EFFECT ON TÜRKİYE BUSINESS OF CARBON BORDER ADJUSTMENTS

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EFFECT ON TÜRKİYE BUSINESS OF CARBON BORDER ADJUSTMENTS

Yasin İpek
119664010

Prof. Dr. Cenktan ÖZYILDIRIM
İstanbul Bilgi University

Assoc. Prof. Dr. Deniz İKİZLERİ
İstanbul Bilgi University

Dr. Anıl KÜÇÜKGÖDE
Esenyurt University

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Name Surname: Yasin İpek
Signature:

ABSTRACT

The aim of the study is to examine the impact of carbon emission restrictions on the international trade of carbon intensive industries and the production of carbon emissions. Carbon is emitted during the production of energy and corresponds to income loss due to carbon border adjustments. Regulations such as carbon taxes and trading permits may decrease exports if countries do not transform their production technologies. In the first part of the thesis, sources of energy and fossil fuels are explained with global warming and carbon emissions. Secondly, carbon intensive sectors such as cement, steel, aluminium, fertilisers, electricity and hydrogen are represented with both figures and tables. Increases in carbon emissions cause additional costs due to carbon border adjustments, which could decrease the growth of export for some countries. Next, to assess the impact of carbon restrictions on the imports of carbon intensive products, data from countries with the largest import volumes were used to measure the international trade of these products, which emit approximately 40% of the Earth’s total carbon. The top eight largest importers were sampled as the primary importer countries of these products.

To eliminate the effect of economic growth, the ratio of total imports of carbon-intensive products to gross domestic product was used as the first dependent variable. The second dependent variable was the total carbon emissions data from the countries exporting to these major countries. Carbon constraint policies were defined using a dummy variable. The effects of these constraints were analysed using regression analysis on panel data from the six countries for the years 2018-2022. According to the regression results, carbon constraints were found to have no significant impact on either the international trade of these products or carbon emissions. These results show that current carbon constraints do not have a significant impact on carbon emissions and the international trade of these products. However, it is important to consider that these constraints are relatively new. In the future, it will be possible to conduct a more robust analysis with a larger dataset.

Keywords: Carbon Emissions; Carbon Restrictions; Imports; GDP; Growth

ÖZ

Çalışmanın amacı, karbon salınımı ve karbon yoğun sanayi mallarının uluslararası ticaretinde sınırda karbon düzenlemelerinin etkisinin incelenmesidir. Karbon salınımı, sanayi malı üretiminde ortaya çıkmaktadır. Sınırda karbon kısıtlamaları uluslararası ticaret yapan tarafların gelir kaybına yol açmaktadır. Üretimini düşük karbon salınımına uygun teknolojiye dönüştüren ülkeler, olumsuz etkilenmelerini önleyebilmektedir. Tezin birinci bölümünde yenilenebilir ve fosil enerji kaynakları açıklanmıştır. İkinci bölümde sınırda karbon düzenlemeleri kapsamında ana sektörler ve üretim miktarları açıklanmıştır. Karbon salınımının artması, düzenlemeler nedeniyle ithalat ve ihracat maliyetini yükselterek büyüme üzerinde olumsuz etkilere yol açabilmektedir. Karbon yoğun sanayi malın ithalatına, karbon kısıtlamalarının etkisini değerlendirmek için en çok ithal eden 8 ülkenin verileri uluslararası ticaret değişimlerini ölçmek için kullanılmıştır. Dünya toplam karbon salınımın yaklaşık %40'ını oluşturan 6 ürün örneklem olarak alınmıştır. Ekonomik büyümenin etkisini ortadan kaldırmak için karbon yoğun malın toplam ithalat değerinin, ithalat yapan ülkelerin gayrisafi milli hasıla brüt değerine oranı birinci bağımlı değişken olarak kullanılmıştır. İkinci değişen olarak ihracat yapan ülkelerin ihracat yaptıkları ülkelere tesir eden toplam karbon emisyon miktarları alınmıştır. Karbon kısıtlamanın varlığı, kukla değişken olarak tariflenmiştir. 2018-2022 yılları için 8 ithalatçı ülkenin panel verisi regresyon analizi ile incelenmiştir. Karbon kısıtlamalarının, 6 adet karbon yoğun malın karbon salınım miktarı ve uluslararası ticareti üzerine anlamlı etkisi tespit edilmemiştir.

Sınırda karbon kısıtlamaları yeni uygulamalar olup, son 5 yıl içerisinde aşamalı şekilde yürürlüğe alınmıştır. Diğer önemli bir durumda analiz edilen veri setinin sınırlı ve küçük olmasıdır. Yakın gelecekte karbon kısıtlamalarının daha çok sayıda ülke tarafından uygulanması ve yaygınlaşması ile daha geniş veri seti ile Analiz yapılması mümkün olacaktır.

Anahtar Kelimeler: Karbon Salınımı; Karbon Kısıtlamaları; İthalat; Gayrisafi Milli Hasıla; Büyüme

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β	level effects
CRI:	carbon restrictions to import
CRIC:	carbon restrictions to import for China
ε:	constant (dummy) variable
i:	top largest importers
R^2	determination coefficient
t:	time series

LIST OF ABBREVIATIONS

ASEAN:	Association of Southeast Asian Nations
b:	Billion
BRICS:	Brazil, Russian Fed., India, China Republic and South Africa:
Carbon Emissions:	Carbon Dioxide Emissions
CBAM:	Carbon Border Adjustment Mechanism
CBAs:	Carbon Border Adjustments
CO2:	Carbon Emissions
COP26:	Conference of the Parties
EGD:	European Green Deal
ERF:	Emission Reduction Funding
ETS:	Emission Trading System
EU:	European Union
EUR:	Euro
GDP:	Gross Domestic Product with Nominal Value
GHG:	Greenhouse Gases
IMF:	International Monetary Fund
IPCC:	Intergovernmental Panel on Climate Change
m:	Million
MENA:	Middle East and North Africa
MRS:	Market Stability Reserve
Mt:	Metric Ton
^{o}C:	Centigrade
OECD:	Organisation for Economic Co-operation and Development
SIM:	Selected İon Monitoring
UK:	United Kingdom
UN:	United Nations
US, USA:	United States of America
USD:	United States of Dollar

INTRODUCTION

Energy consumption has increased dramatically due to economic development and growth. The increasing energy demand of countries has triggered both the consumption of fossil fuels and higher carbon dioxide concentrations. Starting from the discussion of global warming, sanctions and restrictions have been placed at both global and local levels to protect the Earth's environment from the negative impacts of climate change.

Carbon emissions, a well-known aspect of climate change, pose significant challenges to individuals, companies producing carbon emissions through their operations, and financial institutions funding carbon-intensive producers. The Paris Agreement established milestones as global standards to address the challenge of mitigating climate change, according to the IPCC in 2018. Countries that signed the Paris Agreement committed to keeping the average temperature well below two degrees Celsius above pre-industrial levels and taking actions to limit the increase to 1.5 degrees Celsius. By around the middle of this century, countries must reduce their carbon emissions to zero.

Carbon emissions, which are a direct result of climate change, pose an open threat to economies. The risks related to climate change differ from well-known risks such as financial and market risks because they involve both irreversible damages and non-linearity. Given the expected uncertainties, there is little time and a severely restricted budget to meet targets. Prioritizations and leading developments to date, along with new developments in climate and policy-related prevention, are necessary to tackle carbon emissions, which have numerous implications for economic growth.

The European Union’s carbon prevention mechanism aims to impose a fair fee on the carbon emissions of goods entering the EU and to promote healthier industrial production in non-EU countries. The UK and China will apply the same mechanism starting in 2025. The steady introduction of the Carbon Border Adjustment Mechanism (CBAM) is aligned with the free allowances of the emissions trading system to curb carbon emissions. To ensure that a cost has been met for the embedded carbon level in the production of final products imported into countries with carbon emissions restrictions, the CBAM mandates that the carbon price of imports must be equivalent to the domestic price of carbon production. The carbon price for imports is calculated based on allowances expressed in USD or EURO per tonne of CO2 emitted. The CBAM is designed to be compatible with World Trade Organization criteria (The European Parliament and the Council of the European Union, 2023, Carbon Border Adjustment Mechanism Guidance).

Financial institutions, companies, and individuals believe that the struggle against carbon border adjustments will result in additional funding costs or income loss in the near future. Companies in carbon-restricted sectors may face lower growth and need immediate funding, but they have not been preparing for a long time, and there is no comprehensive framework for the restrictions on carbon emissions. To provide alternative financing instruments for businesses in carbon-restricted sectors, no special regulation or legislation currently exists to finance them or prevent income loss while committing to net-zero carbon emissions. On the other hand, financial markets pay high attention to CBAs as individual and corporate customers are keen to promote green banking and payment systems for their financial needs and e-trade environment. Banks and financial institutions understand how to finance additional costs (e.g., carbon taxes, emissions trading system) based on global standards for climate change restrictions. Local authorities plan to regulate their markets and financial sectors to avoid losing customers (i.e., profits) in terms of reputational risk.

This thesis provides a comprehensive study, offering readers detailed information on developments in areas where sectors produce carbon-intensive goods exported globally using current technology. Economic and financial changes for sectors in carbon-restricted areas will significantly impact manufacturing production processes, import and export activities, and transform current lending policies in banking and financial sectors. It is expected that CBAs could be a cornerstone of sustainable development for international trade, triggering economic and financial implications for companies in carbon-intensive sectors due to the need for additional funding resulting from potential profit decreases.

Local authorities have started to consider the merits and negative effects of introducing climate change restrictions. European countries, the United Kingdom, and North America have accepted using a set of policy instruments to transition to a lower carbon-intensive economy. Appropriate carbon pricing within different emissions plans is expected to achieve the targets. The survey by Weron (2014) showed that changes in weather patterns are already factored into the price of electricity in some economies. Carbon pricing may adversely impact existing financial situations related to potential triggers of climate change.

Compared to other scientific topics, there are few studies on the relationship between carbon emission restrictions (e.g., taxes, trading system), imports, and economic growth as standalone issues. The effect of carbon emission restrictions on import/export sectors is a common issue among a few researchers. The effect on Türkiye's growth due to carbon emission restrictions was analyzed by Yerlikaya (2021), Külünk (2013), and Yakut (2021). According to Yerlikaya (2021), "It was determined that energy consumption has a statistical significance level of 10% on growth and that carbon emission has one-way causality on economic growth at a statistical significance level of 1%" (p. 3).

It was noted that some studies on carbon emissions include negative impacts on growth. However, these studies mention the effect on economic growth in a general sense without clearly explaining the impact of carbon restrictions. According to Duman, "The use of these sources is also vital because (1) they emit high amounts of carbon dioxide which leads to environmental degradation; (2) because the reserves are limited and controlled by specific countries, most other countries are importers, creating a burden on their GDPs" (Duman, 2011, p. 6).

This study discusses the measures taken by countries to minimize carbon emissions and explains how carbon emissions impact the growth of imports/exports for carbon-restricted sectors. The first part details the sectors within the scope of CBAs. The second part defines the restrictions on carbon emissions in various countries and addresses issues related to carbon pricing resulting from these restrictions. The relationship between CBAs and the implications for carbon-restricted sectors is examined in terms of production, imports, and carbon-related cost reflections.

Many countries have imposed taxes and trading systems on carbon emissions, and this study examines how carbon taxes and carbon trading impact various sectors. Carbon tax measures the marginal cost arising from the negative impact of greenhouse gases, while carbon trading aims to cap carbon emissions and their associated costs. Both carbon taxes and tradable permits are considered inadequate methods for reducing carbon levels alone. Therefore, further complementary policies and applications, such as environmental tax legislation and incentives, are necessary to reduce carbon emissions.

The final part of this study examines the restrictions on carbon emissions and their effects on carbon-restricted sectors. The study aims to verify the relationship between variables such as carbon emissions and restrictions, the total value of imports, and economic growth.

SOURCES OF ENERGY AND SECTORS IN SCOPE OF THE CBAS

2.1. Sources of Energy

There are two types of resources as non-renewable and renewable. Non-renewable energies are known as primarily energies, including natural gas, fossil fuels like coal. They can be converted in secondarily sources of energy, such as electricity.

2.1.1. Sources of Renewable Energy

Renewable energy stems from existing sources in nature, which are renewed more than it is consumed. Sun and wind keep shining, for instance, are such resources for renewable energy. When compared with non-renewable energies such as fossil fuels, the generation of renewable energies is far lower carbon emissions. They are self-replenishing and generally a lower carbon footprint. It can be used for the production of electricity, water heating/cooling, space and transportation. The transition from fossil fuels to renewable energy is key to mitigate the climate crisis. However, over the past hundreds years, humans increasingly tend to cheaper, fossils fuels energy although they are aware of negative impact of dirtier energies. Here is some types of renewable energies as Bioenergy, Geothermal, Hydropower, Marine, Wind and Solar.

There are a lot of some benefits of renewable energy which affect economy and climate environment issues. Followings are some of the benefits of using renewable energy:

- Lower carbon emissions and air pollution in the production of energy
- Increasing energy independence
- Increasing affordability and cost-competitive with well-known energy sources
- Finding open funding opportunities
- New jobs throughout the development of renewable energy industries
- Expanding clean energy access for people and communities

Clean energy grew by 20% in year 2011 to 28% in year 2021 in the area of global electricity supply. Between 2011 and 2021, use of fossil energy reached to 62% by 8 points and nuclear to 10% by 2 points. Addition to this, the share of sun energy and the share of wind energy grew from 2% to 10% with same change while the share of hydropower dropped to 15% by 1 point. Biomass and geothermal energy grew only to 3% by 1 point. In 2021, China solely managed to reach almost 50% of the global increase in renewable electricity.

2.1.2. Sources of Non-Renewable Energy

Natural gases, oils and coal are non-renewable sources which are known as fossil fuels and, they are components of overall consumed energy. Below are major non-renewable energies as Petroleum, Hydrocarbon gas liquids, Natural gas, Coal and Nuclear energy.

The supplies of non-renewable are limited because they can be mine or extracted in the ground of the earth. They come from layers of prehistoric carbon-intensive materials which are remains of ancient sea plants and animals that lived millions of years ago. This is why called those sources of energy as fossil fuels. In addition to above mentioned, most of the petroleum products are reproduced from raw oils, but petroleum liquids are be derived from natural gas and coal. Fossil fuels had been compressed over millions of years to come with dense energy concentrations of solid material, liquid form or gas, which can be separated chemically and burned to meet human energy requirements'' (Vanek and Albright, 2008: 107).

Hydrocarbon gas are in liquid form geologically including natural gas which was created from oil wells is known wet gas including hydrocarbon gas liquids, together with water vapour and other non-hydrocarbon gases. Hydrocarbon gas liquids are not a lease condensate different from both associated and non-associated gases. The liquid condensate is generally embedded in raw oil through pipelines which transports it to oil refineries.

Nuclear energy is created from uranium which is used for the production of heat and electricity. It is thought that uranium is extracted from the earth's crust, however, it has quite difficult and costly process into nuclear power plants with fuel millions of years ago.

2.1.2.1. Fossil Fuels

They are combination of two or more qualities with fossilized plant million years ago. They are created from the fossils determined by the fossil types, the amount of heat and the level of pressure. Fossil fuels energies comes with sunlight by making photosynthesis to turn into water and carbon dioxide in the molecular blocks of ancient lives. They make their form with atom moles of hydrogen and carbon and, when burned, fuel is served through fossilized hydrocarbon-type compounds.

When the materials start to bury deeply in underground, thanks to increased heat with high pressure. When the heat increases, the molecules in fossil start to separate. The first breakdown makes gradually changed materials. The transitional materials could be derived as a fossil fuel at the same time. But, they produce fewer energy than formed coal, oil and natural gas. This chemical compounds which combine plankton and plants form fossil fuels after million years below the surface of the earth. Plankton turns in oils and natural gas, when plants turn to coal. Those sources are extracted, thanks to mining of coal, the oil drilling and gas as onshore and offshore. They are difficult to get since they include stored energy while burned, fossil fuels as well as the electricity. Major ingredients in the chemical industries are produced.

2.1.2.1.1. Coal

Coal was started to exist from fossilized plants more than million years ago. While the plants spread deeper and deeper below the surface of the earth they go subjected to intense heat.

2.1.2.1.2. Natural Gas

Parallel to oil, natural gas is come from buried plankton and coal in late stages of decomposition. Natural gas is created with higher temperatures than others.

2.1.2.1.3. Oil

It is formed from plankton as well natural gas. While sediment accumulates on surface of the fossilized plankton, intense heat move from the deeper surface of the earth form the plankton in oil.

2.1.2.1.4. Breakdown of the Chemical

Raw oil is a compound of heterogeneous molecules, including highly hydrogen and carbon. The deposit of raw oil includes a singular composition and a part of a number of the hydrocarbons. Depending on this chemical compounds, it could have a set of densities from poor and thick to light and sticky. It is designed neither small nor sour based on remaining amounts of sulphur. It could include from an open golden yellow to dark. To use in both industry and transportation the crude oils are divided in its personalized hydrocarbon-based lubricants. Throughout many types of molecule, there is no specific industry which does not use oil products in a form. Oil is derived as lubricants in sectors of both plastics and cosmetics, and medicine. Generally, oil's combination is grouped in different types of molecules.

Fossil fuels has gradually becoming major problem since the use of the coal-fired steam engines in the 1700s. Every year people now born above 4,000 times the amount of fossils fuels burnt during 1700s. Carbon dioxide which is major effects of the burning of fossil fuels cause far-reaching changes on climate and ecosystems.

Climate change refers to a rise in overall temperatures caused by the emissions of carbon dioxide gases and emissions of methane gases, grouped as greenhouse gases. Earth is now warming faster than at any point in history. Hotter temperatures over time are modifying the examples of weather and the change of climate disrupt the present nature balance. This causes more risks to humankind and all lives on Earth. Global-warming describes related potencies, molecules for greenhouse gases and how long it remains live in the atmosphere. Carbon dioxide is regarded as the gas of reference given a hundred year global warming.

The burning of fossil fuels is the initial reason of prevailing climate change, evolving the ecosystems and resulting in environmental health problems. The related material turns to carbon and carbon goes into air as carbon dioxide at a pace that is thousands of times faster than it started to bury, and faster than could be extracted with the cycle of carbon. Hence, carbon which is released accumulates in atmosphere, then some of which dissolves in oceans causing acidification.

2.1.2.2. Carbon

Carbon is a chemical element. This element is not metallic and one of few elements known since ancient times. Carbon which is the most abundant chemical element together with oxygen, hydrogen and helium constitutes about %2.5 percent of Earth's. According to Kyoto Protocol which aims to slow up global warming, covers below greenhouse gases:

- Non-fluorine (carbon dioxide, methane, nitrous oxide)
- Fluorine (hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, nitrogen tri-fluoride)

2.1.2.2.1. Carbon Emission

When greenhouse gases are released in the atmosphere within the specified period of time or areas, carbon emissions which stem from the burning of fossil fuels and manufacture of related materials including carbon dioxide turned at the same time of consumption of solid, liquid, and fuels are formed. 1 centigrade (abbreviation C) increase in the average global temperature makes global warming over 1.5 centigrade risks, rise in sea level and in extreme cases of weather. The energy with burning of fossil fuels is used to produce electricity, and to power transportation and manufacturers. 87 % of carbon emissions is resulting from the fossil fuels such as oil and coal. The remaining reasons come from the clearing of the change of land use (i.e forest) by 9%, as well as some kind of industrial process such as cement, aluminium and iron manufacturing by 4%.

2.1.2.2.2. How to Measure Carbon Emissions?

With the Paris Agreement at 2015, countries which are signatories must understand what level of their carbon emissions are. Hence they make their plans to reduce emissions. The signatories committed to reduce their emissions and make a national climate actions in order to determine their targets for gas emissions. The agreement require that each country must monitor, verifying and reporting its implementation progress starting from October, 2024. Countries should their plans in every five years. During conference of the parties (COP26) in Glasgow in 2021, countries agreed to accelerate cuts in their emissions before 2030, with demanding average temperature targets. Even if many countries update their action plans to reduce carbon emissions, it is still not enough to the average global temperature reach to below 1.5°C or to keep global warming as it is.

It is required that companies calculate their carbon emissions and report on impacts to authorities. They must reveal their carbon footprints in order to comply with the regulations such as EU. Moreover, customers and investors are keen to promote the green companies. Companies must follow a protocol to validate the accuracy of their calculations. The protocol is known as a global standard for measuring and classifying company’s carbon emissions, from small-medium enterprises to the large corporations and public institutions. It seems possible that the level of carbon emission of company’s operations can be measured with existing technologies and methods. There are three steps to calculate a company’s carbon footprint.

- Each company must build awareness in staff.

- Companies must collect as much data as on their business activities relating to carbon footprint. Management data means to include bills including water, electricity, gas, travel data as airlines tickets and fuel receipts. They must adopt their records in compatible units in order to understand how to measure and report carbon emissions,
- Once company have enough activity and collect data, it calculates their related carbon emission. Each company needs to gather carbon footprint records pertaining to consumption of energy over a period of time, a quarter, half or year.

2.1.3. A General Economic Implications of Climate Change

There are many risks related to climate change arising from the implications between average temperature rise and weather extremes. Climate change constitutes the exposure and vulnerability of economical ecosystems and the origin of life on Earth. It is stated that physical risks are steady global warming and its changes such as increasing sea levels, and natural disasters such as heatwaves. The trajectories of greenhouse gas concentration cause larger negative effects on GDP's. Theoretical studies show that financial and economic losses will rise in the medium and long term. Climate change cause aggregate impact on food prices and core inflation.

The agriculture and fishing sectors are primarily affected due to decreasing yields, crop production and productivity. Increasing sea levels cause damages in coastal infrastructure. Some large areas will be uninhabitable and, a large population in these large areas will be displaced. The upswing in temperatures precipitation could result in transition from these piece of land and change the flows of people movement. This result in rise of energy demand and impacts on health by jumping the death rates. It means that there would be some implications for labour markets and sustainability (Bamber et al., 2019).

It is expected that there will be both adverse supply and demand effects on the economy. For supply side, labour supply and productivity could diminish steadily due to heat attacks, migration and work capability in suspense. The capital stock may be poor and appreciated by reallocated resources, and technology is impacted on such an extent that allocations are dispatched to reconstruction, adaptation and protection for adaptation purposes. Decrease in the productivity of growth pushes down future investments, thus, the rise in need to keep expected consumption. It would cause narrow marginal product of capital together with low rate of interest. In terms of demand effects, movements in energy demand cause some variations in energy prices and changes in preferences. It is expected that there would be preference changes, strong precautionary savings and wealth depreciations.

The economic effects resulting from physical risks have major impact on financial institutions and markets. The effects on macroeconomics result in an upward movement in property and asset values, company revenues and household wealth, meaning to impact on the financial sector. Accordingly, lower credit appetite and loss of market feed back to the real economy. Additionally, climate change have impact on supply chains because of ecological disasters and greenhouse gas emissions respectively. Faiella and Natoli (2018) indicate how extreme events of weather can constitute a source of financial risk by way of banking sector.

Table 2.1. Economic Channels of Climate Change Implications

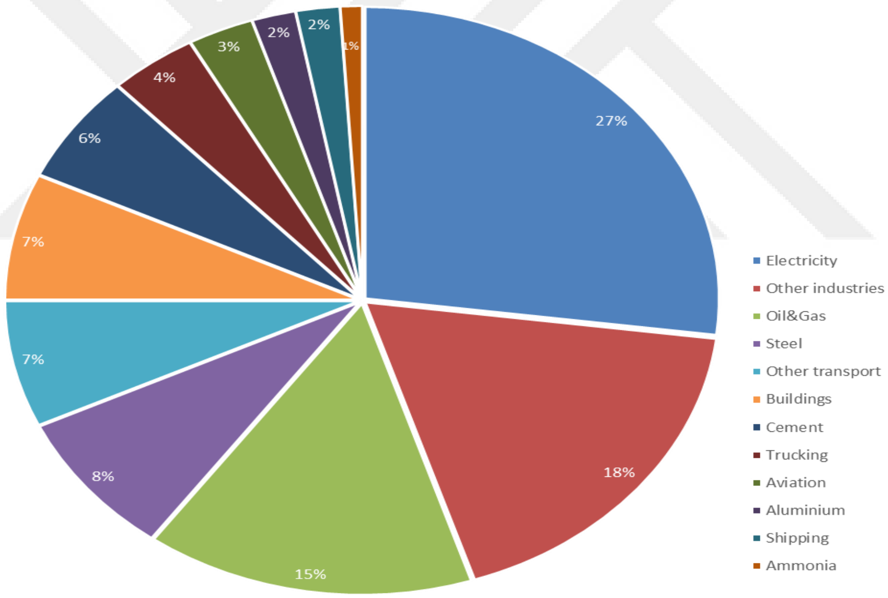
		Gradual warming	Extreme events	Transition risks
Supply shocks	Labour	Loss of hours worked due to extreme temperatures. Increased international migration.	Depredation of workplaces, need to migration	higher structural unemployment.
	Food, energy and other input supply	Decrease in agriculture productivity and yields.	Disruption to transport and production chains.	
	Capital stock	Diversion of resources from effective investment to adaptation capital.	Destruction because of extreme events.	Rise in stranded assets.
	Technology	Diversion of resources to reconstruction activity.	Diversion of resources to reconstruction activity.	Climate policy and regulations as a potential driver of innovation
	Productivity	Lower labour productivity due to extreme heatwaves and lower working capital (un-health issues and death rate).	Lower capital effectiveness because of (possibly permanent) capital and infrastructure destruction.	Uncertainities in productivity while technological progress offset under-investment stemming from transition policies.
Demand shocks	Energy	Rise in electricity demand for summer exceeds the demand in winter.		Higher tax for carbon emissions leading to lower demand for fossil fuels.
	Investment	Change in preferences towards more sustainable goods and services.	Uncertainty about climate events could delay investment. Investment in reconstruction increases following events.	Change in the mix of activity towards high investment (i.e techonolgy) Uncertainty about climate policy may reduce investment.
	Consumption	Change in preferences towards high sustainable goods and services.	If no insurance of household or firms, destruction could cause a permanent decrease in wealth and affect consumption.	Increased sustainability awareness and shift toward greener consumption.
	Trade	Disruption to trade routes due to geophysical changes (such as rising sea levels).	Moves in food prices and disruption to trade flows.	Taxes, regulations and restrictions change routes for trades.
Aggregate impact on output and nominal variables	Output	Lower labour productivity, investment being diverted to mitigation and arable land loss.	Physical destruction (crop failures, disruption to infrastructure, disruption of supply chains).	Frictions resulting from distortive (fiscal) transition policies and/or (fiscal) transition policy uncertainty. Mitigated impact depends on the use of proceeds from (fiscal) transition policies.
	Wages	Pressures on wages with lower productivity.	Inequalities in sectors and economies.	Reallocation of workers across sectors, increasing training needs).
	Inflation	Relative price changes due to shifting consumer demand or preferences and changes in comparative cost advantages.	Increased inflation volatility, particularly in food, housing and energy prices.	Prices affected by transition policies, policy uncertainty, technological changes and movements in consumer preferences.
	Inflation expectations	Climate-related shocks, e.g. to food and energy prices, may affect inflation expectations.	Inducing more homogenous, sudden and frequent revisions of expectations.	Formation of inflation expectations effected by policies.

(Sources: *Adapted from Batten (2018) and the Network for Greening the Financial System*)

2.2. Sectors in Scope of the CBAs

Companies which operates in the cement, steel, aluminium, fertilisers, electricity and hydrogen intensive sectors contribute over forty percent of total greenhouse gas emissions. It is critical that emissions from these sectors are higher than the emissions of any control individually, however, they are not compliant with the trajectory to achieve net zero by 2050. The sectors such as cement and iron are in scope of the most complex de-carbonization challenges because of higher share of intensity in their energies. Below graph 1 presents 40% of global GHG, 85% of manufacturing and 56% of transport emissions.

Figure 2.1. Global Greenhouse Gas Emissions by Sectors



(Source: *IEA, Energy-related Greenhouse Gas in 2022*)

Initially, the CBAM covers the industries of imports of the goods whose sectors are cement, steel and iron, aluminium, fertilisers, hydrogen and electricity. Emission Trade System (ETS) which makes EU, Canada and China etc pay for their own GHG emissions is currently in use and the CBAM have imposed restrictions on limited ETS sectors which indicate more than 50% of the emissions. These sectors were chosen in particular higher risk of carbon leakage and higher intensity of emission. It is planned that the CBAM extend to remaining sectors in ETS in a relatively short period of time. According to the data collected with CBAM, a review will be implemented regularly. Considering the results, the EU commission and countries mentioned above evaluate to whether restrictions extend remaining carbon-intensive goods and industries in the ETS.

2.2.1. Cement

It is defined that cement is binder, a chemical substance used for construction and that it is generally used to bind sand and gravel with together. Concrete which is produced with cement is the well-known type of cement and is materialized with water which is the world's most-consumed source. The production process of cement constitutes nearly six percent of global carbon emissions. It contains heating raw materials in a cement oven by fuel process of burning and it results in the release of carbon in the process. Concrete steadily absorb substantial amounts of atmospheric carbon process compensating approximately 30% of initial carbon emissions. It is figured that approximately 6% of the earth's carbon emissions stemming from the manufacturing cement products which are the one of highest contributor to global warming. Some solutions are familiar for other sectors in response to these greenhouse gas emissions, such as upswing in the energy efficiency of cement plants, fossil fuels replacement with renewable energy, and capture of the carbon which is emitted.

2.2.1.1. Production

Cement is a substance which creates many construction materials and, it is added to different materials to manufacture a hardened substance. Clinker which is first produced during the manufacturing process of cement and then added back into the mixture as a binder in the final product. The capacity of clinker is critical factor for cement production.

China where the country is the most cement producer had approximately 2.1 million (m) metric tons during year 2022. When compared with year 2021, there was a small fall from 2.4b metrics tons to 2.1m in China which has highest volume of cement production than any country in the world. China had the highest capacity of clinker with 2m metric tons worth in year 2022.

India is the second producer in cement sector with 370 thousand (k) metric tons in year 2022. When compared with year 2021, there was a rise in their production from 350k to 370k metric tons of cement. Vietnam is third producer with both 120k tons in year 2022 and 110k tons in year 2021 respectively. Remaining countries produced cement less than 100k tons of metrics. Türkiye produced 85k metric tons in 2022 and 82k in 2021. Their production was slightly less than the US in both year 2022 and year 2021. The US had 95k in 2022 and 93k tons in 2021.

