highest emitting sectors in the trading scheme. The researcher chose only two sectors to deliver more specific comparison, so that the research would be limited and not uncontrollably wide. The selected sectors are also economically and environmentally relevant in the countries.

4.3 Data Analysis Strategy

After finding the research topic, the research questions were formed. Since EU ETS is relatively complex and massive policy method used by the EU, defining the structure, objective and other issues within the trading scheme were crucial part of the research. Besides the EU ETS, the Nordic countries and their used climate policies were explored and defined, so that one can see what other policies the countries are using and to what goal they are aiming for besides being part of the EU ETS. The economic structure and other crucial elements from the pollution point of view in the countries was also seen as an important part of the research.

Being a quantitative study, the data was used to see the quantitative change in the amount of emissions, and in the number of allowances used within the countries over the 14 years. The graphs formed in the data analysis are used to illustrate the picture of the development. The graphs are made to test how the data actually answers to the hypotheses about the functionality of the EU ETS and the emissions reduction in the specific sectors and countries. The data collected was not modified.

5. Analysis and discussion

In this chapter the emissions and allowances from specific sectors within stationary installations are analysed in the four countries over the 14 years of the EU ETS. After presenting the results in graphs, they are discussed thoroughly.

5.1 Emissions from stationary installations

The analysis of the Nordic emissions within the EU ETS framework begins by looking into all the emissions part of stationary installations within the Nordics. Stationary installations refer to operations on following sectors as presented in Table 3 in chapter 2.2.1: *combustion of fuels, refineries, production of iron and steel, production of coke, production of metal ore, production or processing of metals, production of cement and lime, manufacture of non-metallic minerals, production of pulp and paper, production of chemicals* and *other activities* such as *development of carbon capture.*

Figure 4 describes the verified emissions of all stationary installations in Denmark, Finland, Norway and Sweden. In all of the figures the verified emissions are in tonne/CO_2.

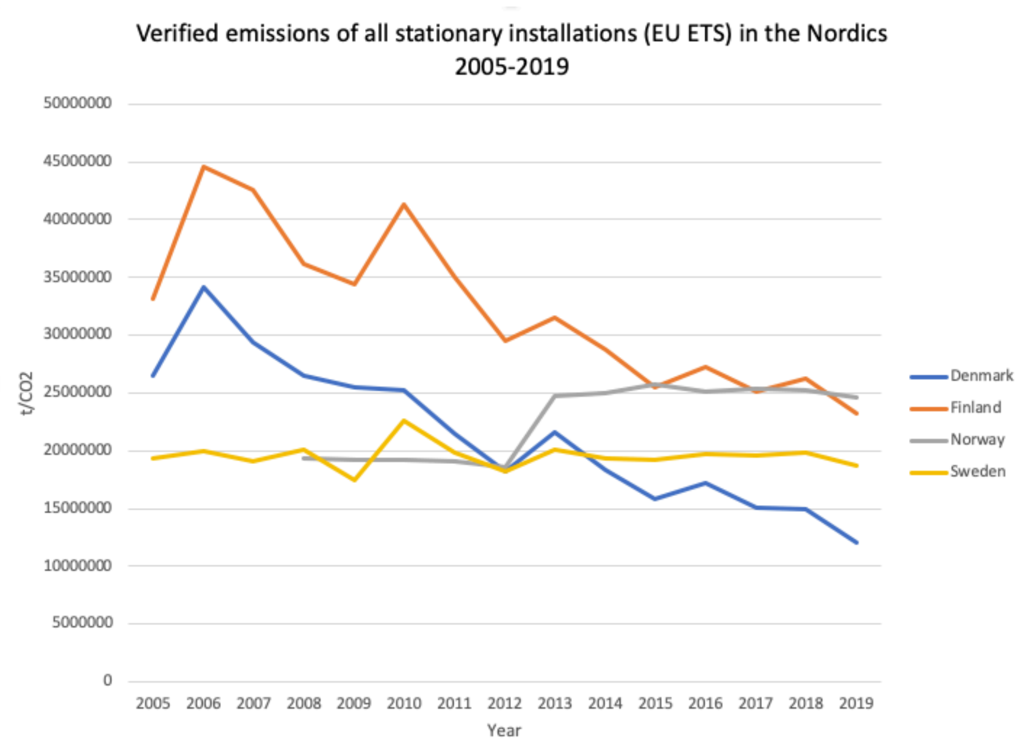


Figure 4: The verified emissions of stationary installations in the Nordics 2005-2019.

In the figure 4 the highest value of verified emissions is approximately 45 million tonnes of CO_2, in Finland in 2006, and the lowest is approximately 12 million tonnes in Denmark in 2019.

Certain abnormalities can be identified in the figure. First of all, Norway joined the EU ETS in 2008, which explains why the emission trend from Norway begins at 2008, when the others have been part of the trading scheme since the beginning: 2005. Norway is also the only country where the emissions have clearly increased since 2012, when Finland and Denmark have downwards sloping curves. However, Sweden's emissions cannot truly be said having a downward sloping trend, since the curve is fairly stable.

In 2013 all the four countries had an increase in their stationary emissions. The overall data on the stationary installations itself does not provide information on the change and one should be careful when reading into the results. Aviation was included in the EU ETS on 2013, but since it does not belong to the stationary installations data, it is not included in this figure. When looked into the policy changes in the trading scheme in 2012-2013, one notices that the aviation is not the only sectoral expansion that happened in 2013; production of aluminium, some chemical productions, and the production of nitrous oxide and perfluorocarbons were also included into the trading scheme. (Seppänen, Magnusson, Yliheljo and Ollikainen, 2015) In Norway this led to an increase in emissions because of production of aluminium, and production or processing of ferrous metals: this is shown in the figure 5. It is important to notice that other Nordic countries do not have as high production in these sectors as Norway but the expansion of the ETS to these sectors affected the slight increase in emissions in 2013 in other countries as well. After these sectors were included into the EU ETS, the amount of emissions in these sectors in Norway has stayed fairly stable as can be seen from the figure 4 and figure 5.

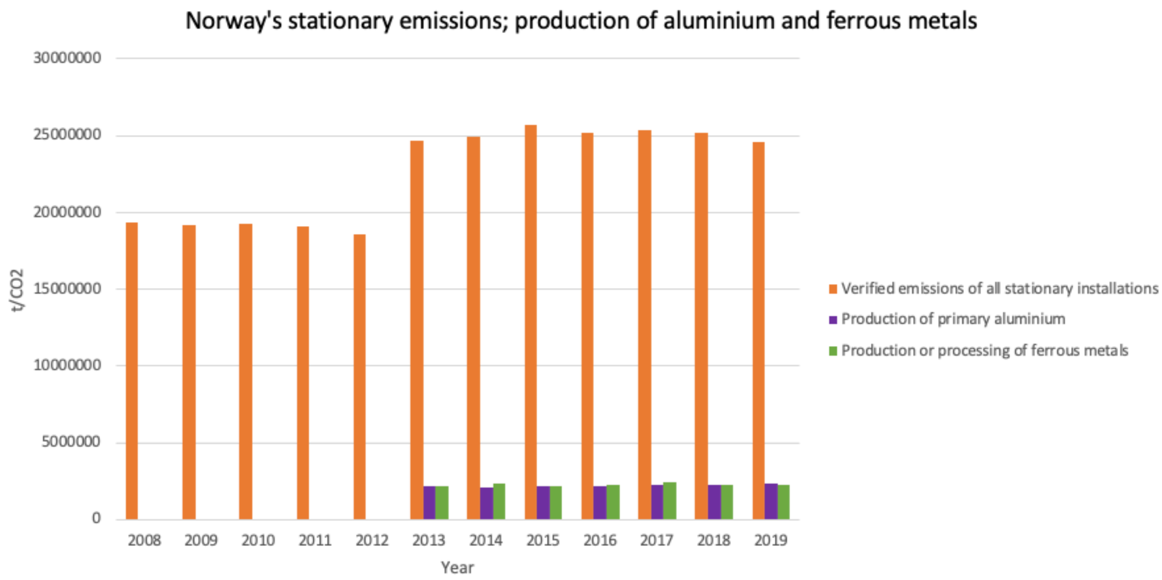


Figure 5: Norway's verified emissions of all stationary installations, production of aluminium and ferrous metals 2013-2019.

Norway and Sweden are the ones out of the four Nordic countries where the emissions trends do not follow the same trend than in Denmark and in Finland. This could indicate that the trading scheme is not working in these countries as it is meant to be working; as described in the beginning of this research, the idea of the trading scheme is that when the allowances are decreasing, the emissions should be decreasing as well. In Norway and Sweden, the allowances, nor emissions have not significantly decreased over the 14 years of the trading scheme. The figure 4 also gives an idea that Finland and Denmark have been reducing the emissions of stationary installations relatively steady over the 14 years of the trading scheme.

5.1.1 Emissions and allocated allowances

The EU ETS is defined by the EU's directive 2003/87/EC. The GHG emissions are listed in the Appendix I. The allowances are either auctioned or given out freely as described in the chapter 2.2.1 of this research. In this chapter the emissions and the allocated allowances are looked into separately in each of the countries. Healy, Graichen, Graichen, Nissen, Gores and Siemons, (2019) argue that the supply for free allocations of allowances was 3.8% lower in 2018, than it was in 2017. This reflects on the method of supply of allowances to existing installations reducing yearly.

