FACULTY OF TECHNOLOGY

The industrial perspective of EU Emissions Trading System: Case Outokumpu Tornio Works

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ABSTRACT

The industrial perspective of EU Emissions Trading System: Case Outokumpu Tornio Works

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The thesis aims to present and evaluate the EU Emissions Trading System (ETS) as a tool for greenhouse gas reduction. The variables affecting the effectiveness of the Emissions Trading System are observed. These include the price development of allowances and the development of an international ETS network. In this thesis, the impacts of the EU ETS on industries and economies are also reviewed. The impacts are studied from three perspectives: the effect on Finnish national economy, the theoretical effect on a random company and the effect on Outokumpu Tornio Works in practice.

This thesis is primarily a literature review. The sources for this study have been EU directives and commission regulations, European Commission official website, research results and other scientific publications. The following parts form the literature review: the introduction and evaluation of the basic idea, presenting the history and studying of the impacts of the EU ETS on Finnish national economy and the theoretical effect on a company. Studying the effect in practice has been done by interviewing the Environmental Counsel of Outokumpu: Kirsi-Marja Fyhr.

This study suggests that the EU ETS is a very efficient and flexible operating system. The Cap & Trade system allows the possibility of efficient greenhouse gas emissions reduction without putting too much pressure on a single company. In practice, however, there are some weaknesses in the system. For instance, the system's efficiency is highly dependent on the pricing of the allowances. In circumstances where the price decreases, for example: an economic downturn, the incentive the system provides will weaken significantly. Furthermore, the ETS is disadvantageous for some of its operators that

operate in the international market. Until 2020, this disadvantage has been compensated for by allocating a bigger share of free allowances to the companies exposable.

Keywords: Emissions Trading System, Allowance, Emissions Permit, Industry perspective, Finland

TIIVISTELMÄ

EU päästökauppajärjestelmä teollisuuden näkökulmasta: Case Outokumpu Tornion tehtaat

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Opinnäytetyön tavoitteena on esitellä ja arvioida Euroopan Unionin päästökauppa-järjestelmää kasvihuonepäästöjen vähennyksen työkaluna. Työssä tarkastellaan muuttujia, jotka vaikuttavat päästökauppajärjestelmän tehokkuuteen. Näitä muuttujia ovat päästöoikeuksien hintakehitys sekä kansainvälisen päästökauppaverkoston muodostuminen. Tässä työssä käsitellään myös EU päästökaupan vaikutuksia yrityksiin ja talouteen. Näitä vaikutuksia tutkitaan kolmesta näkökulmasta: vaikutukset Suomen kansantalouteen, teoreettiset vaikutukset satunnaisesti valittuun yritykseen ja käytännön vaikutukset Outokummun Tornion tehtailla.

Tämä kandidaatintyö on suurimmalta osalta toteutettu kirjallisuuskatsauksena. Tässä katsauksessa on käytetty lähteinä EU direktiivejä ja komission säädöksiä, Euroopan Komission virallista verkkosivua, suomalaisten viranomaisten verkkosivuja, tutkimustuloksia ja muita tieteellisiä julkaisuja. Osat, jotka on toteutettu kirjallisuuskatsauksena ovat perusidean esittely ja arviointi, kausien läpikäynti ja päästökaupan Suomen kansantalouteen aiheuttamien vaikutusten ja teoreettisten yrityskohtaisten vaikutusten tutkimiseen. Käytännön vaikutukset Outokummulla tutkittiin haastattelemalla Outokummun ympäristölakimiestä Kirsi-Marja Fyhriä.

Tutkimus osoittaa, että Euroopan Unionin päästökauppajärjestelmä on erittäin tehokas ja joustava järjestelmä kasvihuonekaasupäästöjen vähennykseen. Päästökatto ja -kauppa -tyyppinen järjestelmä tekee kasvihuonekaasupäästöjen vähentämisestä tehokasta ilman että yksittäisille yrityksille kohdistuu liikaa paineita. Käytännössä päästökauppa-järjestelmässä on kuitenkin joitakin ongelmia. Yksi niistä on järjestelmän tehokkuuden

suuri riippuvuus päästöoikeuksien hinnoittelusta. Silloin, kun päästöoikeuksien hinta laskee, esim. laman seurauksena, myös järjestelmän aikaansaama kannustin päästöjen vähentämiseen heikkenee huomattavasti. EU päästökauppajärjestelmä myös aiheuttaa haasteita osalle toimijoista, jotka kilpailevat kansainvälisillä markkinoilla. Tätä haittaa on kompensoitu vuoteen 2020 asti vain jakamalla suurempia määriä ilmaisjaettuja päästöoikeuksia haitoille alttiille toimijoille.

Asiasanat: Päästökauppa, Päästöoikeus, Päästölupa, Suomi, Yritysnäkökulma

FOREWORDS

The main purpose of the thesis is to present and evaluate the EU Emissions Trading System from the industrial perspective. The practical standpoint from the thesis was reached by studying the operations of the Emissions Trading System in Outokumpu Tornio Works. The thesis was written in between 31.8.2020-31.11.2020.

The supervisor of the thesis was Jenni Ylä-Mella, Postdoctoral researcher of Water, Energy and Environmental Engineering, University of Oulu. I would like to thank Jenni for reviewing and commenting on my thesis and for giving me a fresh perspective and advice for the thesis.

I would also like to thank Environmental Cousel Kirsi-Marja Fyhr for providing her expertise for this thesis. Especially I would like to thank Kirsi-Marja for providing the practical perspective for the case portion of the thesis, and commenting on the content of the thesis and giving me advice for improving it.

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Oulu, 18.11.2020

Kaisa Paaso
Author

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ABBREVIATIONS AND SYMBOLS

Abbreviations

CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CSCF	Cross-Sectoral Correction Factor
EC	European Commission
EES	Energy Efficiency System
ETS	Emissions Trading System
EU	European Union
GDP	Gross Domestic Product
ICAP	International Carbon Action Partnership
MSR	Market Stability Reserve
NER300	New Entrants' Reserve 300, EU's funding programme that got its name and capital from the sale of the 300 million allowances in New Entrants Reserve
RES	Renewable Energy Systems
RGGI	The Regional Greenhouse Gas Initiative
TCI	Transportation and Climate Initiative

SI units and chemical compounds:

CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
E	Energy Content
H_2	Hydrogen
HFCs	Hydrofluorocarbons
HNO_3	Nitric Acid
m	mass [tonnes]
N_2O	Nitrous Oxide
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride

1 INTRODUCTION

Greenhouse gases emitted by human activities are causing an undeniable change in climate (EC, 2020a). Climate change causes many harmful changes in the environment. These changes can be seen globally. A big change that can be seen globally is the rise in sea levels as a result of melting glaciers and the expansion of the warming water. The rise in sea levels has led to floods and erosion. Also, other extreme weather events, like heavy rains, are and will become even more numerous. For example, Northern Europe is continuously increasing in humidity. Then again, in some parts of the world, climate change manifests as drying of ecosystems. In Europe, the Mediterranean area is continuously getting drier. The drying of ecosystems makes the areas more exposed to wildfires and drought. These changes also impact global biodiversity. For some species, the rate of climate change exceeds the rate of adaptation. Many species are at risk of extinction, if the global average temperatures keep rising. (EC, 2020b) EU Emissions Trading System has been developed as a tool of the EU to inhibit climate change. The objective of the EU is to become climate-neutral by 2050 (EC, 2020c).

The topic of the thesis is the Industrial perspective of the EU Emissions Trading System (ETS) case: Outokumpu Tornio Works. At the beginning of the thesis, the basic knowledge of the ETS is disclosed, and its use in influencing industrial development is observed. The history of the Emissions Trading System comprises three separate periods. The fourth period begins at the beginning of 2021. The periods are reviewed, and the incoming changes brought by the fourth period are emphasised. Due to the change of the period (3rd to 4th), the thesis is certainly timely. This part of the thesis is done as a literature review.

At the tail end of the thesis, the practical implications of ETS are considered. This thesis observes the impact of the ETS on the Finnish political economy and the theoretical impact of EU ETS on companies. This thesis especially concentrates on the perspective of Outokumpu Tornio works and the effects of ETS on the company's actions. In addition to that, the impacts of the change of the period, for the company, are reviewed.

2 EU EMISSIONS TRADING SYSTEM

In this chapter, the basic idea of the EU Emissions Trading System (EU ETS) is presented. It begins with discussion of the main objectives of the EU ETS and the actions taken to reach them. The EU ETS is a legally binding emissions reduction tool; the operators ETS covers are required to follow the orders set in the regulatory framework. The legislation of ETS, the operators and their tasks are observed in this chapter. The operators in the system are European Parliament and Commission, authorities of the member states (in Finland these are Energy Authority and the Ministry of Economic Affairs and Employment of Finland), and the industry or aviation operators. The EU ETS covers many fields of industry and most of aviation in EU. The scope of application is also introduced. The operators are required to monitor their emissions. Finally, the main principles of the emissions monitoring are presented.