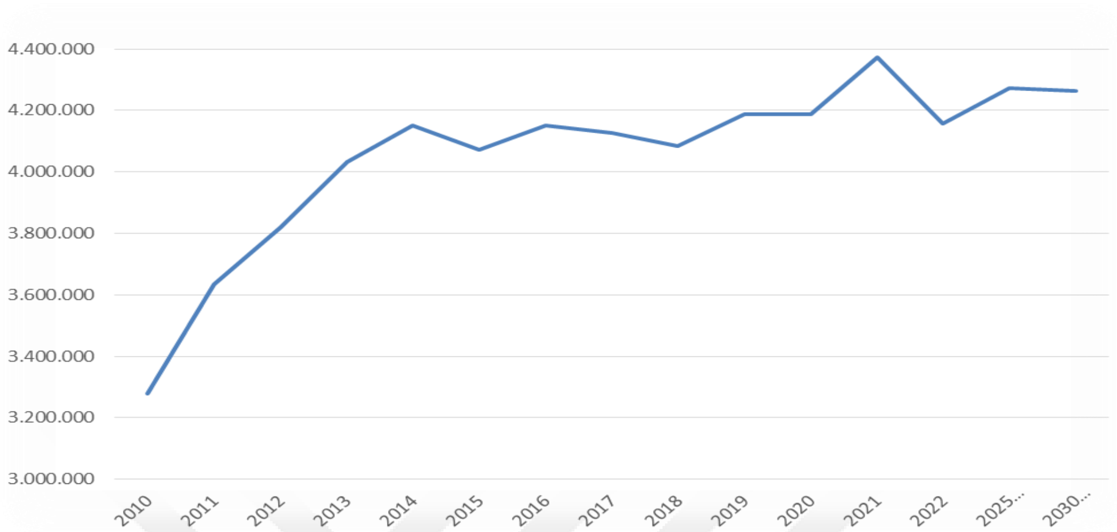
Table 2.2. Cement Production by Country (Metric Tons)

Country	Cement 2022	Cement 2021	Clinker 2022	Clinker 2021
China	2.100.000	2.400.000	2.000.000	2.000.000
India	370.000	350.000	290.000	280.000
Vietnam	120.000	110.000	100.000	90.000
United States	95.000	93.000	100.000	90.000
Turkey	85.000	82.000	92.000	92.000
Brazil	65.000	66.000	60.000	60.000
Indonesia	64.000	65.000	79.000	79.000
Russia	62.000	61.000	80.000	80.000
Iran	62.000	62.000	81.000	81.000
Saudi Arabia	54.000	54.000	75.000	75.000
Egypt	51.000	50.000	48.000	48.000
Mexico	50.000	52.000	42.000	42.000
Japan	50.000	50.000	54.000	54.000
South Korea	50.000	50.000	62.000	62.000
World	**3.278.000**	**3.545.000**	**3.163.000**	**3.143.000**

(Source: *IEA, Global Cement Production, 2021-2022*)

In addition to above, "Other countries" produced about 850k metric tons of cement and reached to 600k tons of clinker capacity. From 2022 to 2025 and 2030, it is expected that there is a slightly increase around 2.5 points. Year 2025 and year 2030 represents the target volume of production in the net zero scenario as follows:

Figure 2.2. Global Cement Production (Tons)

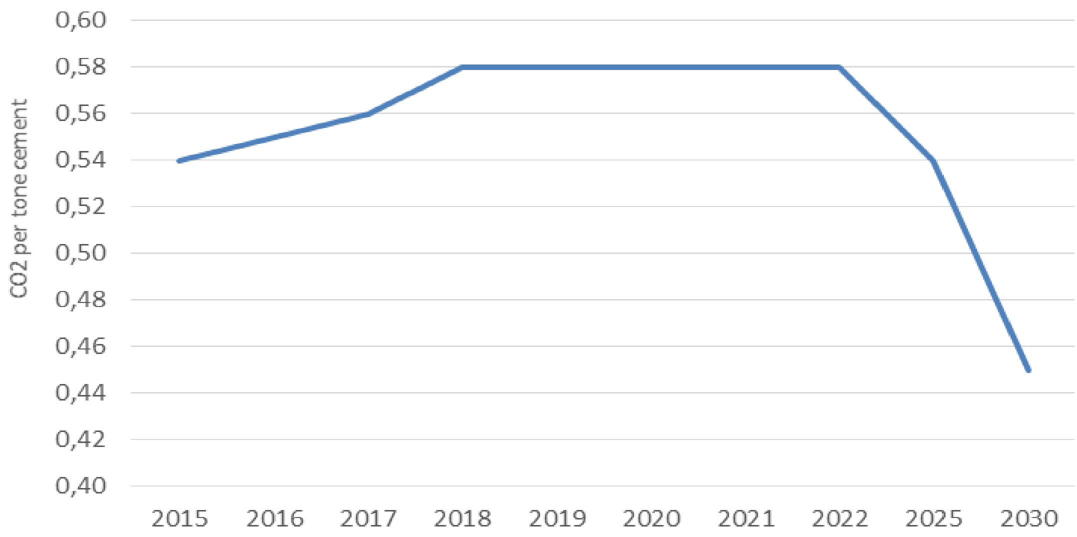


(Source: *IEA, Global Cement Production in the Net Zero Scenario, 2010-2030*)

2.2.1.2. Carbon Emissions

Cement's carbon concentration turns around from five percent in cement structures to eight percent in the road cases in cement (Scalenghe, R., Malucelli, F., Ungaro, F., Perazzone, L., Filippi, N., Edwards, A.C., 2011, p.5112-5117). When cement is manufactured, carbon is emitted in the atmosphere. It is emitted in both calcium carbonate is heated and quicklime (i.e calcium oxide) production and carbon dioxide, and indirectly thanks to the way of energy use when its production covers the CO2 emissions. The industry of cement creates approximately 10% of the earth's human-made carbon emissions, of which 60% is from the process of chemical, and 40% from burning fuel (Netherlands Environmental Assessment Agency & European Commission Joint Research Centre 2014. Trends in global CO2 emissions: 2014 Report). It is estimated by a Chatham House study in 2018 that the four billion tonnes of cement produced yearly is responsible for eight percent of global carbon emissions (Chatham House, the Royal Institute of International Affairs 2018. Making Concrete Change: Innovation in Low-carbon Cement and Concrete). 10 kg cement in every production makes nearly 9 kg of carbon emissions. In the European Union, the consumption of specific energy for the process of cement production has decreased by about 30% in the EU since the seventies. This corresponds to nearly 11 million tonnes of coal per annual with benefits in reduction of carbon emissions.

Figure 2.3 Direct Emissions Intensity of Cement Production



(Source: *IEA, Direct Emissions Intensity of Cement Production in the Net Zero Scenario*)

From 2015 to 2022, carbon emissions per cement tone continued between 0.54 and 0.58 tCO_2. It is expected that there will be a dramatic decrease nearly 10 points as a target in the net zero scenario as above.

Cement industry target to reduce a 25% emissions intensity by 2030 and net-zero by 2050. 61% of cement companies are aware that climate change must be involved in the process of making decisions.

2.2.2. Steel

Iron and steel are known as ferrous metallurgy. It is the scientific study of iron and the mixture of its chemical elements. Steel are two of very common metallurgies used in the manufacturing industry. Iron is a ferromagnetic which means magnetic and attracts other metals. However, Steel is a ferrous alloy which consist of primarily of iron and carbon.

The production process of steel contributes nearly eight percent of global energy related greenhouse gas emissions. There are two type of emissions which are energy-related production and process-related production. Energy-related carbon emissions are mainly resulted from coal use in furnace and the production molten steel. In second type of emission is related to coke and/or natural gas use as a reducing element turn iron ore in iron for mainly steel production.

2.2.2.1. Production

Steel is made by iron ore and related materials, which consists of approximately 98% iron and 2.1% - 0.002% carbon. There are two steelmaking processes which are basic oxygen and electric arc furnace (EAF). The basic oxygen has liquid pig-iron from the blast furnace and scrap steel. Secondly, the EAF uses scrap steel. Steel is 98% recyclable and ubiquitous industry. It is used in many construction materials, automobiles and tracks, weapons and various additional-related steel such as chromium, silicon and nickel.

Only 64 countries produce steel in large quantity when steel is widely used around the world. These countries produced 98% of total steel in 2020. Global production was to 1.95 million tonnes in year 2021 from 1.88 million tonnes in year 2020 with an increase of 3.7 point. The production of steel is one of most energy-intensive and carbon-rich industries in world. The level of global carbon dioxide emissions reached to 8% in 2022 from 7% in 2020. Many countries consider to produce with greener manufacturing techniques in order to reduce the reliance on the production of steel.

China where the country is the most steel producer had approximately 1 million (m) metric tons (Mt) during year 2022. China is the leader in steel production globally, with highest output than others. It was noted that China started to minimize pollution by decreasing the level of steel production from 2020 to 2021. The steel production is very important for Chinese economy.

India became the second country in steel production as of year 2019. They expand their capacity, efficiency, and modernization of its steel industry. On the other hand, Japan aims to achieve carbon neutrality and this may cause a downsizing of Japan's steel industry, which is a primarily source of air pollution.

Russia is the third-largest iron ore reserves in the world, behind only Australia and Brazil, and is one of the world's leading exporters of both iron ore and steel. The United States which is fourth producer provide 320% less carbon per ton of steel produced than the most other countries (China, India, Russia).

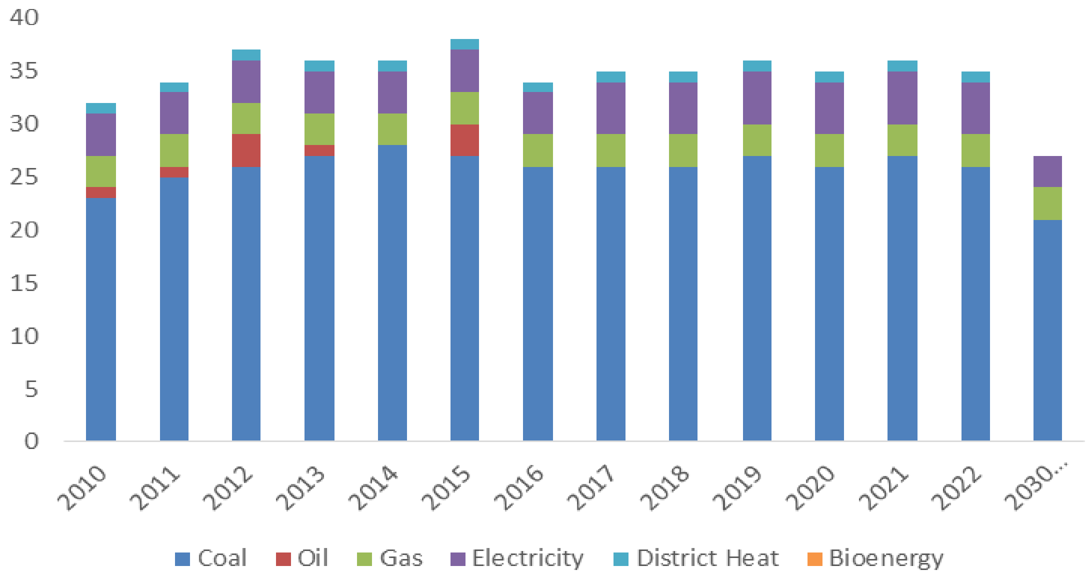
Table 2.3. Steel Production (Metric Tons)

Country	2022	2021	2020	2019
China	1.017.959	1.032.800	1.064.700	996.342
India	125.377	118.100	100.300	111.351
Japan	89.227	96.300	72.700	99.284
United States	80.535	86.000	83.200	87.761
Russia	71.746	76.000	71.600	71.897
South Korea	65.846	70.600	67.100	71.412
Germany	36.860	40.100	35.700	39.627
Turkey	35.134	40.400	35.800	33.743
Brazil	34.089	36.000	31.400	32.569
Iran	30.593	28.500	29.000	25.609
Italy	21.598	24.400	20.400	23.190
Taiwan	20.801	21.000	23.300	21.954
Vietnam	20.004	19.900	23.600	17.469
Mexico	18.386	16.800	18.400	18.387
Indonesia	15.568	12.900	12.500	7.783
France	12.119	11.600	13.900	14.450
Canada	12.098	11.000	12.800	12.897
Spain	11.573	11.000	14.000	13.588
Others	167.727	126.100	160.900	171.050
Total	**2.056.989**	**2.007.621**	**2.054.220**	**2.043.432**

(Source: *World Population Review, Cement Production*)

Addition to this, other countries produced about 320k tons of steel in 2022. From 2019 to 2020, there were no significantly increase in steel production.

Figure 2.4. Energy Demand for Iron & Steel by Fuel in the Net Zero Scenario



(Source: *IEA, Direct Emissions Intensity of Cement Production in the Net Zero Scenario*)

The share of Coal is the highest in the demand of energy for steel and iron. Between year 2010 and year 2030. Electricity is the second demand in energy for steel and iron.

Zero emission of steel was less than one percent of the market in year 2022. A business to business green premium of 40-70% seen as necessary, with around 1-2% affecting consumers. USD 372 billion is needed as capital for net zero emission, with 60% directed to renewing or modifying present assets. On the other hand, net profit margin of sector is very week with 8.5 percent and 10 percent weighted average cost of capital.

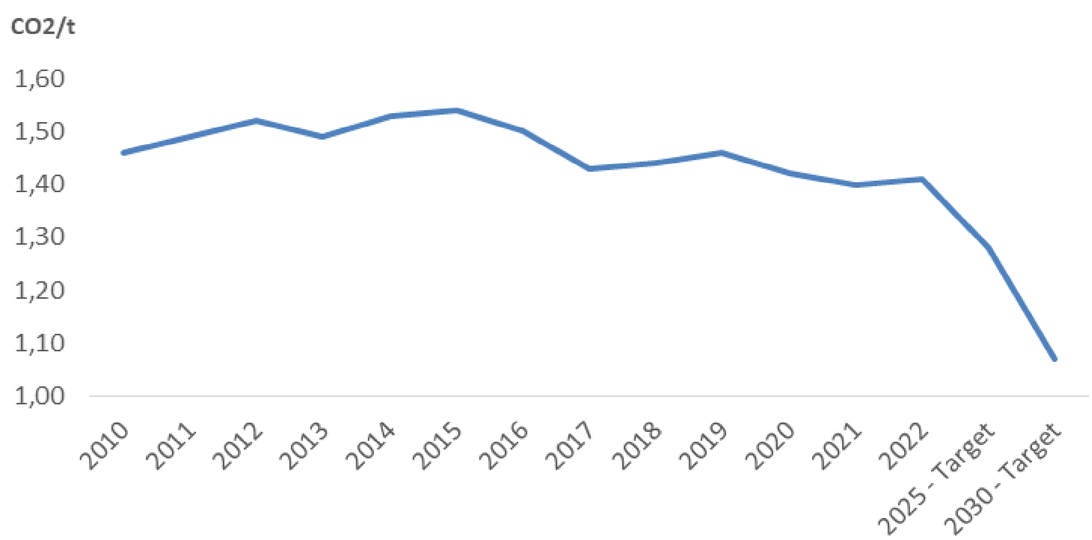
2.2.2.2. Carbon Emissions

In the production of steel, the iron must be separated from the oxygen and a small quantity of carbon must be added. At the same time, the iron ore is melted at a very high temperature in the presence of oxygen and coke. When the iron ore releases its oxygen at very high temperatures, the coke turns in carbon dioxide.

Steelmaking contributes 8% of GHG emissions and, it is seen that this industry is very carbon-intensive in the world. Steel sector aims 45 percent reduction in intensity for primary steel which is used in both clean hydrogen and de-carbonization and, a 65 percent reduction for secondary steel which is used in electric arc furnace with renewables by year 2030. Carbon-friendly production are more costly around 40-70% than existing methods.

Seventy percent of large companies which are traded steel confirm that they reflect climate issues in their decision-making processes. To reach both in clean hydrogen and clean power development requires total amount of capital between 1.8 trillion USD and 2.4 trillion USD.

Figure 2.5. Direct Emissions Intensity of the Iron & Steel Sector



(Source: *IEA, Direct Emissions Intensity of Cement Production in the Net Zero Scenario*)

It is expected that there will be a dramatic decrease nearly 40 points as a target in the net zero scenario by year 2030. Steel industry aims to achieve both 45% reduction in intensity for primary steel and 65% reduction for secondary steel by 2030.

2.2.3. Aluminium

Aluminium which has lower density than other metals is a chemical element. It is highly abundant with twelfth common element and it is about 1.59% mass in the Earth. Despite the fact that aluminium is abundant and common element, all of metallic aluminium is derived from the ore bauxite which is rock with a relatively high aluminium content. It occurs as a product of low iron in tropical climates where it is the largest reserves of bauxite in Vietnam, Guinea, Brazil and Australia.

It has very energy-intensive production and, hence the manufacturers prefer to locate smelters in places where electric access/usage is both abundant and cheap. 1 kilograms (kg) aluminium is produced with 7 kg of oil energy equivalent. This is equivalent to 1.5 kg for steel and 2 kg for plastic. The production process of aluminium contributes about three percent of global energy related greenhouse gas emissions. The emissions of aluminium can be stated as two categories. One of them is related to the process of refining and smelting for fossil-based electricity consumption. Other is resulted from smelting requiring to the use of carbon based anodes.

2.2.3.1. Production

Aluminium metal is mainly used in transportation, packaging, building and construction, electricity-related producing (i.e motors, generators…), household items (furniture, fabrication…), machinery and equipment. Aluminium is used for the above items because it has low density, non-toxic and splinter proof, corrosion resistance, cheaper and mechanical strength.

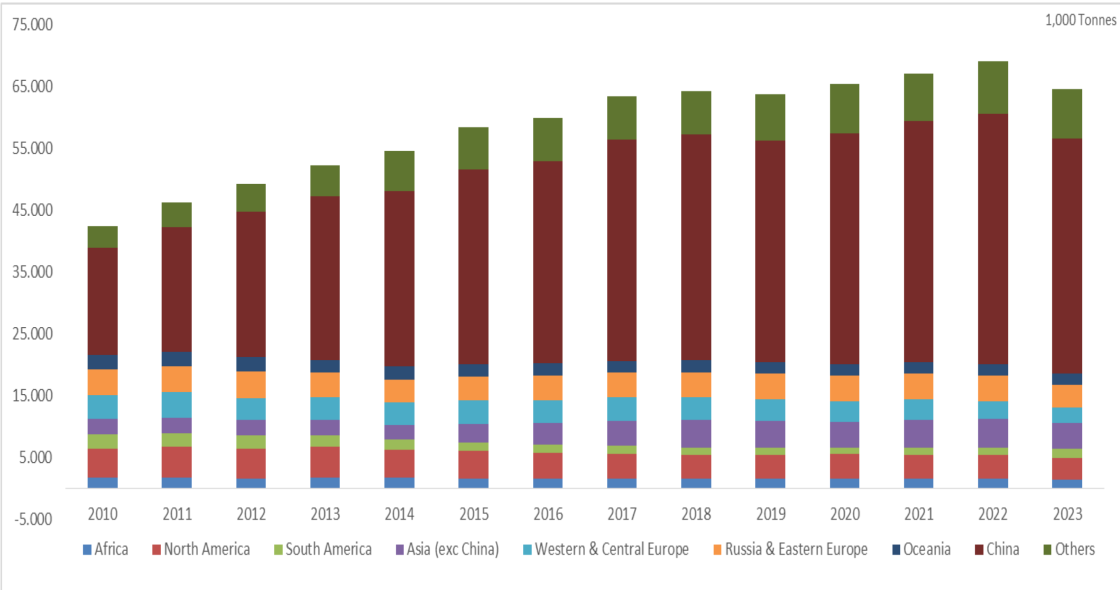
Primary aluminium is made from aluminium oxide which is produced from bauxite. Bauxite is rock with a relatively high aluminium content, excluding recycled aluminium. The production of primary aluminium is defined as total quantity of aluminium in a period. Primary aluminium means that it is quantity of molten/liquid metal and it is weighted before further processing.

From year 2010 to year 2023, approximately 755.8k metric tonnes were produced in the world. The trend of production has steadily increased by average 4 points in annual manner. The level of production of aluminium is determined by the level of the country's capacity of its bauxite mining. China has the highest share of aluminium production with 58 percent in the world as of year 2022 and, they have the largest reserves with smelting capacity as well. China produced 40m metric tonnes of aluminium in 2022.

Excluding China, India and Russia produced 4m metric tons and 3.7m metric tons respectively in 2022. They produce a high portion of aluminium despite of having low bauxite reserves since they have great demand domestically as well.

Canada became the fourth country in aluminium production with three million tons in 2022. They have significant mining infrastructure and strong automotive industry. On the other hand, the UAE has a strong share in the world's mineral treasures, and its production is fifth largest in the world.

Figure 2.6. Aluminium Production



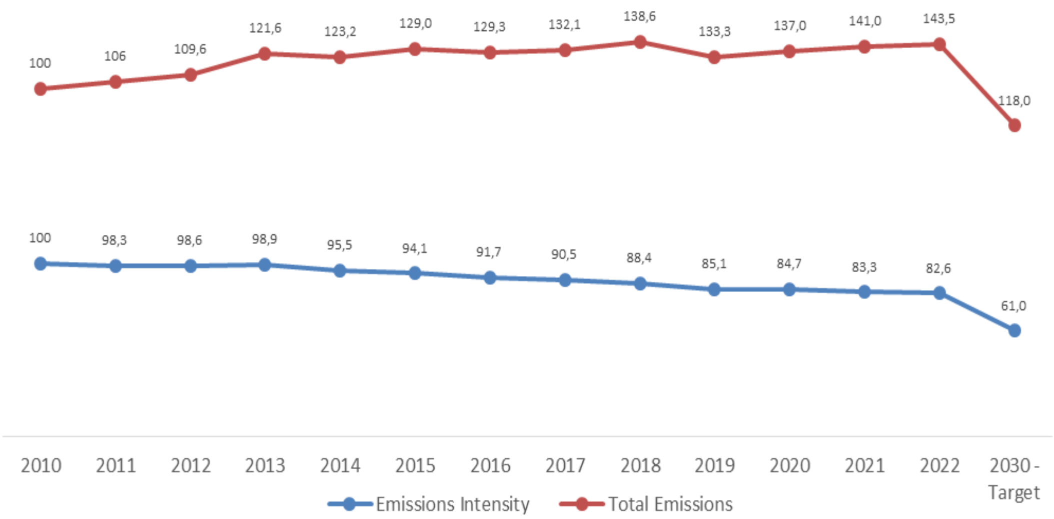
(Source: *The Data Included in the IAI Statistical Report*)

2.2.3.2. Carbon Emissions

Aluminium is one of the leading source of carbon emission with nearly 3 percent of the total industrial emissions in 2022. It is used in a number of intergraded production system and in a number of energy transition especially transportation, electricity and building sectors. During the last annual periods, the average of direct carbon emission of aluminium production has dramatically decreased at almost two percentage per year. Furthermore, this fall must be around 4 percentage per year in order to reach net zero emission by year 2030.

Aluminium production contributes 3% of GHG emissions and the intensity of emissions per tonne of aluminium was 11.2 CO2/t as of year 2021. It is seen that this metal is used in various sectors, which triggers to up in carbon-intensive production environment. The level of carbon emitted grew at 4 percentage between 2019 and 2021. Aluminium sector aims 30 percent reduction in intensity of emissions by year 2030. 71% of aluminium producers are aware that climate change must be involved in the process of making decisions. Carbon-friendly production are more costly around 40% than existing methods.

Figure 2.7. Total Carbon Emissions and Intensity in Aluminium Production



(Source: *IEA, Total Direct CO2 Emissions and Intensity in Aluminium Production in the Net* Zero *Scenario*)

Until year 2022, the intensity of carbon emissions has steadily decreased at an average of 1.5 percentage. At the same period, total volume of emissions reached to 143.5 with an average of 4 points. It is expected that there will be a dramatic decrease nearly 25 points in total volume of emissions and around 20 points in emissions intensity respectively as a target in the net zero scenario by year 2030. Aluminium industry aims to decrease the volume of emissions by low-emissions refining and smelting methods in this period. It is planned that a 30% reduction in emissions intensity must be implemented as a part of net-zero scenarios.

Approximately 70% of the emissions resulted from the aluminium production are due to the consumption of electricity during the process of smelting. This requirement for electricity contributes nearly four percentage of the world's power consumption, which causes an upward as 70% sourced from coal (fossil fuels) and the remaining 30% from hydropower.

2.2.4. Fertilisers (Ammonia)

A fertiliser is any natural material or synthetic situation which is applied to ground. It is the study of chemical elements in order to increase plant reproduction and its effectiveness (i.e growth). Fertilisers are sourced by both industrial production and organic ways. Started from last century, agriculture sector improved itself around synthetically built fertilisers, thanks to the improvements in plant nutrition. The migration to production by the ways of synthetically fertilisers was most significant milestone in changing the global food provisions, allowing for larger-scale industrial agriculture with wide crop yields.

It was noted that nitrogen-fixing chemical processes triggered to increase production capacity during 20th century. Nitrogen fertilisers made the productivity of conventional food provisions boom with growth around 80%. It caused environmental consequences such as eutrophication and water due to carbon emissions from fertilizer production and mining as well nutritional runoff, pollution of oil. The essential nitrogen based fertiliser is ammonia which includes ammonium nitrate, urea and calcium ammonium nitrate. Ammonia industry be the key industry for de-carbonization is due a part of fertilisers.

Ammonia which has higher share emission is a chemical compound. It is largely produced in agriculture industry. It has very energy-intensive production and, hence the manufacturers continue to increase their level of production together with natural gas.5 percent of all human greenhouse gas emissions is estimated to come from carbon, nitrous oxide and methane during manufacturing and using fertilizers. Fertilisers had approximately seven million tons per year of nitrous oxide emissions from 2007 to 2016, which is seen impossible to keep the level of global warming to below 2 °C.

2.2.4.1. Production

Ammonia is mainly used in the production of fibres, chemical intermediates, plastics, pharmaceuticals and explosives. These industries have contribution to global carbon emissions as of 2%. The production of ammonia is taken worldwide in large-scale manufacturing with 183m metric tons in year 2021.

According to a report in 2002, 317b cubic metres of natural gas were spent in the production of ammonia industry in US, which meant less than 1.5 percentage of total annual consumption. Additionally, the ammonia production was nearly 5% of global natural gas consumption, which was behind 2% of world energy production. Ammonia is created from natural gas and air together. The cost of natural gas constitutes around 90% of the production cost of ammonia. An increase in price of gases during the past decade triggered to an increase in fertilizer price as well.

Eight percentage of ammonia is consumed in fertiliser manufacturing. During the last two years (2021-2022), total ammonia production in the world were around 150k tones. Leader manufacturers are orderly China with 28.5%, Russia with 10%, India with 8% and the US with 8.8%.

Table 2.4. Ammonia Production

Country	Year 2021	Year 2022
China	42.000	42.000
Russia	16.300	16.000
United States	12.700	13.000
India	12.100	12.000
Indonesia	6.000	6.000
Saudi Arabia	4.300	4.300
Trinidad&Tobago	4.050	4.200
Egypt	4.000	4.000
Iran	4.000	4.000
Canada	3.760	3.800
Pakistan	3.400	3.400
Qatar	3.270	3.300
Algeria	2.600	2.600
Poland	2.100	2.100
Germany	2.290	2.000
Netherlands	2.000	2.000
Ukraine	2.170	2.000
Australia	1.700	1.700
Oman	1.730	1.700
Malaysia	1.400	1.400
Other countries	17.850	16.400
World Total	**149.720**	**147.900**

(Source: *U.S. Geological Survey, Mineral Commodity Summaries, Ammonia)*

Since there are comparatively lower cost both in natural gas and coal, ammonia is almost produced from fossil fuels. Nearly 70 percentage of ammonia and 20 percentage of ammonia are generated from natural gas and coal respectively.

Table 2.5. Ammonia Feedstocks

Natural Gas	72%
Coal	22%
Heavy Fuel	4%
Naphta	1%
Other	1%

(Source: *U.S. Geological Survey, Mineral Commodity Summaries*)

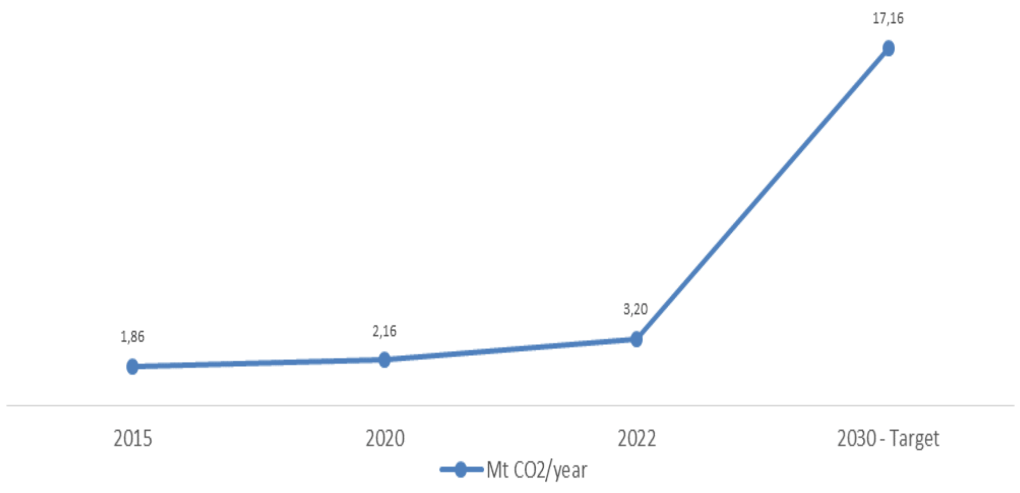
2.2.4.2. Carbon Emissions

The essential nitrogen based fertiliser is ammonia which includes ammonium nitrate, urea and calcium ammonium nitrate. Nitrogen fertilisers are created though ammonia. The reason why ammonia industry is an energy-intensive production is that natural gas supplied by the hydrogen and nitrogen derived from the air are key elements of this energy-intensive process. Nitrogen fertiliser was used around 110 million tons per year in 2012, adding to the actual amount of reactive nitrogen. The nitrous oxide is now the third most significant GHG after carbon dioxide and methane.

Also, urea is a solvent element in water and therefore, it is very easy for use in fertiliser solutions. During summer, it is often spread during rain to minimize the process where ammonia gas (i.e nitrogen) is lost to the air.

Ammonia production contributes 1% of greenhouse gas emissions and the intensity of emissions per tonne of ammonia was 2.6 tCO2 as of year 2020. Ammonia which is used in various sectors is industrially in very energy-intensive production. The level of carbon emitted increased nearly 2% between 2019 and 2021. Ammonia industry aims to achieve 27% intensity of emissions reduction by year 2030. 91% of largely ammonia producers consider to include the climate change in the process of making decisions.

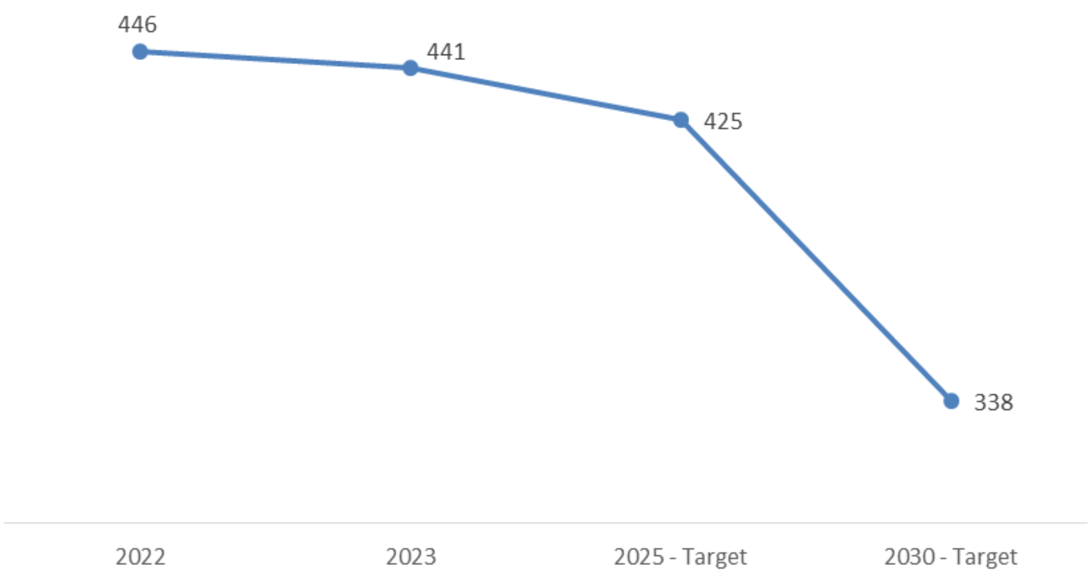
Figure 2.8. Carbon Capture Needs for Ammonia



(Source: *IEA, Direct CO_2 Emissions from Ammonia Production)*

It can be divided two categories for ammonia emissions, which are energy intensive and process related emissions. The energy related emissions are stem from fossil fuel intensive production where needs to process pressure and heat of hydrogen. Also, fossil fuels are used as raw materials in the production process of hydrogen.

Figure 2.9. Direct Carbon Emissions from Ammonia Production



(Source: *IEA, Direct CO_2 Emissions from Ammonia Production*)

The share of fossil fuel usage in the production of hydrogen for ammonia must be decreased from 99% to approximately 30% as above graph 11. However, de-carbonization of the hydrogen input must be prioritized or the transition must be accelerated for hydrogen. This provides 93% reduction in emissions by year 2050.