Denmark

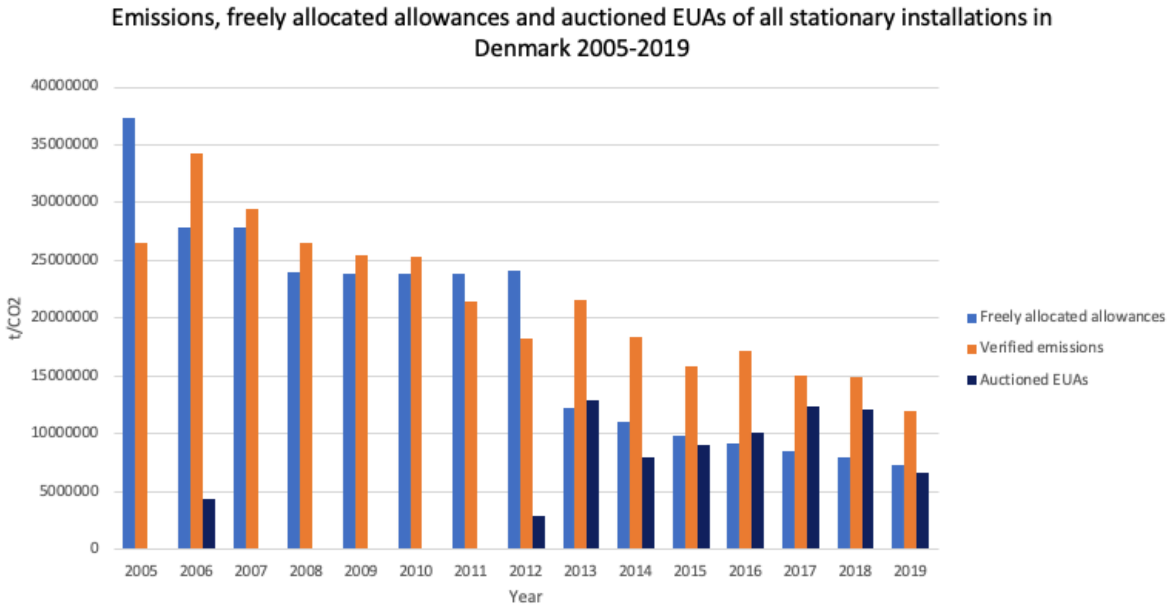


Figure 6: Danish emissions, freely allocated allowances and auctioned 2005-2019.

In Denmark the emissions from stationary installations have been decreasing quite steadily since 2006. Based on the data, in 2013 the amount of freely allocated allowances decreased almost by half. This can be a result of EU's decision to oblige the electricity sector to buy all the allowances; in this figure the change can be seen since the 2013 is the first year when allowances were truly auctioned in Denmark. Since then the allowances being auctioned and given out freely have been in quite equal amounts, with the exception of 2017 and 2018 when higher amount of EUAs were auctioned instead of receiving for free.

More concretely one can see the development of both, the emissions and the allowances of the Danish stationary installations, in the figure 7.

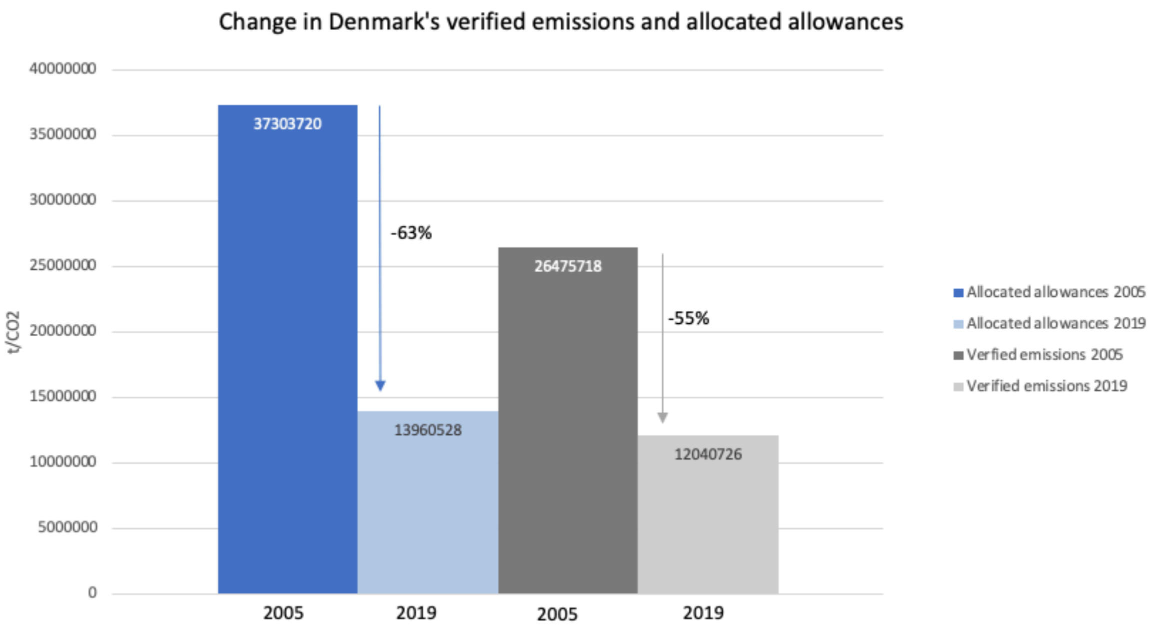


Figure 7: Change in Denmark's verified emissions and allocated allowances.

In this figure the difference of both, the emissions and allocated allowances (freely allocated and auctioned) is presented in 2005 and 2019. As can be seen, the allowances decreased over the 14 years 63%, the number of allowances worth of 37 million tonnes of CO_2 decreased to approximately 14 million tonnes of CO_2. Similarly, verified emissions decreased 55% from 26 million tonnes to 12 million tonnes. From this development one could say that the EU ETS has worked overall in the stationary installations in Denmark as it should work in theory. However, in 2019, there has been an oversupply of allowances in Denmark.

Relatively good progress in the Danish emissions could be linked to the country's ambitious climate policies described in the chapter 2.4.3 and the use of subsidies in the transition to the renewables. Denmark is keen on development of innovations for the sustainable future and has focused on increasing the share of renewables in the energy markets. As researched in the chapter 2.4.3, only one of the three highly emitting industries in Denmark, energy, is included in the EU ETS, and agriculture and transportation are not. Energy is an industry where the transition to renewables highly affects it and Denmark has succeeded in reducing the emissions in the stationary installations over the 14 years. Based on the figure 7, one can see that EU ETS has successfully supported the emission reduction in the stationary installations.

Finland

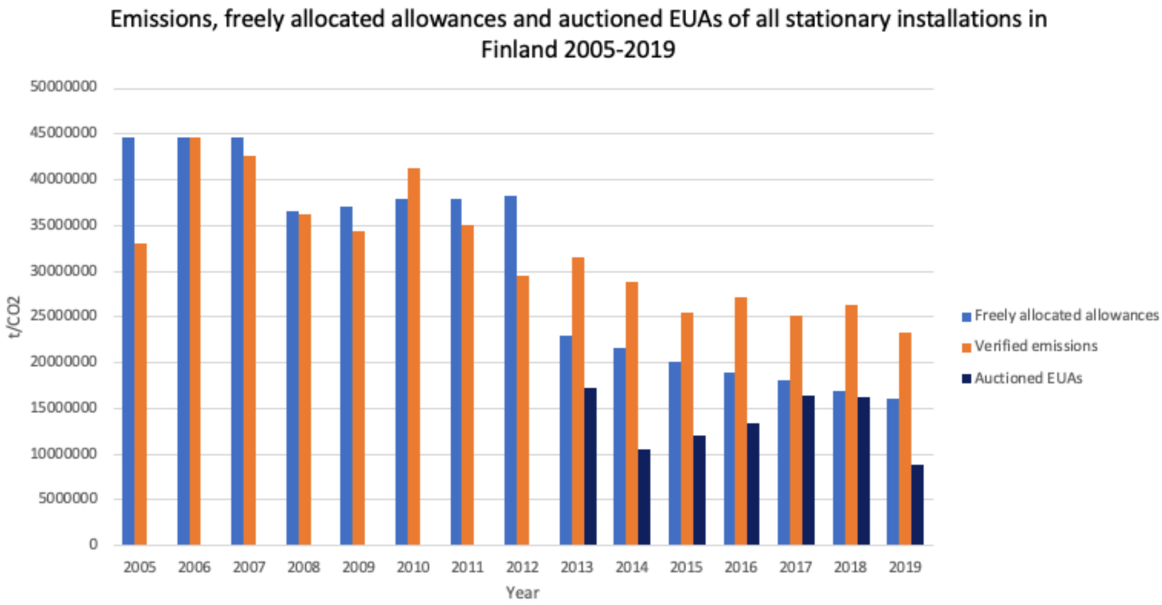


Figure 8: Finnish emissions, freely allocated allowances and auctioned allowances 2005-2019.

As was seen already in the figure 4, Finland was the highest emitting country of the four in the stationary installations sectors in 2005, and mostly throughout all the three phases of the EU ETS. As was seen in the figure 4, the emissions of the stationary installations in Finland went under Norway's in 2018 and were just barely under 25 million tonnes in 2019. Finland's stationary emissions have developed with a similar trend than Denmark's. The sectors in the country did not auctioned any of the EUAs, until 2013. After that EUAs have been auctioned, but not as many as have been received freely. In 2018 the sectors auctioned almost as many EUAs as they received for free, but then again in 2019 less allowances were auctioned than received freely.

More concretely one can see the development of both, the emissions and the allowances of the Finnish stationary installations, in the figure 9.

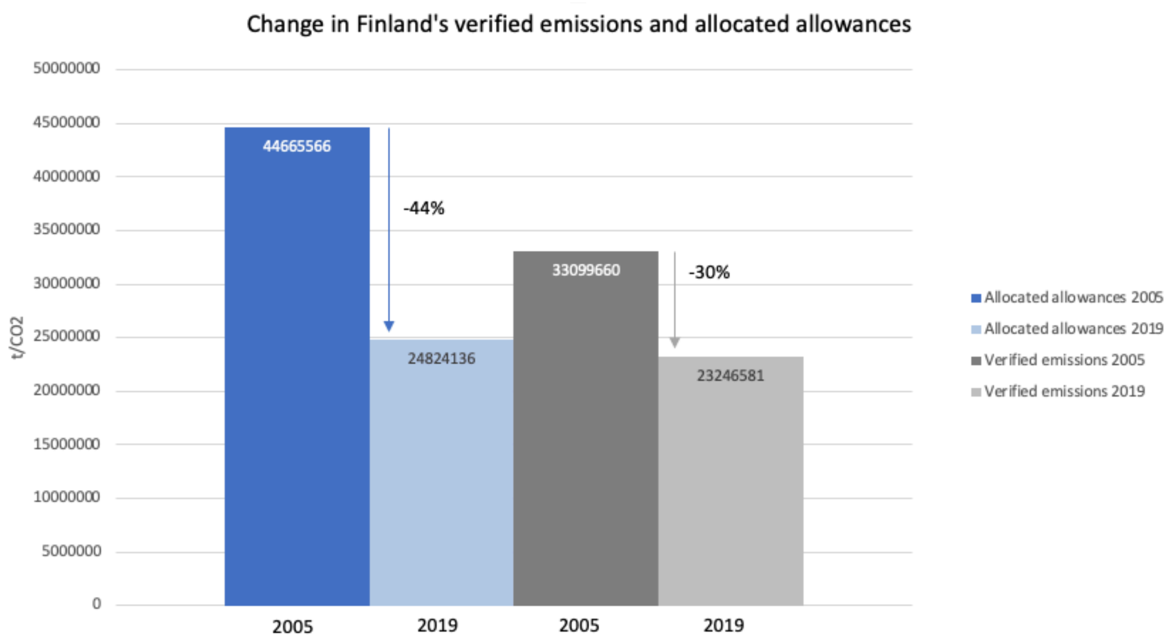


Figure 9: Change in Finland's verified emissions and allocated allowances.