2.1 Basic idea and implementation of the Emissions Trading System

Since the increase in greenhouse gas emissions, the European Parliament and Council have launched the emissions trading system (EU ETS) based on the Kyoto Protocol. EU ETS has two key objectives. The first key objective of EU ETS is to decrease greenhouse gas emissions until concentrations of greenhouse gases in the atmosphere remain constant, and levels of concentrations are low enough to inhibit the critical change of the climate. In the long run, the total amount of greenhouse gases should be decreased by 70 %, based on levels in 1990. (Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC, Preamble 1) The EU ETS is being used in all the countries of European Union with the addition of Iceland, Liechtenstein and Norway. (EC, 2020c) These greenhouse gasses are referred to in this directive (Directive 2003/87/EC, Annex II):

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

The second key objective of the EU Emission Trading System is to increase the cost-effective functioning of the social system (Directive 2003/87/EC, Preamble 19). Therefore, EU ETS supports energy-efficient production (Directive 2003/87/EC, Preamble 20) and favours domestic production (Directive 2003/87/EC, Preamble 19). For example, ETS favours combined heat and electricity production over simple electricity production. (Directive 2003/87/EC, Preamble 20) EU ETS aims to create jobs and forward green growth by directing investments into energy-efficient projects. Through the NER300 fund, it offers an incentive to invest in renewable energy technologies and secure carbon capture and storage. The combination of these actions decreases the cost of energy and reduces fossil fuel dependency in power production. NER300 is a funding programme, founded in 2010, which assists companies that are environmentally friendly. The companies funded via NER300 are either Carbon Capture and Storage (CCS) companies or innovative Renewable Energy Systems (RES) companies. Examples of CCS are oxyfuel and pre- and post-combustion. An example of a RES company is a bioenergy or geothermal energy producing company. NER300 is named after the finance source, which is the sale of 300 million emission allowances sold in auctions. NER300 is one of the tools used by the EU to provide a fertile base for green growth. (EU, 2015)

Monitoring greenhouse gas emissions is critical for the functioning of the EU ETS. The emissions need to be monitored and reported accordingly by the industries covered by EU ETS (Directive 2003/87/EC, Article 14:1). The companies must surrender the number of allowances equal to their total annual emissions (Directive 2003/87/EC, Article 6:2e). In this thesis, the definition of "allowance": allowance to emit a tonne of CO_2 or the amount of another greenhouse gas according to the carbon dioxide equivalent (Directive 2003/87/EC, Article 3:a). The allowances can be received in three ways:

- Free Allocation
- Trading
- Auctions

The Decision of Harmonised Allocation Rules, Commission Decision 2011/278/EU, sets the orders for distributing allowances free of charge (Commission Decision 2011/278/EU, Article 1). Free allocation decreases gradually. The situation is different in each sector covered by ETS. At the beginning of the ETS, the proportion of allowances distributed for free in the manufacturing industry was 80 %; at the end of phase III, in

2020, it is 30 %. Since 2013, power generators have not been receiving any allowances for free. On the contrary, airlines still receive most of their allowances for free in the third phase:2013-2020. (EC, 2020d) The allowances can be traded freely. In the trade, an institution in need of allowances searches for a company with superfluous allowances and buys some. Consequently, both institutions take advantage of the ETS's flexibility, and the environmental impact is the same as if the institutions had both used all distributed allowances. The allowances can also be traded by companies or operators that operate in different countries. Trading of this sort is a financial incentive for companies to reduce emissions. The price of the allowances depend on the market situation and are likely to increase as the ETS proceeds (COM/2000/0087, 3). As ETS proceeds, the number of allowances distributed for free decreases, and the allowances need to be bought more often (Energiavirasto, 2020). A decrease in the number of allowances distributed for free affects the development and makes the reduction of greenhouse gases happen where it is cheapest (Työ- ja elinkeinoministeriö, 2020). In the third phase, most of the allowances are auctioned. Auctions are organised by the European Energy Exchange or a stock market exchange. (Energiavirasto, 2020)

2.2 Operators in the system

In the EU Emission Trading System, there are multiple operators. The chief ETS operator is the European Parliament and Council. European Parliament and Council operates by legislation which sets the framework and ground rules for the other ETS operators (Communication department of the European Commission, 2020). The Commission co-operates with the Parliament. The main task of the Commission is to enforce the directives and laws given by the Parliament and Council. In addition, the Commission also gives legal advice (Euroopan komissio, 2020) and appoints a Central Administrator (Directive 2003/87/EC, Article 20). The Commission is the mediating operator between the Parliament, Central Administrator and ETS Member States (Directive 2003/87/EC, Article 9, 14 & 21). The Central Administrator's main function is to keep an objective record of the emissions of institutions and also the trading and cancelling of allowances. Additionally, the Central Administrator checks all the emitting, trading and cancelling activities for ambiguities. If ambiguities appear, it contacts the state that is responsible for them (Directive 2003/87/EC, Article 20). States handle the distribution of the allowances among the institutions (Directive 2003/87/EC, Article 24:2). Annually, the member states submit a report of the actions to the Commission, focusing on the

distribution of the allowances, emission monitoring and verifying. The Commission will give the member states advice on development about these topics. (Directive 2003/87/EC, Article 21) The institutions are responsible for monitoring the emissions emitted by them and keeping a record of the allowances traded by them (COM/2000/0087, 9,2).

2.3 Regulatory Framework

The core of the legislation of the ETS is The Emissions Trading Directive 2003/87/EC. It is complemented by secondary legislation, which includes several regulations. The Emissions Trading Directive contains important information on the function and main principles of ETS. It includes information and rules for the distribution of allowances; information about trading, auctions, etc. There is information about the trading system's coverage. This includes the greenhouse gases that are monitored and the industries and countries participating. The levels of penalties and the means of enforcement are also presented. The directive briefly reviews the administrative structure of the EU and introduces the operators of the ETS. Basic information about the monitoring and reporting of emissions is also included (EC, 2020e).

More information about monitoring of emissions is found in Monitoring and Reporting Regulation (MRR) Commission Regulation (EU) No 601/2012. It contains detailed information about the requirements and monitoring methods. The instructions for reporting the emissions is detailed carefully in this regulation, and are mandatory for institutions making the reports. An independent evaluator objectively verifies the reports. The Accreditation and Verification Regulation Commission Regulation (EU) No 600/2012 includes requirements of the evaluators and industries for these matters. (EC, 2020e) In the verification process, the verifier is a legal person or entity (Commission Regulation (EU) No 600/2012, Article 3:3) that evaluates whether the industry's report is complete and if the operator has been operating according to the emissions permit. The verifier also observes if the industries have been following an appropriate monitoring system and checks that there are no major distortions in the report's data (Commission Regulation (EU) No 600/2012, Article 7:4).

The companies must surrender the number of allowances equivalent to the monitored total annual emissions of the company (Directive 2003/87/EC, Article 6:2e). Some industries receive more free allowances than others (EC, 2020f). The Decision of

Harmonised Allocation Rules, Commission Decision 2011/278/EU sets the orders for distributing allowances, free of charge (Commission Decision 2011/278/EU, Article 1). In this decision, participating countries are guided to appoint the industries that will receive allowances for free (Commission Decision 2011/278/EU, Article 10:1). In this decision, process-specific benchmark values are given. For example, for EAF high alloy steel production, the benchmark value for distributed allowances is 0,352 allowances per tonne when fuel's exchangeability and electricity have been accounted for. (Commission Decision 2011/278/EU, Annex I)

Most of the allowances are auctioned in the third phase, 2013-2020. Detailed information about the auction process and organising the auctions is found in The Auctioning Regulation, Commission Regulation (EU) No 1031/2010 (Commission Regulation (EU) No 1031/2010, Article 1). In allowance auctions, all the bidders give their bids simultaneously without seeing the bids other bidders have given. In addition to the price agreed, the victorious bidder needs to pay an auction clearing price. (Commission Regulation (EU) No 1031/2010, Article 5) If several bidders have the same bid, the victor will be selected by a randomising algorithm. (Commission Regulation (EU) No 1031/2010 Article 7) All information about distributed, auctioned and traded allowances are public and found in the registry of EU (Directive 2003/87/EC, Article 20:2). The Registry Regulation, Commission Regulation (EU) No 389/2013, contains information about the functioning of the registry (Commission Regulation (EU) No 389/2013, Article 1). The Central Administrator maintains the Union registry. It has an operation link to EU Transaction Log and the greenhouse gas emissions trading system registries, so the information about trading and auctioning allowances will be updated. (Commission Regulation (EU) No 389/2013, Article 7:3).

2.4 Scope of application

EU Emissions Trading System covers multiple sectors of industry. The EU ETS covers the carbon dioxide emissions of fuel combustion in all the institutions with a total rated thermal input surpassing 20 MW. EU ETS also covers many other industrial processes. The EU ETS covers the following sectors:

- Metals Production
- Production of ceramics

- Organic material production
- Chemical Industries
- Geological Storage of CO_2
- Aviation Sector

EU ETS covers the generality of the metal industry of the EU. The system covers carbon dioxide emissions from roasting, sintering and pelletisation of metal ore. The coverage in further processing depends on the total rated thermal input of the industry and also metal produced. For the production of pig iron and steel, whether primary or secondary fusion, the EU ETS covers carbon dioxide emissions of companies with a minimum production rate capacity of 2,5 tonnes per hour. EU ETS covers carbon dioxide emissions of the production and processing of other metals, ferrous or non-ferrous, if the total rated thermal input is at least 20 MW. Nevertheless, the coverage in the production of primary aluminium differs from the rest. EU ETS completely covers carbon dioxide and perfluorocarbons emissions of primary aluminium production. For secondary aluminium, the same rules apply as for any other non-ferrous metal. (Directive 2003/87/EC, Annex I)

Production of cement clinker and ceramics is covered partially by the EU ETS. The system's coverage depends on the substance and the production rate (mass flow) of the product. The ETS covers carbon dioxide emissions of cement clinker produced in rotary kilns, but only in companies with a production rate of at least 500 tonnes/day, and in companies that use a different production method with a production capacity of 50 tonnes/day or above. A minimum capacity of fifty tonnes per day also restricts the ETS coverage of carbon dioxide emissions from lime, calcination of dolomite and magnesite production. If the total rated thermal input is 20 MW at the minimum in a company that produces gypsum products or fires or calcinates the gypsum, the company's CO_2 emissions are covered by EU ETS. Furthermore, the carbon dioxide emissions from glass production or the production of mineral wool for insulation (manufactured from glass, rock or slag) are covered if the total melting capacity exceeds 20 tonnes per day. Production of other ceramic products is covered if the production rate exceeds 75 tonnes/day. (Directive 2003/87/EC, Annex I)