2.2.5. Electricity

It is defined that electricity is the set of physical phenomenal presence of matter possessing an electric charge. This physical phenomena as electricity means heating, electric discharges and lighting. Electricity demand has steadily been increasing since countries continues their economy improvements. Fossil fuels which cause to carbon emission triggered to increase concerns related to environmental issues with the generation of electricity production, thanks to the increasing demand of the electricity.

Electricity is a very known and easy element to transfer energy and, there are growing and a number of uses. The production of electricity means the generation of electric power. It was noted that there are types of utilities related to electric power sector whose industries are transmission, distribution and storage. Based on the needs of electricity power, it is generated by both coal-fired stations and gas-fired power stations. However, their share of electricity generation must be decreased as a part of the transformation requiring to mitigate the effects of climate change. This provides to capture the GHG emissions.

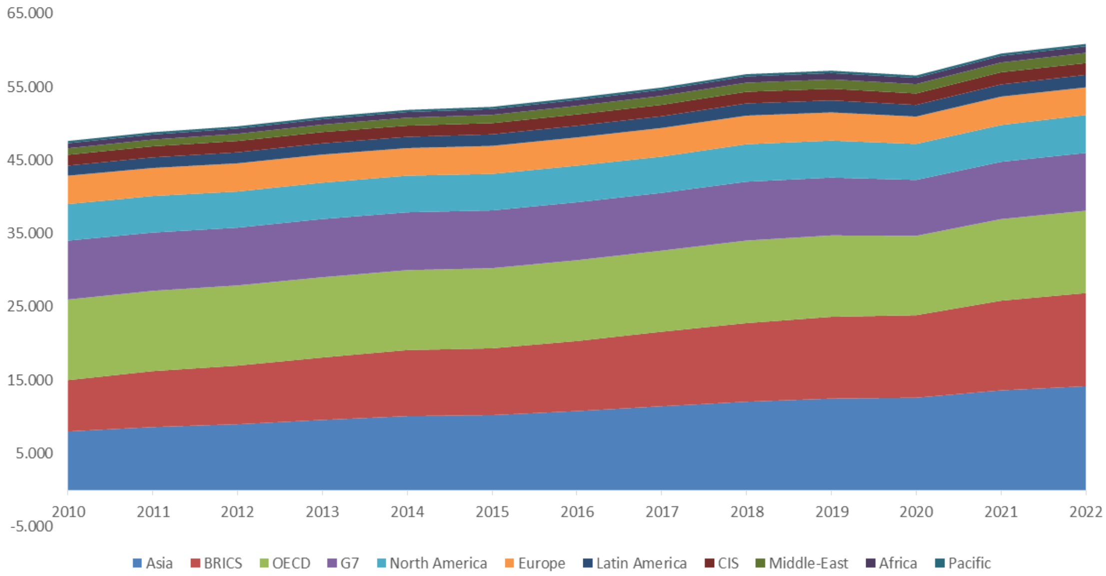
According to International Energy Agency (IEA), low-carbon electricity generation requires to attribute 85 percent of total world electrical output by year 2030 in order to net zero emissions target.

2.2.5.1. Production

Total global electricity generation in year 2021 was 28k terawatt hour (TWh), which constituted coal with 36%, gas with 23%, hydrogen with 15%, nuclear with 10%, wind with 6.6%, solar with 3.7%, oil and other fossil fuels with 3.1%, biomass with 2.4% and, geothermal and other renewables with 0.33%. According to the Energy Information Administration, the global capacity of electricity in year 2022 was around 8.9 TW and, it was quadrupled from year 1981 to year 2022.

After a 5.7% increase in year 2021, the increase in total world electricity generation dropped as 2.3% in 2022, returning to previous decade’s average growth rate. It was noted that there is no change in country order, which was pulled by China with +3.7%, India with +9.7% and the US with +3.2%, with the boom (+7.9%) in Indonesia and Saudi Arabia (+5.9%).

Figure 2.10. World Electricity Generation by Region



(Source: *IEA, Energy-related Productions by Regions)*

In 2022, China is the leading generator with 7.5 petawatt hours of electricity. 65% of its electricity power has been produced from coal as a main source, where other sources are hydropower, natural gas and nuclear energy. The reason why there is high electricity generation is that China has large industries and infrastructures as well individual consumption.

The US became the second country in electricity generation with 4.2 petawatt hours in every annual. They includes different sources of energy and technologies to produce electricity. 40% of its electricity power has been generated by natural gas. Following to natural gas, coal, nuclear energy and renewable energies (geothermal, solar power, hydro) have been used at a rate of 19%, 20% and 20% respectively.

Excluding China and US, India and Russia generated 1.5 petawatt hours of electricity and 1.08 petawatt hours of electricity respectively in every year. India widely uses the renewable sources with hydro plants to produce electricity. Contrary to India, Russia's electricity is traditionally generated by the way of fossil fuels.

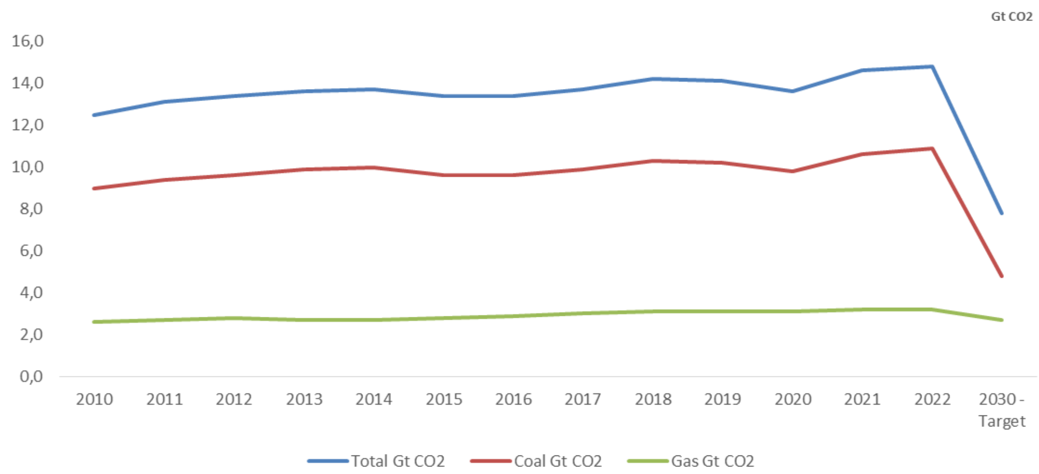
2.2.5.2. Carbon Emissions

According to their type of electricity generation, countries have contributed to climate change in different. The US and China have generated their electricity power at a rate of 70% and 80% respectively by the usage of fossil fuels, however, France has only 10% share of fossil fuels in its total generation. The clean electricity for decarbonisation depends on the amount of and the type of country's source. For each electricity unit with the production process of coal and gas-fired materials as of a part of GHG emissions has damage to the world ten times that of other generation methods.

The significant portion of global carbon emissions is resulted from fossil fuel related electricity production. In the US, fossil fuel intensive electric generation has contributed as 65% of whole country emissions of sulphur dioxide which is primary source of acid rain. The generation of electricity is the highest combined source carbon monoxide.

Coal-fired power manufactures which is a kind of fossil fuel station produces carbon emission more than ten billion tons each year. More than half was pertaining to China. The United Nation Secretary reminded that the electricity generation from coal power stations must be stopped by the OECD countries until 2030. Carbon is emitted from the ignition of natural gas in order to spin turbines to generate electricity.

Figure 2.11. Electricity and Heat Carbon Emissions



(Source: *IEA, Electricity and Heat Carbon Emissions)*

2.2.6. Hydrogen

Hydrogen is a type of gas, which is the most abundant chemical in the Earth. It exists in molecular forms such as organic compounds and water. It is produced by steam reforming which is the reaction of water and methane. Hence, steam reacts with methane to form hydrogen at high temperatures. Hydrogen is an energy carrier rather than a resource since hydrogen is not naturally generated in useful quantities.

Hydrogen is mostly used in both fossil fuel production and ammonia production. Fossil fuels are the primary source of hydrogen as well as carbon monoxide reacting of hydrocarbon with water and natural gas. The hydrogen production by fossil fuels which is called 'gray hydrogen' results in carbon emissions. If it is generated through carbon capture and storage, it is called as 'blue hydrogen'. Hydrogen generated by the means of renewable energies is referred to as 'green hydrogen'. Gray hydrogen is the most produced hydrogen than blue hydrogen and green hydrogen, which contributed at the rate of 1.8 to global GHG emissions in 2021.

Hydrogen is a converter of heavy petroleum sections into lighter ones and a core element of fuel cells for the generation of electricity as transportation fuel.

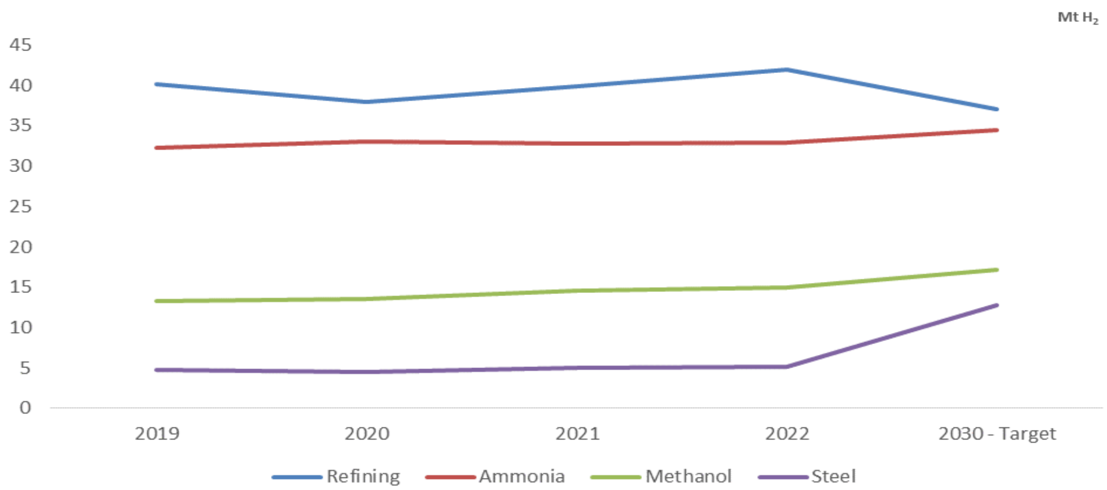
2.2.6.1. Production

Despite of an abundance of hydrogen as an element, it is hydrogen is consistently found as part of different compound, such as water or methane. It must be separated in pure hydrogen for use in fuel cell electricity vehicles. Hydrogen fuel is put together with oxygen by the means of a fuel cell, generating electricity and water through an electrochemical step.

87 million tons of hydrogen in 2020 and 94 million tons of hydrogen in 2021 were produced respectively. As of year 2021, hydrogen produced is used in industry with 57%, oil refining with 43% and in ammonia for fertilisers. The hydrogen market was valued at 155 billion USD as of year 2022, where its growth rate is expected as 9.3% by 2030.

Hydrogen is an alternative energy services with fossil fuels. Additionally, it supports buildings, industrial processes and store energy. It has various functions in industry. For instances, oil refineries yearly use nearly 38 million Mt and the rest of industry 51million Mt of hydrogen, globally, also chemical properties. Hydrogen economy can provide unlock the potential of fuel for personal mobility, high intense heat for manufacturing, thermal comfort in construction and buildings, and industrial uses of energy.

Figure 2.12. Global Hydrogen Demand by Sector



(Source: *IEA, Hydrogen Demand, 2019-2030)*

It was noted that refining industry uses hydrogen at the rate of 43% as of year 2021. During last consecutive four years, the demand for hydrogen in oil refining industry grew at average rate of 40%. By 2030 its growth is expected as 37%. However, the growth of ammonia demand was averagely 32.8% and it is expected 34.5% with the increase 2.4 points.

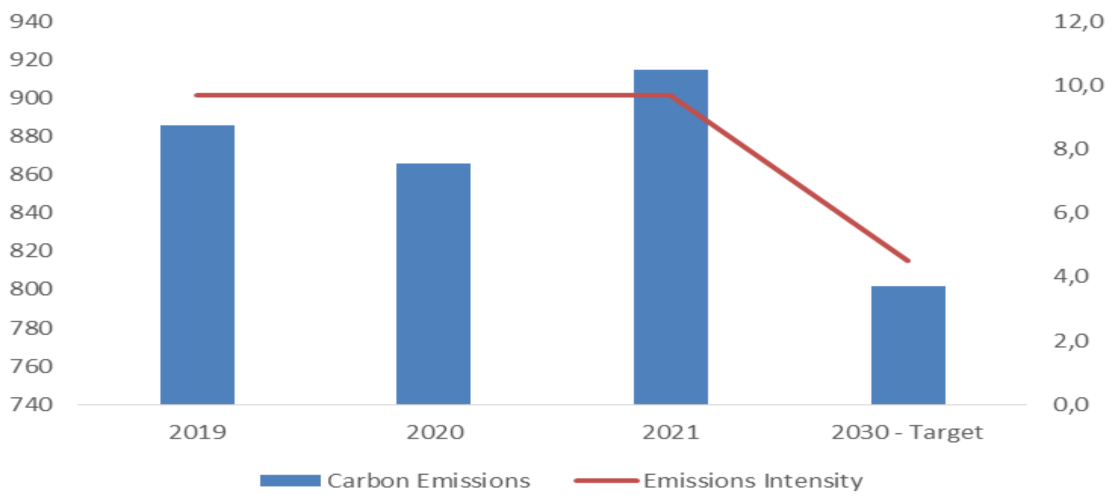
2.2.6.2. Carbon Emissions

In year 2021, Most of hydrogen were generated from fossil fuels whose production elements were 70% of natural gas and 30% of coal gasification. Low carbon was less than dedicated production. 1.8 percentage of global GHG was from hydrogen production, which was equivalent to 2.8% of energy-related carbon emissions (i.e 915 million tons).

Hydrogen fuel provides heat with high temperature intensively for the industries which are cement, chemicals, steel and glass, hence hydrogen contributes to the decarbonisation. For example, hydrogen-electric trucks will almost eliminate tailpipe emissions.

Blue whose production source is hydrocarbons with storage and carbon capture and gray whose production source is fossil fuels and natural gas will replace with gray hydrogen, which is planned to produce in greater total volumes. Especially, they will be in heavy industry where hydrogens are produced with high temperature process for electricity, feedstock for ammonia and organic chemicals instead of coal-intensive steelmaking, long-haul transporting such as aviation and shipping, and energy storage.

Figure 2.13. Global Hydrogen Production Carbon and Average Emissions Intensity



(Source: *IEA, Hydrogen Production, 2019-2030)*

Oil and gas industry which used intensively hydrogen contributes to global GHG emissions at the rate of 15%. Despite of a reduction of emission growth as 4%, the contribution to global carbon emissions is high share of total emissions. In addition to this, the demand for hydrogen in oil and gas industry is expected to grow 0.6 times by year 2050.

RESTRICTIONS AND THE CBAM

3.1. CBAs

3.1.1. Legislation

As the European Union, Canada, the US and China flourishes in its own solution for climate change, there are important milestones in its legislative history. The first trigger was the Paris Agreement which was introduced in force on November 2016 under UN. The signatories agreed to keep the increase in the global average temperature well below 2 centigrade over pre-industrial levels and to follow efforts to limit the increase to 1.5 centigrade.

After the Paris Agreement, the council of the EU, the US congress and some countries announced the 'European Green Deal (EGD)' which goals to keep and develop the UN'S capital, and to provide more healthy earth and well-being of people from environment-related risks and impacts. The countries stated that the strategies for dealing with challenges of climate change and reaching the aims of the Paris Agreement were at the core of the EGD. The EGD which was announced by the European Council on December 2019 set the net zero target by 2050. As the EU aims to meet the goals of the Paris Agreement, the EU communicated to UN Framework Convention on Climate Change that net GHG is to be reduced by at least 55 percentage by year 2030.

In year 2021, the European Commission declared a package of proposals to make the EU's climate, transport, energy, building, and taxation policies fit for mitigating GHG emissions by at least 55% by 2030, in comparison with 1990 levels. In order to reach the emission reductions in the decades, the commission announced the legislative tools to deliver on the targets and fundamentally migrate EU economy and society to a green and prosperous future with the Fit for 55 package. The proposals as a part of Fit for 55 package:

- The EU ETS

- The Effort Sharing Regulation
- Regulation on Land Use, Forestry and Agriculture
- Renewable Energy Directive
- Energy Efficiency Directive
- Revised Alternative Fuels Infrastructure Regulation
- Fuel Aviation and Maritime Initiatives
- Revision of the Energy Taxation Directive
- Carbon Border Adjustment Mechanism

Above proposals are all complementary and connected together. The EU needed a balanced package which is called Fit for 55, and the revenues. The package aims to ensure a migration the EU to a green, fair and competitive across sectors. Before above proposals is determined to discover the opportunities and costs of the green transformation. In order to reach the commission's proposal where to increase the reduction target of net carbon emissions to at least 55 percentage in comparison to 1990's levels, a comprehensive impact assessment was implemented to underpin the commission's proposal the in September, 2020. The legislative proposals with fit for 55 package are put in place by this impact assessment. This will bring the interconnection within all parts of the EU package. Since the enforcement of Fit for 55 package in July 2021, many policies were to better shape through the discussions together with the co-legislators such as the Council and the European Parliament and signed in the EU laws. All formed the CBAM.

It is seen that there is less stringent climate change and environmental policies in non-EU countries. The EU commission agreed that they have a very high and strong risk of carbon league shifting from outside of European area. This undermines the EU climate solutions. Therefore, the EU needed a mechanism (i.e CBAM) for importing from outside in order to force the non-EU to de-carbonization in the industries. The European Union (EU) Carbon Border Adjustment Mechanism (CBAM) is focusing on carbon-intensive goods which are cement, steel/iron, aluminium, fertiliser and electricity in the first phase.

The EU CBAM is a domestic instrument to force a fair price for the foreign imports of carbon-intensive goods into the EU and to push non-EU countries to low-carbon emission production. It is seen that there has been a gradual introduction of the CBAM. The period of transition to the CBAM is aligned with the stop process of the allocation of the incentives under the EU ETS to achieve the decarbonisation of EU related industry.

3.1.2. Reporting

The European Parliament together with and the Council of the EU approved the EU CBAM Regulation which is effective from 10 May 2023. The CBAM entered its transitional phase started from 1 October 2023 and, the first reporting will be implemented in quarterly manner due the end day of January 2024. The definitive period of the CBAM enters in force in January, 2026.

The CBAM is firstly in a transitional period until the end of year 2025. The importers into the EU must report their carbon emissions embedded in their imported goods without paying any adjustment in transition period started from year 2023. In order to ensure the time for the robust transition, this reporting continues until the end of year 2025. Once the phase of operation becomes effective in 2026, the importers into the EU must declare the quantity of goods imported and the amount of embedded emissions in total goods imported in previous year, giving up the corresponding amount of the CBAM certificates.

As of year 2026, the importers within scope of the CBAM will register with their authorities where CBAM certificates can be brought. The price of the CBAM certificates is based in the weekly average auction price of European Union Emission Trading System allowances as euro per ton of carbon emitted.

The importers into the EU must declare annual quantity of goods and the embedded emissions of goods imported for the preceding year by 31 May. Moreover, the importers gives up the number of CBAM certificates which is equal to the amount of GHG emissions in the goods. In a nutshell, the CBAM is followed as below:

- The mechanism is applied on the actual emissions in the goods. The methodology will fully compliant with the reporting of carbon emissions under the ETS for the similar goods production in the EU.
- As of the definitive period of the CBAM in year 2026, the importers into the EU buy the CBAM certificates corresponding to the price the carbon, which would have been

paid. The goods are in scope if they are produced under the EU pricing rules of carbon emissions.

- If the importers prove whether the third country producers has already paid the carbon price in the production of those goods, based on verified data from third country producers, this amount can be deducted from the importer's net balance.

Transitional Phase

In this phase, the CBAM is only aiming to concentrate on reporting and monitoring. It is noted that there is no financial adjustments or a purchase of CBAM certificates. The importers of CBAM goods submit a quarterly report including the volume of embedded emissions in goods to be imported in the EU, as well as any carbon pricing due. Effective from 1st January 2025, it is possible to become an authorized declarant for CBAM in order to be ready for post transitional phase.

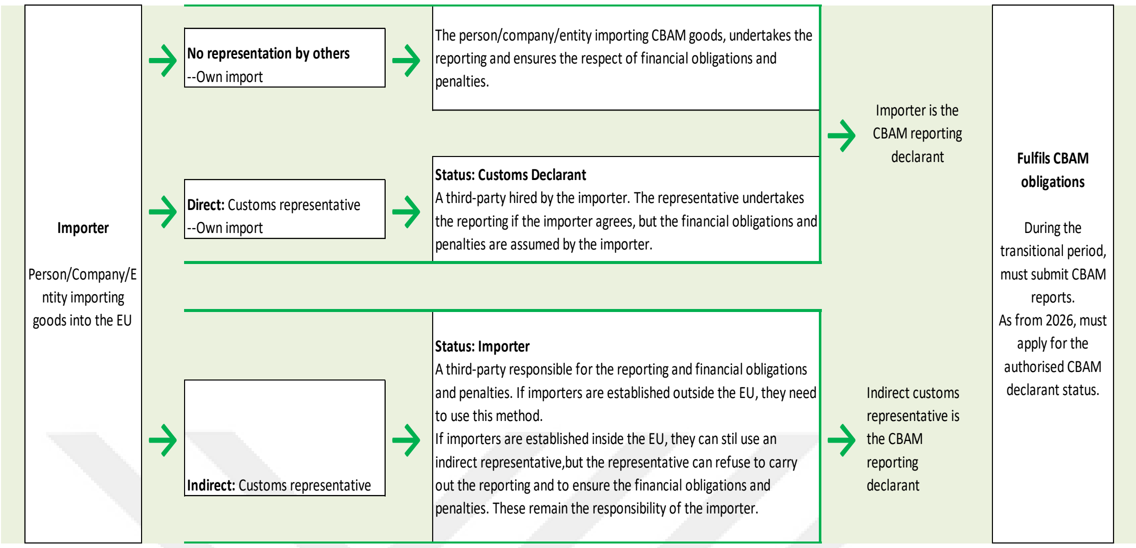
Assessments and Scope Extension

The EU commission will analyse the reported information and use a periodical review of the CBAM. The assessments will be submitted in analysis to the European Parliament before the start of the phase next to transition. The European Parliament and the Council review the reports and the analysis including functional implications and implementation of the CBAM. Their assessments includes whether there is a need of any extension to other goods out of scope, determining the methods and progress made in global discussions.

Post Transitional Phase between 2026 and 2034

Only authorized declarants will be able to import goods approved by the CBAM, effective from 1st January 2026. Those declarants which will be authorised as part of the CBAM must buy CBAM certificates which correspond to the volume of carbon emissions in the goods imported. In order to insure coherence with Emission Trading System, the CBAM certificates are phased and they will be in line with free allowances in the Emission Trading System.

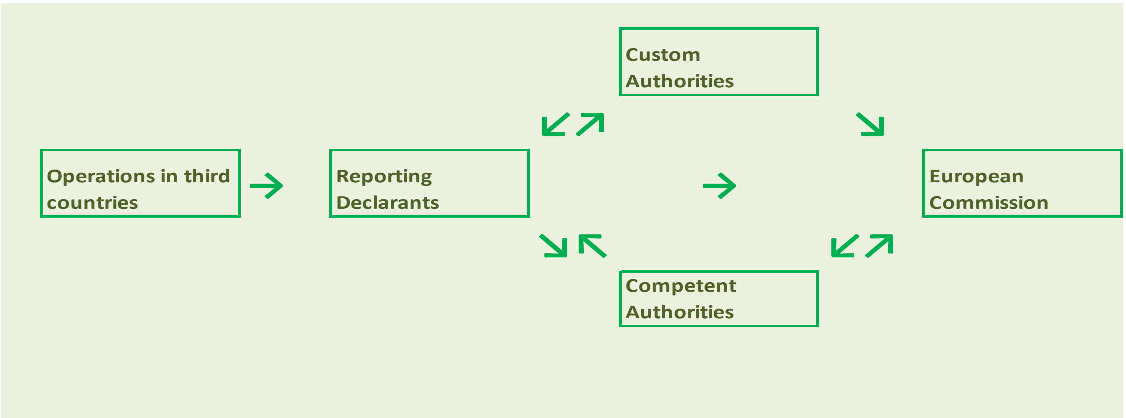
Figure 3.1. Rules for Representatives



(Source: *EU CBAM Implementation Regulation for the Transitional Phase*)

Figure 3.1 represents who the person is responsible for the reporting obligation. The reporting declarant is determined based on the location of import facilities. If it is outside the EU, the importers must use an indirect customs representative who is only responsible for the reporting as declarant.

Figure 3.2. Interactions between the Reporting Declarants and Officials



(Source: *EU CBAM Implementation Regulation for the Transitional Phase*)

In the transitional phase of CBAM, it was designed to provide adequate time for stakeholders to prepare for fully compliance with the requirements. It is noted that there is no authorization process in those flow. Stakeholders are operators in 3rd parties, reporting declarants, customs authorities and European Commission. Additionally, competent authorities verify the process steps, provide information and feedback to the reporting declarants about the CBAM reports.

3.2. Carbon Emission Restrictions

It is seen that jurisdictions is using steady a policy instruments for carbon pricing:

- 40 countries and 25 jurisdictions currently put a price on carbon
- Carbon pricing initiatives in use include 8 giga tonnes of carbon, corresponding to 15% of global emissions.
- Additionally, 46 initiatives related to carbon pricing are underway. 23 of 46 initiatives are emissions trading systems and remaining initiatives are about the imposition of carbon taxes nationally.

Globally, there are a few types of preventative measures to reduce the level of GHG emissions. They are mostly based on various approaches of carbon pricing, which are already in use. Nationals and jurisdictions such as states or unions keen for either purely a price signal or purely an ETS. A hybrid approach is in agenda for a few of countries. It is seen that the emerging trends in carbon pricing approaches trigger a close and intense linkage between jurisdictions for carbon markets.

The EU's long-term budget for the next seven years will provide support to the green transition. 30% of programmes under the EUR 2 trillion 2021-2027 Multiannual Financial Framework and Next Generation EU are dedicated to supporting climate change related actions; 37% of the EUR 723.8 billion (in current prices) Recovery and Resilience Facility, which will finance Member States' national recovery programmes under Next Generation EU, is allocated to climate change related actions.

The restrictions in scope of the CBAM which imposes the carbon pricing measures on non-EU countries encourage both importers into the EU and its countries (i.e non-EU) in order to reduce the risk of carbon intensive production processes. It applies on a selected sectors at higher risk of carbon emissions: cement, aluminium, hydrogen, iron&steel, fertilisers and electricity generation. Started from 1 October 2023, official reporting process is valid for the goods of those sectors with the goal of facilitating a roll-out and to establish a communication with third parties. The importers into the EU begin will begin to pay for the CBAM financial adjustment will begin in year 2026.

As part of the Fit for 55 package, the European Union is taking preventative measures to reduce their carbon emissions as below:

- Emissions trading system for industry
- Carbon pricing on imported goods
- Cutting emissions from transport in Europe
- Reducing emissions from the energy sector
- Tackling carbon emissions from other sectors

The EU commission proposed an amendment on phase 4 of the EU ETS between 2021 and 2030, which are five essential milestones:

- A more ambitious reduction factors for greenhouse gases emissions,
- Revised set of rules for the allocation of allowances at zero cost
- Extension of the EU ETS to maritime transporting
- A separate new EU ETS for road transporting and buildings
- Rise in the Innovation and Modernization Funds and new rules on the usage of ETS revenues

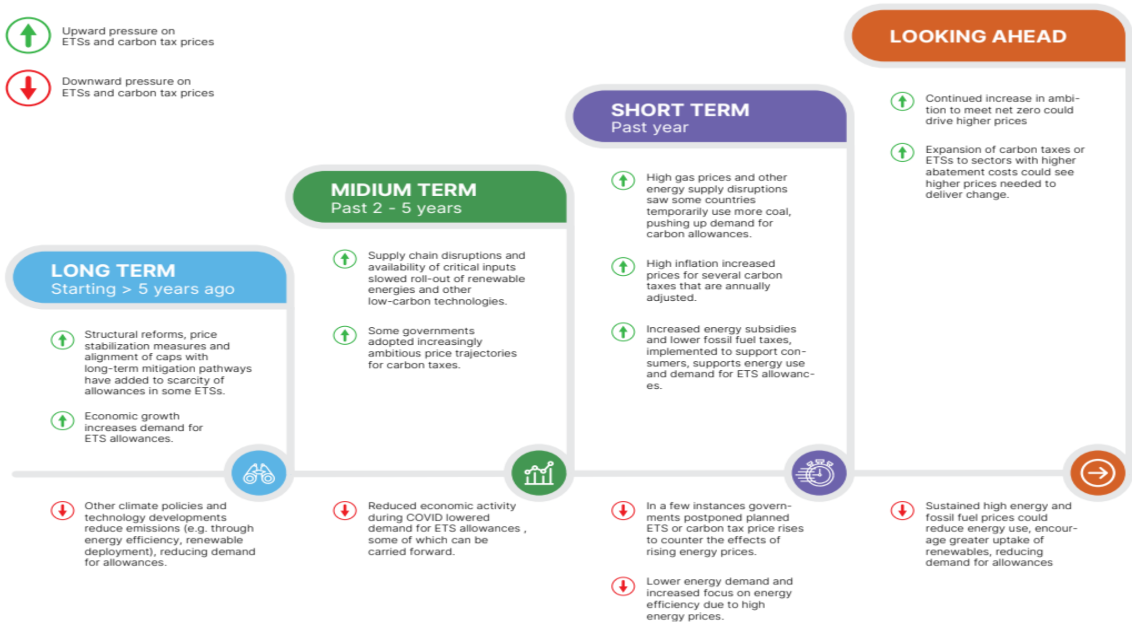
It is noted that there are the most known measures as carbon taxes and emissions trading system. Both gives the emitters attractive incentives to take action in reducing their emissions. This provides either to lower the tax bills or to lower the cost of the permits. The governments increase their revenues through taxes or through the auction in emissions trading system. The governments can give the further revenue back to low-income taxpayers in order to help them to establish less carbon-intensive production process. It can be used to help the low-income taxpayers pay for goods, especially energy-related goods, which its price will be more expensive as a result of the carbon price.

It is believed by many economists that and carbon pricing is the best available tools to mitigate the impacts of climate change because carbon pricing touch every part of the whole economy interdepartmental. It provides the rewards for any actions reducing greenhouse gas emissions. Carbon pricing cause the market flexibility to find out the less costly ways to reach lower emissions rather than making policies exactly how emissions should be reduced.

Several regions and countries around the world already implement carbon pricing, including the EU, California and some northeast states in the US and China.

Addition to policy updates, energy related markets have been the most significant factor determining prices in most ETSs. Estimations of global consumption growth of energy have been revised down much in alignment of increasing fossil fuel price. Lower energy use could decrease demand for ETS allowances. It causes a dampening effect on prices as long as those prices are set by allowance demand and supply.