In this figure the difference of both, the emissions and allocated allowances (freely allocated and auctioned) is presented in 2005 and 2019. As can be seen, the allowances decreased over the 14 years 44%, the number of allowances worth of almost 45 million tonnes of CO_2 decreased to approximately 25 million tonnes of CO_2. Similarly, verified emissions decreased 30% from 33 million tonnes to 23 million tonnes. The fall is not as steep as Denmark's, but one can see that in Finland the EU ETS has worked as it was meant to work in theory; when the amount of allowances is decreased, the emissions are decreased. However, in 2019, there has been an oversupply of allowances in Finland, similarly to Denmark.

Now, if these figures are compared with Denmark's, one can see that the amount of emissions in 2019 is almost as high as the amount of emissions was in Denmark in 2005, before the EU ETS. In Denmark that figure was 26 million tonnes, and in Finland the number is 23 million tonnes in 2019. Reasons for this can be looked for from the economic structure of the countries. Finland is highly dependent on energy intensive industries, as described in the chapter 2.4.4, and the use of fossil fuels is still high. Part of the stationary installations are the forest industries, such as paper and pulp production, which is an important industry economically in Finland, but also both are emission intensive, since they affect the carbon capture at the same time when they produce emissions.

Finland has been slower in transition to renewable energy than other Nordics and one form of energy production that has been under controversy discussions for many years, is the production of peat, which is described as slowly renewable fuel by the UN. Using peat as an energy source also destroys carbon captive areas, such as mires and forests. (Yle, 2019) Finland is the only country of the four Nordic countries who is using peat as an energy source. Even though the country has achieved reductions in the stationary installations, the amount of emissions was still quite high in 2019. However, as in Denmark, the EU ETS has supported the emissions reduction within these sectors, and this could indicate that the reductions can be further achieved in the Phase IV of EU ETS.

Norway

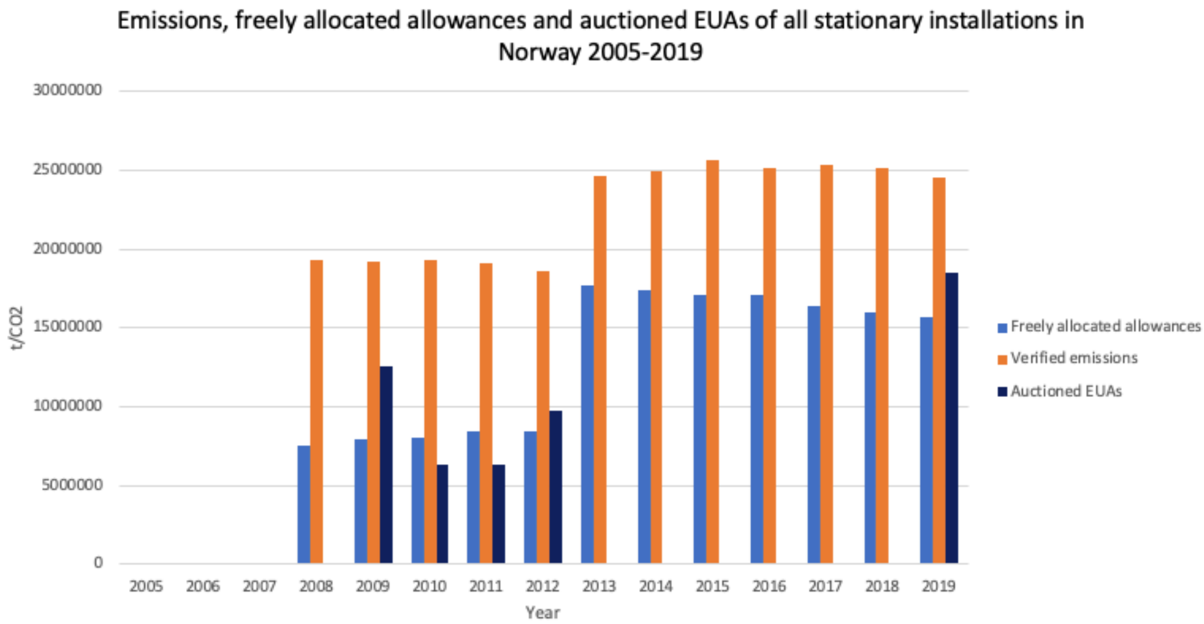


Figure 10: Norwegian emissions, freely allocated allowances and auctioned allowances 2005-2019.

Norway's emission trend with stationary installations is very different than in Denmark or Finland. The figure 10 is very interesting compared to the same figure in Denmark and Finland and it shows that the trading scheme has not been used in the same way in Norway than in the two countries. Neither, the emissions nor the allowances have reduced in Norway during the 14 years of the trading scheme. Reason for the 2013 increase was looked in the beginning of the chapter 5 and other abnormalities in the data should be looked into here.

One interesting abnormality in this figure is that the auctioned allowances are used in 2009, 2010, 2011 and 2012, and then suddenly again in 2019. When the two other countries had a high increase in auctioned allowances in 2013, that could be assumed to be at least partly because of the change in EU's policy to make the power sector trade all their allowances, this seems not to affect Norway. A logic explanation would be that it is because of the electricity used in Norway is mainly renewable hydropower, as described in the chapter 2.4.5. Rapid increase in auctioned allowances in 2019 is an interesting feature of this figure. Since no new sectors were included in the scheme during the years 2018 and 2019, reason for the increase in auction could be anything, but one could assume that sudden interest in the auctioning is in the reform of the scheme; when the MSR was installed, 2019 was the first year since the beginning of EU ETS when the price of tonne of CO_2 was almost €30, as described in this research in chapter 2.2.4.

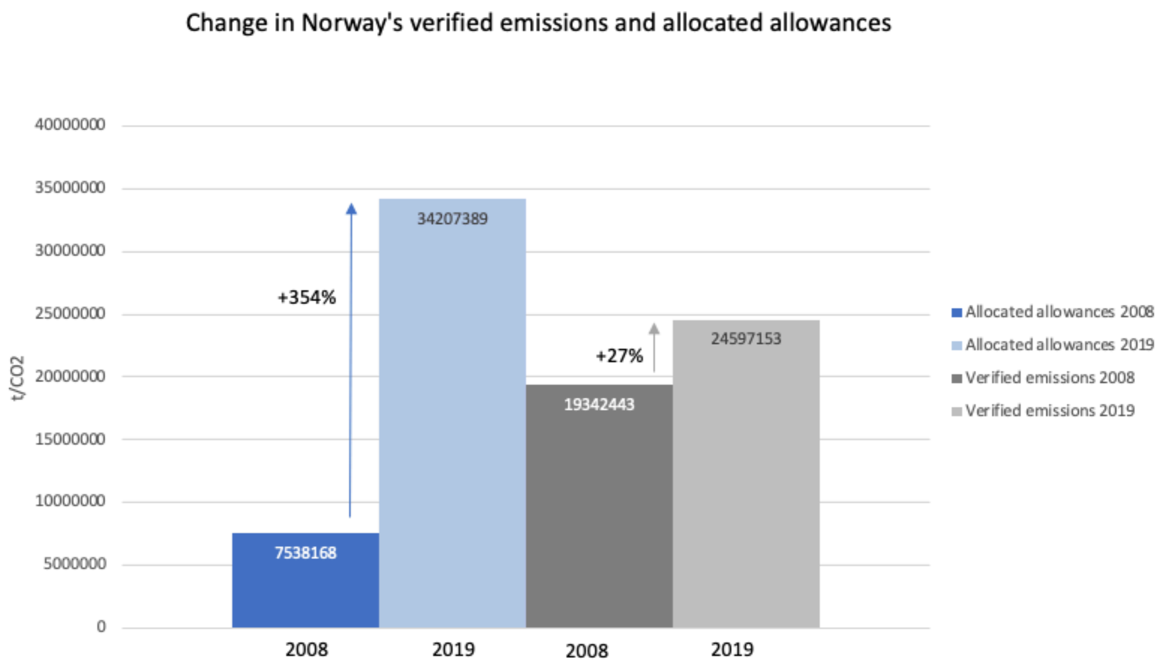


Figure 11: Change in Norway's verified emissions and allocated allowances.

In this figure 11 the difference of both, the emissions and allocated allowances (freely allocated and auctioned) is presented in 2005 and 2019. As can be seen, the allowances increased over the 14 years 354%, the number of allowances worth of only 7 million tonnes of CO_2 increased to approximately 34 million tonnes of CO_2. Similarly, verified emissions increased 27% from 19 million tonnes to approximately 25 million tonnes. The development of the emissions and allowances has moved to opposite directions in Norway compared to Denmark and Finland.

The expansion of the sectors within the trading scheme has led to a need of higher amount of allowances, and also the verified emissions within stationary installations has increased. Even if this seems quite an extreme increase as presented separately, one should remember that in reality the amount of emissions in 2019 has been approximately on a same level than in Finland. What is interesting, is that the number of allowances is worth 10 million tonnes of CO_2 more than in Finland, and 20 million tonnes of CO_2 more than in Denmark. Part of the reason to this is in the very high increase in auctioned allowances in 2019. Norway also had an oversupply of allowances still in 2019.