EU ETS covers carbon dioxide emissions from the production of many organic materials: The production of pulp from fibrous materials regardless of the production rate;

production of cardboard or paper with a minimum capacity of 20 tonnes/day; carbon black production, if the total rated thermal input in the combustion units is at least 20 MW; and bulk organic chemicals production by cracking, oxidation, reforming or by similar processes with a minimum production rate of 100 tonnes/day production. The EU ETS also covers certain heavy hydrocarbon processing. It covers the CO_2 emissions of oil refining and coke production, regardless of the production rate. (Directive 2003/87/EC, Annex I)

EU ETS covers nitrous oxide and carbon dioxide emissions from several chemical industry sectors. Both greenhouse gases are covered in the production of nitric, adipic, glyoxal and glyoxylic acids. Industry sectors where only carbon dioxide emissions are covered include, the production of ammonia, hydrogen, soda ash and sodium bicarbonate, regardless of the production rate. The CO_2 emissions of synthetic gas production by reformation or oxidation are covered when production rate is at least 25 tonnes/day. (Directive 2003/87/EC, Annex I)

Additionally, the carbon dioxide emissions of the geological storage of carbon dioxide are covered. (Directive 2003/87/EC, Annex I) The purpose of the geological storage of CO_2 is the permanent containment of carbon dioxide and to prevent and eliminate the negative effects of the emissions (Directive 2009/31/EC of the European Parliament and of the Council, Article 1:2). The CO_2 is stored in underground geological formations (Directive 2009/31/EC, Article 3:1). The EU Emissions Trading System covers the emissions from the capture, transportation and storing of carbon dioxide. (Directive 2003/87/EC, Annex I)

EU ETS covers the carbon dioxide emissions of the aviation sector. The coverage includes the flights departing and arriving in an airport located in the region of the country participating in the ETS, with a few exceptions. EU ETS does not cover the flights of states' leadership and their closest assistants or relatives, other than a member state, on an official mission. The Emissions Trading System does not cover flights related to search and rescue: medical service, fire-fighting, humanitarian flights, police and customs flights, or military flights performed by a military aircraft. Also, ETS does not cover flights that do not carry passengers or cargo. For example, pilot training flights, scientific research flights, or testing an aircraft's equipment. Another considerable sector not covered by EU ETS is small-scale aviation. This includes flights flown by aircraft with a

maximum take-off mass of less than 5 700 kg; and flights performed by a commercial air transport operator, with less than 243 flights in three four-month periods in a row or fewer than 10 000 tonnes of total annual emissions. EU ETS does not cover some flights of the routes in the outermost regions, flights performed under the Chicago Convention rules, or flights that terminate on the same airport from which the aircraft has taken off without making an intermediate landing. (Directive 2003/87/EC, Annex I)

2.5 Monitoring of the greenhouse gases

All the industries covered by EU ETS need to acquire the emissions permit. Only an installation capable of monitoring and reporting its emissions, can get a greenhouse gas emissions permit. (Directive 2003/87/EC, Article 5)

The monitoring can be executed by either measuring the emissions or calculating them. Calculating is done by the following formula (1): (Directive 2003/87/EC Annex IV):

Activity data × Emission factor × Oxidation factor (1)

Activity data is any measurable data directly proportional to the amount emitted greenhouse gas, emission factor is the process specific value, and oxidation factor is the oxidised percentage of the carbon.

A good example of activity data is the amount of used fuel. The oxidation factor considers the amount of unoxidised carbon in the fuel that does not add CO_2 emissions. Default oxidation factors must be used unless activity-based factors provide a better picture of the process. (Directive 2003/87/EC Annex IV) Different kinds of activity-based monitoring systems are used in different fields of industry. For example, calculating according to mass balance is recommended for monitoring CO_2 emissions in the steel industry. However, depending on the source stream, industries may choose another activity factor.

In some monitoring systems, monitoring is based on measurements. For example, N_2O emissions can be monitored by measuring the concentration of N_2O in the steam, which is then used in calculations. (Commission Regulation (EU) No 601/2012, Annex IV) If the concentration of a component is high in steam, the percentage concentration of the desired component can be solved using a method where the percentage concentrations of

the other components of the steam are subtracted from 100 %. This method requires measuring all the concentrations of the other components. (Commission Regulation (EU) No 601/2012, Annex VIII) The measurements must be confirmed by calculations (Directive 2003/87/EC, Annex IV).

3 EVALUATION OF THE EU EMISSIONS TRADING SYSTEM

EU ETS has been an efficient operating model since it has reached its key objectives. The ETS created a foundation for a functioning carbon dioxide market. It has resulted in an evaluation of the prices of the emission allowances. Of course, the regulation's insecurities have affected the evaluation; nevertheless, the progress in supply/demand - proportion has created the advance in pricing. (Fallmann et al., 2015)

3.1 Efficiency and flexibility of EU ETS

The ETS is a truly resilient and flexible operating model. This is because it can effortlessly be modified to consider changes, for example, the development of technology. (Fallmann et al., 2015) ETS also adapts to the economy's situation since the pricing of the allowance changes, based on economic and political changes. In an economic downturn, the demand for allowances decreases since industries' production rates fall. This drops the prices of the allowances and hence reduces the stress of the policy. Then again, in times of economic growth, the demand for allowances increases, and allowances' prices rise. The ETS is also flexible for companies. (Eden et al., 2016) Trading allowances make ETS easier for the companies to accept because the flexibility will help the prerequisites to not be considered too strict (Fallmann et al., 2015). In the EU ETS, flexibility is the freedom to decide if or when to invest in reducing greenhouse gas emissions. Companies can bank their emissions to be used later if the number of emissions allowances is greater than emissions emitted. Hence, changes in the production rate, and future innovations can be considered. (Eden et al., 2016)

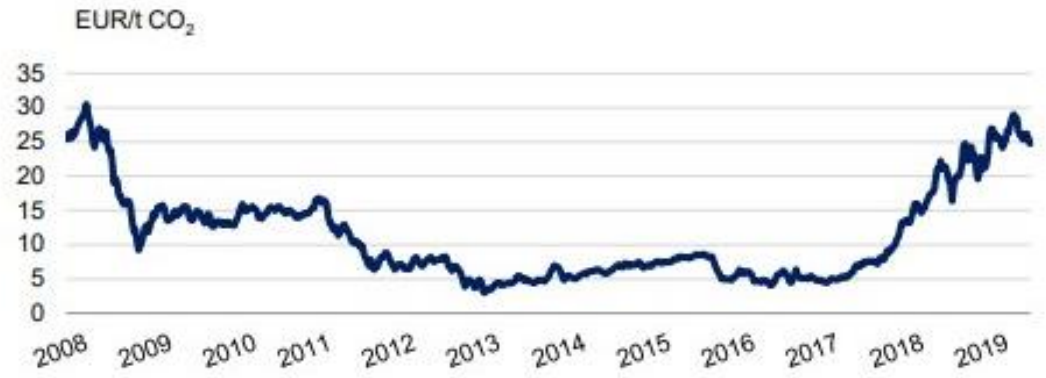
EU Emissions Trading System covers 45 % of the European Union's greenhouse gas emissions (ICAP, 2020). The programme's coverage is moderate, and it does not apply to companies with small-scale greenhouse gas emissions. The ETS affects only 11 000 industries and 600 aircraft operators. The efficiency of the system is respectable as a major decrease in emissions is achieved by controlling few companies. The efficiency of the ETS is based on the capping method. Unlike the CO_2 tax-method, the top value of the emissions can be set in ETS. This makes the result of the emissions reduction predictable. As desired, improvement in energy efficiency and decrease of greenhouse gas emissions

levels have been occurring, but not as fast or large-scale as required to reach the long-term goal of the low-carbon industry. (Fallmann et al., 2015)

3.2 The dependency on allowance pricing

It is disquieting that an absence of a minimum price or other safeguards, could cause the price of the allowances to decrease, making the reduction of CO_2 emissions pointless for the companies (Fallmann et al., 2015). This low abatement target is a crucial weakness of the present EU ETS (Venmans, 2012). To achieve a sustainable transition to the low-carbon economy, the current incentives will be insufficient in the long term. (Fallmann et al., 2015) For example, at the end of the first phase, the price of the allowances fell very low, and from 2012-2015, the price of the allowances stayed below 10 €/t CO_2 for 3 years. (Makkonen et al., 2019) Development of allowance prices from 2008 to 2019 is illustrated in Figure 1

Figure 1: Pricing of the EU Allowances presented as a function of time © Makkonen et al., 2019



(EUA Price, 2019)

During the times of low allowance prices, the effect of the EU ETS was at a weak level. In the first phase of the ETS, most member countries were distributing the majority of their allowances for free. Since the levels of emissions were not monitored before the beginning of the ETS, some companies were abating the reduction of greenhouse gases emissions on purpose. The number of allowances distributed for free in the second phase is directly proportional to the number of allowances used in the first phase; consequently,

ETS favoured the companies that were postponing the emissions reduction in the first two phases. (Venmans, 2012)

3.3 Global ETS network

Operations like EU ETS are being developed and are already in use around the world. This chapter discusses the Emissions Trading Systems, either, in force or under development in each continent. Without an international, comprehensive ETS or a global price for CO_2 emissions, the risk of carbon leakage exists. Carbon leakage, in this thesis, means companies with high greenhouse gas emissions transferring their operations to either countries where Emissions Trading Systems are not present, or countries where the prices of the allowances are significantly lower. (Eden et al., 2016) This chapter gives perspective on the consideration of the carbon leakage situation in 2020 and the near future.