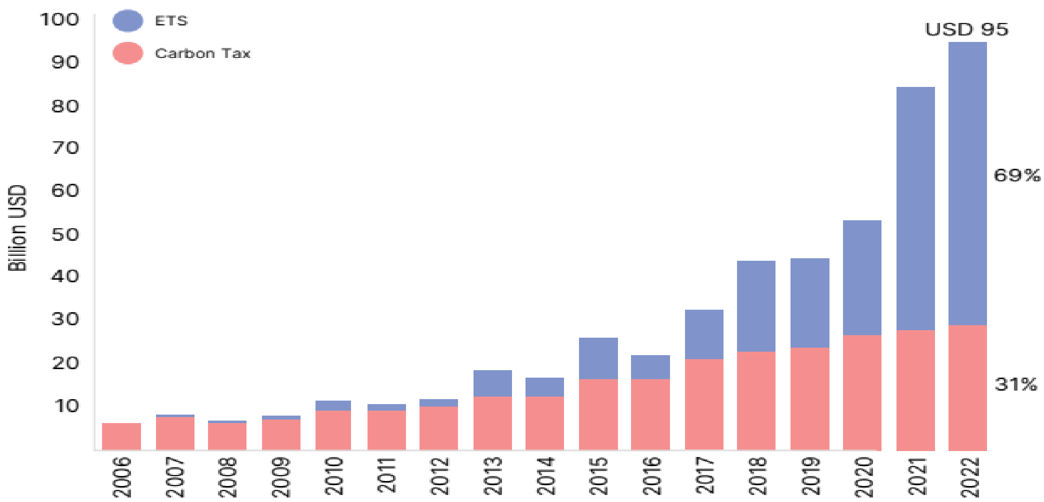
Figure 3.3. Recent ETS and Carbon Tax Price Developments



(Source: *World Bank Group - State and Trends of Carbon Pricing 2023)*

As of April 2023, nearly 5% of global GHG emissions are directly covered by a carbon price at the range expected by 2030. Carbon taxes and ETSs in operation reach to 23% of total GHG emissions.

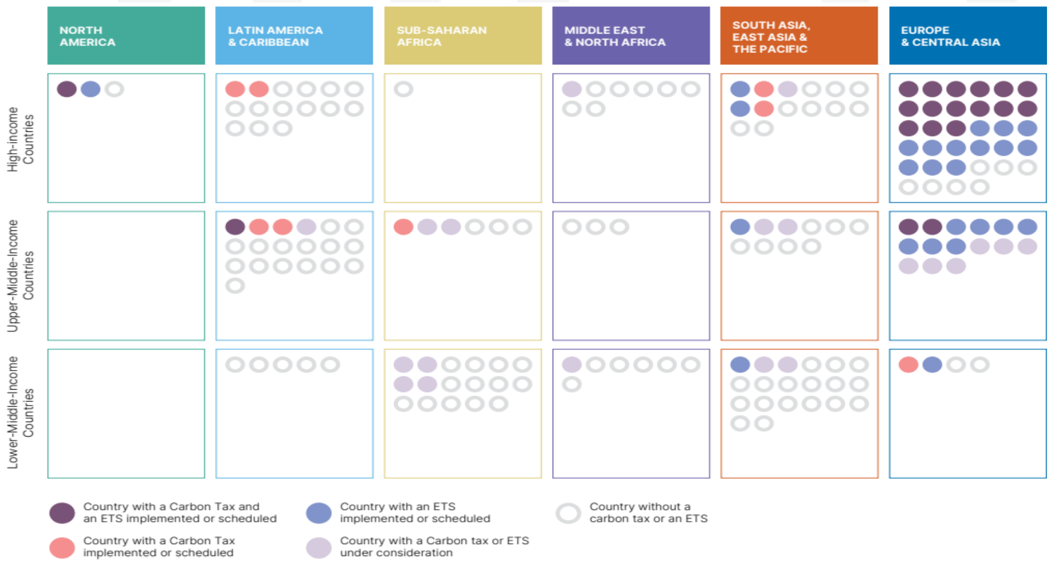
Figure 3.4. Evolution of Global Revenues from Carbon Taxes and ETSs



(Source: *World Bank Group - State and Trends of Carbon Pricing 2023)*

Global revenues received from both carbon taxes and ETSs increased by above 10% in year 2022, which reached to around USD 95 billion.

Figure 3.5. Countries with Carbon Taxes and ETSs by Regions and Income Levels



(Source: *World Bank Group - State and Trends of Carbon Pricing 2023*)

The majority of carbon pricing (tax, ETSs) are mostly located in higher income countries such as the EU and North America. They have at least one carbon pricing method including either carbon taxes or ETS. China has almost total ETS accounts for the emissions covered in the Pacific and East Asia. While some of Latin America countries as well as South Asia and the Caribbean have carbon taxes. Moreover, Mexico is the one implementing an ETS. It is seen that there is no examples of carbon pricing in Africa and the Middle East and that ant methods of carbon pricing are mostly limited to middle-income countries.

3.2.1. Carbon Taxes

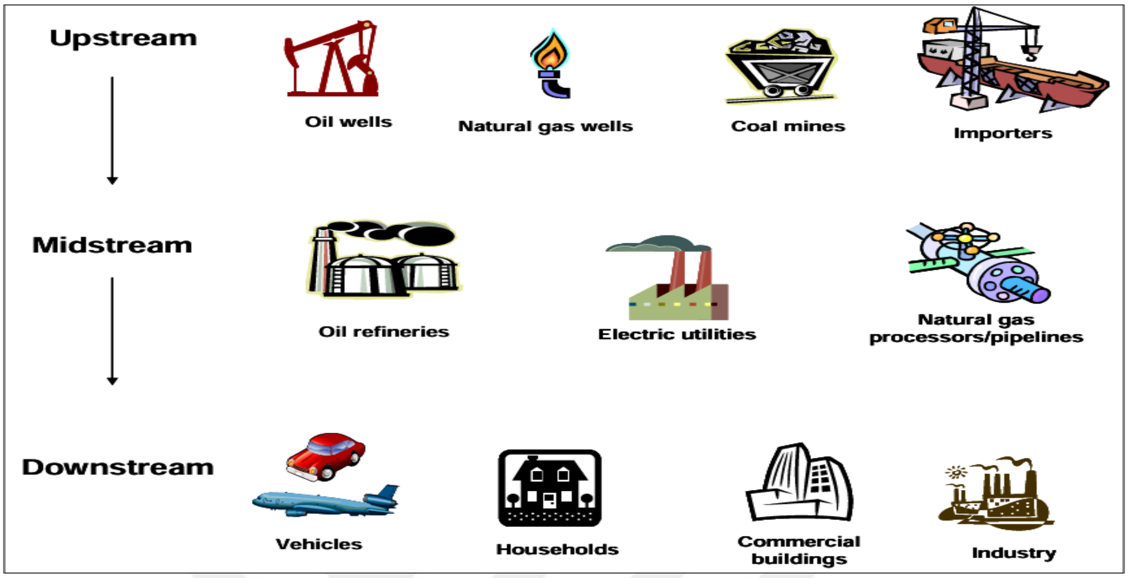
Carbon pricing policy is a tool to achieve lower emissions of carbon and other GH gases. The carbon pricing aims to a shift the costs of emission to producer. When producers must pay for each tonne of carbon emitted, producers have an economic incentive to avoid fossil fuels as production resource, provide their energy efficiency, and shift in low-carbon technology. It is very hard to determine the price of carbon emitted. Carbon tax and emissions trading system are main approaches to carbon pricing methodology.

Carbon taxes directly determine a price per tonne of carbon emissions. The fall in emissions depends heavily on how much carbon emitters change their attitude in response to the tax. A carbon tax needs policymakers to explicitly set the fee on each tonne of carbon emissions on yearly manner. High tax rates cause more reductions in emissions, high revenues, and more expensive prices. Policymakers can prefer to different approaches to define a carbon tax rates:

- To achieve specific outcomes to emissions
- To balance carbon emitted and its estimates of the damages
- To increase specific amounts of tax revenue

A carbon tax is not solely guarantee to achieve minimum level of reducing of greenhouse gases different from emissions trading system, however, it can ensure a certainty about the price signal on carbon. A potential tax on the usage of fossil fuel triggers a price signal around total economy with being incentive, thus it can result in both a move to less carbon-intensive manufacturing and a total reduction of carbon emissions.

Figure 3.6. Options for Taxation in the Energy Production-to-Consumption Chain



(Source: *Prepared by Congressional Research Service Carbon Tax: Deficit Reduction and Other Considerations)*

Electric utilities could be deemed under downstream entities because electricity is a source of emissions (i.e., midstream). Their emissions are linked with the electricity consumption of their customers as downstream consumers.

It is accepted that carbon taxes or fees will help reduce GHG emissions and Revenues received from carbon taxes could provide a range of policy objectives. Tax revenues from carbon-intensive ecosystem depend heavily upon the rate and scope of the tax as well as market factors. For example, a USD 20 for each ton of carbon taxes on the US carbon emissions would generate around USD 90 billion in first year.

3.2.2. Carbon Trading System (Emissions Trading System)

An authority determines a cap (limit) on the GHG emissions in the industries of selected sectors, and issues several tradable allowances keeping under the level of the limit. One tone of emissions typically corresponds to per allowance. The emitters are needed to surrender one allowance for per ton of emissions which are accountable. It is either freely received or bought allowances from authorities, and emitters can prefer to trade them or keep them for future usage.

The establishment of a market to use in trade the ETSs cause a price for allowances which creates a promotion to decrease emissions. A very strict limits turns into less allowance supply, hence the allowance price tends to increase more and to create an attractive incentive. The trade ability on the market results in the convergence of prices and prices of uniform signal, which triggers lower-emission goods and services. A set cap in advance results in a long term signal for market, hence the emitters could make a plan and effort into market accordingly.

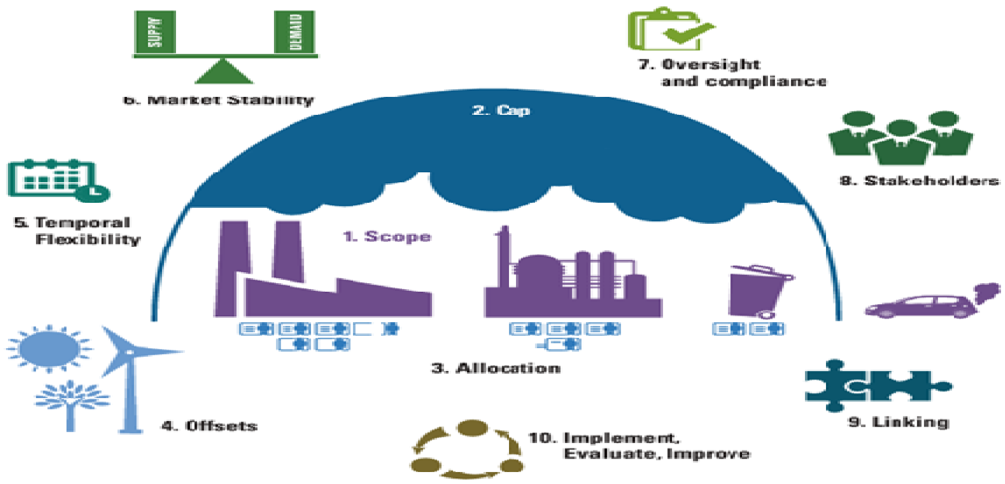
Emissions Trading System is designated in ten steps as follows, which involves a set of assessments, decisions and actions to be taken.

- Deciding the scope
- Setting the cap and distributing allowances
- Considering the use of offsets
- Deciding on temporal flexibility
- Addressing price predictability and cost containment
- Ensuring compliance and oversight
- Engaging stakeholders, communicate, and build capacities
- Considering linking
- Implementing, evaluating, and improving

It is noted that there are some keystones of ETS design including high-level decision points. These decisions determine the definition of its root shape and route, which are grouped as below:

- Which sectors to cover, where to place, and whether the system link with others in the short or longer term
- The form of the cap
- The development of the allocation plan and mechanisms for market management
- Whether to start with a pilot or phased introduction of sectors.

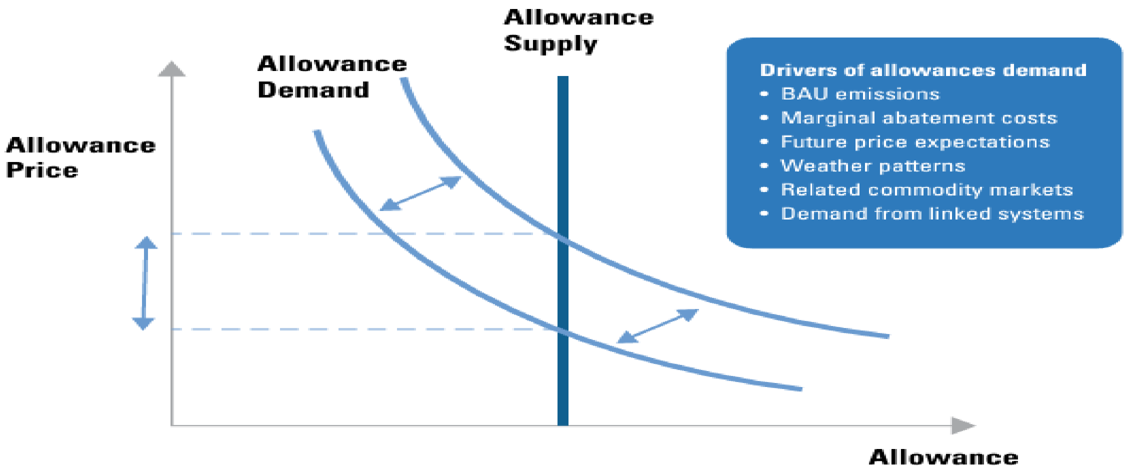
Figure 3.7. ETS Design in 10 Steps



(Source: *International Carbon Action Partnership Emissions Trading in Practice)*

Global demand for GHG emissions in ETSs depends heavily upon the emitter's attitude, market external conditions and sudden shocks independent from ETS design. The features impacting on demand includes the level of emissions, marginal decreasing costs, price expectations, weather conditions, linkage with commodities and the level of demand linked systems.

Figure 3.8. ETS Allowance Price Formation



(Source: *International Carbon Action Partnership Emissions Trading in Practice*)

3.2.2.1. The EU ETS

Emissions trading system (a cap-and-trade system) sets the amount of emissions to be released. The EU distributes a limited number of emissions permits by auctions. The emitters (i.e producers, manufacturers) must have permits for each tons of emissions released. They can trade their permits, hence the emitters who are not higher cost-effective producers in their emissions must buy extra permits from emitters who are. The resulting carbon price relies on the level of the supply and the level of demand for permits.

The European Union Emissions Trading System (EU ETS) became the cornerstone of the European Union's policy to mitigate the impacts of climate change. It is the most cost-effective way of reducing GHG emissions. It is now the first carbon market globally and continues the biggest one. It enforces the industries to hold a permit for each ton of carbon where companies have emitted. Companies where sectors are determined must but EU ETS at auctions. This provides a financial incentive to produce less carbon emission.

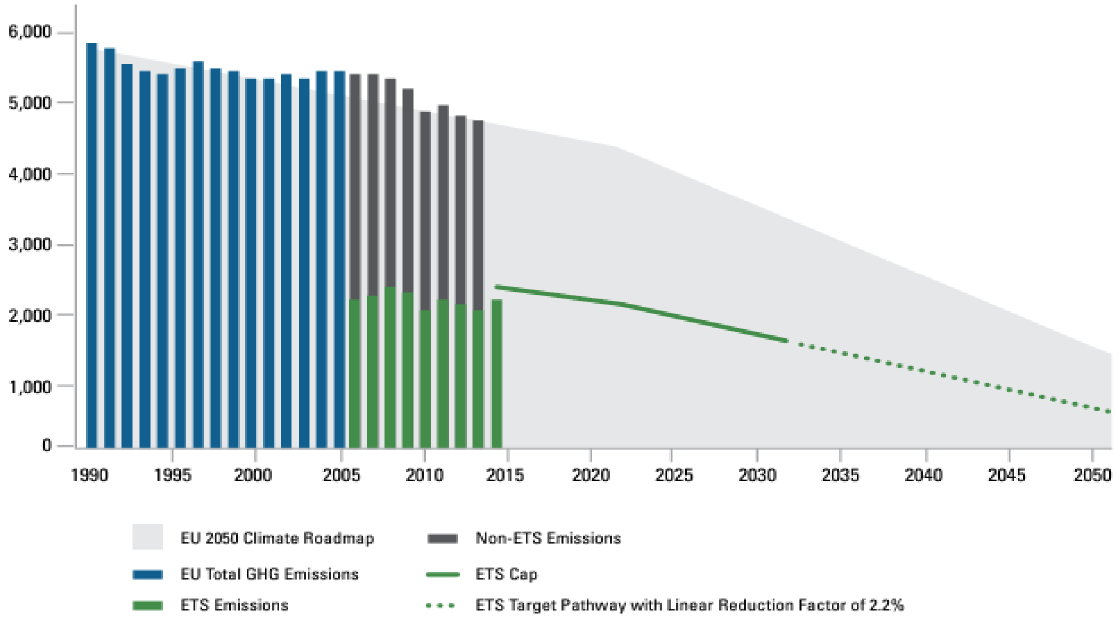
The EU ETS includes nitrous oxide, perfluorcarbons gases as well as carbon dioxide. In the scope of carbon dioxide, below areas are restricted with ETS:

- Heat generation and electricity
- Energy intensive sectors (oil refineries, steel, iron, aluminium, cement, metals, ceramics, paper and bulk organic chemicals
- Aviation within the EU Area, including departures to Switzerland and the United Kingdom
- Maritime transporting

The EU ETS controls nearly 40% of whole EU GHG emissions by its own rules and includes nearly 10.000 power stations and factories in the European Union. Based on the latest updated scheme which European Parliament approved in April 2023, reforms cover the cut of carbon emissions in selected sectors through the EU ETS to 62% until year 2030, started from year 2005' levels.

As of 2015, the European Union prepared the Market Stability Reserve (EU MSR) to closely align the demand and supply of allowances as 24% of whole EU ETS reserve. After eight years from year 2015, the EU MSR was extended to 2023 to keep the EU against falling carbon prices due to external shocks. Less carbon prices mean that there is lower incentive for industries to reduce GH gases.

Figure 3.9. EU Emissions Reduction Targets and Role of ETS



(Source: *International Carbon Action Partnership Emissions Trading in Practice, 2015a*)

3.2.2.1.1. Cap Setting

The cap corresponds to the limit of greenhouse gases emissions permitted at maximum. It means that the number amount of allowances of emissions is ready in use to cover entities. Regulatory body investigate to reconcile targets for climate change with their feasibility when they define a limit (i.e cap).

The current allowance prices were USD 83 at the average 2022 auction price and USD 85 at the average secondary market respectively. The followings are last updated prices available as of December 29, 2023.

Figure 3.10. ICAP Allowance Price Explorer

(Source: *International Carbon Action Partnership ETS, 31 December 2023)*

3.2.3. Other Restrictions

Apart from carbon pricing, Emission Reduction Funding (ERF) is a different way of preventative measure to cut emissions. Taxpayer funds its schemes in which government takes credits corresponded to emission reduction projects. Funding way where payments are released, providing pre-set level outcomes for emissions reductions are achieved. Many ERF programs goal to purchase validated reductions in carbon (or GHG) emissions while it improves access to cleaner energy and more healthy benefits. It is now operational use in Australia.

A hybrid system can be possible based on specific needs of the jurisdiction considering carbon pricing, which combines emissions trading system and carbon tax. For instance, a jurisdiction can set up a carbon tax which supports lower tax liability for less emission and an emission trading system with either minimum or maximum price per ETS allowance. Mexico and South African prefer to use a hybrid approach.

A crediting mechanism can be known as an incentive tool, which is based on programs or projects to achieve measurable reductions in the GHG emissions. The mechanisms which have a separate registry issue carbon credits as to an accounting protocol. Those credits are used to ensure compliance under international agreement, national policies or corporate objectives related to GHG mitigation.

3.3. Due Diligence for the Restricted Sectors

3.3.1. Sectors Restricted in European Union

3.3.1.1. Cement

The EU imported a total of USD 421.8m at 2022, by 80% from year 2018 to year 2022. 79 of countries exported the cement to the EU in this period.

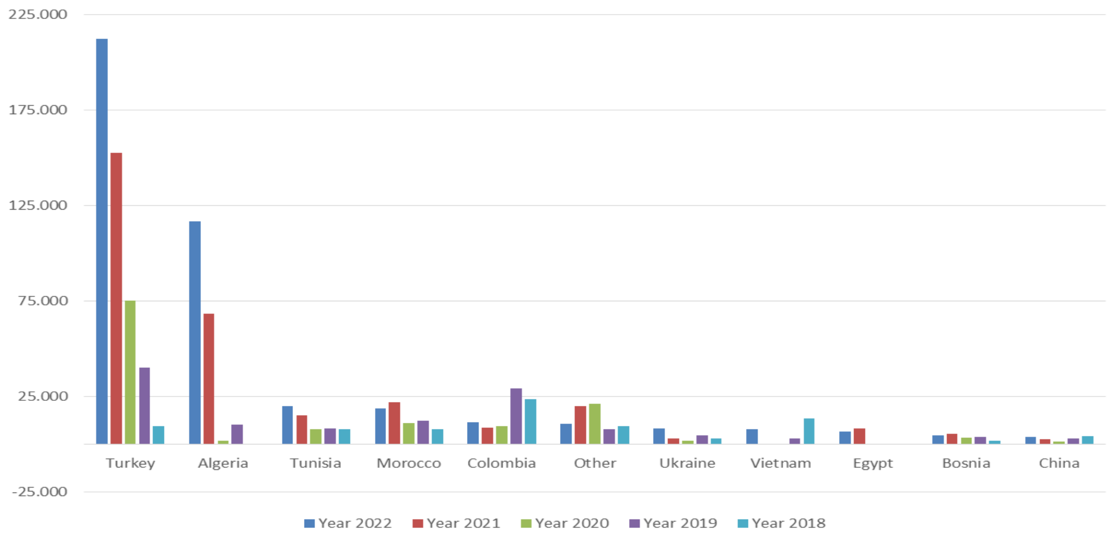
Table 3.1. Total Imports of Cement in EU (USD 1.000)

Year 2022	421.757
Year 2021	307.445
Year 2020	134.772
Year 2019	123.840
Year 2018	82.339

(Source: *World Integrated Trade Solutions, Cement Clinkers)*

Türkiye is the first importer of cement in the EU for four consecutive years. During this period, imports from Columbia, Vietnam and China decreased 107%, 69% and 14% respectively. However, Algeria and Türkiye increased their shares by 100% and 95% respectively.

Figure 3.11. Imports of Cement in EU (USD 1.000)



(Source: *World Integrated Trade Solutions*, *Cement Clinkers*)

3.3.1.2. Steel

As of year 2022, the EU imported a total of USD 920.7m. The value of imported steel in the EU increased by 89.5% from year 2018 to year 2022. 51 of countries exported to EU.

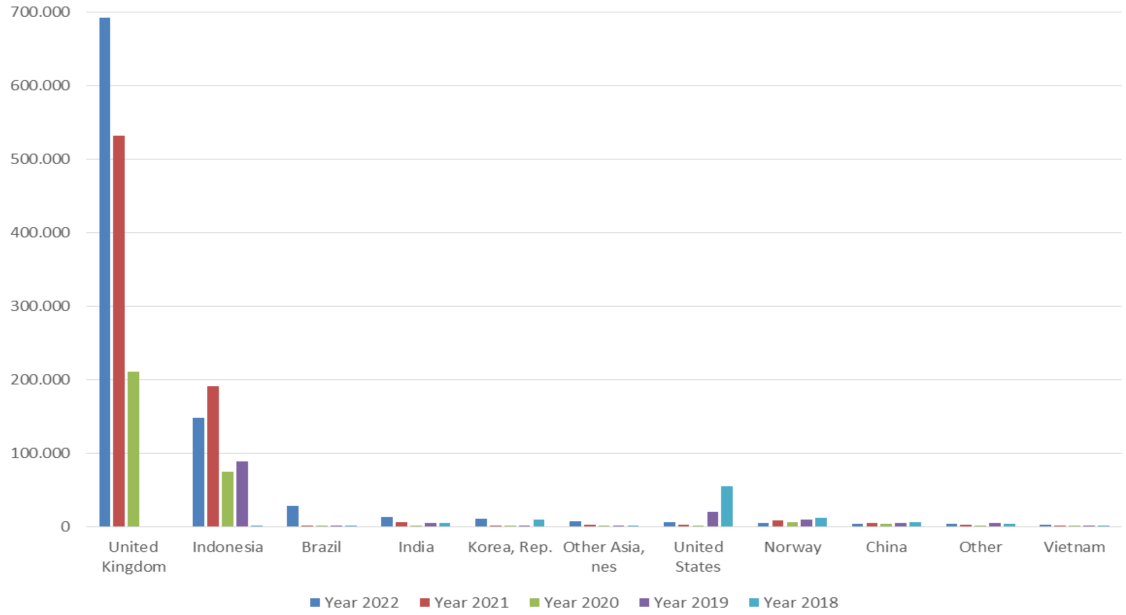
Table 3.2. Total Imports of Steel in EU (USD 1.000)

Year 2022	920.745
Year 2021	753.901
Year 2020	303.881
Year 2019	137.119
Year 2018	96.141

(Source: *World Integrated Trade Solutions, Steel, semi-finished products imports)*

Started from year 2020, the UK is the first importer of steel in the EU for three consecutive years. During this period, imports from Indonesia, Brazil and India increased by 99%, 99% and 61% respectively in both quantity and value. However, the US, Norway and China decreased 814%, 125% and 43% respectively.

Figure 3.12. Imports of Steel in EU (USD 1.000)



(Source: *World Integrated Trade Solutions, Steel, semi-finished products imports*)

3.3.1.3. Aluminium

As of year 2022, the EU imported a total of USD 513.2m. The value of imported aluminium in the EU kept in constant from year 2018 to year 2022. 48 of countries exported the aluminium to the EU in this period.

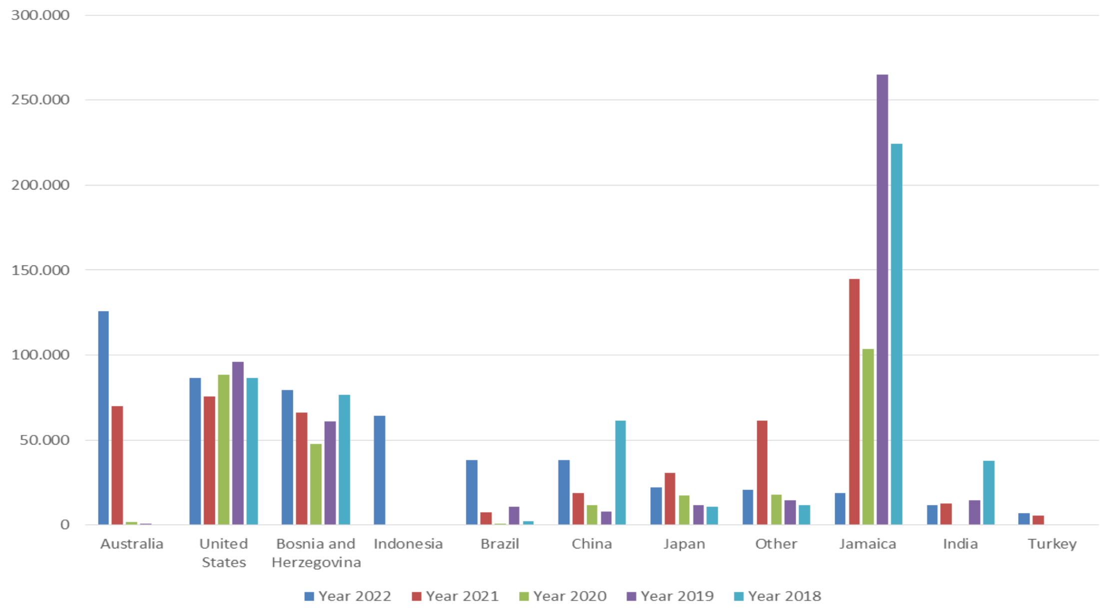
Table 3.3. Total Imports of Aluminium in EU (USD 1.000)

Year 2022	513.237
Year 2021	492.606
Year 2020	289.460
Year 2019	481.408
Year 2018	512.247

(Source: *World Integrated Trade Solutions, Aluminium*)

Started from year 2020, Australia is the first importer of steel in the EU for year 2022. During this period, imports from Australia, Indonesia and Brazil increased by 100%, 100% and 95% respectively in both quantity and value. However, China, Jamaica and India decreased 60%, 1.083% and 220% respectively.

Figure 3.13. Imports of Aluminium in EU (USD 1.000)



(Source: *World Integrated Trade Solutions, Aluminium)*

3.3.1.4. Fertilisers (Ammonia)

As of year 2022, the EU imported a total of USD 386m. The value of imported fertilisers in the EU increased by 80% from year 2018 to year 2022. 37 of countries exported the fertilisers to the EU in this period.

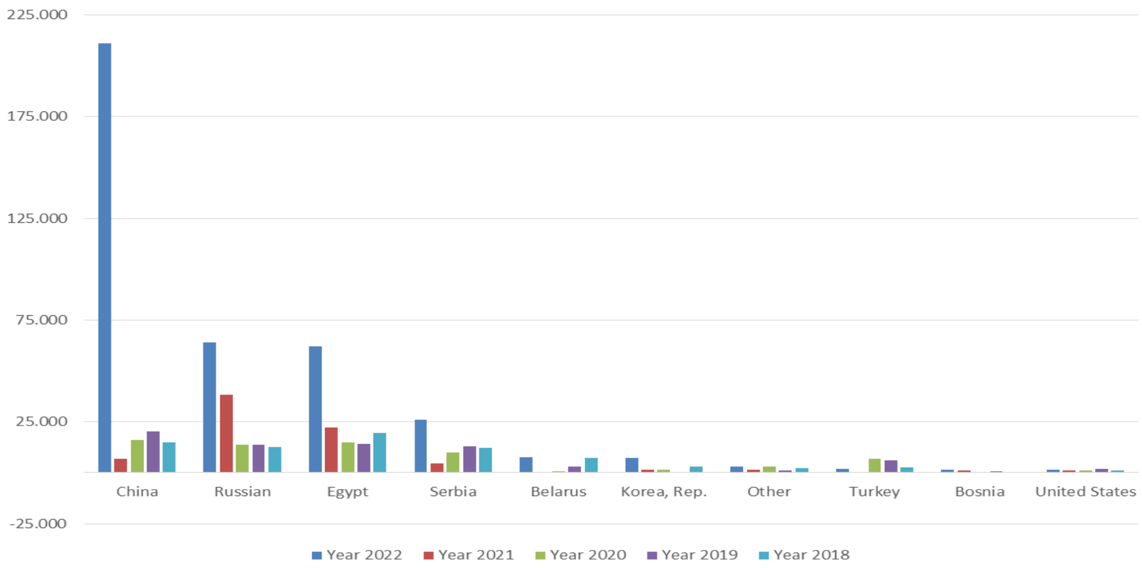
Table 3.4. Total Imports of Fertilisers in EU (USD 1.000)

Year 2022	386.059
Year 2021	78.271
Year 2020	68.536
Year 2019	74.048
Year 2018	76.296

(Source: *World Integrated Trade Solutions, Fertilizers*)

Started from year 2020, China is the first importer of steel in the EU for year 2022. During this period, imports from China, Russian and Egypt increased by 93%, 80% and 68% respectively in both quantity and value. However, Türkiye decreased 58% in that time.

Figure 3.14. Imports of Fertilisers in EU (USD 1.000)



(Source: *World Integrated Trade Solutions, Fertilizers*)

3.3.1.5. Electricity

As of year 2022, the EU imported a total of USD 23.2b. The value of imported electrical energy in the EU increased by 82% from year 2018 to year 2022. 19 of countries exported the electrical energy to the EU in this period.