Sweden

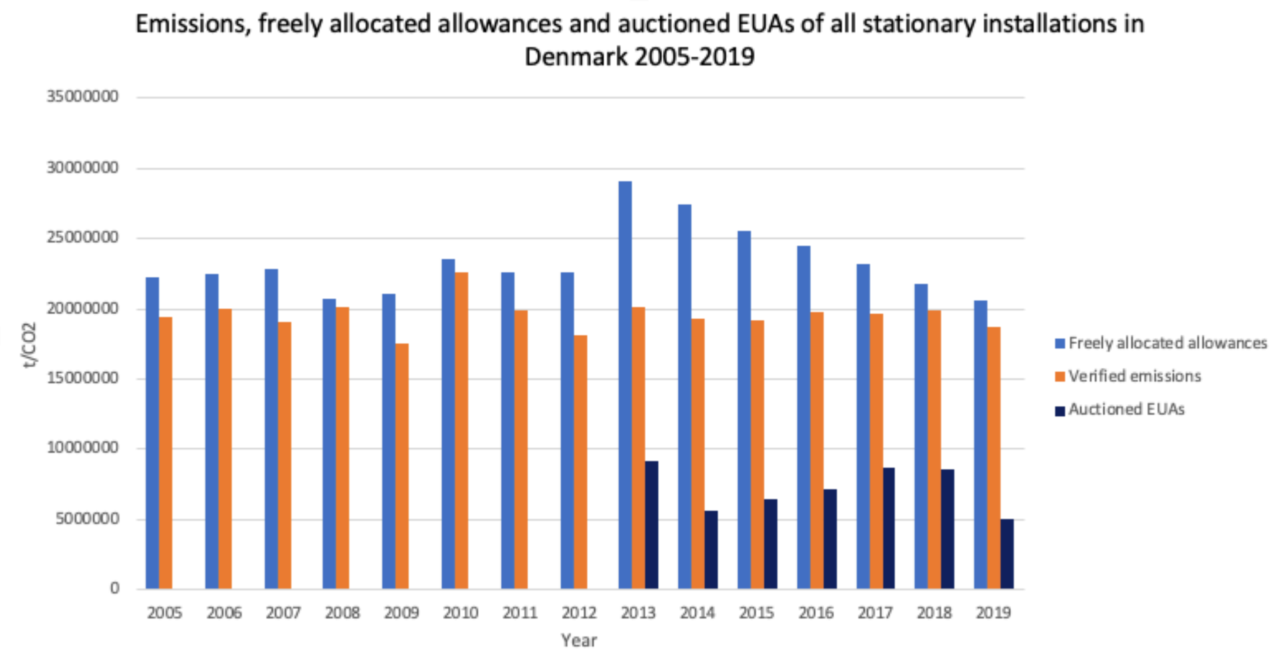


Figure 12: Swedish emissions and freely allocated allowances 2005-2019. Data from EEA, 2020.

In Sweden the emissions of stationary installations have been the most stable through the 14 years of EU ETS. Based on the figure 4 and figure 12, it seems that no drastic changes in the Swedish emissions or allowances have happened, after the increase in 2010. Since 2010, the country has managed to decrease the emissions back to similar levels they were in the beginning of the trading scheme. The amount of allowances has changed more than the emissions in Sweden. Sweden has used auctioning since 2013 like Denmark and Finland, but in fairly low amounts. The development of the amount of emissions and allowances in Sweden can be seen in figure 13.

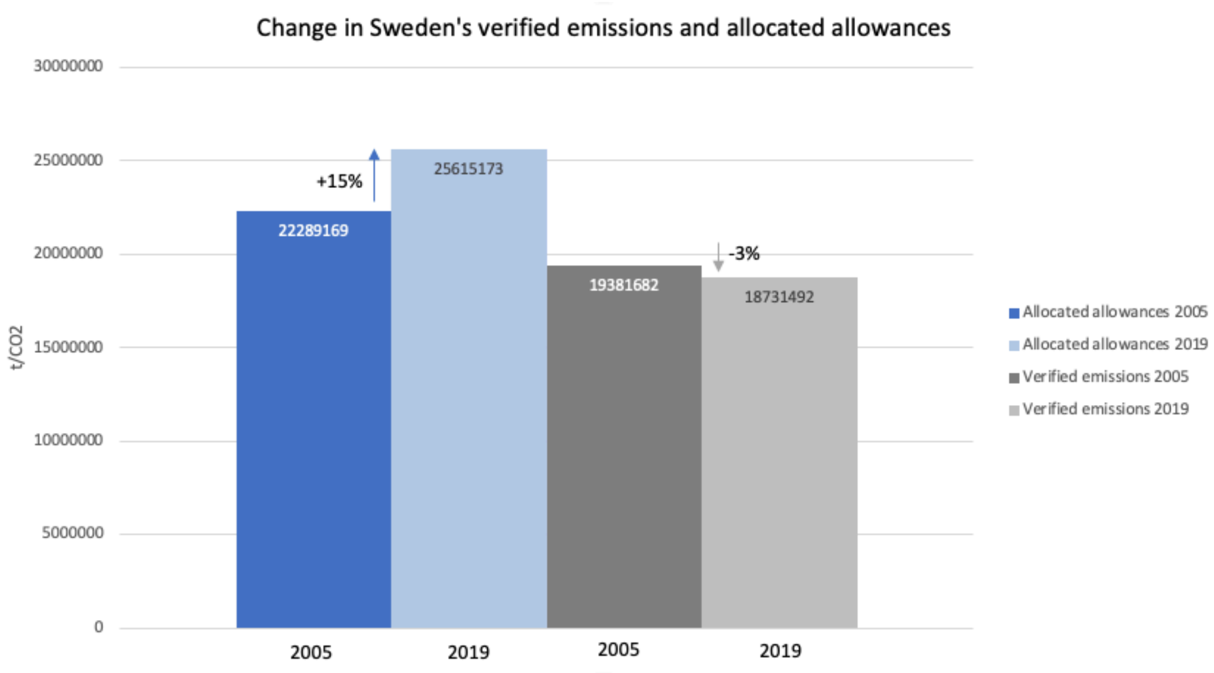


Figure 13: Change in Sweden's verified emissions and allocated allowances.

In this figure the difference of both, the emissions and allocated allowances (freely allocated and auctioned) is presented in 2005 and 2019. As can be seen, the allowances increased over the 14 years 15%, the number of allowances worth of 22 million tonnes of CO_2 increased to approximately 26 million tonnes of CO_2. Verified emissions decreased 3% from 19 million tonnes to 18 million tonnes. This figure also confirms that Sweden is very different compared to the other Nordic countries in the emissions and allowance development. The allowances have increased, and the emissions have decreased a very modest amount. As seen in the figure 4, since the emissions curve is fairly stable over the 14 years; this change is not very significant, and one would not be able to say that the difference is because of the EU ETS. One should notice that the emissions in Sweden have been fairly low over the 14 years in comparison with other countries. As other countries, Sweden also had an oversupply of allowances in 2019, and the difference between the emissions and allowances is around 7 million tonnes.

5.2 Differences between the countries in chosen sectors

This part of the analysis is to look into the differences between the countries more in detail specifically in two chosen sectors. The specific sectors are *combustion of fuels* and *refining of mineral oil.* These sectors were chosen because all the four countries have economic activities on the sectors and the sectors are highly energy intensive. In both of the sectors the allowances are freely received, no data on auctioned allowances existed in these sectors. This was recognised after the data was chosen and analysed.

5.2.1 Combustion of fuels

Combustion of fuels is the highest emitting stationary sector in the EU ETS. In total emissions from this sector accounted 65% of the emissions in the EU ETS in 2018. Emissions from the sectors are all based on the consumption of fossil fuels, and the amount of emissions in this sector significantly changes when the fuels are changed to renewables. Healy, et al., 2019 argue that in this sector the installations had to mainly auction their allowances, but based on the data, this was not the case in the Nordics, where only information on free allowances in the sector was found in the European Environment Agency's source. Combustion of fuels has also been the main driver in emissions reduction during the Phase III, and this is a sector that is significantly affected by changes in energy mix, the transition to renewables. (Healy, et al., 2019)

The differences on emission reduction of the sector amongst the four countries are looked into in the figure 14.

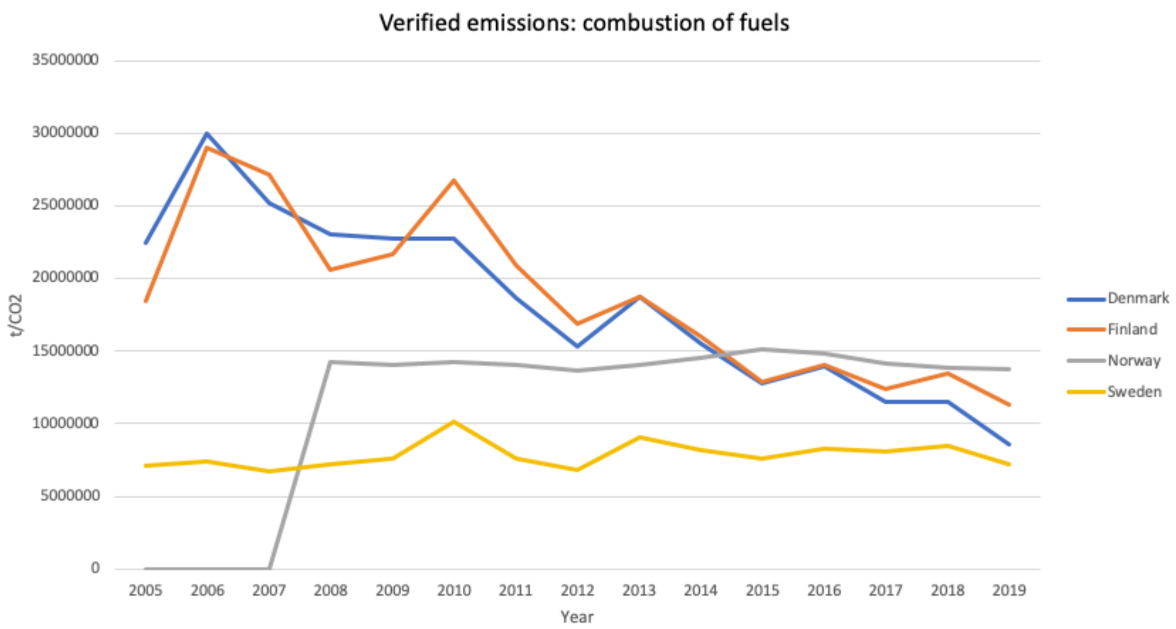


Figure 14: Verified emissions of combustion of fuels in the Nordics.

This figure does not show significant differences compared to the emissions development of all the stationary installations seen in previous chapters. The development of the curves is very similar than among all the stationary sectors. Most interesting difference is the curve of Denmark and Finland, since within this sector the emissions seem to be closer than overall, both are decreasing over the 14 years. Norway and Sweden have fairly stable curves within this sector.