3.3.1 Emissions Trading Systems in force

The EU Emissions Trading System is, globally, the largest emissions trading system in force, in 2020. It covers 45 % of the emissions of Europe. The other Emissions Trading Systems in force in 2020 are smaller, either national or they cover a smaller area. The Emissions Trading Systems in force in 2020 can be seen in figure 2. (ICAP, 2020)*)*

Figure 2: The Emissions Trading Systems is force 2020 © 2020 by International Carbon Action Partnership (ICAP)

In total, there are 12 ETS programmes in force in Asia. Two of them are national systems, 8 of them are small-scale pilot operators in China, and the last 2 are smaller programmes operating in Japan. The second biggest ETS, worldwide, is the Korea Emissions Trading Scheme which covers more than 2/3 of the Korean greenhouse gas emissions. The system was launched in 2015, and it covers 610 of the country's biggest emitters. Another Asian country where national ETS is in force is Kazakhstan. Kazakhstan Emissions Trading Scheme covers around 50 % of the emissions of the country. It was launched in 2013 and suspended from 2016-2017. However, the system was relaunched in 2018. A national ETS is being developed in China. In 2020, in China, there are multiple small-scale pilot Emissions Trading Systems operating. These pilot systems have been launched in Guangdong, Shenzhen, Fujian Province, Shanghai, Hubei, Chongqing, Tianjin and Beijing. All of these cover a small area. Most of the systems only cover carbon dioxide emissions, but the Chongqing pilot has the same greenhouse gas coverage as EU's ETS. The coverage of the systems varies between 40-60 %. At the turn of 2020s, there is not a nationwide ETS in Japan either. In Japan, there are two Emissions Trading Systems that are bilaterally linked. They are called Tokyo Cap-And-Trade Program and Saitama Target Setting Emissions Trading System. These programmes operate in different fields of industries, and each of them covers about 20 % of the greenhouse gas emissions of the area they cover. In Australia and Oceania, there is only one ETS programme in force: the national programme of New Zealand. It is called the New Zealand Emissions Trading Scheme and covers 51 % of the country's greenhouse gas emissions. (ICAP, 2020)

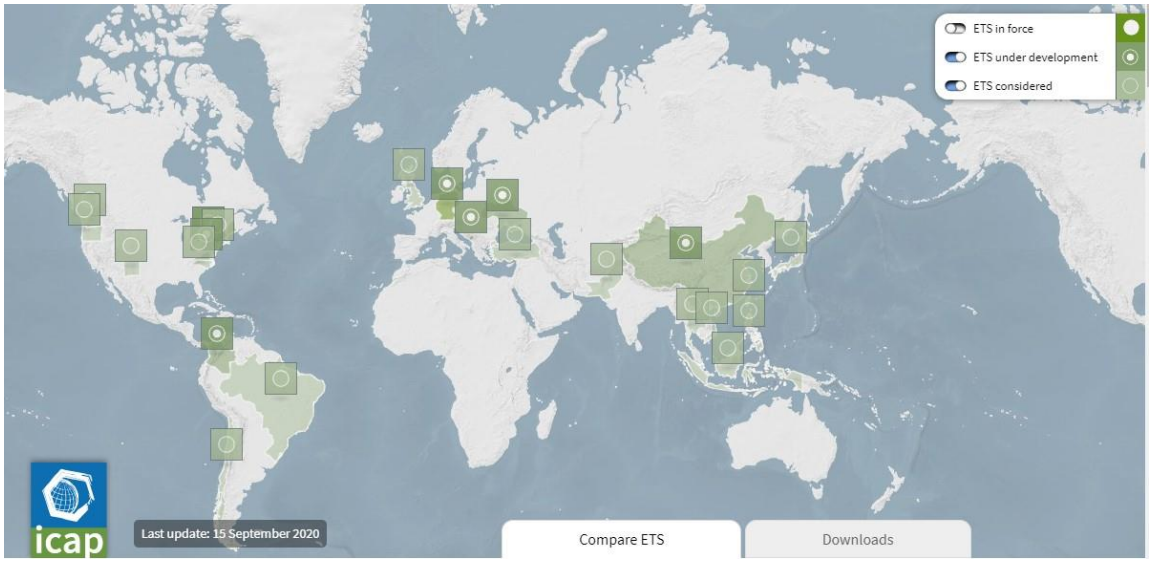
In Africa or South America, there are no Emissions Trading Systems in force. In North America, there are six Emissions Trading Systems. Three of them are in the United States of America. The Regional Greenhouse Gas Initiative (RGGI) covers states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont. It includes Fossil Fuel Electric Generating Units and covers about 18 % of the greenhouse gas emissions of the area. In the state of Massachusetts, completing RGGI operates The Massachusetts Limits on Emissions from Electricity Generators system. It regulates the emissions from electricity generators and covers about 12 % of the greenhouse gas emissions of the state. Therefore, 30 % of the greenhouse gas emissions in Massachusetts are covered by ETS. The states of Virginia and Pennsylvania are considering launching an ETS and linking to RGGI. The most efficient ETS in the USA is the California cap-and-trade program which covers 80 % of the state's greenhouse gas emissions. The California cap-and-trade programme is

officially linked with Québec's cap-and-trade system in Canada. The Québec's cap-and-trade system is also truly efficient since it covers 82 % of the greenhouse gases of the area. It was founded in 2013. Another Canadian ETS programme is called Nova Scotia's cap-and-trade program. This programme was founded in 2018, and it covers about 80 % of the greenhouse gases of the area. Although the efficiency of the programmes is great, the area covered by them is small. The sixth ETS programme running in North America is Mexican ETS pilot. It is operating on a trial basis from 2020-2022 to test and evolve the system before announcing the permanent ETS. This pilot covers 37 % of the greenhouse gas emissions of Mexico. (ICAP, 2020)

3.3.2 Emissions Trading Systems under development

In addition to ETS systems in force, many ETS programmes are being developed and under consideration in 2020. They can be seen in Figure 3. The systems under preparation are mainly located in North America, Europe and Asia. (ICAP, 2020)

Figure 3: Emissions Trading Systems under development and the ones considered © 2020 by International Carbon Action Partnership (ICAP)



One of the most important systems under development is the national ETS programme in China (ICAP, 2020). EU is giving its support and guidance for launching the functional, national ETS-programme in China. This project is called EUChina ETS. The target of the project is to deepen the co-operation of the European and Chinese ETS specialists by doing joint research or developing an emission trading network. This will help both operators to improve their systems and find possible weaknesses of the developing

system. (EUChina-ETS, 2020) The China National ETS will overtake EU ETS as the biggest ETS in the world. The China National ETS is the only ETS being developed in Asia. In Europe, three ETS programmes are being developed. One of them is in Ukraine. The Ukraine ETS preparations were launched in 2017 due to the EU-Ukraine Association Agreement. Another European country launching ETS is Montenegro, which will cover industry and power sectors and will pursue a 1,5 % yearly decrease of greenhouse gas emissions. In addition to the EU ETS, Germany is launching an own national ETS which completes the coverage of EU ETS in the country. In the German national ETS, the CO_2 price is charged to the following: fuel oil; LPG; natural gas; coal and gasoline distributors, if distributed to use in transportation or heating purposes. There are two Emissions Trading systems under development in Northern America. One of them is in Virginia, USA. The ETS of Virginia will follow the major guidelines of the RGGI and will probably link into it later. The other ETS being developed in the USA is the Transportation and Climate Initiative (TCI) which, in some of the states, is completing the RGGI and in some states, will become the only ETS in force. The objective of the TCI is to develop a pricing mechanism for CO_2 emissions of the transportation sector. An ETS is being developed in South America, Colombia. This programme is called the National Program of Greenhouse Gas Tradable Emission Quotas, and the allowance distributions and auctions will be organised by the Ministry of Environment and Sustainable Development (Minambiente). The ETS of Colombia will complete the country's ongoing reduction mechanisms such as carbon dioxide taxing. (ICAP, 2020)

Even though many Emissions Trading Systems are in force or under development, there are major areas where ETS programmes are not even being considered. These areas are, for example, Australia, Africa and Russia completely, most of the USA, Canada, South America and Asia. (ICAP, 2020) Before international comprehensive ETS or global price for CO_2 emissions is introduced, the risk of carbon leakage exists (Eden et al., 2016). This is because the ambitious climate policies might lead to a disadvantage for European production compared to competitors that do not face similar costs in operations. The costs operators are facing because of the Emissions Trading System are divided into two: direct and indirect costs. Direct costs of the ETS are the costs related with the emissions of the participants. Indirect costs are costs passed on by suppliers, for example, energy producers increasing the price of electricity. Because of these costs, companies might want to relocate their operations or make investments outside of Europe. This would impair the benefits of the EU ETS and might even lead to an increase in global emissions.

The direct costs are compensated for by a greater amount of allowances distributed for free, whereas indirect costs are compensated for by national compensation programmes. (EU, 2015)

4 PHASES OF THE EU EMISSIONS TRADING SYSTEM

The basis of the EU Emissions Trading System is the Kyoto protocol that became effective in 1997. It was the first legally binding emissions reduction programme, and set reduction targets for 37 countries. As the EU's political instrument to reach these emissions reduction targets, the Green Paper with ideas on starting the EU ETS was presented by the European Commission. The Emissions Trading Directive was then presented in 2003, and the system launched in 2005. The history of the EU Emissions Trading system consists of three phases. The fourth phase starts at the beginning of 2021. (EC, 2020g) In this chapter, the phases of the system are introduced.