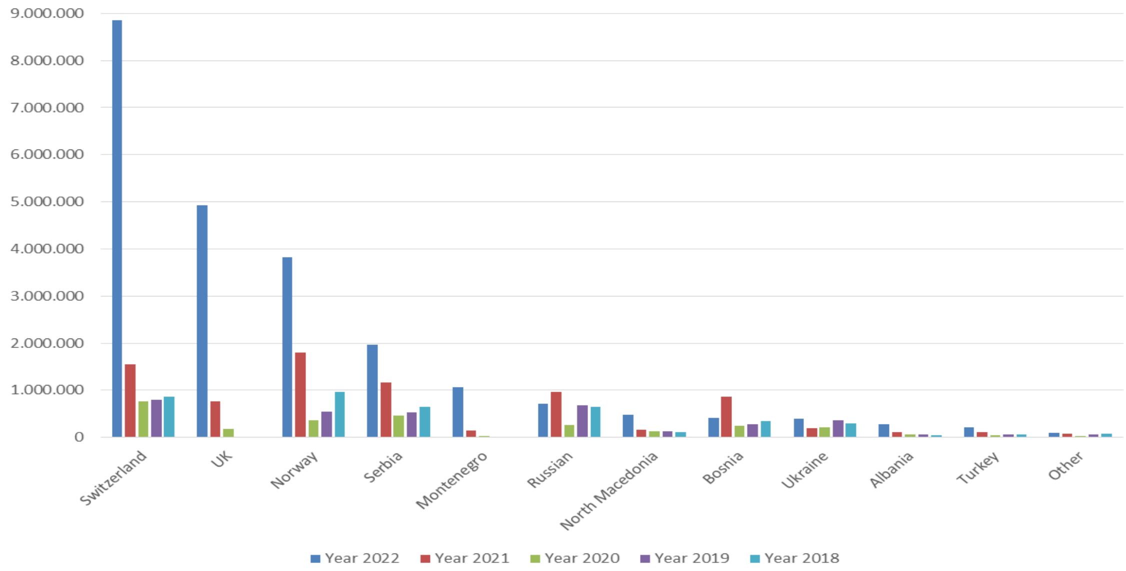
Table 3.5. Total Imports of Electrical Energy in EU (USD 1.000)

Year 2022	23.229.614
Year 2021	7.899.418
Year 2020	2.793.984
Year 2019	3.517.464
Year 2018	4.087.561

(Source: *World Integrated Trade Solutions, Electricity Energy*)

Started from year 2019, Switzerland is the first importer of electrical energy in the EU for four consecutive years. During this period, imports from Switzerland, the UK, Norway and Serbia increased by 90%, 100%, 75% and 67% respectively in both quantity and value. However, Imports of electricity energy decreased to zero for China, Mexico and Belarus in that time.

Figure 3.15. Imports of Electrical Energy in EU (USD 1.000)



(Source: *World Integrated Trade Solutions, Electrical Energy*)

3.3.1.6. Hydrogen

As of year 2022, the EU imported a total of USD 4.1m. The value of imported hydrogen in the EU increased by 77% from year 2018 to year 2022. 35 of countries exported the hydrogen to the EU in this period.

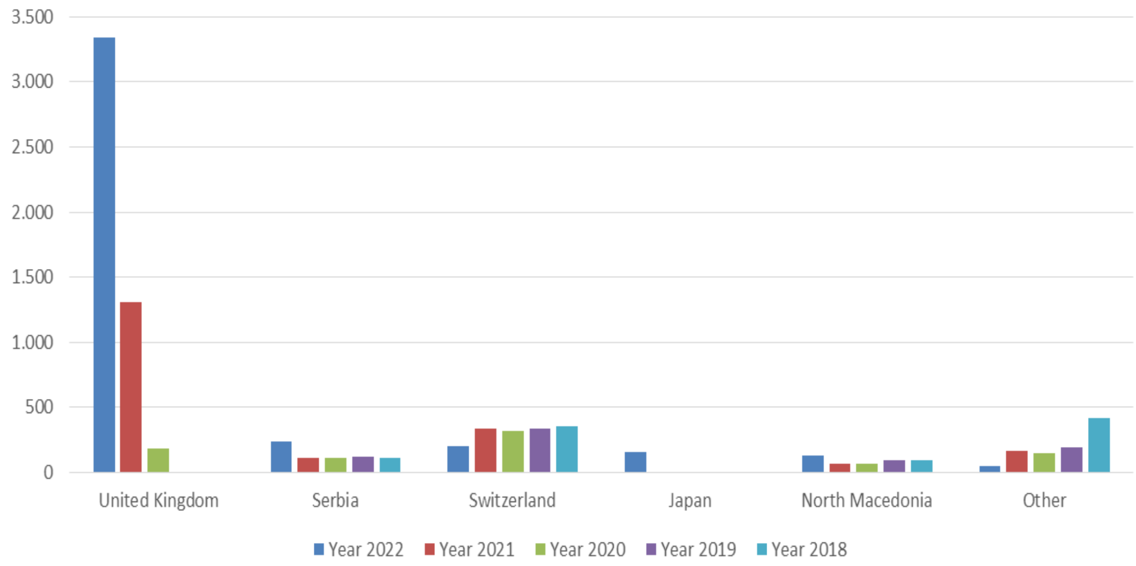
Table 3.6. Total Imports of Hydrogen in EU (USD 1.000)

Year 2022	4.117
Year 2021	1.982
Year 2020	819
Year 2019	733
Year 2018	963

(Source: *World Integrated Trade Solutions, Hydrogen)*

Started from year 2020, the UK is the first importer of electrical energy in the EU for three consecutive years. During this period, imports from the UK, Serbia and Japan increased by 100%, 55%, and 100% respectively in both quantity and value. However, Switzerland decreased by 74%.

Figure 3.16. Imports of Hydrogen in EU (USD 1.000)



(Source: *World Integrated Trade Solutions, Hydrogen*)

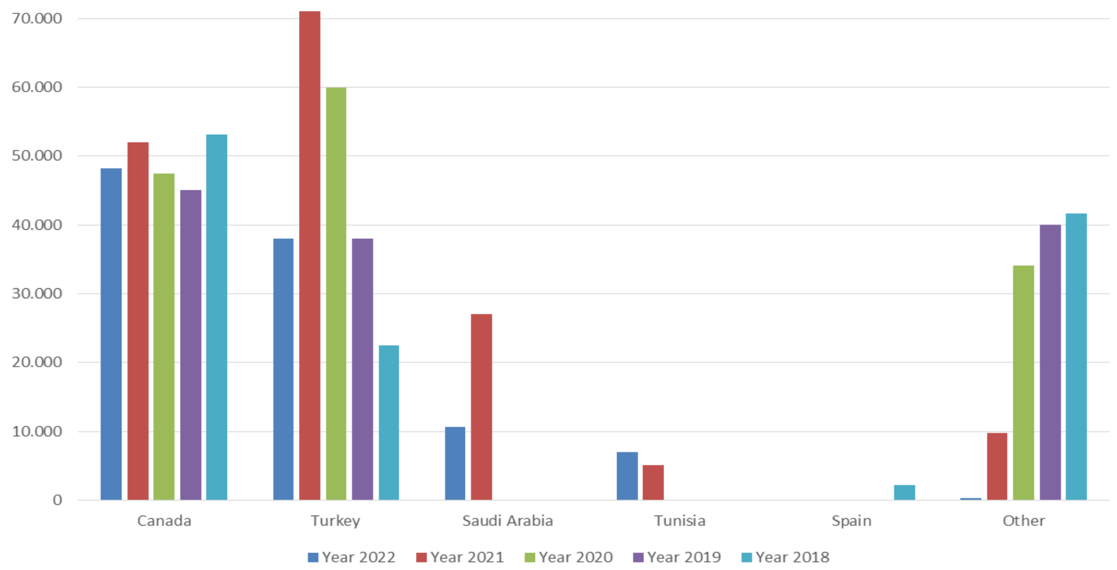
3.3.2. Sectors Restricted out of EU

3.3.2.1. Cement

3.3.2.1.1. United States

As of year 2022, the US imported a total of USD 104.2m. The value of imported cement in US decreased by 15% from year 2018 to year 2022. 21 of countries exported the cement to US in this period. Started from year 2020, Canada is the first importer of cement in US for four consecutive years. During this period, imports from Canada decreased by 10%. However, Türkiye, Saudi Arabia and Tunisia increased their shares 41%, 100% and 100% respectively in both quantity and value.

Figure 3.17. Imports of Cement in US (USD 1.000)

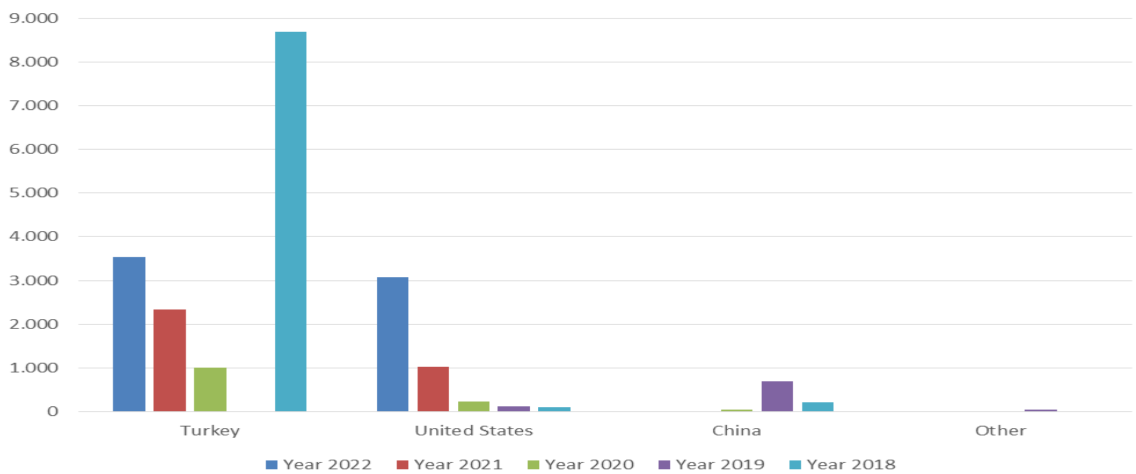


(Source: *World Integrated Trade Solutions, Cement Clinkers*)

3.3.2.1.2. Canada

Canada imported a total of USD 6.6m in 2022, by 36% from year 2018 to year 2022. 12 of countries exported the cement to Canada in this period. Türkiye is the first importer of cement in Canada for three consecutive years.

Figure 3.18. Imports of Cement in Canada (USD 1.000)

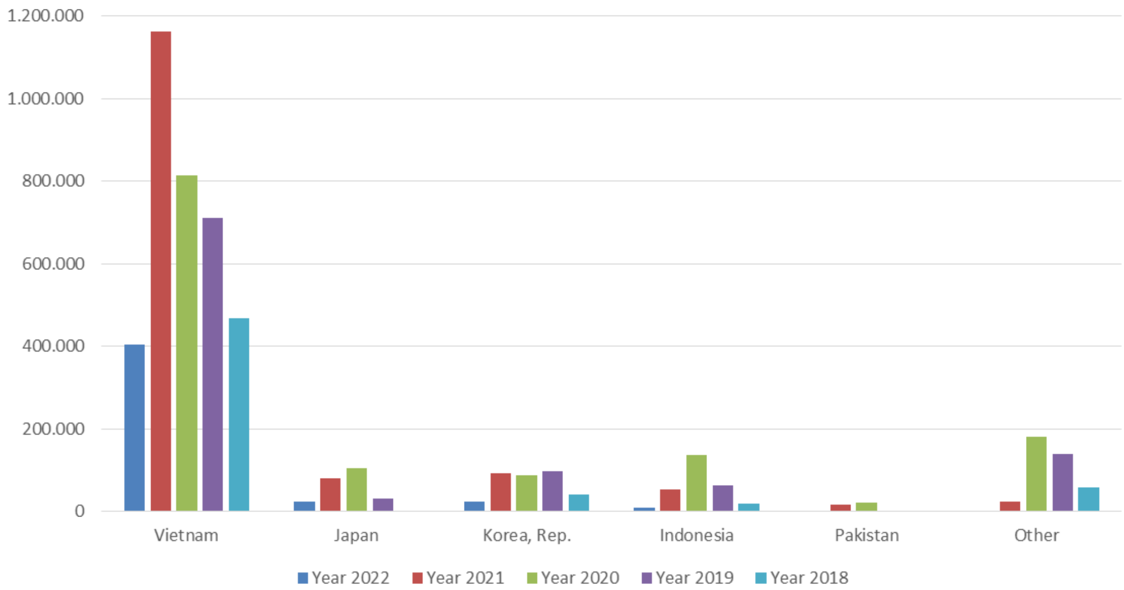


(Source: *World Integrated Trade Solutions, Cement Clinkers*)

3.3.2.1.3. China

As of year 2022, China imported a total of USD 460.8m. The value decreased by 28% from year 2018 to year 2022. 48 of countries exported to China in this period. Vietnam is the first importer of cement in China for five consecutive years. Imports from Korea, Indonesia and Vietnam decreased by 78%, 131% and 16% respectively in both quantity and value.

Figure 3.19. Imports of Cement in China (USD 1.000)

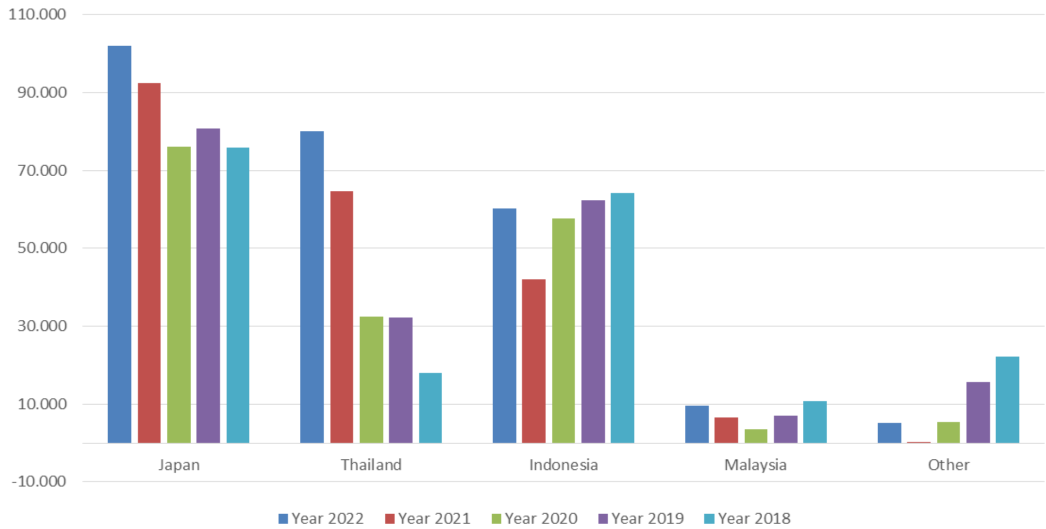


(Source: *World Integrated Trade Solutions, Cement Clinkers*)

3.3.2.1.4. Australia

As of year 2022, Australia imported a total of USD 256.9m. The value of imported cement in Australia increased by 26% from year 2018 to year 2022. 11 of countries exported the cement to China in this period. Started from year 2018, Japan is the first importer of cement in Australia. Imports from Japan and Thailand increased by 26% and 78% respectively in both quantity and value. However, imports from Indonesia and Malaysia decreased 7% and 11% respectively.

Figure 3.20. Imports of Cement in Australia (USD 1.000)

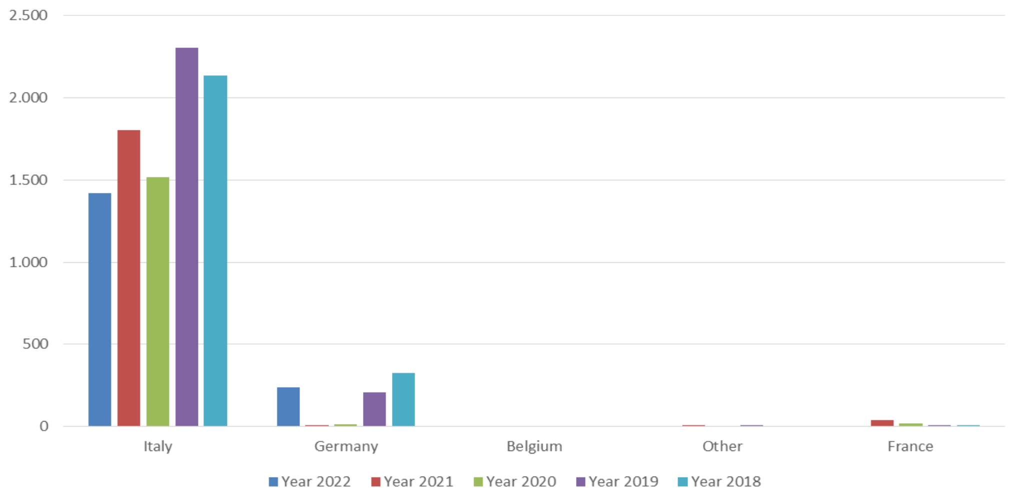


(Source: *World Integrated Trade Solutions*, *Cement Clinkers*)

3.3.2.1.5. Switzerland

As of year 2022, Switzerland imported a total of USD 1.7m. The value of imported cement in Switzerland decreased by 49% from year 2018 to year 2022. 23 of countries exported the cement to Switzerland in this period. Started from year 2018, Italy is the first importer of cement in Switzerland. During this period, imports from Italy and Germany decreased by 51% and 38% respectively in both quantity and value.

Figure 3.21. Imports of Cement in Switzerland (USD 1.000)

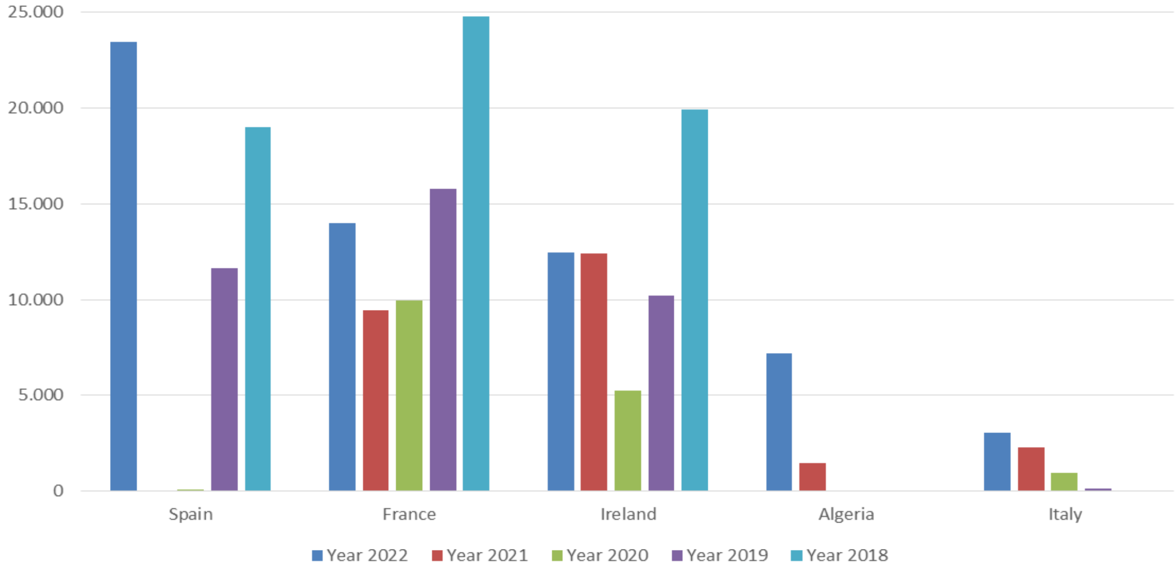


(Source: *World Integrated Trade Solutions, Cement Clinkers*)

3.3.2.1.6. United Kingdom

As of year 2022, the UK imported a total of USD 61.6m. The value of imported cement in the UK decreased by 28% from year 2018 to year 2022. 18 of countries exported the cement to the UK in this period. Started from year 2018, Spain is the first importer of cement in the UK. During this period, imports from France and Ireland decreased by 77% and 60% respectively in both quantity and value.

Figure 3.22. Imports of Cement in UK (USD 1.000)

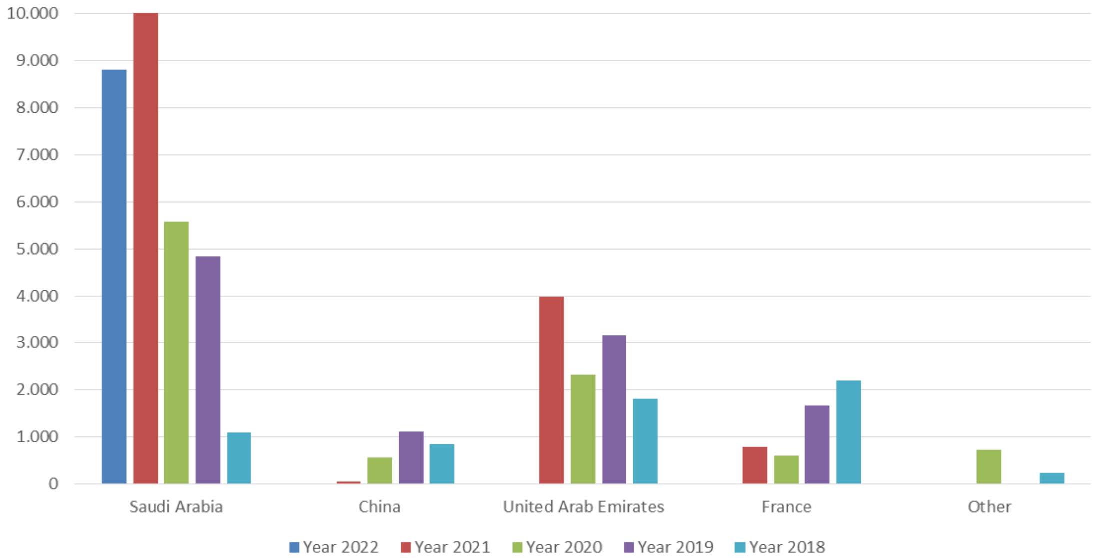


(Source: *World Integrated Trade Solutions, Cement Clinkers*)

3.3.2.1.7. South Africa

As of year 2022, South Africa imported a total of USD 8.8m. The value of imported cement in South Africa increased by 30% from year 2018 to year 2022. 26 of countries exported the cement to South Africa in this period. Started from year 2018, Saudi Arabia is the first importer of cement in South Africa. During this period, imports from United Arab Emirates and France decreased respectively in both quantity and value.

Figure 3.23. Imports of Cement in South Africa (USD 1.000)



(Source: *World Integrated Trade Solutions*, *Cement Clinkers*)

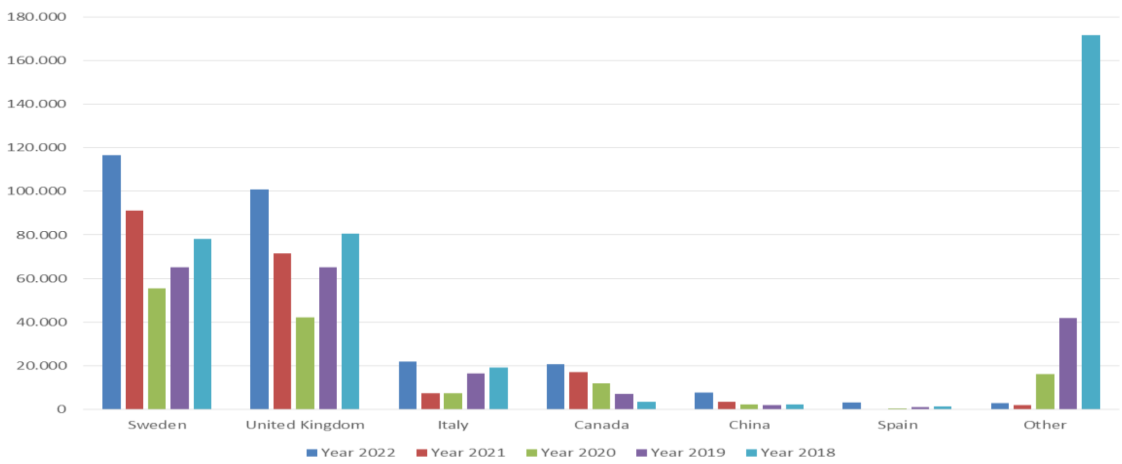
3.3.2.2. Steel

3.3.2.2.1. United States

The US imported a total of USD 274m in 2022. The value of imported steel in US decreased by 30% from year 2018 to year 2022. 35 of countries exported the steel to US in this period.

Started from year 2018, Sweden is the first importer of steel in US for five consecutive years. During this period, imports from Sweden, the UK and Italy increased by 33%, 20% and 13% respectively in both quantity and value.

Figure 3.24. Imports of Steel in US (USD 1.000)

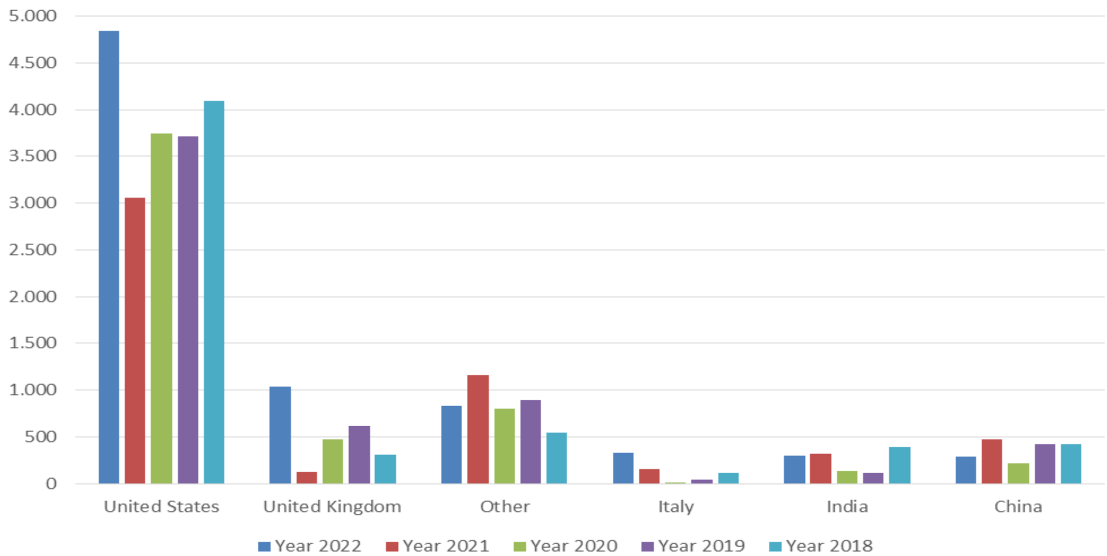


(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products)*

3.3.2.2.2. Canada

Canada imported a total of USD 7.6m in 2022, by 23% from 2018 to 2022. 45 of countries exported to Canada. The US is the first importer of steel for three consecutive years.

Figure 3.25. Imports of Steel in Canada (USD 1.000)

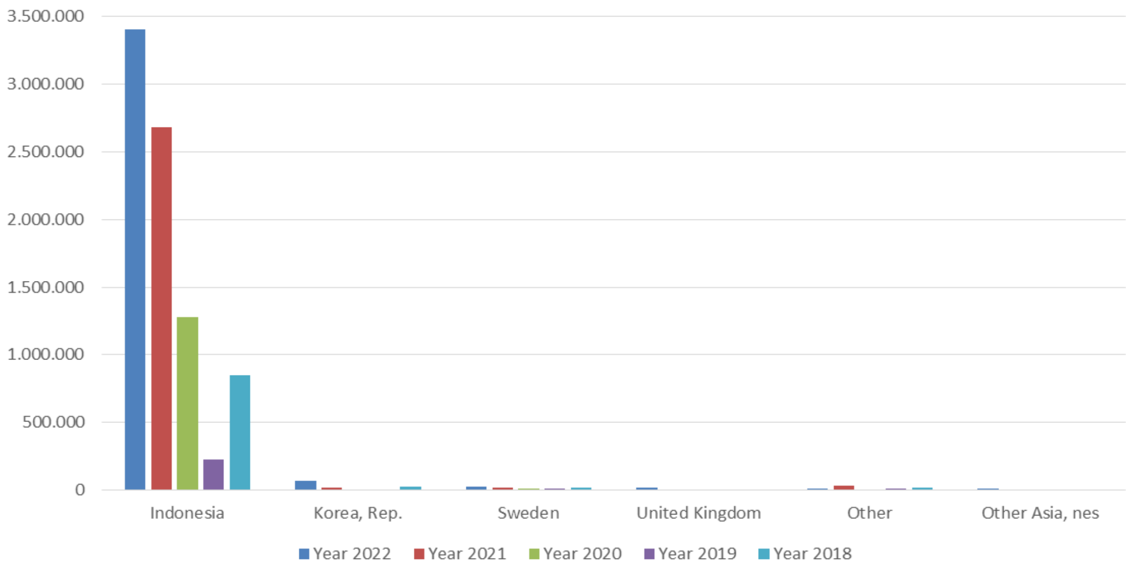


(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products*)

3.3.2.2.3. China

As of year 2022, China imported a total of USD 3.5b. The value of imported steel in China decreased by 74% from year 2018 to year 2022. 35 of countries exported the steel to China in this period. Started from year 2018, Indonesia is the first importer of steel in China for five consecutive years. During this period, imports from Indonesia, Korea, Sweden and the UK increased by 75%, 63%, 27% and 88% respectively in both quantity and value.

Figure 3.26. Imports of Steel in China (USD 1.000)

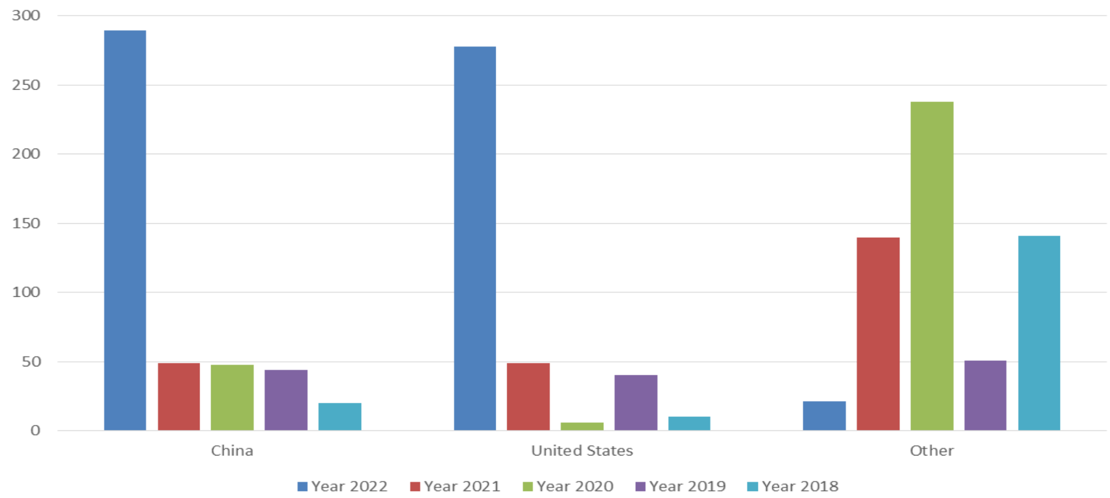


(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products*)

3.3.2.2.4. Australia

As of year 2022, Australia imported a total of USD 589k. The value of imported steel in Australia increased by 71% from year 2018 to year 2022. 16 of countries exported the steel to China in this period. Started from year 2018, China is the first importer of steel in Australia. During this period, imports from China and the US increased by 93% and 96% respectively in both quantity and value.