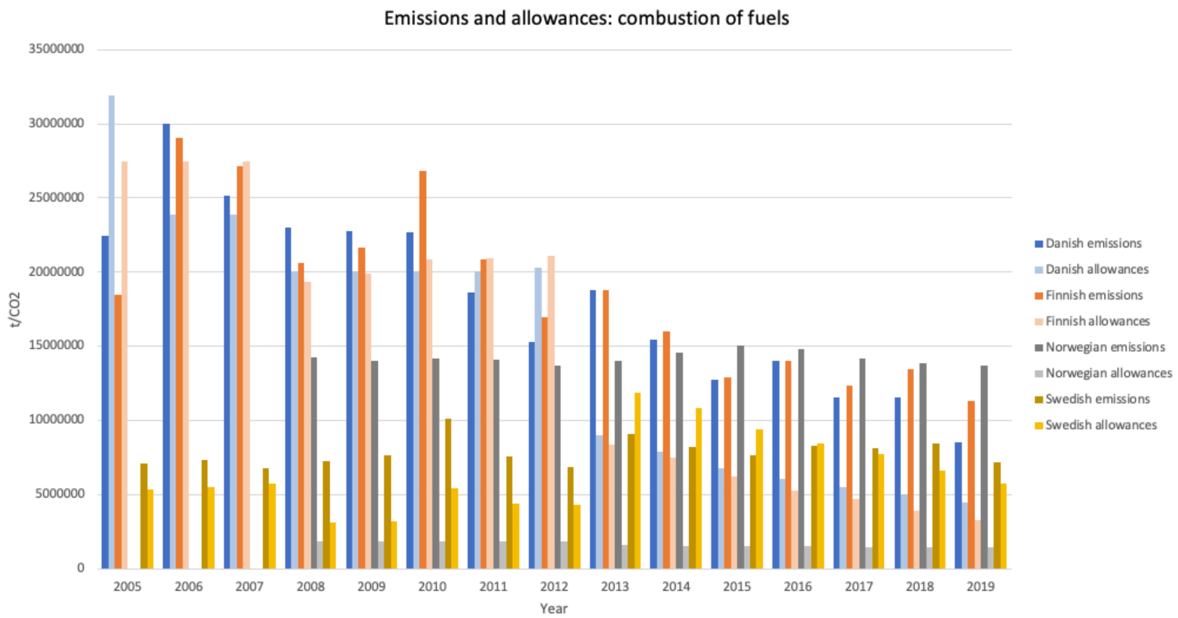


Figure 15: Verified emissions and allocated allowances of combustion of fuels in the Nordics.

When looked into the emissions and allowances more in detail, one can see that the difference in number of allowances is quite notable between the countries. For example, Denmark and Finland started in the beginning with high emissions but also with high number of allowances, when Sweden has stayed quite stable in both. Then again Norway's emissions within the sector have stayed similar throughout the years, as well as the number of allowances. The peculiar difference with Norway is, that the number of allowances has stayed very low, and the emissions have not changed, but stayed a lot higher than the amount of allowances. This might be because the data did not provide information on auctioned allowances. Norway has been the highest emitting country in the sector from the four countries since 2015. Similar comparison would be interesting to make e.g. in 2030 to see if Norway's emissions would have started to decrease.

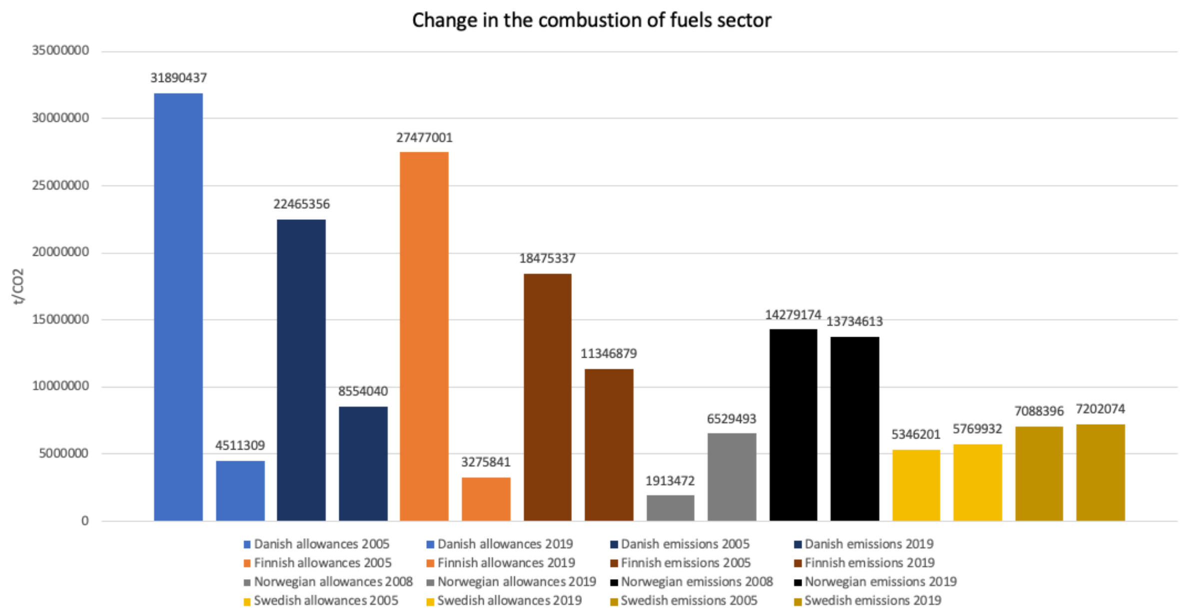


Figure 16: Change compared between the countries.

Figure 16 compares the situation among the countries in 2005, or in Norway's case 2008, and 2019. This figure strengthens the analysis of Denmark and Finland decreasing the emissions as well as the number of allowances, although emissions have been still higher in 2019 than the number of allowances; this is the case for all the four countries, so this sector has an oversupply of emissions. Norway and Sweden have both increased the amount of allowances, but the emissions have not truly decreased.

5.2.2 Refining of mineral oil

Refining of mineral oil is a sector with high energy intensity. Based on the data, this sector is however less emitting than the combustion of fuels sector, in 2018 refineries were the fourth highest emitting sector in EU ETS. (Healy et al., 2019) This is also a sector where no allowances are auctioned, or the data was not available in the used source.

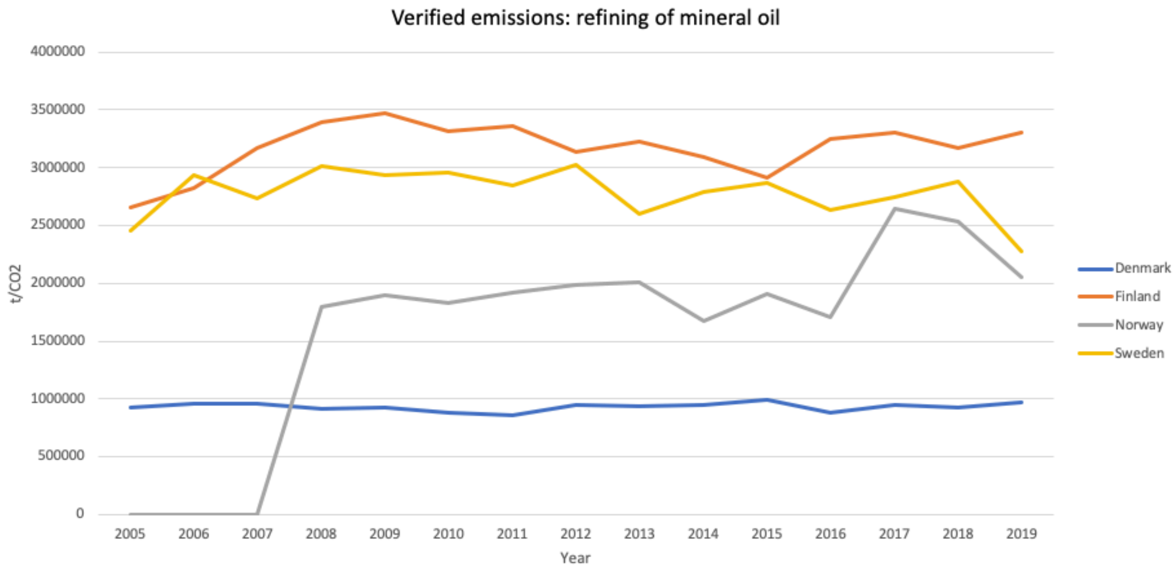


Figure 17: Verified emissions of refining of mineral oil in the Nordics

Figure 17 indicates that the emissions in the sector in any of the countries have not decreased a lot. Denmark has the most stable emissions on the sector of the four, around 10 million tonnes annually. In 2018, both Norway and Sweden have reduced emissions rapidly and the trend continues in 2019. Finland has the highest amount of emissions in the sector.

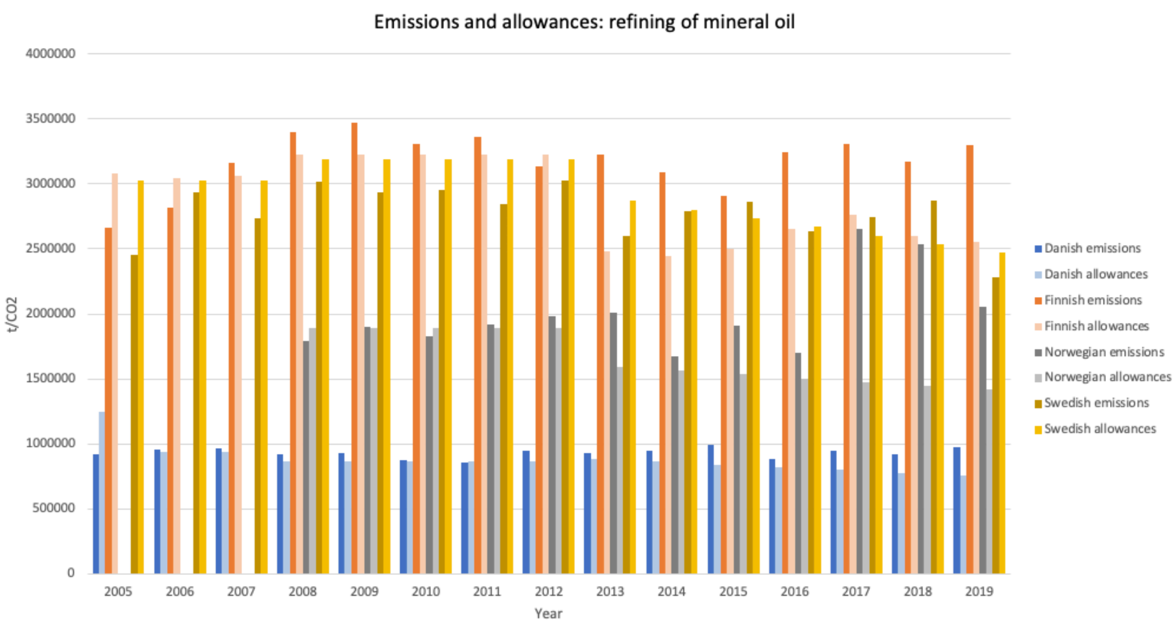


Figure 18: Verified emissions and allocated allowances of refining mineral oil in the Nordics

The figure 18 compares the emissions and allowances in the countries throughout the 14 years. In this sector Finland has been the highest emitting country throughout the years, only in 2006

Sweden had higher emissions in the sector. In Finland the trend seems to be that first too many allowances were given out, and later on the number of the allowances has been decreased but this has not affected the emissions. In Sweden, the trend seems to be that the number of the allowances has been higher than the emissions until for most of the times, except for years 2015, 2017 and 2018. These are the only years when emissions have surpassed the number of allowances.