4.1 Phase I in 2005-2007

The first 3-year period of the ETS was a pilot phase and mostly "learning by doing" (EC, 2020g) since the EU ETS was the first Emissions Trading Scheme in the world (ICAP, 2020). Initially, the EU ETS only covered carbon dioxide emissions of the energy-intensive industries and power generation. During phase I, the free trade of allowances was established. EU ETS provides an opportunity for allowances trading within the EU. Another successful establishment made during phase I was founding of the monitoring, reporting and verifying system which is critical for the functioning of the EU ETS in the long run. (EC, 2020g)

In phase I, most of the allowances were distributed for free. Before phase I, there was no reliable monitoring of the greenhouse gases emissions, therefore, the amounts of the allowances demanded were difficult to evaluate. In evaluation, the demand for allowances was expected to be significantly higher than it actually was. As a result, the price of the allowances fell really low. The allowances for phase I could not be banked for phase II; the surplus of allowances was prevented in the second phase. Even though the price development of the allowances was not ideal during the first phase, the idea of incurring costs for greenhouse gas emissions was introduced. Albeit the surplus of the allowances was massive, emissions were traded in the first phase. In 2005, the number of allowances traded in the EU ETS was 94 million pieces. In 2006, the amount of the traded allowances rose to 460 million. In 2008, the amount of traded allowances approached a billion pieces. (EC, 2020g)

4.2 Phase II in 2008-2012

In the second phase, the coverage and efficiency of the EU ETS improved. Iceland, Liechtenstein, and Norway joined the system as new countries. The coverage was also improved by adding nitrous oxide (N_2O) as a monitored greenhouse gas. However, it was only included by some countries and only on the condition that it was emitted from the production of nitric acid (HNO_3). Additionally, the aviation sector joined the EU ETS at the beginning of 2012. (EC, 2020g) This requires aviation operators operating in the EU area, whether they are European or not, to monitor, report and verify their emissions. The emissions from the aviation field, during its participation in the EU ETS, have decreased more than 17 million tonnes yearly. From 2021, the global emissions of the aviation sector will be reduced by the orders of the International Civil Aviation Organisation (ICAO). (EC, 2020h) The efficiency of the EU ETS was improved by lowering the emissions cap and decreasing the number of allowances distributed for free. The portion of allowances distributed for free was still around 90 %. Auctions were held by some countries already in the second phase. (EC, 2020g) During the first two phases, there was no EU-wide cap, but national caps were in force (EC, 2020c).

Although the data of the monitoring of emissions collected in the first phase was put to account in the second phase, the surplus of allowances could not be completely avoided. This was due to the 2008 economic crisis, which decreased the demand for the allowances. At the beginning of the second phase, the amount of traded allowances kept rising and increased to 2,3 billion in 2008. In 2009, the amount of the traded allowances rose from 2.3 billion to 5.4 billion allowances. Between the years 2009 & 2010, the amount of the traded allowances did not change much due to the economic crisis. Though in 2010, the amount of traded allowances rose to 6.7 billion. In 2012, the number of allowances reached 7.9 billion which is worth 56 billion euros. (EC, 2020g) Throughout the second phase, the prices of the allowances were quite low. The price reached its top value in 2008; being around 30 €/t CO_2. In 2009-2011, the price of the allowances fluctuated around 15 €/t CO_2, until it fell again in 2012, to half of the previous price. (Makkonen et al., 2019) The price development can be seen in Figure 1.

4.3 Phase III in 2013-2020

At the beginning of the third phase, the EU-wide capping system replaced the national caps. The cap in 2013 was set to 2,084,301,856 allowances. The cap is lowered year-by-year, reducing by 38,2 million allowances. The reduction was set in line with the EU climate action targets for 2020. (EC, 2020i) The 2020 climate target consists of three parts. The first, is a 20% reduction in greenhouse gas emissions, relative to the 1990 levels. EU ETS is the main tool for that. In the third phase, new greenhouse gases were added. During the third phase, the EU ETS covered CO_2 emissions; N_2O emissions from nitric, adipic and glyoxylic acid production; and PFC emissions from the production of aluminium. (EU, 2015) The second part of the EU climate targets is to produce 20 % of the energy in a renewable way. This is mostly executed by national programmes, but also the EU NER300-project which supports renewable energy innovations. The last part of the 2020 EU climate action targets is a 20 % improvement in energy efficiency. The operations to achieve this objective are presented in the Energy Efficiency Directive. (EC, 2020j)

In the third phase of EU ETS, auctioning became the default method to distribute the allowances. Auctioning is the most transparent way to distribute the allowances, and it sets the principle “Polluters should pay” in force. In the third phase 57 % of the total distributed allowances were auctioned. In the energy generation sector, distributing the allowances for free ended in 2013. This means that in the energy generation field, all allowances need to be bought. Yet, this excludes the following countries: (EC, 2020k) Bulgaria, Cyprus, Czechia, Estonia, Hungary, Lithuania, Poland and Romania. In these countries, the gradually decreasing distribution of free allowances was in use until 2019. (EC, 2020l) In the manufacturing industry, the number of allowances distributed for free has decreased gradually. In 2013, 80 % of the allowances were distributed for free, whereas in 2020 the portion has fallen to 30 %. The portion of allowances distributed for free was reduced gradually year-to-year while the portion of auctioned allowances increased. The only exception was the manufacturing sectors, which are susceptible to carbon leakage. In the aviation sector, free allocation of allowances is still the default method of allowance distribution. Only 15 % of allowances are auctioned in the aviation field. (EC, 2020k)

In the third phase, the change of the allocation method from free distribution to auctioning can be seen in the price development of the allowances. From 2012 to 2013, the price of the allowances kept falling, being under 5 €/t CO_2 at its lowest level. During the period 2014-2016, price began to rise slowly. It almost reached 10 €/t CO_2 at the beginning of 2016. In 2016, the price of the allowances drastically fell back to 5 €/t CO_2 and stayed there also in 2017. During the period 2017-2018, the price of the allowances rose rapidly to 15 €/t CO_2. The price kept rising, but more moderately, and almost reached 30 €/t CO_2 in 2019. (Makkonen et al., 2019)

4.4 Phase IV in 2021-2030

To complete the emissions reduction target of EU that is set for 2030, the sectors covered by the EU ETS are required to decrease their greenhouse gas emissions by 43 % compared to the 2005 numbers. This is enabled by setting the emissions cap to decrease by 2,2 % annually from 2021 onwards. Procedures to achieve these targets are introduced in the revised Emissions Trading Directive 2003/87/EC, which sets the main perceptions for the operations of the EU ETS for years 2021-2030. This revised directive was set in force in 2018. (EC, 2020m) In the revision of ETS, directive changes were made, for example, to the operation of the Market Stability Reserve (EC, 2020n).

To strengthen the Emissions Trading System, the opportunity of the surplus of allowances should be avoided in the future. For that, the Market Stability Reserve (MSR) is reinforced. (EC, 2020m) MSR was already in use during the third phase as a back-loading system. Back-loading does not affect the total amount of the allowances auctioned during a phase but affects the timing of the auctioning. This will decrease the short-term surplus of allowances and make the ETS adapt to the changes in demand for allowances. Between 2019-2023, the amount of the allowances allowed to be added yearly to the MSR will be temporarily increased. From 2023 onwards, the number of allowances stored in the MSR will be limited and the number of allowances exceeding the previous year's volume auctioned will be invalided. (EC, 2020n)

In most sectors, the free distribution of the allowances is predicted to be phased out at the end of the fourth phase. Altogether, more than 6 billion allowances are predicted to be distributed for free to the industry. After the year 2026, the distribution is predicted to fall from a maximum of 30 % to 0 % until 2030, the end of phase IV. This cut in the free

allocation does not affect the sectors susceptible to carbon leaking, minimizing relocation of operations outside of the EU. These sectors will receive 100% of their allocations for free. (EC, 2020m) This means that the highly susceptible sectors that are on the carbon leakage list receive 100 % of the suitable benchmark value for free (EC, 2020f). The system to distribute the allowances will be modified to adapt to the changes in production rates more effectively. The distributions to industries are adjusted to follow the annual differences by comparing the annual production rate to the rolling average of two years. If the change in production rate is more than 15 %, adjustment is necessary. Additionally, the list of the industries allowed to receive allowances distributed for free is examined every five years. To adjust the level of free distribution, the bench values will be updated two times during the fourth phase. (EC, 2020m)

In addition to the NER300 project, introduced in thesis in chapter 2.1, and launched in 2010 (EU, 2015), several low-carbon funding mechanisms will be launched during the fourth phase. Two examples are the innovation fund and the modernisation fund. The innovation fund will expand the support of the NER300 programme. It supports the introducing of innovative technologies and breakthrough innovation in the field of industry with a fund size of approximately 450 million allowances. The modernisation fund operates in the carbon-dependent areas of lower-income ETS member states. It supports the modernising of the energy production sector, widening the energy sources and uplifting energy efficiency. (EC, 2020m)

5 THE EU EMISSIONS TRADING SYSTEM IN FINLAND

The EU Emissions Trading System covers almost half of the greenhouse gas emissions in Finland. The Finnish national Emissions Trading Authority: Energy Authority, takes care of the free allocation in phase IV. The authority responsible for the Finnish Emissions Trading legislation is the Ministry of Economic Affairs and Employment of Finland. (Työ- ja elinkeinoministeriö, 2020) In this chapter, the impacts of the EU Emissions Trading System in the Finnish economy and theoretical implications in Finnish companies are discussed, and the Finnish regulatory framework is presented.