Figure 3.27. Imports of Steel in Australia (USD 1.000)

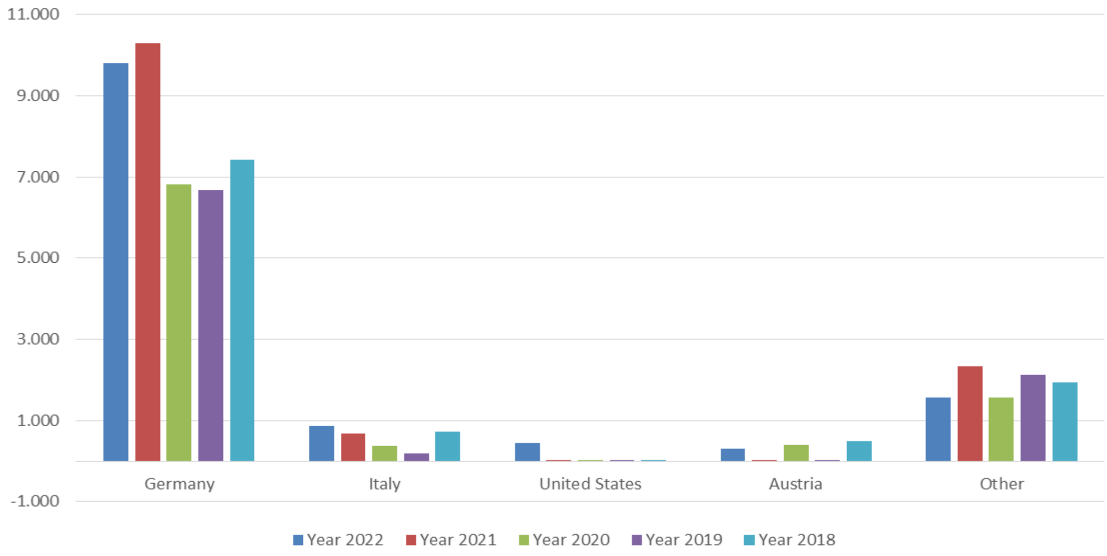


(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products*)

3.3.2.2.5. Switzerland

As of year 2022, Switzerland imported a total of USD 12.9m. Total value of import increased by 18% from year 2018 to year 2022. 37 of countries exported the steel to Switzerland in this period. Started from year 2018, Germany is the first importer of steel in Switzerland. During this period, imports from Germany and Italy increased by 24% and 17% respectively.

Figure 3.28. Imports of Steel in Switzerland (USD 1.000)

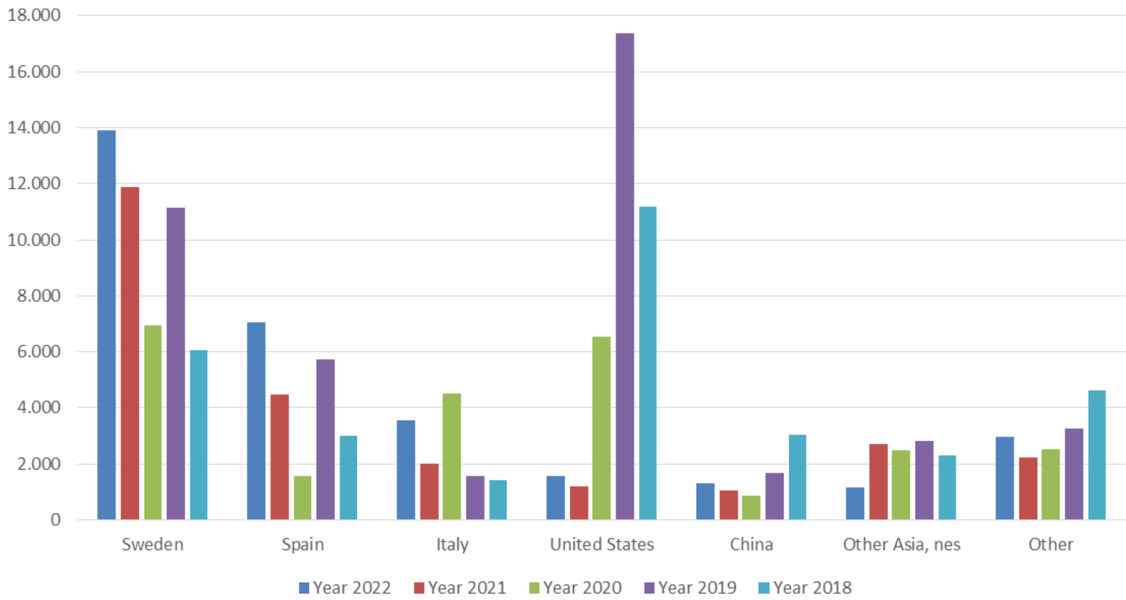


(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products*)

3.3.2.2.6. United Kingdom

As of year 2022, the UK imported a total of USD 31.5m. The value of imported steel in the UK decreased by 1% from year 2018 to year 2022. 49 of countries exported the steel to the UK in this period. Started from year 2018, Sweden is the first importer of steel in the UK. During this period, imports from Sweden, Spain and Italy decreased by 56%, 57% and 60% respectively in both quantity and value. However, imports from the US decreased 6x.

Figure 3.29. Imports of Steel in UK (USD 1.000)

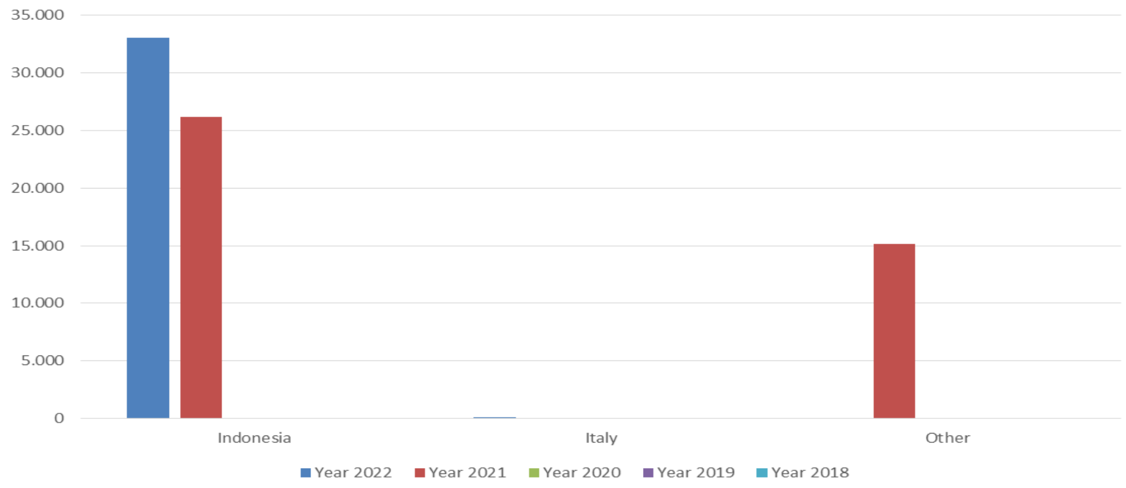


(Source: *World Integrated Trade Solutions, Steel, stainless; Semi-finished Products*)

3.3.2.2.7. South Africa

As of year 2022, South Africa imported a total of USD 33.2m. The value of imported steel in South Africa increased by 30% from year 2018 to year 2022. 35 of countries exported the steel to South Africa in this period. Started from year 2018, Saudi Arabia is the first importer of steel in South Africa. During this period, imports from United Arab Emirates and France decreased respectively in both quantity and value.

Figure 3.30. Imports of Steel in South Africa (USD 1.000)



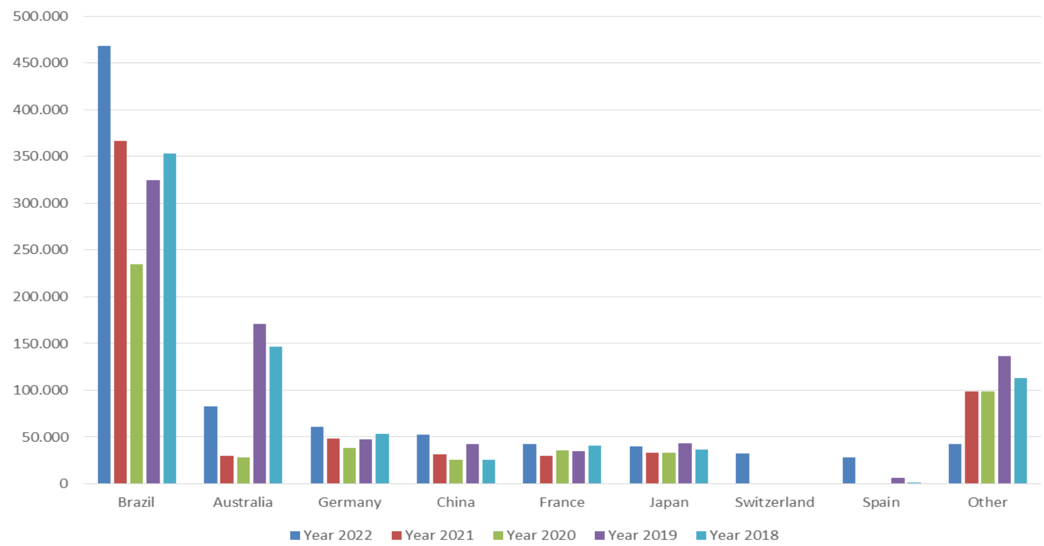
(Source: *World Integrated Trade Solutions, Steel, Semi-finished Products*)

3.3.2.3. Aluminium

3.3.2.3.1. United States

As of year 2022, the US imported a total of USD 851m. The value of imported aluminium in US increased by 9% from year 2018 to year 2022. 49 of countries exported the aluminium to US in this period. Brazil is the first importer of aluminium in US for five consecutive years. During this period, imports from Brazil, Germany and China increased by 25%, 13% and 51% respectively in both quantity and value. However, Australia decreased 76% at that time.

Figure 3.31. Imports of Aluminium in US (USD 1.000)

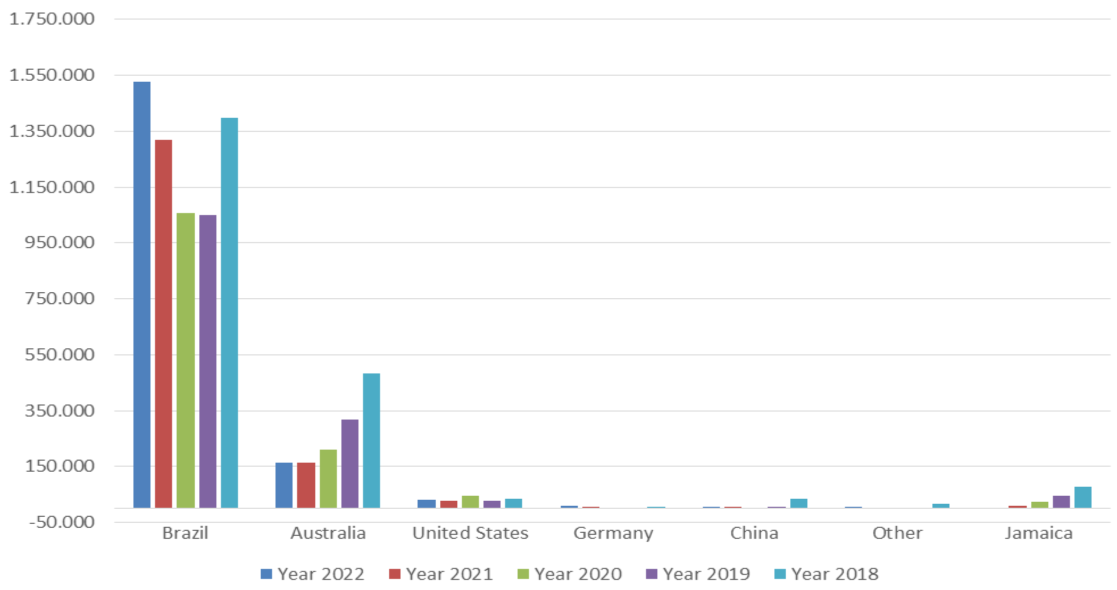


(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.3.2. Canada

Canada imported a total of USD 1.7b in 2022, which decreased by 13% from year 2018 to year 2022. 53 of countries exported the aluminium to Canada in this period. Brazil is the first importer of aluminium in Canada for five consecutive years. During this period, imports from Brazil and Germany increased by 9% and 48% respectively in both quantity and value. However, Australia, the US and China decreased dramatically.

Figure 3.32. Imports of Aluminium in Canada (USD 1.000)

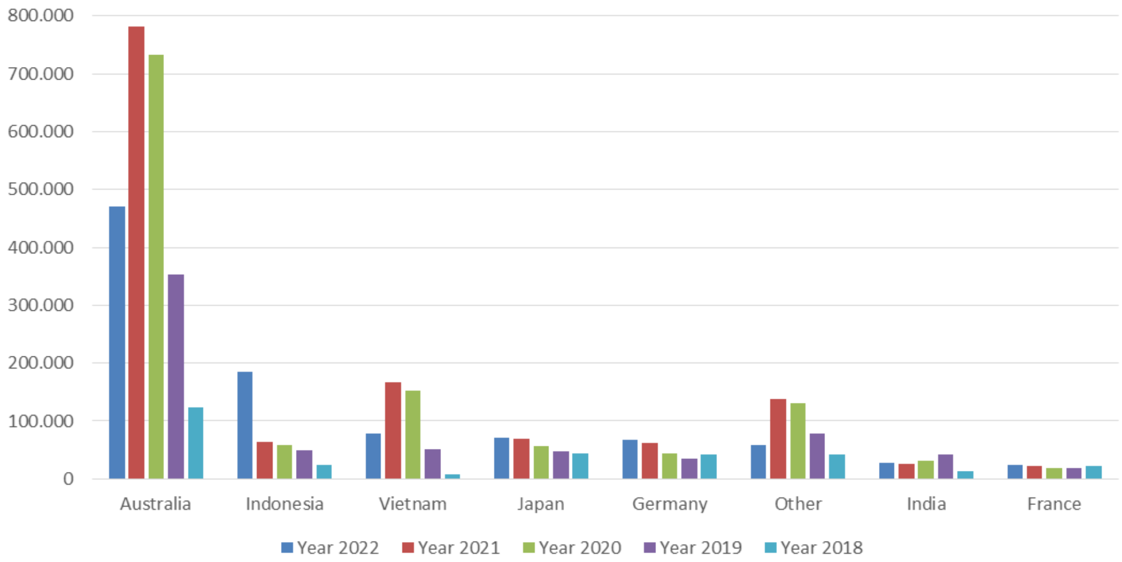


(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.3.3. China

As of year 2022, China imported a total of USD 982.8m. The value of imported aluminium in China increased by 67% from year 2018 to year 2022. 48 of countries exported the aluminium to China in this period. Started from year 2018, Australia is the first importer of aluminium in China for five consecutive years. During this period, imports from Australia, Indonesia, Vietnam, Japan and Germany increased by 74%, 87%, 90%, 37% and 36% respectively in both quantity and value.

Figure 3.33. Imports of Aluminium in China (USD 1.000)

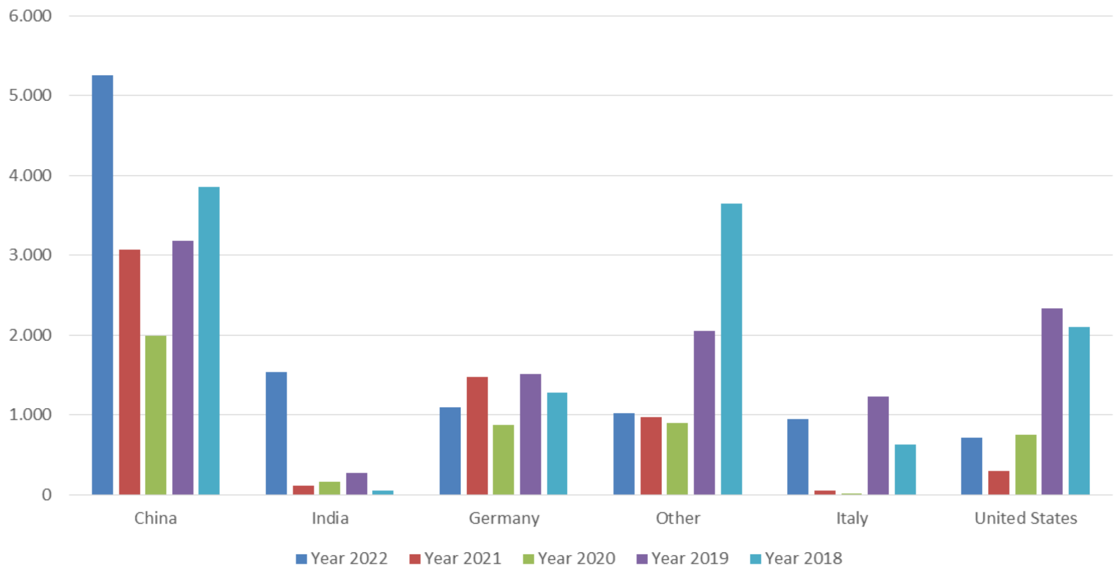


(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.3.4. Australia

Australia imported a total of USD 10.6m in 2022. Total value decreased by 9% from year 2018 to year 2022. 29 of countries exported the aluminium to Australia. China is the first importer in Australia. During this period, imports from China and India increased by 27% and 97% respectively in both quantity and value. However, Germany decreased by 16%.

Figure 3.34. Imports of Aluminium in Australia (USD 1.000)

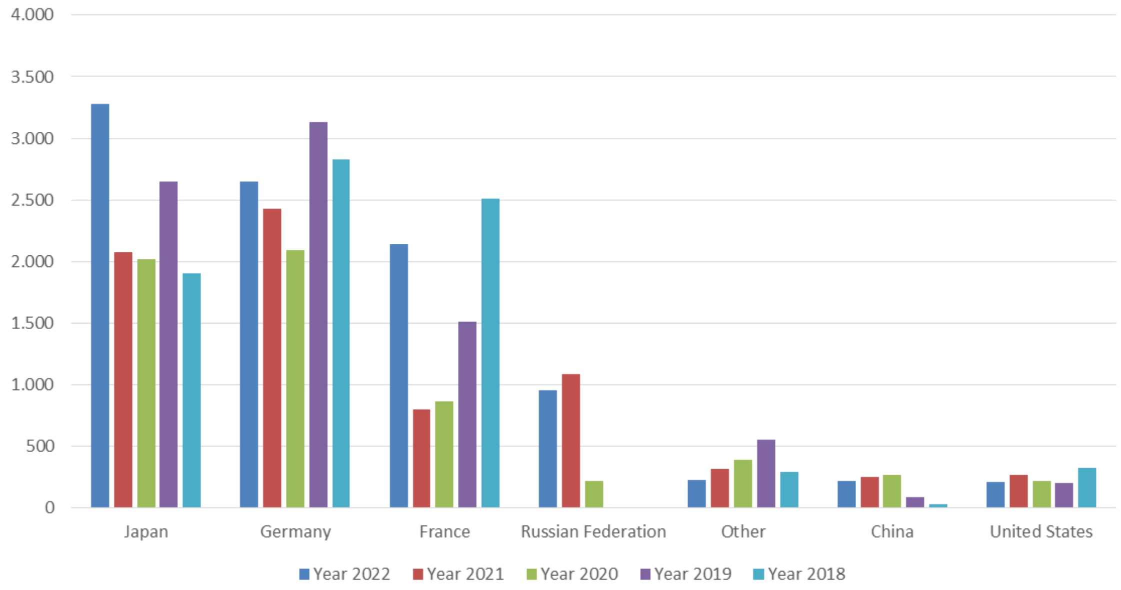


(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.3.5. Switzerland

Switzerland imported a total of USD 9.6m in 2022. The value of imported aluminium in Switzerland increased by 19% from 2018 to 2022. 33 of countries exported the aluminium to Switzerland in this period. Japan is the first importer of aluminium in Switzerland for five consecutive years. During this period, imports from Japan increased its share by 42% in both quantity and value. However, Germany and France decreased by 7% and 17% respectively.

Figure 3.35. Imports of Aluminium in Switzerland (USD 1.000)

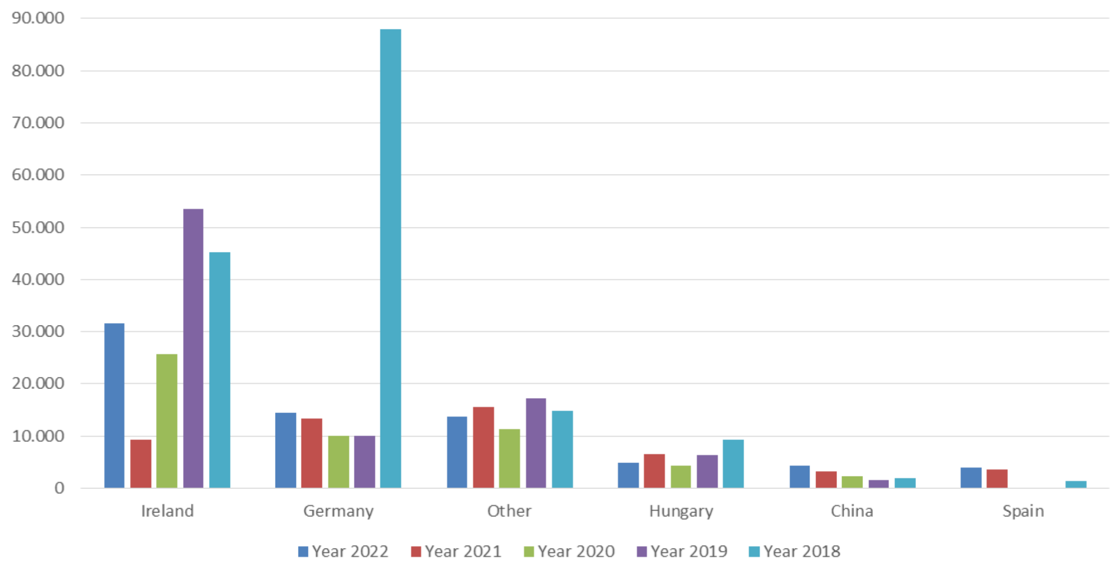


(Source: *World Integrated Trade Solutions*, *Aluminium*)

3.3.2.3.6. United Kingdom

The UK imported a total of USD 72.9m in 2022. The value of imported aluminium in the UK decreased by 1.2x from year 2018 to year 2022. 38 of countries exported the aluminium to the UK in this period. Started from year 2018, Ireland is the first importer of aluminium in the UK for five consecutive years. During this period, imports from China and Spain increased by 56% and 64% respectively in both quantity and value. However, Ireland, Germany and Hungary decreased by 43%, 511% and 87% respectively.

Figure 3.36. Imports of Aluminium in UK (USD 1.000)

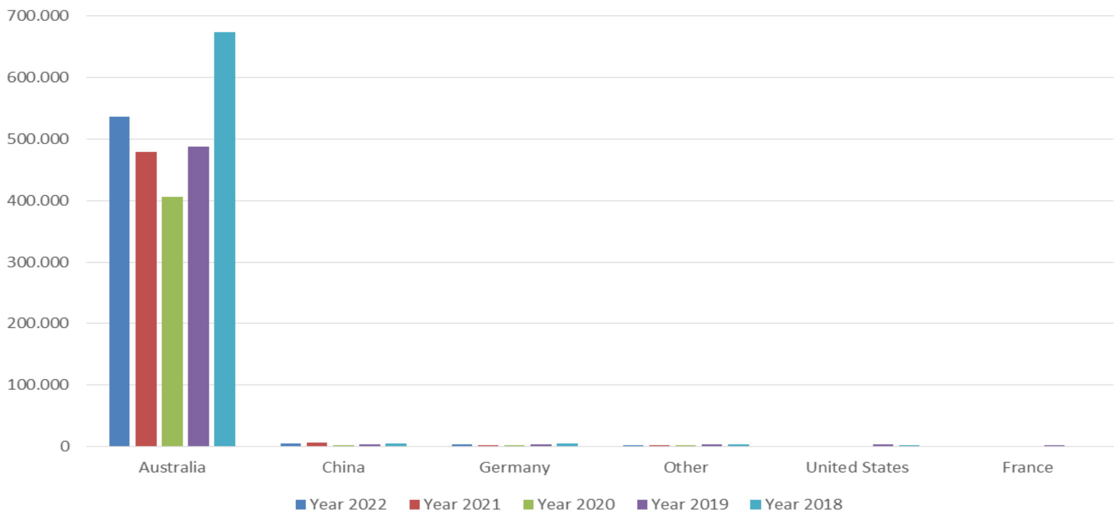


(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.3.7. South Africa

South Africa imported a total of USD 550m in 2022. Total value decreased by 26% to year 2022. 38 of countries exported the aluminium to South Africa. Australia is the first importer of aluminium in South Africa for five consecutive years. During this period, China increased its share by 7%. However, Australia, Germany and the US decreased by 26%, 33% and 78% respectively in both quantity and value.

Figure 3.37. Imports of Aluminium in South Africa (USD 1.000)



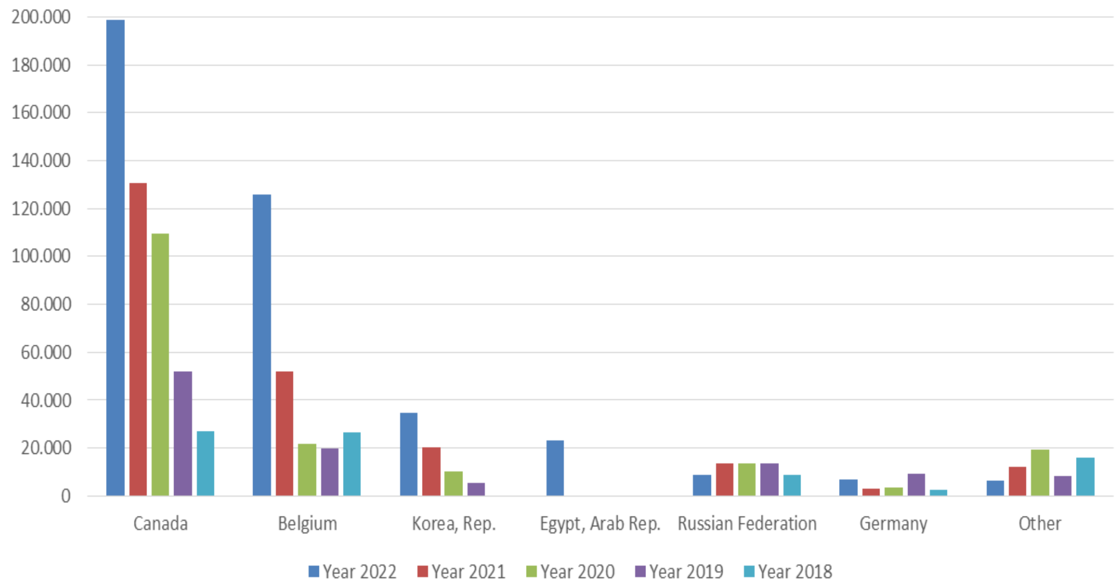
(Source: *World Integrated Trade Solutions, Aluminium*)

3.3.2.4. Fertilisers (Ammonia)

3.3.2.4.1. United States

As of year 2022, the US imported a total of USD 404.7m. The value of imported fertilisers in US increased by 9% from year 2018 to year 2022. 30 of countries exported the fertilisers to US in this period. Canada is the first importer of fertilisers in US for five consecutive years. During this period, imports from Canada, Belgium and Korea increased by 86%, 79% and 100% respectively. However, Netherlands decreased by 2x at that period.

Figure 3.38. Imports of Fertilisers in US (USD 1.000)



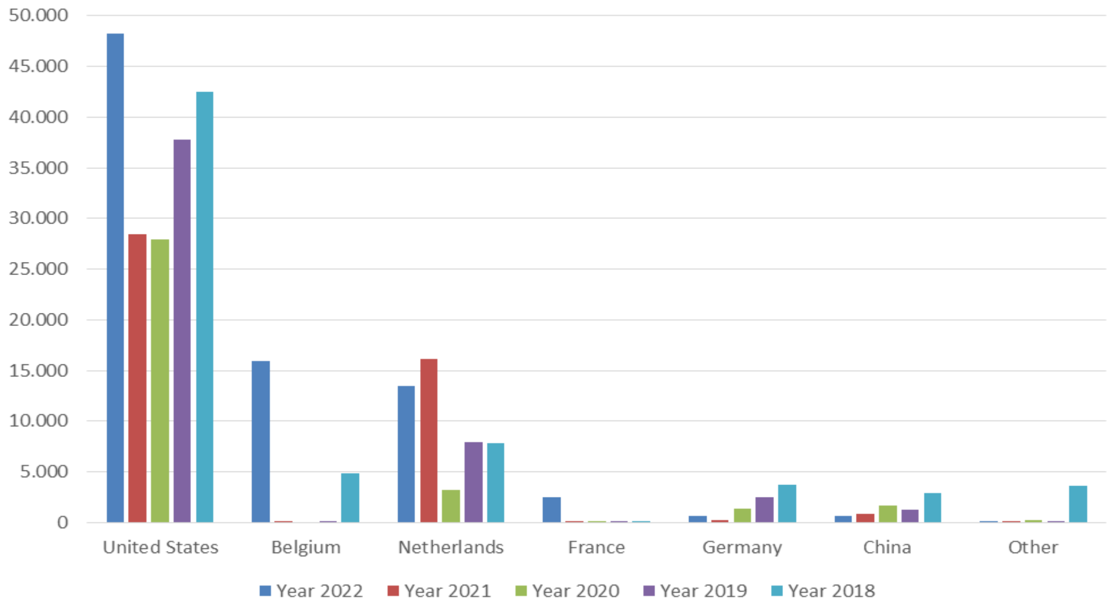
(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.2. Canada

As of year 2022, Canada imported a total of USD 81.5m. The value of imported fertilisers in Canada increased by 20% from year 2018 to year 2022. 23 of countries exported the fertilisers to Canada in this period. The US is the first importer of fertilisers in Canada for five consecutive years.

During this period, imports from the US, Belgium and Netherlands increased by 12%, 70% and 42% respectively in both quantity and value. However, Germany and China decreased by 4.5x and 3.6x respectively.

Figure 3.39. Imports of Fertilisers in Canada (USD 1.000)

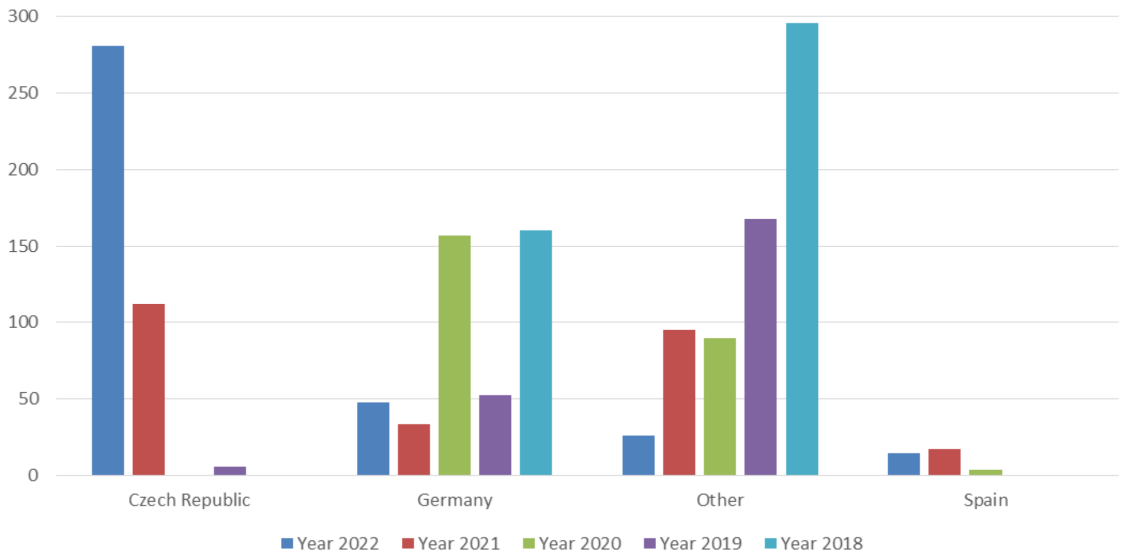


(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.3. China

China imported a total of USD 369k in 2022, decreased by 24% from 2018 to 2022. 22 of countries exported to China in this period. Czech Republic is the first importer of fertilisers in China for two consecutive years. During this period, imports from Germany and Spain decreased by 2x and 10x respectively in both quantity and value. Only, Czech Republic increased its share by 100% at that period.