In Norway the amounts in both were close to each other until 2016, when the amount of emissions suddenly increased but the number of allowances did not change. This change is a peculiar one, since the sudden increase in emissions was almost 10 million tonnes of CO_2. The emissions decreased again in 2018 and they kept on decreasing in 2019, as also in Sweden. This indicates that the installations in the sector increased their activities in 2016 and 2017.

Denmark is the lowest emitting country of the four in the sector. When looked into the trend, one can see that the emissions and allowances are also quite close to each other within the sector and changes are minimal. This is interesting especially in the beginning of the trading scheme, since both, Finland and Sweden have been very high in emissions during that time, so the reasons to the difference could be looked into from the economic factors of the countries.

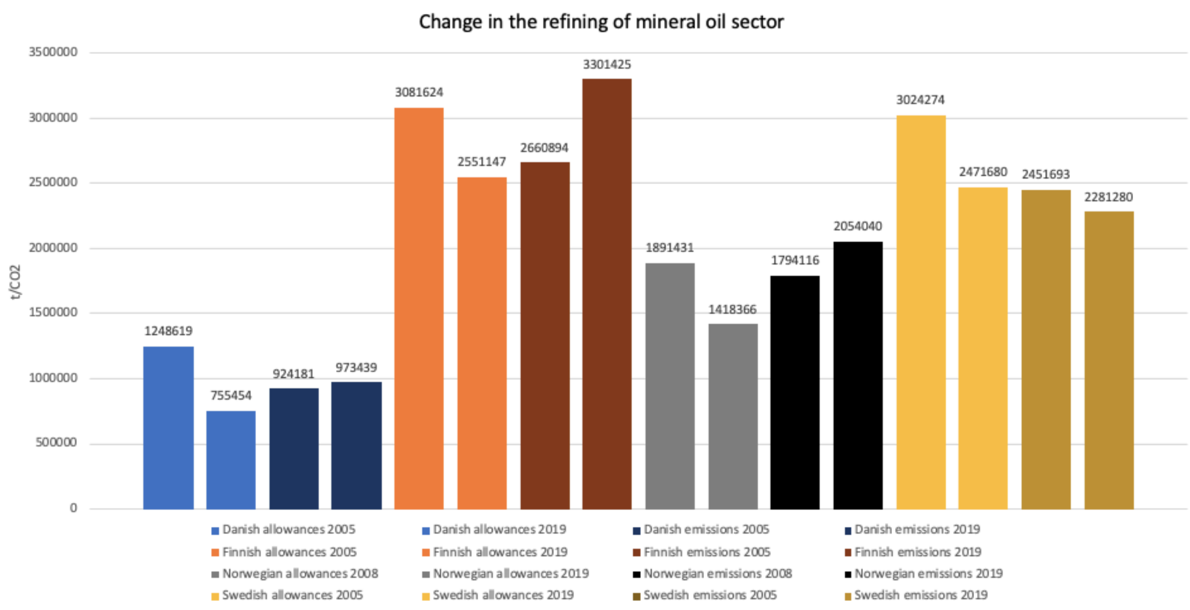


Figure 19: Change compared between the countries.

Figure 19 compares the situation among the countries in 2005, or in Norway's case 2008, and 2019. From this figure one can see the differences among the countries. The changes with the emissions and with the allowances are very little, especially if compared with the combustion of fuel sector and how the figure 16 shows the differences in that sector. The differences among the sectors indicate that the sector level differences in the EU ETS can be very high, and depending on numerous factors, countries are successful and unsuccessful in decreasing the emissions in different sectors. In this sector the Sweden is the only one who has an oversupply of allowances, the others have higher amount of emissions than they have allowances for.

6. Conclusion

The EU ETS has been important in setting a trend for carbon trading over the 14 years of its existence. Whether it has been important for the Nordics and helped the countries in achieving their emissions goals, is an interesting question. It is true that the EU ETS has affected the emissions reduction to some extent, especially in certain sectors. The market differences affect the situation overall and create differences in reductions among the countries in different sectors. However, some of the problematic sectors are the non-ETS sectors, such as agriculture, buildings, transportation and LULUCF, which are typically emission intensive in the Nordic region.

The EU ETS is partly successful, and cost-effective policy, and the theoretical strength of it is that is does equalize the marginal abatement costs among the actors. This is jeopardized when the countries use other instruments, in the case of Nordics direct and indirect subsidies, such as feed-in tariffs and trade with green certificates. The EU ETS has been reformed by extending the carbon trading to new sectors, with the MSR reform, and the Union has changed the logic how the free allowances are given out to the industries. All of these have been important changes, but especially the latter was an improvement so that the system then would avoid the passing of the costs to the consumers even when they got the allowances for free.

For EU, ETS is a flagship policy in the climate change mitigation, and even though it has been criticised over the years, it is the single greatest instrument in the EU's battle with emissions. One of the clear challenges of the ETS is that only 45% of the emissions are covered by the scheme, other 55% of the emissions are fought with other mechanisms, such as Effort Sharing Targets. In 2020, the sectors covered by ETS have reduced their emissions by 21% compared to 2005. No indicators exist about EU expanding the ETS to cover more sectors; the new climate policy, Green Deal, sets methods and targets for the reduction within the ETS, and in non-ETS sectors. (European Commission, 2020b)

Table 5: Short answers to the research questions

Are there clear differences between sectors in the emission reductions over the three phases of EU ETS in the four Nordic countries?	Yes.
What are the main differences within the emission reductions in the stationary installations over the 3 phases of EU ETS within these countries?	Denmark and Finland seem to have a trend that the countries should have, based on the theory behind ETS. The two countries have reduced emissions over the 14 years over all from stationary installations. Sweden has not really reduced or increased the emissions in the stationary installations, and Norway's emissions have increased.
Which country has reduced emissions most effectively in the chosen sectors of combustion of fuels and refining of mineral oil?	When it comes to all the stationary installations, Denmark has reduced the emissions most, 55%. It is also clear that Denmark has reduced highest amount of emissions in the combustion of fuels sector, in 2019 Denmark emitted almost 15 million tonnes less than in 2005. In refining of mineral oil, only Sweden has reduced emissions in the sector over the 15 years.
Is the trend similar in the number of allowances than in the amount of emissions?	Partly. Based on the analysis of the two sectors and all the stationary installations, the trend seems to not to always be the same than with the emissions.
What are the national policies used in these countries that affect the reductions besides the EU ETS?	The countries have various policies affecting the emissions reduction, mainly they use national indirect and direct subsidies in supporting the transition to renewable industries, such as carbon tax and feed-in tariffs.

The analysis of all stationary installations, combustion of fuels and refining of mineral oil, showed that the EU ETS is not always working as it should. Substantial differences in the amount of emissions and allowances existed in these sectors among the countries, and often the industries had a surplus of allowances, or they had very low amount of allowances compared to the emissions. It seems that EU ETS is working in Denmark and Finland with the stationary installations as it has been planned to work. Norway and Sweden are very different within the comparison and it would be interesting to look into this difference more in detail. The most significant difference in the figure is that when Denmark and Finland have decreased emissions over the three Phases of the trading scheme, Sweden has had fairly stable emissions and Norway's emissions have increased. Finland was the highest emitting country for 13 years out of the 14 looked into, in 2019 Norway had higher emissions in the stationary installations.

Based on this analysis, the hypothesis: *When the number of the allowances is decreased, the emissions are decreasing* is not completely true. The differences among the sectors indicate that the sector level differences in the EU ETS can be very high and they depend on numerous factors; the importance of a sector to the country, costs in decreasing the emissions, etc.

It seems to be true that the climate goals are difficult to achieve with this rate of reductions. The investigated industries are the highest emitting and the fourth highest emitting sectors of the EU ETS, and the emissions trend among them is not completely downward shaping curve. However, the Nordics are proved to be relatively ambitious with their climate policies, and the moral in the matter is relatively high among the countries. The Nordics are not very high in emissions in comparison with other countries globally or within the region, but the emissions per capita are some of the highest among the OECD countries. The Nordics could shape their national policies so that they would not be overlapping with the ETS, but the strong cooperation within the region and the ambition on research and development in sustainable technologies, are promising factors shaping the future of the climate cooperation and goals in the future.

6.1 Recommendations and limitations:

This research paints a picture of the past 14 years in specific emission and energy intensive industries in four of the Nordic countries. The research has a limitation of the data missing from the last year of the Phase III, but the 14 years provide relatively good information of the emissions development over the three Phases of the EU ETS. The data source did not provide data on auctioned allowances in either of the chosen sectors, so the analysis on the development in auctioning could not be made. Information on the cost of reducing the emissions in the countries was not accessible.

It would be interesting to see how the relationships in the Nordic region and with the Nordics and EU develop in climate policies over the years. The relationship with the national subsidies, direct and indirect ones, on renewable energy and EU ETS in emissions reduction could be looked into in detail. Also, the emissions reduction in the non-ETS sectors could be followed and analysed, especially if the EU sets new methods through the new Green Deal. Similar research to this one would be interesting to do in the end of the Phase IV, around the year 2030, to see how the instruments and the emissions have developed when closing into more ambitious climate goals. In all the Nordics the emission reductions are highly dependent on the changes in these sectors, since they are emission and energy intensive industries. Also, the effect of MSR on the auctioning of allowances, could be researched in the future after the fourth Phase of the EU ETS has begun.