5.1 Regulatory Framework

The Finnish regulatory framework of the Emissions Trading consists of the following legislation:

- Act on the Use of the Kyoto Mechanisms 109/2007
- Emissions Trading Act 311/2011, previously 683/2004
- Act on Aviation Emissions Trading 34/2010

The purpose of Ministry of Economic Affairs and Employment of Finland Act on the Use of the Kyoto Mechanisms 109/2007 is to establish an administrative framework for participation in activities and emissions trading under the Kyoto Protocol. It also provides the registry, established by the Emissions Trading Act 683/2004, to function as the national registry required for the implementation of the Kyoto Protocol. (Act 109/2007, Section 1) The Act 109/2007 applies to joint implementation projects that take place in Finland; and joint implementation projects or clean development mechanism projects, which produce emissions units to be added to national register, but do not necessarily take place in Finland. Additionally, the Act applies to the storage of emissions units in the national registry; domestic and international emissions trading activities that transfer allowances between national registry accounts, or between an account in the national registry and an account in another registry that is linked to the transaction log of the climate agreement. (Act 109/2007, Section 2). The Ministry of Environment participates in international emissions trading on behalf of the Finnish government and handles the transactions of the allowances in international and domestic emissions trading. (Act 109/2007 Section 4)

The other main Finnish Act related to EU ETS in Finland is the Emissions Trading Act 311/2011. It enforces the Emissions Trading Directive 2003/87/EC in Finland (Act 311/2011, Section 1). The scope of application defined in the 311/2011 is equal to the scope of application in the Emissions Trading Directive 2003/87/EC Annex I, except for the aviation sector. The Act 311/2011 does not apply to coverage of the aviation sector by Emissions Trading System: the law concerning the ETS of aviation in Finland is 34/2010. (Act 311/2011, Section 2). Additionally, the act 311/2011 contains the general requirements for the operators, for example, the greenhouse gas emissions permit and monitoring, verification and surrender of allowances. In the version that will come into force at the beginning of 2021, the operators will be required to apply for an acceptance of the monitoring plan (Act 311/2011, Section 7). The Act 311/2011 contains information about the application and approval of the emissions permit and monitoring plan acceptance. The acceptance and permit can be granted until further notice or for a limited time (Act 311/2011, Sections 9-10). In Finland, like all the member states of EU ETS, the distribution of the emission allowances is done via the methods of harmonised allocation according to The Decision of Harmonised Allocation Rules, Commission Decision 2011/278/EU. The distribution methods are auctioning, free distribution and distribution via modernisation fund. The allowances can also be stored in the Market Stability Reserve MSR. (Act 311/2011, Section 19a) The amounts of the allowances distributed for free will be calculated and decided by the Ministry of Economic Affairs and Employment of Finland (Act 311/2011, Section 25).

The Act 311/2011 does not apply to coverage of the aviation sector by the Emissions Trading System: the law concerning the ETS of aviation in Finland is 34/2010. (Act 311/2011, Section 2). Finnish Transport and Communications Agency Act on Aviation Emissions Trading 34/2010, enforces the directive 2008/101/EC which incorporates the aviation sector into the Emissions Trading Directive 2003/87/EC in Finland (Act 34/2010, Section 1). The scope of application defined in the 34/2010 is equal to the scope of application in the Emissions Trading Directive 2003/87/EC Annex I aviation section (Act 34/2010, Section 2). The Act 34/2010 defines the responsibilities of the aircraft operator. The aircraft operators are required to monitor their emissions and tonne-kilometres, prepare an annual report and verify the report. Additionally, the operators need to make a monitoring plan and deliver the report and the information necessary for the application of free allowances to the Finnish Transport and Communications Agency. The operator must inform the Finnish Transport and Communications Agency about the changes in

operation, emissions monitoring, and aircraft operator. Annually, the operator is required to surrender the number of allowances equivalent to the total amount emitted during the previous year. (Act 34/2010, Section 4)

5.2 The effect of the EU Emissions Trading System in the Finnish economy and companies

Gross Domestic Product (GDP) per capita is the most crucial metric of economic growth (Poropudas, 2012). GDP is described as the sum of final uses of goods and services of resident institutional units (Tilastokeskus, 2013). The number of exports impacts the value of GDP. The decrease in export reduces the value of GDP. EU ETS has a significant role in affecting the competitiveness of the export industry (Känkänen et al., 2017) so it might lead to a reduction in export and therefore decrease in GDP/capita. The impact on exports is divided into two distinct categories: exports outside the EU and inside the EU. For exporting outside the EU, the Emissions Trading System can cause a disadvantage for the operators it covers. This disadvantage arises because the costs, which ETS causes, are directly added to the production costs. Since they cannot be transferred to the price of the product, it weakens the viability of the company. The impact on exports inside the EU is more complex and depends on, for example, the electricity and carbon intensity of the production. (Känkänen et al., 2017)

The EU ETS can also impact the domestic market of the product if the production costs in domestic production rise higher than in products imported from the EU or outside (Känkänen et al., 2017). The rise in imports reduces the value of GDP. In the fourth phase, the decrease in the amount of free allocation and the increased use of the Market Stability Reserve will raise the price of the allowances and therefore rise the costs caused by the EU ETS. (Känkänen et al., 2017) This impact has been inhibited in the sectors most internationalised since they are the most exposed to the carbon leakage, and still receive significant amounts of allowances for free (EC, 2020m). Hence, the impact on export cannot be predicted precisely.

Evaluations (Koljonen et al., 2014, Honkatukia et al., 2011) using computational models often predict a decrease inGross Domestic Product and the numbers of employees, especially in the short term. The overall impact of renewable energy targets for GDP is positive (Lindroos et al., 2012) but does not overcome the negative effect of ETS. The

evaluations presented use the computational model: VATTAGE. The evaluation is proportional to the suppositions in the calculations, for example, the supposed price of allowances, which is always an estimation. Another factor affecting the results is predictions of international market development and consequently, the Finnish economy as a functional part of it. The impact on Finnish GDP can be explained by the rise in companies' expenses caused by the costs incurred from the Emissions Trading System. Companies are predicted to partially cover the costs by increasing the price of their products. This rise in product prices has a negative impact on GDP and numbers of employees. The objectives to increase the amount of renewable energy production mitigate the adverse effects by reducing the price of electricity. The investments in renewable energy production increase the employment rate and GDP. (Hokkanen T., 2015)

The results of the empirical evaluations (Grotenfelt I., 2019, Wagner et al. 2014, Abrell et al., 2011) performed in the EU are more uniform than the computational modelling results. The results reached by empirical evaluation are statistically insignificant, and therefore EU ETS does not have an impact on the factors observed (Grotenfelt I., 2019, Wagner et al. 2014, Abrell et al., 2011). The Finnish research done by Grotenfelt I. studies the effect of the EU ETS on the turnover, number of employees and operating profit of companies. It has been estimated by a difference-in-differences method that can be implemented as linear regression. According to the results of estimations done by Grotenfelt I., EU Emissions Trading system did not have a significant impact on the turnover of studied companies. The impact was calculated separately for each phase of the ETS, and minor variety between the phases was noticeable. The only statistically significant effect was observed in the third phase in some estimations, so Emissions Trading System might have had a positive impact on the turnover of companies. Generally, ETS did not have an impact on the turnovers. The results remain similar in every phase of the Emissions Trading System and with different calculation methods, for example, by adding control variables or expanding the sample size of the control group. The average error of the estimate might cause the minor variety in the impact calculation and cause unreliability in the modelling. When the research sample is limited to contain only Finnish industrial companies, the results were similar to previous results. The impact on the Emissions Trading System was not statistically significant, but a minor negative impact was observed. The estimates of phase I were positive, and the estimates in phases II-III were negative. From this, it can be deduced that the Emissions Trading System has

a minor negative impact on the turnover of the Finnish industrial companies. However, the impact was not statistically significant in any phase. (Grotenfelt I., 2019)

The empirical study (Grotenfelt I., 2019) observed that the impact of the EU Emissions Trading System on the number of employees was not statistically significant in phases I-II. In phase III, the ETS had a noticeable positive impact on the number of employees. The result remained similar when different calculation methods were used in the study (Grotenfelt I., 2019). The exact amount of the increase in number of employees cannot be generalised, and the impact varies depending upon the industry. This is due to the differences in capital intensity and the number of employees. Additionally, financial shocks and economic downturns cause variability in the number of employees. When the research sample is limited to contain only Finnish industrial companies, the impact of the Emissions Trading System on the number of employees was found to be positive in every phase of the system. In the third phase, the impact was significant. (Grotenfelt I., 2019) The main problem regarding the empirical evaluation of the impact is forming the control group for the study. This is because the companies are not randomly picked to participate in ETS. If the control group does not respond to the sample, the results of the study cannot be exact. If observational data used in the study is qualified and accurate and forming of the control group is successful, then the results are fairly accurate estimates of the actual policy implications. The indirect impact of ETS also causes uncertainty in the predictions done with the empirical evaluations. The indirect impact of the ETS means that the policy change is not only purely targeted at those covered by the change but also leaks in part to external operators. (Hokkanen T., 2015)

6 CASE OUTOKUMPU TORNIO WORKS

In this chapter, the EU Emissions Trading System in Outokumpu Tornio Works is observed. Outokumpu Tornio Works covers the ferrochrome (FeCr) and steel production of the Outokumpu factories in Tornio. The production chain begins from the mine in Kemi. For ferrochrome production, it covers process steps of sintering and smelting of products. For the steel production melting, hot rolling and cold rolling of the products are covered. (Fyhr, 2020a)