Figure 3.40. Imports of Fertilisers in China (USD 1.000)

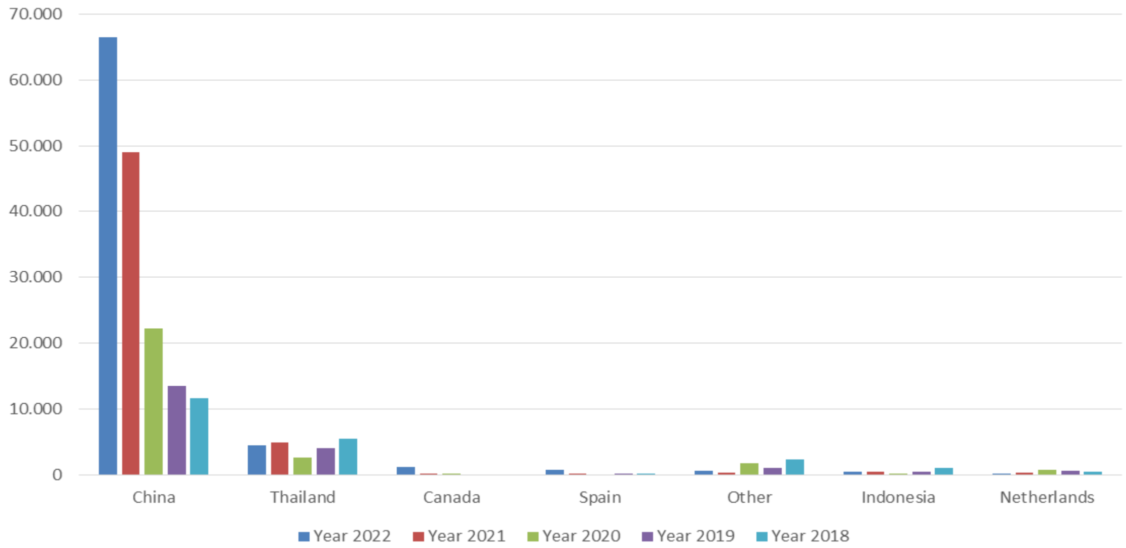


(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.4. Australia

Australia imported a total of USD 73.7m in 2022, which decreased by 9% from year 2018 to year 2022. 24 of countries exported to China in this period. China is the first importer of fertilisers during five consecutive years. Imports from China and Canada increased by 83% and 100% respectively in both quantity and value. However, Thailand decreased by 25%.

Figure 3.41. Imports of Fertilisers in Australia (USD 1.000)



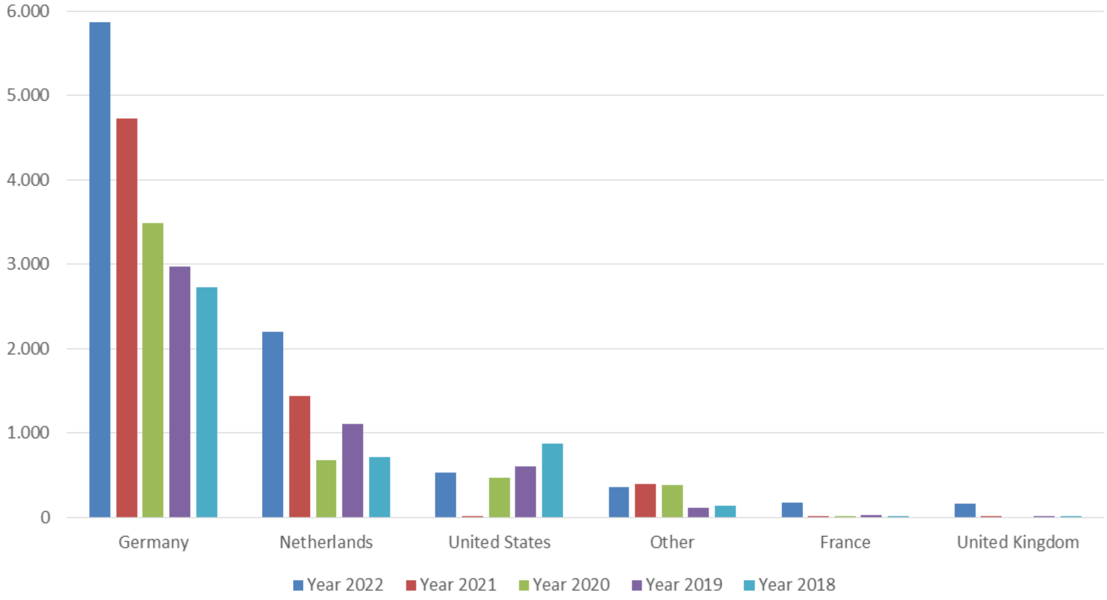
(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.5. Switzerland

As of year 2022, Switzerland imported a total of USD 9.3m. The value of imported fertilisers in Switzerland increased by 52% from year 2018 to year 2022. 24 of countries exported the fertilisers to Switzerland in this period.

Started from year 2018, Germany is the first importer of fertilisers in Switzerland for five consecutive years. During this period, imports from Germany and Netherlands increased by 53% and 67% respectively in both quantity and value. However, the US decreased by 64%.

Figure 3.42. Imports of Fertilisers in Switzerland (USD 1.000)



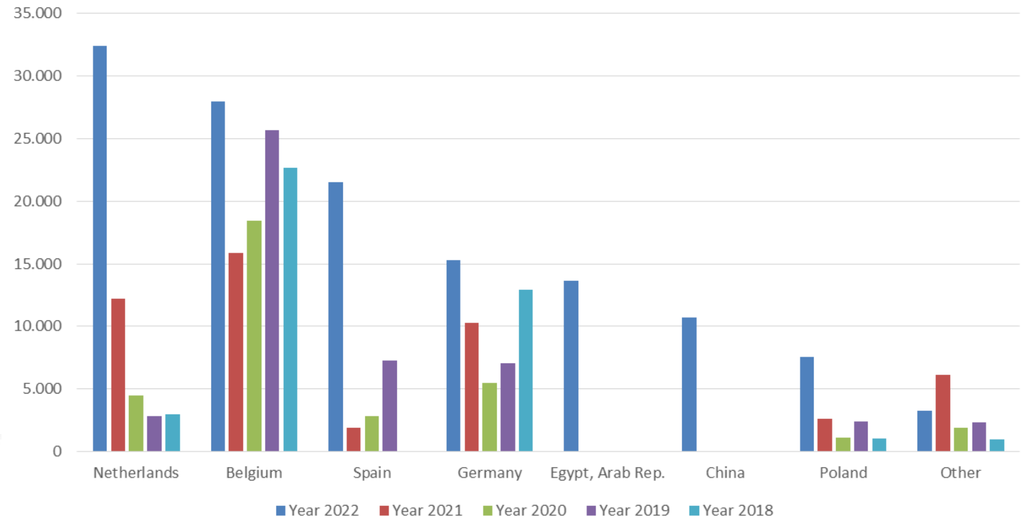
(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.6. United Kingdom

As of year 2022, the UK imported a total of USD 132.4m. Total value increased by 69% from year 2018 to year 2022. 18 of countries exported the fertilisers to the UK in this period.

Netherlands is the first importer of fertilisers in the UK for year 2022. During this period, imports from Netherlands, Belgium, Spain and Germany increased by 91%, 19%, 100% and 15% respectively in both quantity and value.

Figure 3.43. Imports of Fertilisers in UK (USD 1.000)

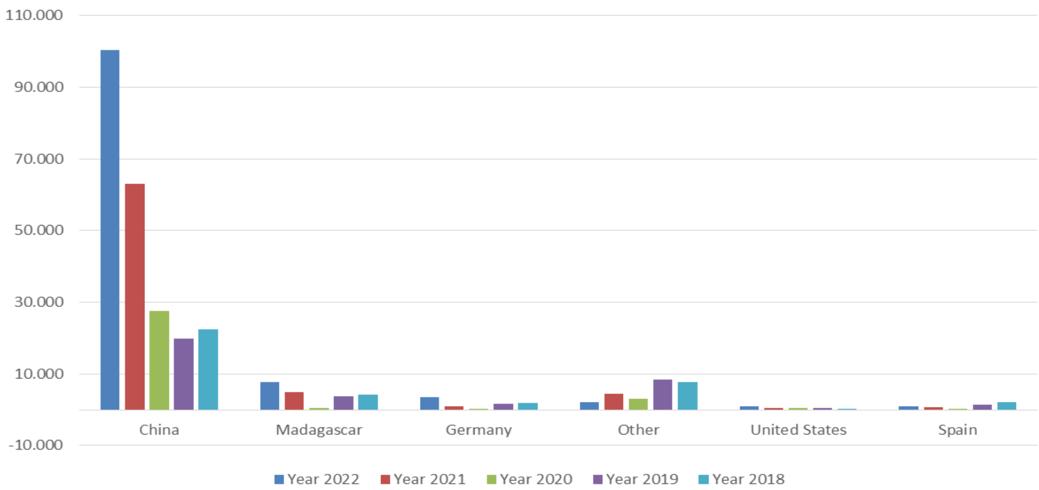


(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.4.7. South Africa

South Africa imported a total of USD 115.6m in 2022, which increased by 67% from 2018 to 2022. 27 of countries exported to South Africa in this period. China is the first importer of fertilisers for last consecutive years. Imports from China, Germany and the US increased by 78%, 47% and 96% respectively. However, Spain decreased by 130%.

Figure 3.44. Imports of Fertilisers in South Africa (USD 1.000)



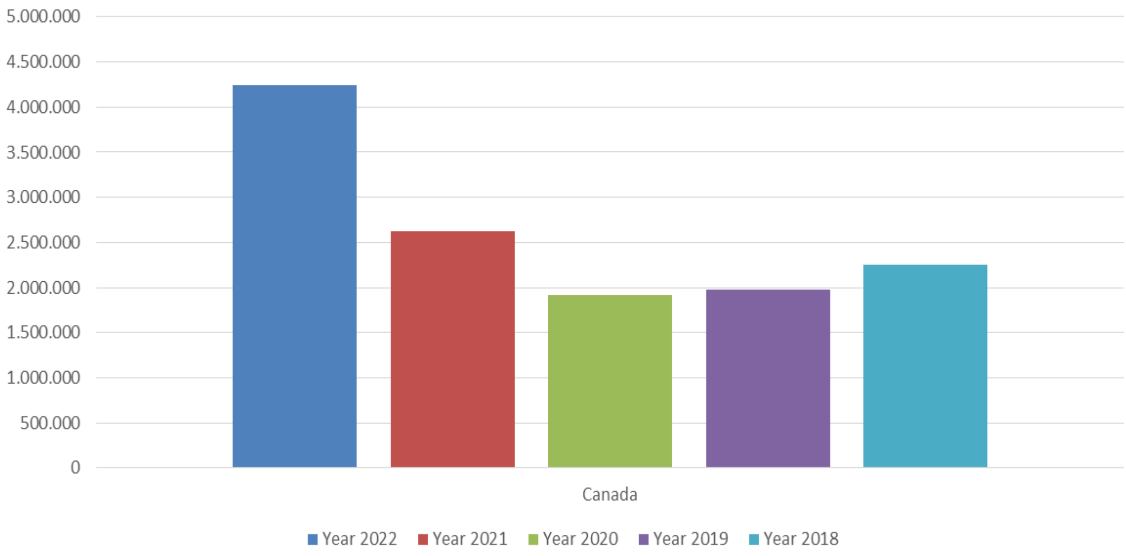
(Source: *World Integrated Trade Solutions, Fertilisers*)

3.3.2.5. Electricity

3.3.2.5.1. United States

As of year 2022, the US imported a total of USD 4.2b. The value of imported electrical energy in US increased by 47% from year 2018 to year 2022. The US has been imported of electrical energy from Canada for five consecutive years.

Figure 3.45. Imports of Electrical Energy in US (USD 1.000)

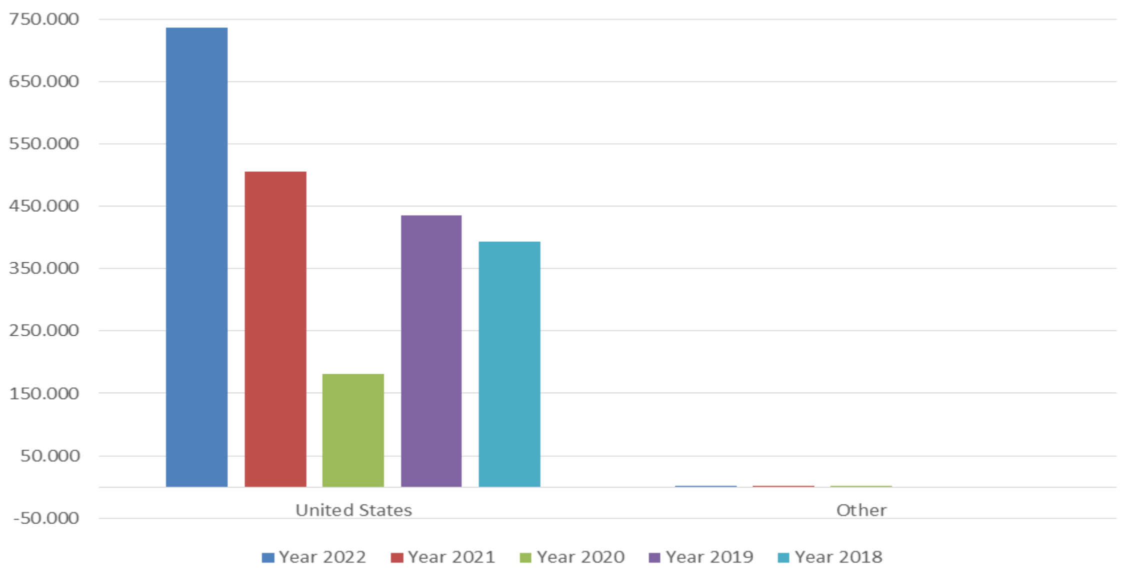


(Source: *World Integrated Trade Solutions, Electrical Energy*)

3.3.2.5.2. Canada

As of year 2022, Canada imported a total of USD 736.7m. The value of imported electrical energy in Canada increased by 47% from year 2018 to year 2022. 6 of countries exported the electrical energy to Canada in this period. Canada has imported of electricity energy from the US, approximately as 100%.

Figure 3.46. Imports of Electrical Energy in Canada (USD 1.000)

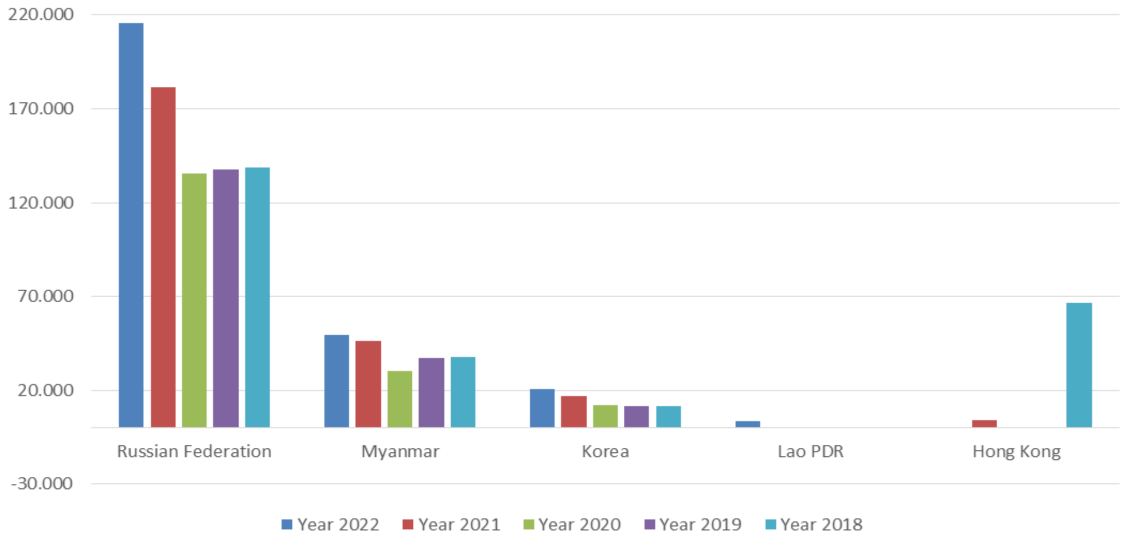


(Source: *World Integrated Trade Solutions, Electrical Energy*)

3.3.2.5.3. China

China imported a total of USD 289.1m in 2022, which increased by 12% from 2018 to 2022. 5 of countries exported the electrical energy to China in this period. Russian Federation is the first importer of electrical energy in China for five consecutive years. During this period, imports from Russian, Myanmar and Korea increased by 36%, 23% and 44% respectively.

Figure 3.47. Imports of Electrical Energy in China (USD 1.000)



(Source: *World Integrated Trade Solutions*, *Electrical Energy*)

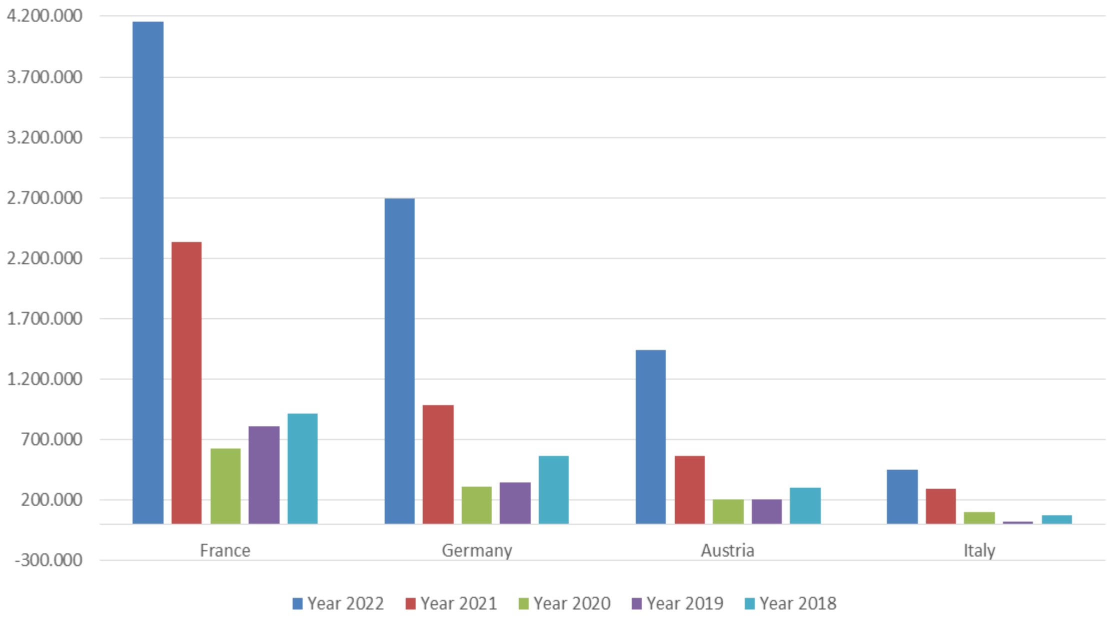
3.3.2.5.4. Australia

Australia has not been importing of electrical energy.

3.3.2.5.5. Switzerland

Switzerland imported a total of USD 8.7b in 2022, which increased by 79% from 2018 to 2022. 4 of countries exported to Switzerland in this period. France is the first importer of electrical energy in Switzerland. During this period, imports from France, Germany, Australia and Italy increased by 78%, 79%, 79% and 84% respectively in both quantity and value.

Figure 3.48. Imports of Electrical Energy in Switzerland (USD 1.000)



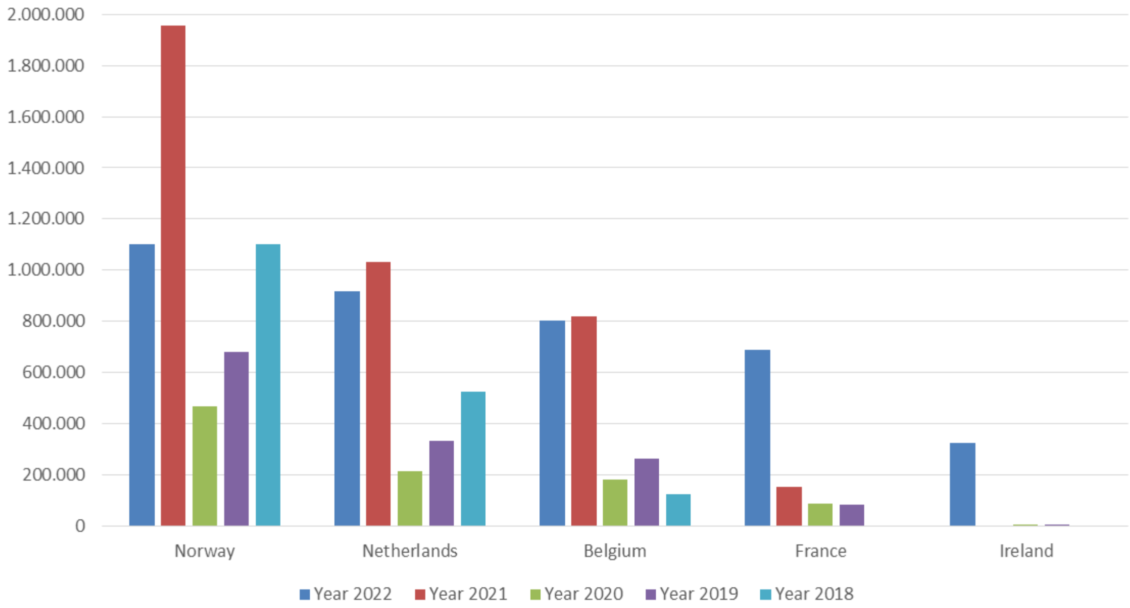
(Source: *World Integrated Trade Solutions, Electrical Energy*)

3.3.2.5.6. United Kingdom

As of year 2022, the UK imported a total of USD 3.8b. Total value increased by 54% from year 2018 to year 2022. 6 of countries exported the electrical energy to the UK in this period.

Started from year 2018, Norway is the first importer of electrical energy in the UK. During this period, imports from Netherlands, Belgium, France and Ireland increased by 43%, 85%, 100% and 100% respectively in both quantity and value.

Figure 3.49. Imports of Electrical Energy in UK (USD 1.000)



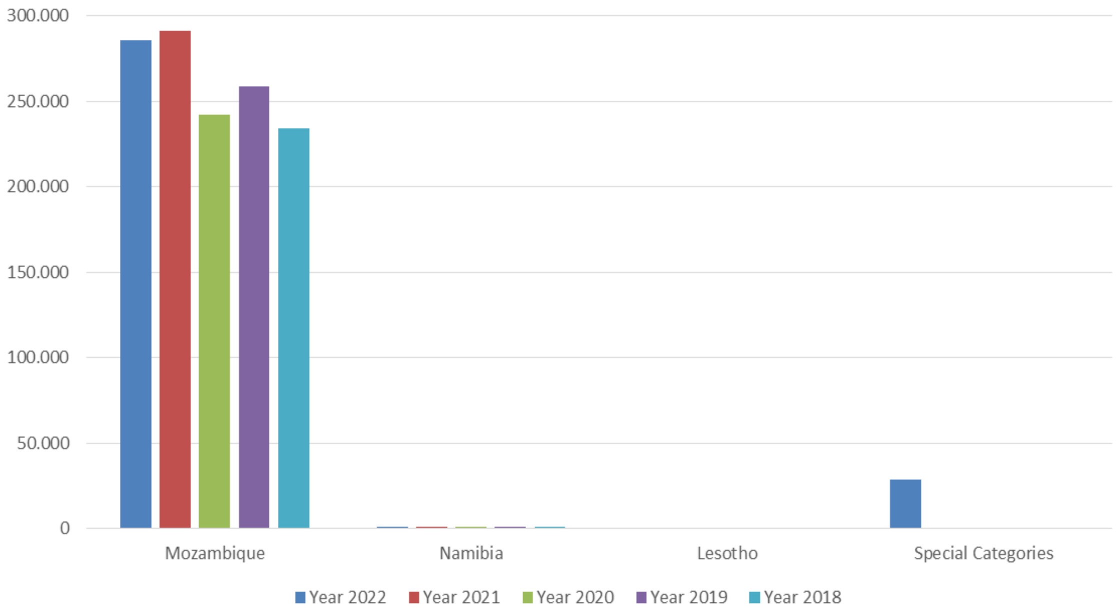
(Source: *World Integrated Trade Solutions*, *Electrical Energy*)

3.3.2.5.7. South Africa

As of year 2022, South Africa imported a total of USD 315.3m. The value of imported electrical energy in South Africa increased by 25% from year 2018 to year 2022. 5 of countries exported the electrical energy to South Africa in this period.

Started from year 2018, Mozambique is the first importer of electrical energy in South Africa for five consecutive years. During this period, imports from Mozambique, and Lesotho increased by 18% and 100% respectively in both quantity and value. However, Namibia decreased by 21%.

Figure 3.50. Imports of Electrical Energy in South Africa (USD 1.000)



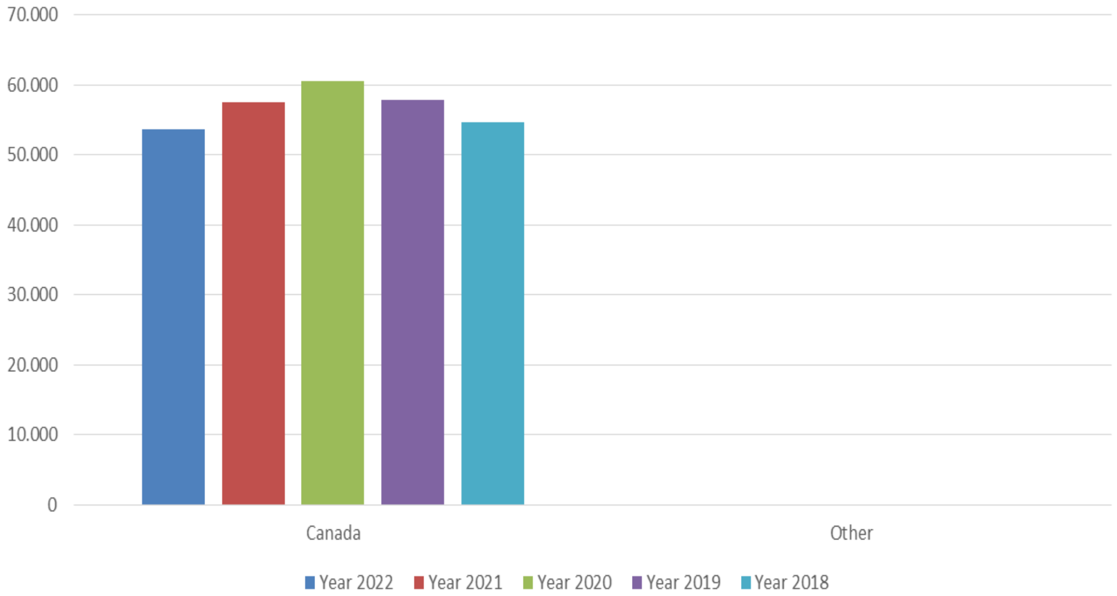
(Source: *World Integrated Trade Solutions, Electrical Energy*)

3.3.2.6. Hydrogen

3.3.2.6.1. United States

As of year 2022, the US imported a total of USD 53.6m. The value of imported hydrogen in US kept in constant from year 2018 to year 2022. 8 of countries exported the hydrogen to the US in this period. Started from year 2018, Canada is the first importer of hydrogen in the US for five consecutive years. During this period, imports from Canada and France decreased by 2% and 10% respectively in both quantity and value.

Figure 3.51. Imports of Hydrogen in US (USD 1.000)

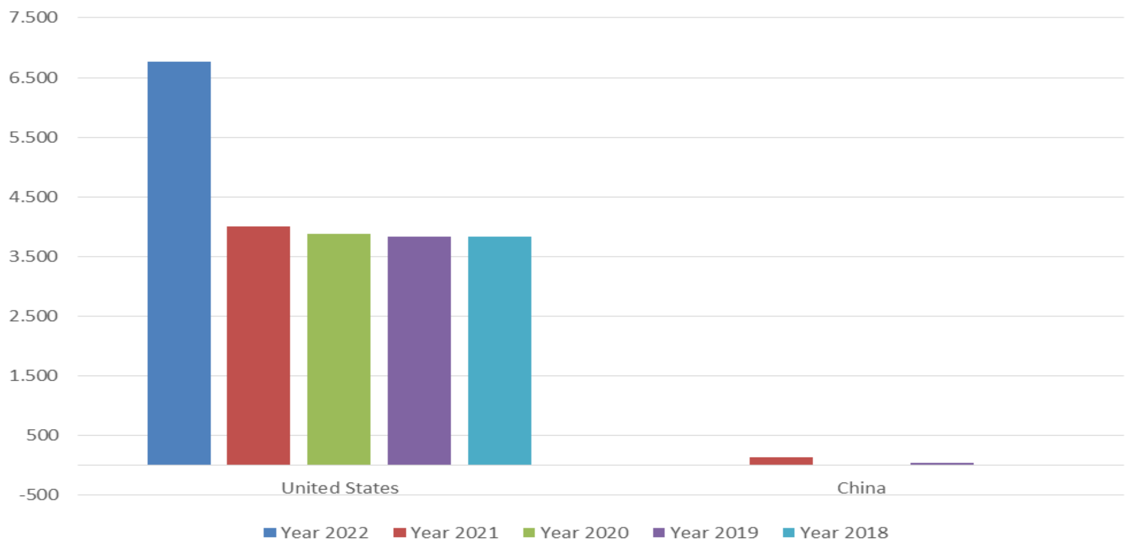


(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.2. Canada

Canada imported a total of USD 6.7m in 2022. The value of imported hydrogen in US increased by 43% from year 2018 to year 2022. Seven of countries exported the hydrogen in Canada in this period. The US is the first importer of hydrogen for five consecutive years. During this period, imports from the US increased by 43% in both quantity and value.

Figure 3.52. Imports of Hydrogen in Canada (USD 1.000)

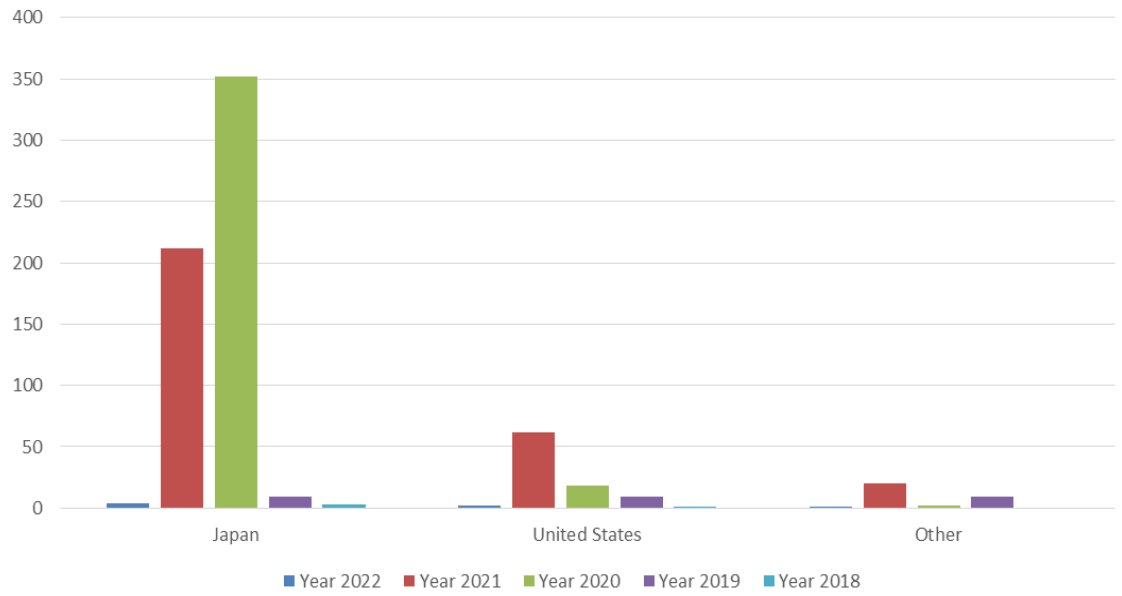


(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.3. China

As of year 2022, China imported a total of USD 6.2m. The value of imported hydrogen in China increased by 37% from year 2018 to year 2022. 8 of countries exported the hydrogen to China in this period. Started from year 2018, Japan is the first importer of hydrogen in China for five consecutive years. During this period, imports from Japan, the US increased by 9% and 63% respectively in both quantity and value.