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APPENDIX I

Greenhouse gasses refered to in European Union’s directive 2003/87/EC

Carbon dioxide (CO_2)

Methane (CH_4)

Nitrous Oxide (N_2O)

Hydrofluorocarbons (HFCs)

Perfluorocarbons (PFCs)

Sulphur Hexafluoride (SF_6)

APPENDIX II

The data tables.

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
DENMARK				
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	37303720	2005
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	27907569	2006
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	27902895	2007
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	23983428	2008
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	23912314	2009
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	23906256	2010
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	23908972	2011
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	24090918	2012
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	12226328	2013
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	11072867	2014
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	9874591	2015
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	9149687	2016
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	8515121	2017
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	7944390	2018
Denmark	20-99 All stationary installations	1.1 Freely allocated allowances	7346528	2019
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2005
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	4371750	2006
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2007
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2008
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2009
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2010
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2011
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	2837000	2012
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	12890000	2013
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	7951000	2014
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	9000000	2015
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	10055500	2016
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	12310000	2017
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	12136000	2018
Denmark	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	6614000	2019
Denmark	20-99 All stationary installations	2. Verified emissions	26475718	2005
Denmark	20-99 All stationary installations	2. Verified emissions	34199588	2006
Denmark	20-99 All stationary installations	2. Verified emissions	29407401	2007
Denmark	20-99 All stationary installations	2. Verified emissions	26548563	2008
Denmark	20-99 All stationary installations	2. Verified emissions	25461124	2009
Denmark	20-99 All stationary installations	2. Verified emissions	25266362	2010
Denmark	20-99 All stationary installations	2. Verified emissions	21465658	2011
Denmark	20-99 All stationary installations	2. Verified emissions	18185550	2012
Denmark	20-99 All stationary installations	2. Verified emissions	21601954	2013
Denmark	20-99 All stationary installations	2. Verified emissions	18388751	2014
Denmark	20-99 All stationary installations	2. Verified emissions	15795936	2015
Denmark	20-99 All stationary installations	2. Verified emissions	17220334	2016
Denmark	20-99 All stationary installations	2. Verified emissions	15062601	2017
Denmark	20-99 All stationary installations	2. Verified emissions	14954342	2018
Denmark	20-99 All stationary installations	2. Verified emissions	12040726	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
DENMARK				
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	31890437	2005
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	23847604	2006
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	23843385	2007
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	20065420	2008
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	20080090	2009
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	20080188	2010
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	20084030	2011
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	20265976	2012
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	8975830	2013
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	7912337	2014
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	6781240	2015
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	6104950	2016
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	5540814	2017
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	5038616	2018
Denmark	20 Combustion of fuels	1.1 Freely allocated allowances	4511309	2019
Denmark	20 Combustion of fuels	2. Verified emissions	22465356	2005
Denmark	20 Combustion of fuels	2. Verified emissions	30027875	2006
Denmark	20 Combustion of fuels	2. Verified emissions	25175538	2007
Denmark	20 Combustion of fuels	2. Verified emissions	23014052	2008
Denmark	20 Combustion of fuels	2. Verified emissions	22792051	2009
Denmark	20 Combustion of fuels	2. Verified emissions	22713875	2010
Denmark	20 Combustion of fuels	2. Verified emissions	18651738	2011
Denmark	20 Combustion of fuels	2. Verified emissions	15325196	2012
Denmark	20 Combustion of fuels	2. Verified emissions	18786395	2013
Denmark	20 Combustion of fuels	2. Verified emissions	15479301	2014
Denmark	20 Combustion of fuels	2. Verified emissions	12757507	2015
Denmark	20 Combustion of fuels	2. Verified emissions	14004821	2016
Denmark	20 Combustion of fuels	2. Verified emissions	11524680	2017
Denmark	20 Combustion of fuels	2. Verified emissions	11527811	2018
Denmark	20 Combustion of fuels	2. Verified emissions	8554040	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
DENMARK				
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	1248619	2005
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	936465	2006
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	936465	2007
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	864456	2008
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	864452	2009
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	864452	2010
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	864452	2011
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	864452	2012
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	883731	2013
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	862219	2014
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	840738	2015
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	819328	2016
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	797976	2017
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	776701	2018
Denmark	21 Refining of mineral oil	1.1 Freely allocated allowances	755454	2019
Denmark	21 Refining of mineral oil	2. Verified emissions	924181	2005
Denmark	21 Refining of mineral oil	2. Verified emissions	953340	2006
Denmark	21 Refining of mineral oil	2. Verified emissions	960849	2007
Denmark	21 Refining of mineral oil	2. Verified emissions	916113	2008
Denmark	21 Refining of mineral oil	2. Verified emissions	927494	2009
Denmark	21 Refining of mineral oil	2. Verified emissions	875212	2010
Denmark	21 Refining of mineral oil	2. Verified emissions	855276	2011
Denmark	21 Refining of mineral oil	2. Verified emissions	948991	2012
Denmark	21 Refining of mineral oil	2. Verified emissions	930478	2013
Denmark	21 Refining of mineral oil	2. Verified emissions	943464	2014
Denmark	21 Refining of mineral oil	2. Verified emissions	990980	2015
Denmark	21 Refining of mineral oil	2. Verified emissions	885080	2016
Denmark	21 Refining of mineral oil	2. Verified emissions	947335	2017
Denmark	21 Refining of mineral oil	2. Verified emissions	920522	2018
Denmark	21 Refining of mineral oil	2. Verified emissions	973439	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
FINLAND				
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	44665566	2005
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	44617969	2006
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	44620371	2007
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	36530616	2008
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	37068088	2009
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	37921895	2010
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	37992388	2011
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	38169199	2012
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	22896931	2013
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	21606691	2014
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	20090018	2015
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	18960796	2016
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	18032144	2017
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	16995891	2018
Finland	20-99 All stationary installations	1.1 Freely allocated allowances	15993636	2019
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2005
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2006
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2007
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2008
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2009
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2010
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2011
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2012
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	17208500	2013
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	10615000	2014
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	12015000	2015
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	13424500	2016
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	16434500	2017
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	16201000	2018
Finland	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	8830500	2019
Finland	20-99 All stationary installations	2. Verified emissions	33099660	2005
Finland	20-99 All stationary installations	2. Verified emissions	44621453	2006
Finland	20-99 All stationary installations	2. Verified emissions	42541353	2007
Finland	20-99 All stationary installations	2. Verified emissions	36163675	2008
Finland	20-99 All stationary installations	2. Verified emissions	34354480	2009
Finland	20-99 All stationary installations	2. Verified emissions	41297988	2010
Finland	20-99 All stationary installations	2. Verified emissions	35083373	2011
Finland	20-99 All stationary installations	2. Verified emissions	29497920	2012
Finland	20-99 All stationary installations	2. Verified emissions	31488865	2013
Finland	20-99 All stationary installations	2. Verified emissions	28760187	2014
Finland	20-99 All stationary installations	2. Verified emissions	25474207	2015
Finland	20-99 All stationary installations	2. Verified emissions	27228178	2016
Finland	20-99 All stationary installations	2. Verified emissions	25140824	2017
Finland	20-99 All stationary installations	2. Verified emissions	26262140	2018
Finland	20-99 All stationary installations	2. Verified emissions	23246581	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
FINLAND				
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	27477001	2005
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	27485372	2006
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	27482091	2007
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	19342475	2008
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	19915825	2009
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	20887302	2010
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	20963025	2011
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	21127786	2012
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	8362357	2013
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	7468510	2014
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	6254342	2015
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	5284158	2016
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	4681253	2017
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	3935221	2018
Finland	20 Combustion of fuels	1.1 Freely allocated allowances	3275841	2019
Finland	20 Combustion of fuels	2. Verified emissions	18475337	2005
Finland	20 Combustion of fuels	2. Verified emissions	29054836	2006
Finland	20 Combustion of fuels	2. Verified emissions	27122849	2007
Finland	20 Combustion of fuels	2. Verified emissions	20584227	2008
Finland	20 Combustion of fuels	2. Verified emissions	21635292	2009
Finland	20 Combustion of fuels	2. Verified emissions	26797934	2010
Finland	20 Combustion of fuels	2. Verified emissions	20882613	2011
Finland	20 Combustion of fuels	2. Verified emissions	16937009	2012
Finland	20 Combustion of fuels	2. Verified emissions	18769793	2013
Finland	20 Combustion of fuels	2. Verified emissions	16044683	2014
Finland	20 Combustion of fuels	2. Verified emissions	12923051	2015
Finland	20 Combustion of fuels	2. Verified emissions	14037562	2016
Finland	20 Combustion of fuels	2. Verified emissions	12368493	2017
Finland	20 Combustion of fuels	2. Verified emissions	13428412	2018
Finland	20 Combustion of fuels	2. Verified emissions	11346879	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
FINLAND				
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3081624	2005
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3048215	2006
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3064919	2007
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3226316	2008
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3226312	2009
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3226312	2010
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3226312	2011
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	3226312	2012
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2484911	2013
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2441750	2014
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2496178	2015
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2656024	2016
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2766813	2017
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2603078	2018
Finland	21 Refining of mineral oil	1.1 Freely allocated allowances	2551147	2019
Finland	21 Refining of mineral oil	2. Verified emissions	2660894	2005
Finland	21 Refining of mineral oil	2. Verified emissions	2820834	2006
Finland	21 Refining of mineral oil	2. Verified emissions	3167151	2007
Finland	21 Refining of mineral oil	2. Verified emissions	3398489	2008
Finland	21 Refining of mineral oil	2. Verified emissions	3468966	2009
Finland	21 Refining of mineral oil	2. Verified emissions	3310397	2010
Finland	21 Refining of mineral oil	2. Verified emissions	3359069	2011
Finland	21 Refining of mineral oil	2. Verified emissions	3133843	2012
Finland	21 Refining of mineral oil	2. Verified emissions	3223099	2013
Finland	21 Refining of mineral oil	2. Verified emissions	3090764	2014
Finland	21 Refining of mineral oil	2. Verified emissions	2912592	2015
Finland	21 Refining of mineral oil	2. Verified emissions	3247606	2016
Finland	21 Refining of mineral oil	2. Verified emissions	3307048	2017
Finland	21 Refining of mineral oil	2. Verified emissions	3175226	2018
Finland	21 Refining of mineral oil	2. Verified emissions	3301425	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
NORWAY				
Norway	20-99 All stationary installations	1.1 Freely allocated allowances		2005
Norway	20-99 All stationary installations	1.1 Freely allocated allowances		2006
Norway	20-99 All stationary installations	1.1 Freely allocated allowances		2007
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	7538168	2008
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	7965928	2009
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	8002071	2010
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	8422612	2011
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	8422612	2012
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	17691805	2013
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	17388077	2014
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	17082606	2015
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	17111843	2016
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	16401054	2017
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	15994452	2018
Norway	20-99 All stationary installations	1.1 Freely allocated allowances	15682389	2019
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2005
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2006
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2007
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2008
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	12600000	2009
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	6334000	2010
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	6330000	2011
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	9754732	2012
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2013
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2014
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2015
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2016
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2017
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2018
Norway	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	18525000	2019
Norway	20-99 All stationary installations	2. Verified emissions		2005
Norway	20-99 All stationary installations	2. Verified emissions		2006
Norway	20-99 All stationary installations	2. Verified emissions		2007
Norway	20-99 All stationary installations	2. Verified emissions	19342443	2008
Norway	20-99 All stationary installations	2. Verified emissions	19215690	2009
Norway	20-99 All stationary installations	2. Verified emissions	19274275	2010
Norway	20-99 All stationary installations	2. Verified emissions	19083018	2011
Norway	20-99 All stationary installations	2. Verified emissions	18560346	2012
Norway	20-99 All stationary installations	2. Verified emissions	24675466	2013
Norway	20-99 All stationary installations	2. Verified emissions	24958429	2014
Norway	20-99 All stationary installations	2. Verified emissions	25679092	2015
Norway	20-99 All stationary installations	2. Verified emissions	25172647	2016
Norway	20-99 All stationary installations	2. Verified emissions	25389439	2017
Norway	20-99 All stationary installations	2. Verified emissions	25178069	2018
Norway	20-99 All stationary installations	2. Verified emissions	24597153	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
NORWAY				
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	0	2005
Norway	21 Combustion of fuels	1.1 Freely allocated allowances	0	2006
Norway	22 Combustion of fuels	1.1 Freely allocated allowances	0	2007
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	1913472	2008
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	1913451	2009
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	1897355	2010
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	2352722	2011
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	2352722	2012
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	7465759	2013
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	7309396	2014
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	7163472	2015
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	7398365	2016
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	6869028	2017
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	6679568	2018
Norway	20 Combustion of fuels	1.1 Freely allocated allowances	6529493	2019
Norway	20 Combustion of fuels	2. Verified emissions	0	2005
Norway	21 Combustion of fuels	2. Verified emissions	0	2006
Norway	22 Combustion of fuels	2. Verified emissions	0	2007
Norway	20 Combustion of fuels	2. Verified emissions	14279174	2008
Norway	20 Combustion of fuels	2. Verified emissions	14050357	2009
Norway	20 Combustion of fuels	2. Verified emissions	14211337	2010
Norway	20 Combustion of fuels	2. Verified emissions	14097513	2011
Norway	20 Combustion of fuels	2. Verified emissions	13674805	2012
Norway	20 Combustion of fuels	2. Verified emissions	14057838	2013
Norway	20 Combustion of fuels	2. Verified emissions	14589636	2014
Norway	20 Combustion of fuels	2. Verified emissions	15082842	2015
Norway	20 Combustion of fuels	2. Verified emissions	14833267	2016
Norway	20 Combustion of fuels	2. Verified emissions	14169145	2017
Norway	20 Combustion of fuels	2. Verified emissions	13879755	2018
Norway	20 Combustion of fuels	2. Verified emissions	13734613	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
NORWAY				
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	0	2005
Norway	22 Refining of mineral oil	1.1 Freely allocated allowances	0	2006
Norway	23 Refining of mineral oil	1.1 Freely allocated allowances	0	2007
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1891431	2008
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1891431	2009
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1891431	2010
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1891431	2011
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1891431	2012
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1588524	2013
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1560933	2014
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1533018	2015
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1504811	2016
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1476300	2017
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1447512	2018
Norway	21 Refining of mineral oil	1.1 Freely allocated allowances	1418366	2019
Norway	21 Refining of mineral oil	2. Verified emissions	0	2005
Norway	22 Refining of mineral oil	2. Verified emissions	0	2006
Norway	23 Refining of mineral oil	2. Verified emissions	0	2007
Norway	21 Refining of mineral oil	2. Verified emissions	1794116	2008
Norway	21 Refining of mineral oil	2. Verified emissions	1898188	2009
Norway	21 Refining of mineral oil	2. Verified emissions	1832396	2010
Norway	21 Refining of mineral oil	2. Verified emissions	1922346	2011
Norway	21 Refining of mineral oil	2. Verified emissions	1986712	2012
Norway	21 Refining of mineral oil	2. Verified emissions	2008402	2013
Norway	21 Refining of mineral oil	2. Verified emissions	1671782	2014
Norway	21 Refining of mineral oil	2. Verified emissions	1906090	2015
Norway	21 Refining of mineral oil	2. Verified emissions	1703967	2016
Norway	21 Refining of mineral oil	2. Verified emissions	2649794	2017
Norway	21 Refining of mineral oil	2. Verified emissions	2535104	2018
Norway	21 Refining of mineral oil	2. Verified emissions	2054040	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
SWEDEN				
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	22289169	2005
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	22483602	2006
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	22846480	2007
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	20774672	2008
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	21089586	2009
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	23543513	2010
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	22595814	2011
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	22573139	2012
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	29081450	2013
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	27401839	2014
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	25603951	2015
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	24439716	2016
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	23159203	2017
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	21783589	2018
Sweden	20-99 All stationary installations	1.1 Freely allocated allowances	20573173	2019
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2005
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2006
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2007
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2008
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2009
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2010
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2011
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	0	2012
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	9167500	2013
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	5648500	2014
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	6398000	2015
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	7148500	2016
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	8751500	2017
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	8627000	2018
Sweden	20-99 All stationary installations	1.3 Allowances auctioned or sold (EUAs and EUAAs)	5042000	2019
Sweden	20-99 All stationary installations	2. Verified emissions	19381682	2005
Sweden	20-99 All stationary installations	2. Verified emissions	20002497	2006
Sweden	20-99 All stationary installations	2. Verified emissions	19040731	2007
Sweden	20-99 All stationary installations	2. Verified emissions	20080518	2008
Sweden	20-99 All stationary installations	2. Verified emissions	17491867	2009
Sweden	20-99 All stationary installations	2. Verified emissions	22661193	2010
Sweden	20-99 All stationary installations	2. Verified emissions	19853885	2011
Sweden	20-99 All stationary installations	2. Verified emissions	18172023	2012
Sweden	20-99 All stationary installations	2. Verified emissions	20143270	2013
Sweden	20-99 All stationary installations	2. Verified emissions	19326501	2014
Sweden	20-99 All stationary installations	2. Verified emissions	19236229	2015
Sweden	20-99 All stationary installations	2. Verified emissions	19736083	2016
Sweden	20-99 All stationary installations	2. Verified emissions	19647724	2017
Sweden	20-99 All stationary installations	2. Verified emissions	19856395	2018
Sweden	20-99 All stationary installations	2. Verified emissions	18731492	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
SWEDEN				
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	5346201	2005
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	5473602	2006
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	5723249	2007
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	3114021	2008
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	3176310	2009
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	5411273	2010
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	4365977	2011
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	4306870	2012
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	11889542	2013
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	10829759	2014
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	9421155	2015
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	8442946	2016
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	7737201	2017
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	6655580	2018
Sweden	20 Combustion of fuels	1.1 Freely allocated allowances	5769932	2019
Sweden	20 Combustion of fuels	2. Verified emissions	7088396	2005
Sweden	20 Combustion of fuels	2. Verified emissions	7374849	2006
Sweden	20 Combustion of fuels	2. Verified emissions	6746716	2007
Sweden	20 Combustion of fuels	2. Verified emissions	7231315	2008
Sweden	20 Combustion of fuels	2. Verified emissions	7631025	2009
Sweden	20 Combustion of fuels	2. Verified emissions	10137260	2010
Sweden	20 Combustion of fuels	2. Verified emissions	7601811	2011
Sweden	20 Combustion of fuels	2. Verified emissions	6834517	2012
Sweden	20 Combustion of fuels	2. Verified emissions	9113110	2013
Sweden	20 Combustion of fuels	2. Verified emissions	8198087	2014
Sweden	20 Combustion of fuels	2. Verified emissions	7639776	2015
Sweden	20 Combustion of fuels	2. Verified emissions	8264494	2016
Sweden	20 Combustion of fuels	2. Verified emissions	8124800	2017
Sweden	20 Combustion of fuels	2. Verified emissions	8474800	2018
Sweden	20 Combustion of fuels	2. Verified emissions	7202074	2019