6.1 Emissions Trading System from an Administrative Point of View

The administrative tasks related to the EU Emissions Trading System in Outokumpu Tornio Works are done by 2 persons and can be divided into three: (Fyhr, 2020a)

- Applying for and reviewing the emissions permit & the monitoring plan
- Application for the free allowances
- Application for the compensation of the indirect costs of emissions trading

The companies need to have the emissions permit before the operations can be started. Emissions permit is obtained on behalf company by a national competent authority, in Finland Energy Authority, and it will be valid until further notice. The emissions permit will also be reviewed at the turn of the phases by Energy Authority. However, the emissions permit needs to be reviewed if significant changes appear. During phases I-III, the monitoring plan has been a part of the emissions permit, and changes in the monitoring plan have required updating the emissions permit. In Outokumpu Tornio Works, the emissions permit has been updated almost annually due to the changes in the monitoring plan, for example, an introduction of a new monitoring device or a raw material. In phase IV, the monitoring plan will be separated from the emissions permit. This will allow the monitoring plan to be updated separately and make the emissions permit more permanent. (Fyhr, 2020a)

The applications for free allowances need to be done in advance for each phase. The application is prepared by the company applying and verified by an independent verifier before it is sent to authorities. First, the application is sent to the appropriate Finnish

authority which is Energy Authority in phase IV, and was the Ministry of Economic Affairs and Employment in previous phases. The Finnish authority makes preliminary decisions of amounts of allowances that will be granted to companies and delivers the information to the European Commission. European Commission calculates the allowances and if needed, publishes a Cross-Sectoral Correction Factor (CSCF) and accepts the companies to the free allocation district. The Finnish Energy Authority makes the final decisions of the free allocation on an installation level after receiving information about the corrector CSCF. The application is prepared and accepted according to The Decision of Harmonised Allocation Rules, Commission Decision 2011/278/EU, in the fourth phase according to the Commission Regulation determining transitional Union-wide rules for harmonised free allocation of emission allowances 2019/331/EU. The application process can be long. For example, the applications for the free allowances in the fourth phase needed to be filed by the end of May 2019 and as of the beginning of November 2020, the results of decisions have not been taken. (Fyhr, 2020a)

The compensation of the indirect costs of emissions trading is a national support system designed for the sub-sectors susceptible to carbon leakage. The recommendation for this kind of system is presented in the Emissions Trading Directive 2003/87/EC Article 10a: 6 and national support systems are operated in some European countries. The system compensates the increase in the energy costs caused by the emissions trading system, in the energy sector. The compensation of the indirect costs of emissions trading has been in effect in Finland since 2016. After 2020, the previous system will be replaced by support for industrial electrification and modernisation and introduced by Ministry of Economic Affairs and Employment of Finland. The 2020 compensation will be applied in 2021. The application for compensation is made retroactively based on energy consumption and production rate relative to the monitored baseline. The annual energy consumption is compared to the baseline value, and in case of significant changes, the compensation can be changed. The applications are prepared in companies and verified by an independent verifier. The application is sent to the Energy Authority which makes decisions about compensation. (Fyhr, 2020a)

6.2 Practical Measures Related to Emissions Trading

The practical measures are mostly related to the monitoring plan of the company. In Outokumpu Tornio Works, there are around 25-30 people that do work related to Emissions Trading as a part of their job. The tasks can be divided into two: (Fyhr, 2020a)

- Monitoring of the quality and quantity of raw material and fuel flow
- Maintenance of the monitoring devices

Outokumpu Tornio Works is considered as one balance area which covers the ferrochrome (FeCr) and steel production of the Outokumpu factories in Tornio. The carbon dioxide emissions from raw materials are monitored using the mass-balance formula, where the difference of the quantity of carbon going in production as raw material and coming out as a product or storage is assumed to burn in the process and form carbon dioxide

$$[m(t)_{CO2}] = \sum[m(t)_{feed} \times \text{emission factor}_{feed}] - \sum[m(t)_{products} \times \text{emission factor}_{product}] - \sum[m(t)_{storage} \times \text{emission factor}_{storage}] \quad (2)$$

where $m(t)_i$ is the mass of flow i in tonnes [t] and emission factor_i is process specific feature of the flow i [t/t]

The quantity of the feed can be measured at the beginning of the process in the production section of the Ferrochrome Works and steel melting shop by weighing the raw material with various types of scales. The maintenance of the scales is also one of the practical tasks the EU Emissions Trading System induces. This includes the checking of the validity of the measurements and calibration repairing of the scale according to the maintenance program. The operation of the scales plays a major role in the monitoring of emissions from raw materials. The emission factor of a raw material [m(t) (CO_2) / m(t) (material)] can be calculated by multiplying the carbon content of the material flow [m(t) (C) / m(t) (material)] by the conversion factor 3,664 [m(t) CO_2 / m(t) C]. To calculate the emission factor, the carbon content of the raw or product material must be known. The carbon content of the raw material can be measured in a laboratory from the samples taken from the flows according to the sampling program. Some of the measurements can be done in the laboratory of Outokumpu Tornio Works, but most of them are done in another laboratory that is accredited for certain studies. The samples need to be collected,

prepared in a laboratory, and dispatched by employees of Outokumpu Tornio Works. (Fyhr, 2020a)

The monitoring of the emissions of fuels used in the process differs from the monitoring of raw materials. For the fuels, the measuring is done by multiplying the feed of fuel in volume and multiplying it by emission factor and oxidation factor (Fyhr, 2020a)

$$[m(t)_{CO2}] = \sum[E(MJ)_{Feed} \times \text{emission factor}_{feed} \times \text{oxidation factor}_{feed}] \quad (3)$$

Where E_i is the Energy content of the flow i [MJ], emission factor = feature of the flow [t/MJ] and oxidation factor is feature of the fuel [*unitless*]

The energy content (E) of fuel can be calculated by multiplying the volume [V(m^3) fuel] of the fuel used by the calorific value of the fuel (MJ/m^3). The emission factor used is the mass of the carbon dioxide emissions per the energy used [m(t) CO_2 / E(MJ)]. Oxidation factors used in Outokumpu are the national constants. The quality of the fuels used is monitored continuously online, whereas the quantity of the feed is monitored using flow meters.

6.3 The Emission Allowances of Outokumpu Tornio Works

Outokumpu operates in one of the sub-sectors highly exposed to carbon leakage (Fyhr, 2020a). The companies that are considered highly exposed receive a greater amount of free allowances than many other institutions (EC, 2020f). Until the end of phase III 2020, the number of allowances received by free allocation has been sufficient, and the number of allocated allowances has exceeded the amount of emissions. This can be seen in table 1.

Table 1: The amount of allowances received via free allocation and emissions (t) of the Outokumpu Tornio Works presented annually 2013-2020

Position limits	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
allocation	788 644	774 943	761 106	747 149	733 065	718 867	704 519	690 129
emissions	640 401	697 716	708 489	672 884	640 260	705 200	684 373	

Unlike in the previous phases, the fourth phase is divided into two allocation phases: the free allowances are applied twice, for 2021-2025 and 2026-2030 separately. Since the results decisions of the free allocation application for phase IV 2021-2025 are not yet taken, i.e., process is pending, the amounts received via free allocation can only be estimated. The estimation can be seen in table 2.

Table 2: The approximation of the allowances received via free allocation without taking CSCF into account in the years 2021-2025 presented annually

Position limits	**2021**	**2022**	**2023**	**2024**	**2025**
allocation	ca. 660000	ca. 660000	ca. 660000	ca. 660000	ca. 660000
emissions					

The average amount of emissions between 2013-2019, calculated by the information of the table 1, is 678 475 tonnes. This is significantly more than the 660 000 allowances permitted, as shown in table 2, therefore the need to purchase allowances will appear. (Fyhr, 2020a) Calculated with the 2.11.2020 EU Allowance price which is 23,67 €/allowance (Ember, 2020), purchasing the allowances (28 475 pcs) would cost around 674 000 € annually. Due to the yearly variation in amounts of emissions and free allocation, the number needed to purchase varies. (Fyhr, 2020a)

To ensure that the need for emission allowances is met properly, the yearly production volume and other activity levels are measured. The annual value of the activity levels should be sufficiently similar to the values in free allocation decision. In Outokumpu Tornio Works, the volume of production and other activity levels have varied a little but stayed within limits permitted in the previous phases. In phase IV, the permitted limits will be tightened, so changes in amounts of allowances distributed for free will change more easily. Therefore, the system will react faster to changes. This facilitates more efficient allocation of allowances. The volume of production and other activity levels are tracked by Outokumpu, and they are reported to the Ministry of Economic Affairs and Employment annually. The monitored benchmarks in Outokumpu Tornio Works are

product benchmarks (2 pieces), heat benchmark, fuel benchmark, and process emissions approach. (Fyhr, 2020a)

6.4 Preparations for the Phase IV

The administrative preparations for the change of EU ETS phase were started years before the change was timely. The preparations were started by following the development of the regulatory framework closely. By following the forming of legislation, the impacts of changing the phase could be predicted. The necessary applications also needed to be prepared well in advance. In between the phases, the free allowances are applied, and the emission permit is reviewed. (Fyhr, 2020b)

In phase IV, rules of the system change. The change strengthens the impact of the Emissions Trading System in the companies because the new rules will induce a shortage of allowances and therefore raise the price of theirs. This incentive will be noticed especially in Outokumpu Tornio Works, because allowances may need to be purchased for the first time, in the fourth phase. The shortage of allowances and rising prices will make companies consider new ways to cut their emissions. Cutting the emissions might mean investments in changing the processes, or improving the energy efficiency of the existent process systems, or modifying them in other ways to make them less CO_2 intensive. (Fyhr, 2020b)

6.5 Reduction of greenhouse gas emissions in Outokumpu Tornio Works

The most important way to reduce emissions in Outokumpu is improving resource efficiency. Resource efficiency can be improved by enhancing energy efficiency and material efficiency. (Fyhr, 2020b)

Energy Efficiency is continuously improved by process step specifically by reducing electricity or fuel consumption. In Outokumpu Tornio Works Energy Efficiency System, EES+ is in use. (Fyhr, 2020b) EES+ is a system that helps the companies to create systematic methods to achieve improvement in energy efficiency: setting measurable objectives, monitoring consumption, and specifying responsibilities. The EES+ system is based on continual improvement within organisations. The improvement is made in

cycles of reviewing energy policy, energy planning, implementation and orientation, checking the process and reviewing of management. (Motiva Oy, 2015) The European Commission has listed the use of clean hydrogen (H_2), fuel cells and other alternative fuels as the priority for the emissions reduction in the industry sector in Green Deal (COM/2019/640 2.1.3).