Country	Main Activity Sector Name	ETS information	Value t/CO2	Year
SWEDEN				
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3024274	2005
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3024274	2006
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3024274	2007
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3186180	2008
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3186180	2009
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3186180	2010
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3186180	2011
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	3186180	2012
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2870362	2013
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2803788	2014
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2737197	2015
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2670711	2016
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2604296	2017
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2538002	2018
Sweden	21 Refining of mineral oil	1.1 Freely allocated allowances	2471680	2019
Sweden	21 Refining of mineral oil	2. Verified emissions	2451693	2005
Sweden	21 Refining of mineral oil	2. Verified emissions	2939240	2006
Sweden	21 Refining of mineral oil	2. Verified emissions	2739082	2007
Sweden	21 Refining of mineral oil	2. Verified emissions	3018116	2008
Sweden	21 Refining of mineral oil	2. Verified emissions	2939159	2009
Sweden	21 Refining of mineral oil	2. Verified emissions	2957670	2010
Sweden	21 Refining of mineral oil	2. Verified emissions	2847035	2011
Sweden	21 Refining of mineral oil	2. Verified emissions	3023274	2012
Sweden	21 Refining of mineral oil	2. Verified emissions	2596336	2013
Sweden	21 Refining of mineral oil	2. Verified emissions	2786094	2014
Sweden	21 Refining of mineral oil	2. Verified emissions	2865251	2015
Sweden	21 Refining of mineral oil	2. Verified emissions	2637710	2016
Sweden	21 Refining of mineral oil	2. Verified emissions	2745232	2017
Sweden	21 Refining of mineral oil	2. Verified emissions	2875171	2018
Sweden	21 Refining of mineral oil	2. Verified emissions	2281280	2019