Improvement in material efficiency reduces the emissions of the production cycle. Material efficiency reduces the consumption of raw materials and re-processing of the materials. By improving the quality of production in Outokumpu Tornio Works, the energy and material efficiency has ameliorated. In good quality production, the frequency of errors decreases. Production errors in the steel industry often result in re-processing of products or material loss. Re-processing requires electricity and fuel, and this energy consumption could have been avoided by successful production in the first place. The consumption of primary raw materials has also been reduced by using recycled steel in production. (Fyhr, 2020b) In Outokumpu Tornio Works, the content of recycled steel in the products is outstandingly higher than the global average, which is 60 %. In Outokumpu, in 2019, the percentage of secondary raw materials was 89,6 %. (Outokumpu, 2020) An important compound to be recovered in the factory complex is carbon monoxide (CO). A closed furnace in ferrochrome production makes it possible to capture the carbon monoxide generated as a process gas. The carbon monoxide can be utilised in the Tornio Works as a source of energy. The CO is primarily consumed in the hot rolling mill, cold rolling mill and ferrochrome works and can be used instead of natural gas. Part of the carbon monoxide is also sold to power plants and a limestone and calcium carbonate production factory nearby. (Fyhr, 2020b)

In addition to resource and energy efficiency, Outokumpu also constantly strives to develop processes by means of research and development work. The aim is to make the current production processes, especially in FeCr works and steel melting shop, less CO_2 intensive. The objective is to reduce the emissions in all levels of production with new, improved technological solutions. (Fyhr, 2020b)

7 EUROPEAN COMMISSION GREEN DEAL

The European Green Deal is the Communication From The Commission to the European Parliament, presented in December 2019, to achieve the objective of the European Union to become climate neutral in 2050. It provides ideas for improving and completing the existing EU ETS and other systems. The Green Deal is an extensive EU climate programme and it has many policy areas. Climate action is one of them. The main goals of Green Deal regarding climate action are to reduce the amount of the net greenhouse gas emissions to zero by the year 2050 and decouple economic growth from the use of resources across Europe. In addition to emissions reduction, the Green Deal covers the following sectors: biodiversity, sustainable food systems and agriculture, Clean energy, cleaner construction sector, Sustainable industry and mobility, and Eliminating pollution (EC, 2020o)

The objective of the European Union is to become climate-neutral in 2050. The European Commission proposed the European Climate Law to develop the political commitment into a legal obligation. (EC, 2020o) The regulation constucts the structure for the permanent and systematic reduction of greenhouse gas emissions, and to increase the removal of the emissions by sinks, natural or other (Proposal 2020/0036(COD), Article 1). The European Climate Law would oblige the relevant Union institutions and the Member states to ensure the operations achieve the climate-neutrality objective (Proposal 2020/0036(COD), Article 2). The commission assesses the progress of the member states towards the climate neutrality goal (Proposal 2020/0036(COD), Article 5:1) and the actions of the European Union towards the climate neutrality (Proposal 2020/0036(COD), Article 5:2). The commission shall collaborate with all parts of society and encourage actions towards climate-neutrality. The Commission will enable a complete and accessible system at all levels, covering national, regional and local levels. (Proposal 2020/0036(COD), Article 8)

If ambivalence towards reduction of greenhouse emissions persist while the EU tightens its targets, the risk for carbon leakage exists. In the Green Deal, the European commission presents a new way to prevent the carbon leakage as an alternative for the actions presented in the EU ETS: the Carbon Border Adjustment Mechanism (CBAM). This mechanism would ensure the prices of imported products reflect the carbon content of the product. This would help EU products remain competitive. (COM/2019/640 2.1.1)

Carbon Border Adjustment Mechanism would apply only to certain industries that are exposed to carbon leakage. The exact formulation of the approach is yet to be determined (EC, 2020p) but it will comply with the World Trade Organisation rules and some other international obligations (COM/2019/640 2.1.1). CBAM was proposed legally for the first time in September 2020. The European Commission will suggest it again in the second quarter of 2021. However, the Parliament's Committee on the Environment, Public Health and Food Safety (ENVI) is preparing their own report about the CBAM. (European Parliament, 2020)

In the Commission Green Deal, many changes for the current Emissions Trading System are proposed. One of them is the proposition to include the maritime sector in EU ETS and reduce the amount of allowances distributed for free to airlines. The European Commission also proposes the expansion of EU ETS coverage to include road transport, because greenhouse gas emissions of transportation need to be reduced by 90 % to achieve climate neutrality. (COM/2019/640 2.1.5) The European Commission will propose a revision of the Emissions Trading directive to support the achievement of more ambitious climate goals (COM/2019/640 Annex). As part of the revision of the EU Emission Trading System, the Commission will examine the role of the Innovation Fund and Modernisation Fund; they are aiming to strengthen it. They will consider whether part of the profits from selling allowances should be allocated to the EU budget. This would strengthen the just transition towards low-carbon and climate-resilient activities. To strengthen the fair transition, the Just Transition Fund will be proposed. (COM/2019/640 2.2.1)

8 CONCLUSIONS

As a conclusion of this study, it can be said that the EU Emissions Trading System is an efficient tool for the reduction of greenhouse gas emissions. Its redeeming quality is the cap & trade feature which makes it possible to set a top value for emissions, and make the reduction happen where it is cheapest and easiest. As discussed in chapter 3.3, the fault of emissions trading systems globally is the disadvantage to regional production. This has been compensated by greater free allocation, but it is not a sustainable solution for the problem. The commission's careful suggestion for a carbon border adjustment mechanism, in case the environmental policies will not be tightened globally, could be at least a temporary solution for the problem. Nevertheless, the hope for international Emissions Trading System is hopefully not forlorn since more countries and areas are continually joining the ETS. If the international emissions trading system can be launched or carbon border adjustment mechanism put into service, the free allocation could be stopped and the incentives for greenhouse gas reduction would become effective and equal for all since the risk of carbon leakage would be overcome.

The carbon adjustment border mechanism would be an excellent idea to expand the effect of emissions trading globally. However, if the carbon borders are not set in all the countries with an emissions trading system, the benefits of them will be limited. The carbon borders affect the imports to the area they are set for, so they benefit the production of the area. Hopefully, new emissions trading systems will be launched, and the coverage of the emissions trading systems will expand globally. In a world of free competition, the carbon border adjustment might raise opposition, especially by the countries that do not have an emissions trading system and therefore would face many customs. A worldwide emissions trading system would harmonise the rules and effect of ETS, and the pricing of allowances. This would create a base for fair competition where energy efficiency, material efficiency, renewable energy sources and emissions reduction are competitive advantages.

The coverage of some Emissions Trading Systems in the world, for example: the EU ETS, is not very comprehensive. The coverage of EU ETS is about 45 %, and it only covers the largest companies and aviation. The aim is to reach carbon neutrality in the EU by 2050. Reaching it would be easier if EU ETS covered a higher percentage of the emissions in the EU. This could be enabled by adding the transportation sector to EU ETS and

increasing coverage of the industrial sector and energy production. Expanding the coverage of the Emissions Trading System would also equalise the competition in some fields of industry. The system has induced an edge in competition for small-scale companies and therefore prevented the emissions reduction from becoming an undeniable competitive advantage. For emissions reduction to become a competitive advantage, the pricing of the allowances should remain sufficiently high. Market Stability Reserve is a good tool for adjusting the number of allowances in the market. This will help to keep emissions reduction a priority for the companies even in the times of economic downturn. However, this will increase the stress on companies because of the policy. The decrease in the price development should have reduced the stress the system lays onto the industries in an economic downturn. But with MSR affecting the price development, the release is not as great.

The financial stress induced by the direct costs of EU ETS on Outokumpu Tornio Works has not been major, because the free allocation of allowances in the first three phases has been sufficient. This is predicted to change in the fourth phase, so the financial stress would increase. The indirect costs induced for the company, however, have been significant. The indirect costs are mainly due to the rise in electricity prices and cause ample financial stress for the company. The stress the EU Emissions Trading System induces for the companies is not only financial. The stress induced in the practical side of companies can be noticed in the case portion, chapter 6 of the thesis. The administrative side of the EU ETS requires plenty of applications and co-operation with authorities. Additionally, to predict the future development of the system, the preparations and changes in legislation are followed closely. In great factory complexes like Outokumpu Tornio Works, the monitoring of emissions is a complicated process that requires the attention of many employees. The monitoring does not require full work input of any of the employees but appears in smaller daily tasks.

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