Figure 3.53. Imports of Hydrogen in China (USD 1.000)



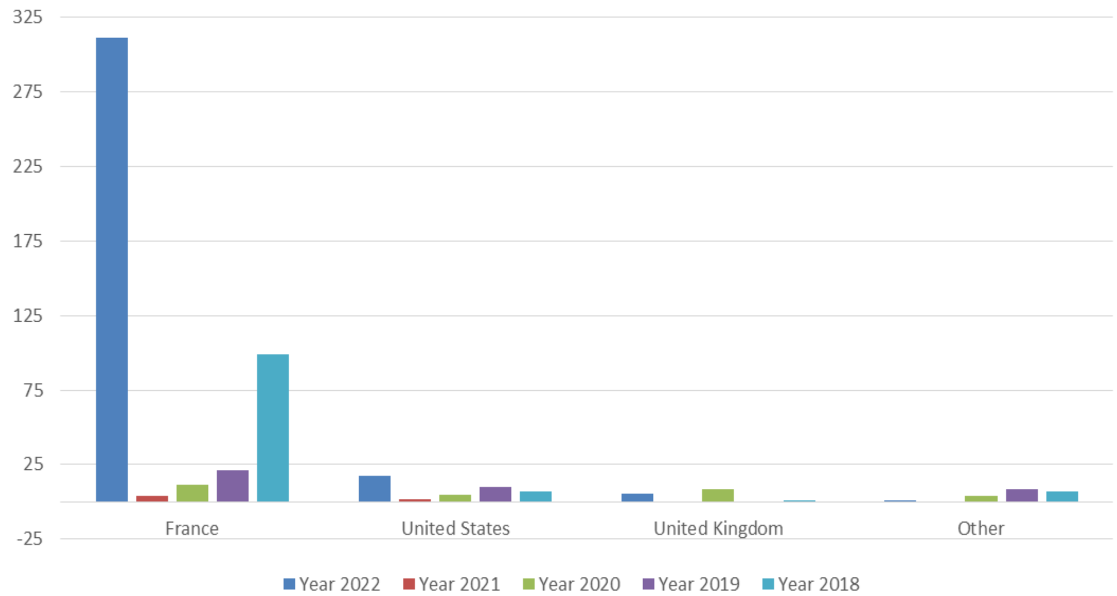
(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.4. Australia

Australia imported a total of USD 335k in 2022, which increased by 66% from year 2018 to year 2022. 8 of countries exported the hydrogen to China in this period.

Started from year 2018, France is the first importer of hydrogen in Australia for five consecutive years. During this period, imports from France, the US and the UK increased by 68%, 59% and 82% respectively in both quantity and value.

Figure 3.54. Imports of Hydrogen in Australia (USD 1.000)

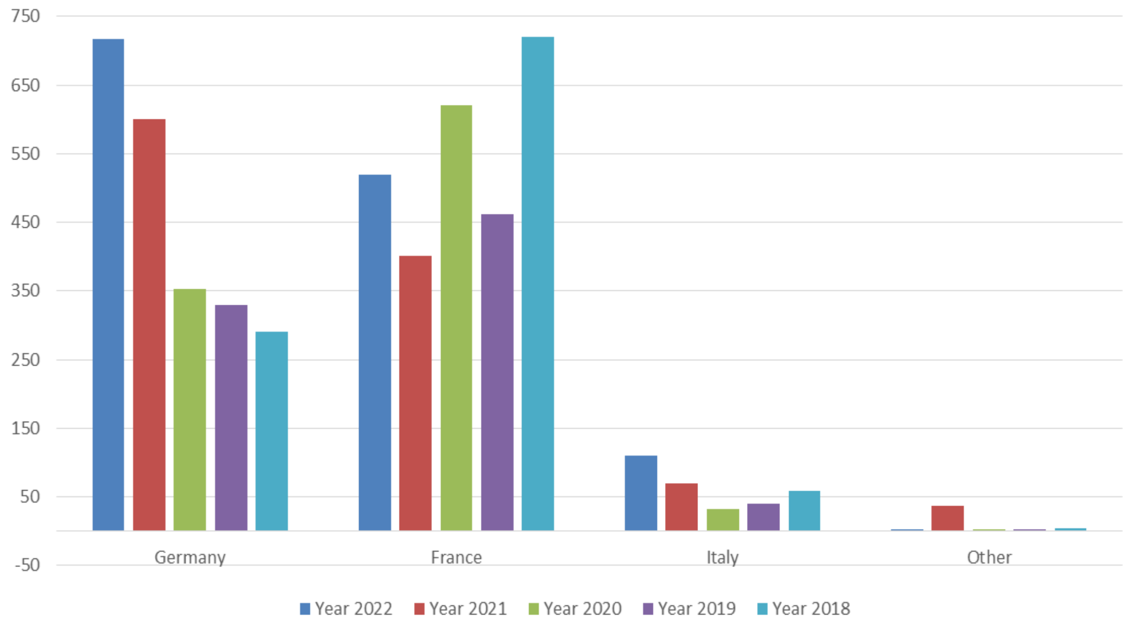


(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.5. Switzerland

As of year 2022, Switzerland imported a total of USD 1.4m. Total value increased by 20% from year 2018 to year 2022. 9 of countries exported the hydrogen to Switzerland in this period. Started from year 2018, Germany is the first importer of hydrogen in Switzerland. During this period, imports from Germany and Italy increased by 59% and 46% respectively in both quantity and value. However, France decreased by 39%.

Figure 3.55. Imports of Hydrogen in Switzerland (USD 1.000)



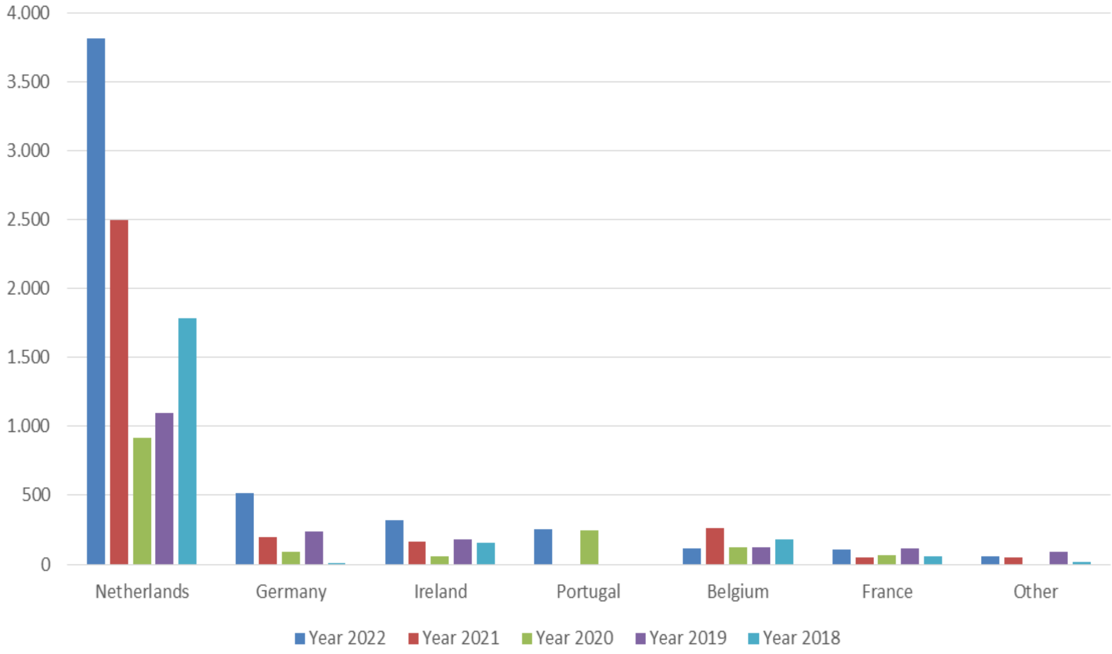
(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.6. United Kingdom

As of year 2022, the UK imported a total of USD 5.1m. The value of imported hydrogen in the UK increased by 58% from year 2018 to year 2022. 11 of countries exported the hydrogen to the UK in this period.

Started from year 2018, Netherlands is the first importer of hydrogen in the UK. During this period, imports from Netherlands, Germany and Ireland increased by 53%, 100%, and 52% respectively in both quantity and value. However, Belgium decreased by 60%.

Figure 3.56. Imports of Hydrogen in UK (USD 1.000)

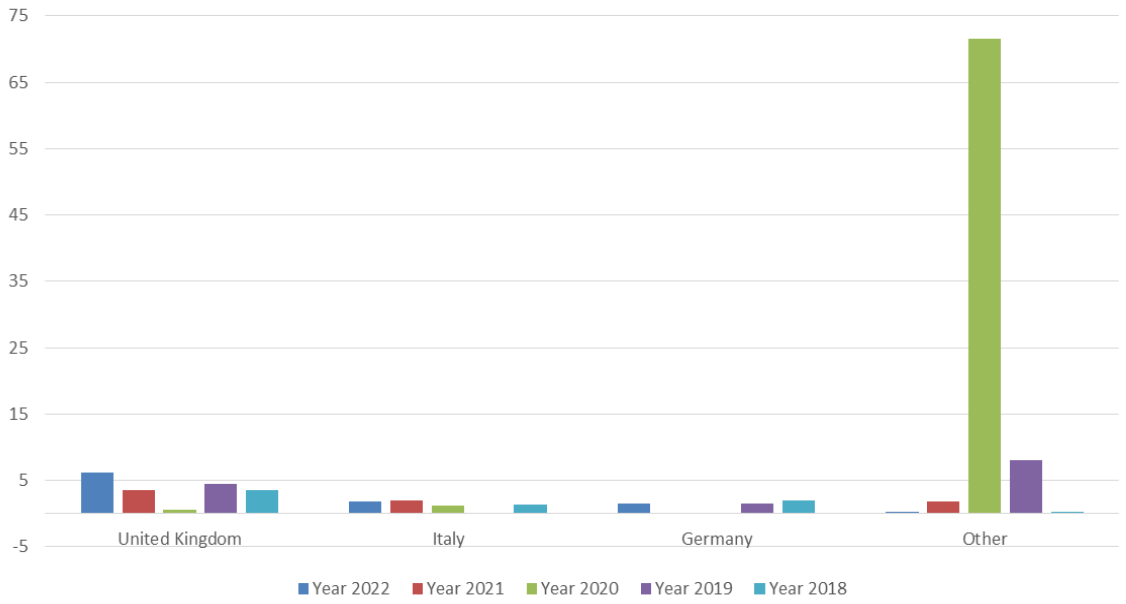


(Source: *World Integrated Trade Solutions, Hydrogen*)

3.3.2.6.7. South Africa

South Africa imported a total of USD 10m, which increased by 26% from year 2018 to year 2022. 9 of countries exported to South Africa. The UK is the first importer of hydrogen for three consecutive years. Imports from the UK and Italy increased by 41% and 26% respectively in both quantity and value. However, Germany decreased by 34%.

Figure 3.57. Imports of Hydrogen in South Africa (USD 1.000)



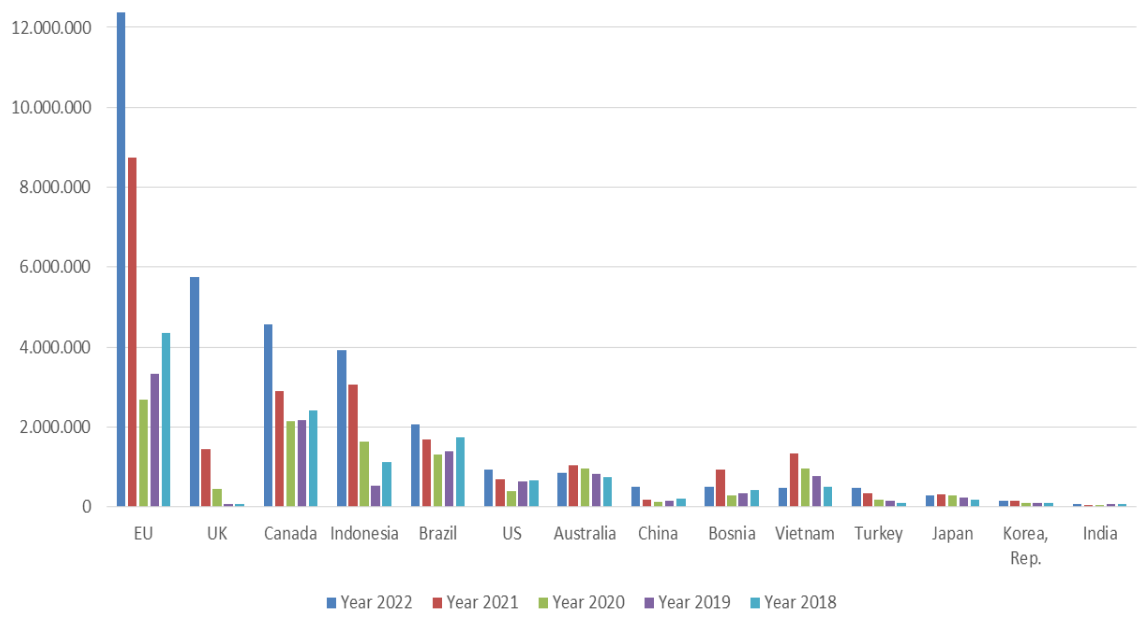
(Source: *World Integrated Trade Solutions, Hydrogen*)

3.4. Effects on Sectors of the Carbon Emission Adjustments

3.4.1. Import of Restricted Goods

It was noted that there are top 14 countries which have been importing the carbon intensive goods to restricted regions or countries. These are Australia, Bosnia and Herzegovina, Brazil, Canada, China, EU, India, Indonesia, Japan, Korea Republic, Türkiye, the United Kingdom, the United States and Vietnam. Below table presents total value and annual change for imports of cement, steel, aluminium, fertilisers, electricity and hydrogen.

Figure 3.58. Top Largest Exporters of Carbon Intensive Goods (USD 1.000)



(Source: *World Integrated Trade Solutions, Top Largest Exporters for Cement, Steel, Aluminium, Fertilisers, Electric Energy and Hydrogen*)

In the EU area, Türkiye is highest exporters of cement for five consecutive years. The UK has been exporting of steel, electrical energy and hydrogen increasingly to the EU starting from year 2020 after Brexit. The EU highly imported of aluminium from Australia in 2022. For fertiliser, China is highest importers.

In the US area, Canada and Türkiye are highest exporters of cement for five consecutive years. The EU and Canada have been exporting of steel and fertilisers increasingly to the US starting from year 2018. The US highly imported of aluminium from Brazil and the EU. On the other hand, Canada is solely imported for both for electrical energy and hydrogen.

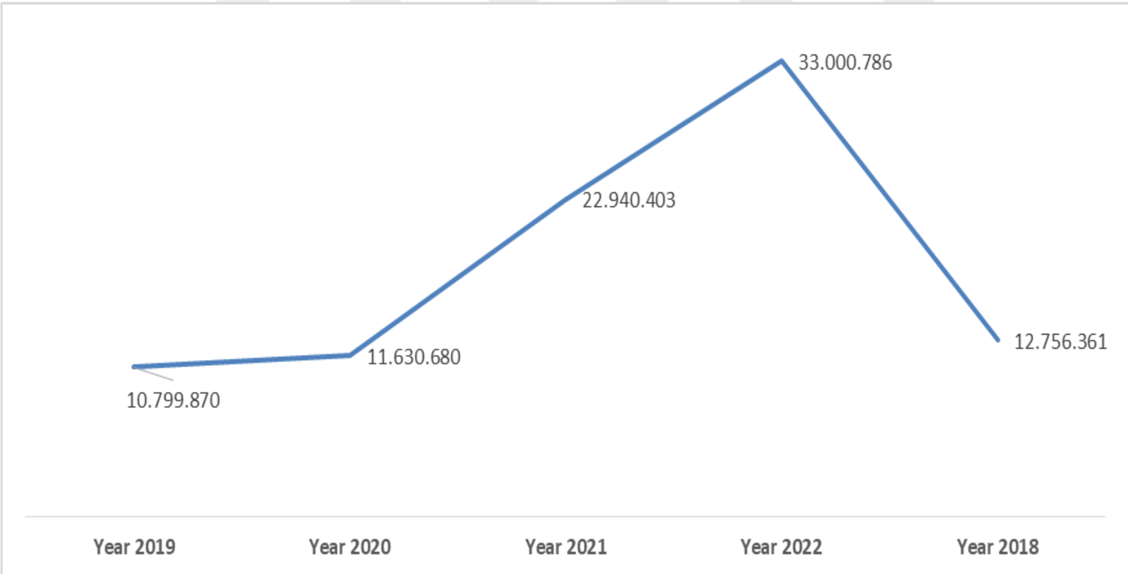
In Canada, Türkiye and the US are first importers for cement. The US is highest importer for both steel and fertilisers. The US is solely importer of electrical energy and importer of hydrogen. Canada has been highly importing aluminium from both Brazil and Australia.

China has been importing of cement in high portion. Vietnam has averagely 96% of steel imports. Imports of aluminium has been provided by Vietnam in high portion. However, China has not imported any electrical energy from foreign countries. It was noted that there are very few imports of fertilisers and imports of hydrogen from foreign countries.

Japan has exported cement increasingly for last five years. Australia has imported both steel and hydrogen very few and, there has been no imports of electrical energy. China and Canada are highly importers for aluminium.

The EU is solely importer of goods for Switzerland. The UK has been importing of all these goods from the EU together with the US. Very few of cement and hydrogen has been imported for South Africa and, there was no import of electrical energy. China is first importer for fertilisers and second importer for aluminium. The EU has been importing of aluminium in first.

Figure 3.59. Total Top Largest Exporters of Carbon Intensive Goods (USD 1.000)

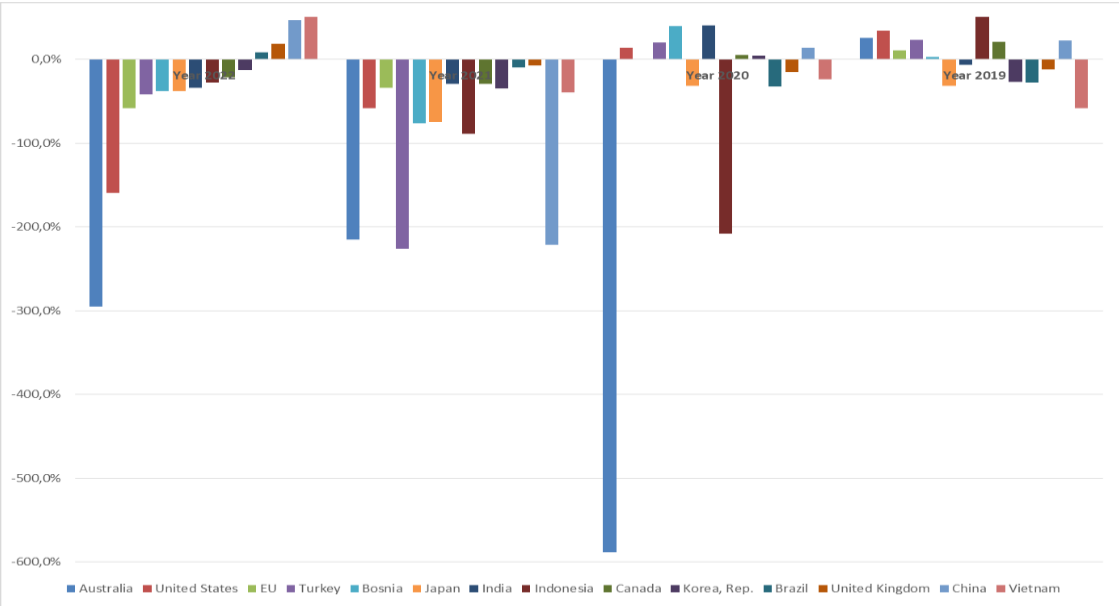


(Source: *World Integrated Trade Solutions, Top Largest Exporters for Cement, Steel, Aluminium, Fertilisers, Electric Energy and Hydrogen*)

It was noted that there has been decreasing trend excepting five countries, which are Brazil, the UK, China and Vietnam.

The UK has positive trend after year 2020 due to Brexit. It was seen that negative trend started from year 2020. However, after pandemic covid-19, it was expected that there would be increasing foreign trade for these goods. Especially, Australia has both continuous and high negative percent for four consecutive years.

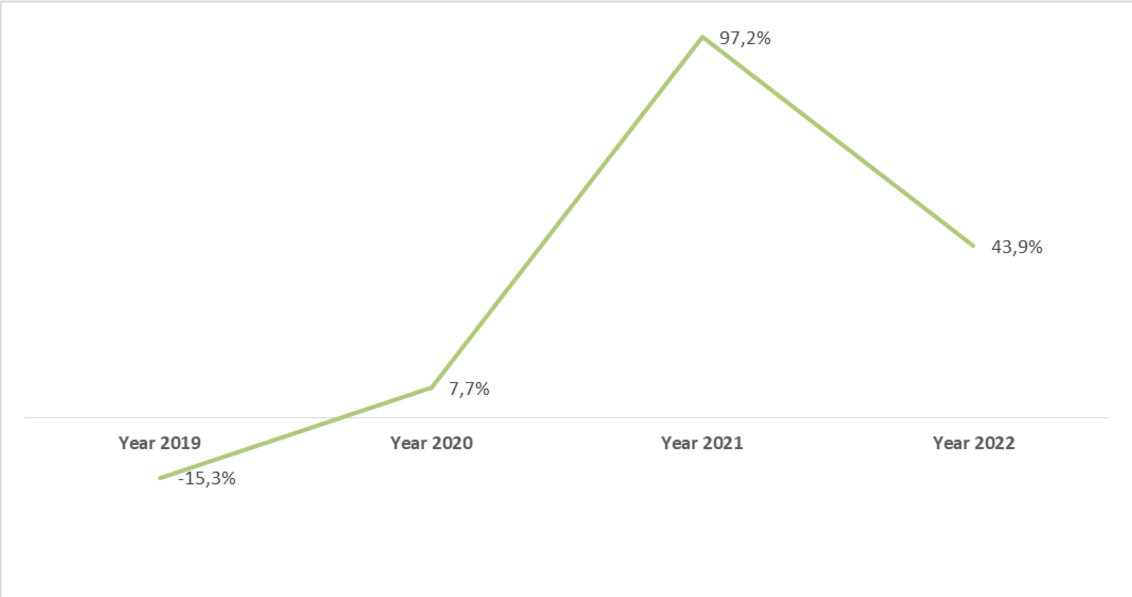
Figure 3.60. Changes for Top Largest Exporters of Carbon Intensive Goods



(Source: *World Integrated Trade Solutions, Top Largest Exporters for Cement, Steel, Aluminium, Fertilisers, Electric Energy and Hydrogen*)

Based on the huge volume of electric energy, annual changes for total value of carbon intensive goods are cement, steel, aluminium, fertilisers, electric energy and hydrogen are seen negative in comparison with the trend of solely goods.

Figure 3.61. Total Changes for Top Largest Exporters of Carbon Intensive Goods



(Source: *World Integrated Trade Solutions, Top Largest Exporters for Cement, Steel, Aluminium, Fertilisers, Electric Energy and Hydrogen*)

3.4.2. Carbon Emissions

The emissions are the sum of carbon emissions from energy, flaring, methane, in carbon dioxide equivalent, associated with the production, transportation and distribution of fossil fuels and industrial processes.

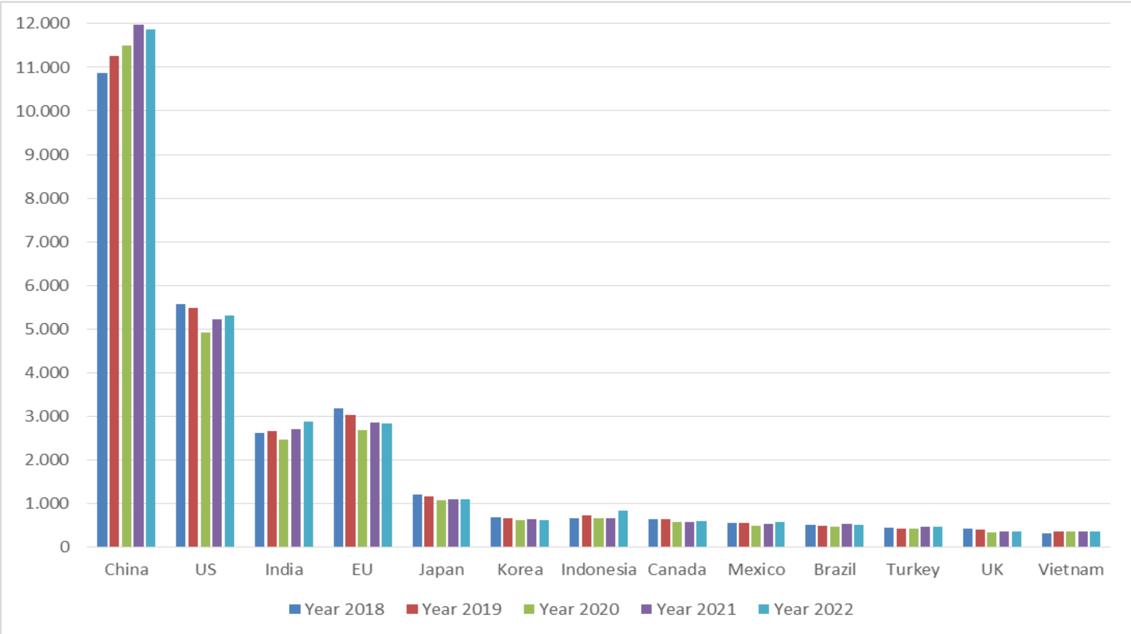
For cement production, Raw materials are processed by fuel process of burning which results in the release of carbon.

In the production of steel, the ore is melted at a very high temperature in the presence of oxygen and coke which turns to carbon dioxide. All of metallic aluminium is derived from the ore bauxite which is rock with a relatively high aluminium content. It occurs as a product of low iron in tropical climates.

The essential nitrogen based fertiliser is ammonia where natural gas supplied by the hydrogen and nitrogen derived from the air are key elements of this energy-intensive process.

Electricity is generated by fossil fuels such as coal and gas-fired materials. On the other hand, Hydrogen is already generated from fossil fuels whose elements are both natural gas by 70% and coal with 30%. It is used as key energy element for cement, steel and electricity.

Figure 3.62. Carbon Equivalent Emissions (Million Tonnes)



(Source: *Energy Institute Statistical Review of World Energy Data, 2023*)

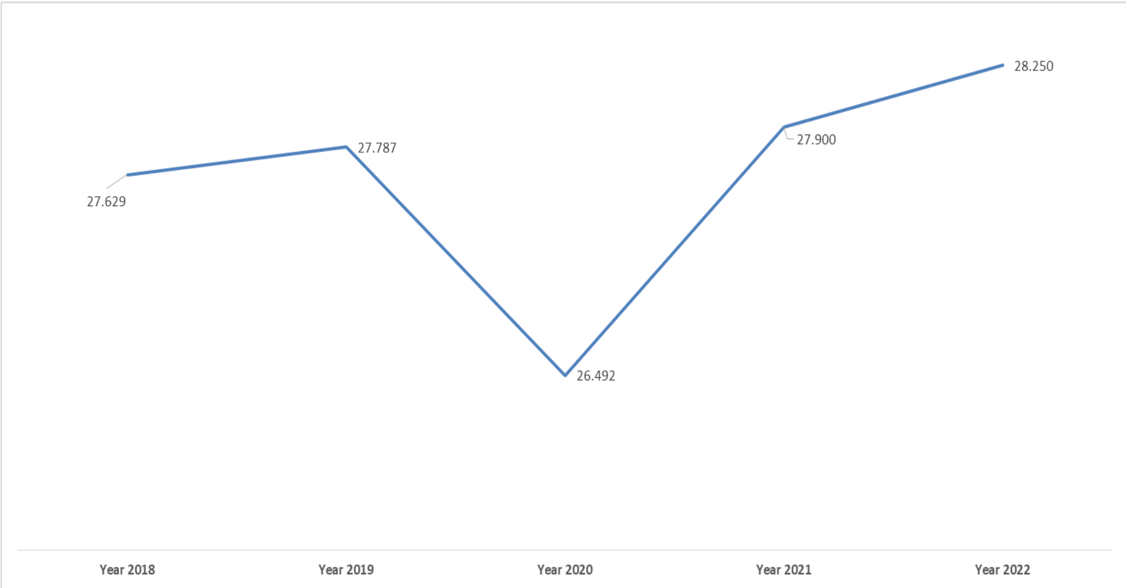
China is biggest emitter of carbon when compared with leading countries such as the US, the EU and India. They have emitted 10.9 million tonnes of carbon and their share is 30.2% of world as of year 2022. The growth rate of carbon emissions for year 2022 decreased by 0.8%, however, during last ten years the growth rate of carbon emissions increased by 1.6%.

The US is second emitter of carbon in the world as of year 2022. Their share was 13.5% and, they were second country with 5.6 million tonnes after China. On the other hand, for as year 2022 the growth rate increased by 1.7%.

India and the EU are third and fourth countries which are the most carbon emitters after China and the US respectively. India have 7.3% share and the growth rate per annum as of 2022 increased by 6.1%. Although the EU have high share with 7.2% in world's carbon emissions, their growth rates per annum for both 2022 and 2012-2022 decreased by 0.7% and 1.6% respectively.

Japan, South Korea, Indonesia and Canada are following countries which have been producing higher carbon emissions when compared with other countries in the world.

Figure 3.63. Total Carbon Equivalent Emissions (Million Tonnes)



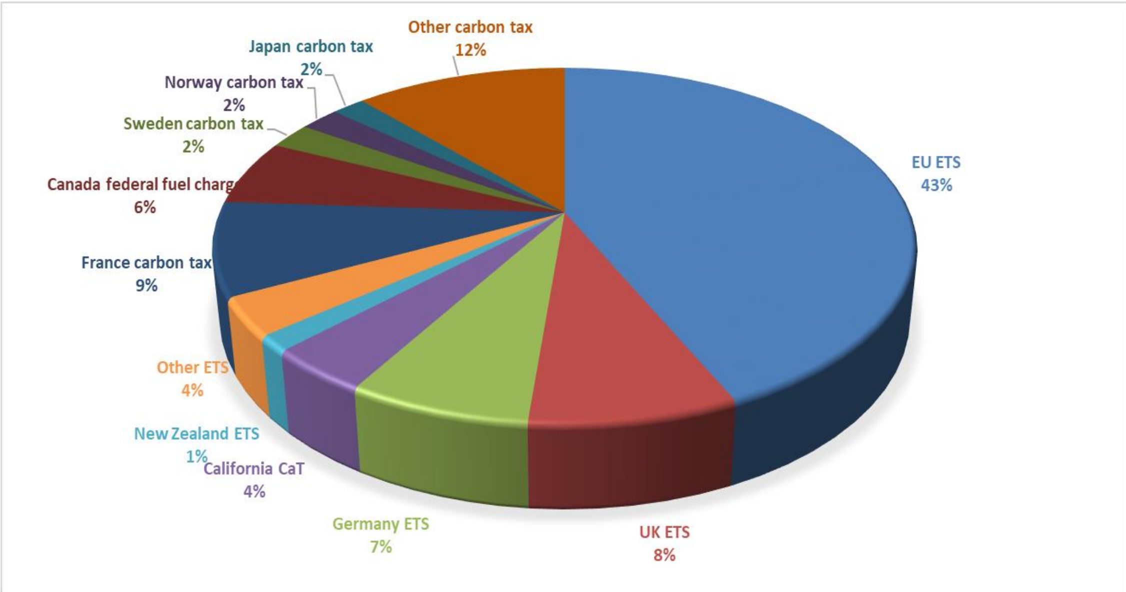
(Source: *Energy Institute Statistical Review of World Energy Data, 2023*)

Based on Figure 3.61., it is noted that top largest exporters of carbon intensive goods continue to produce 72% of total carbon emissions in the world. Addition to this, there are upward trends in the growth rates per annum for both 2022 and 2012-2022, for example, 1.3% as of 2022.

3.4.2.1. Carbon Pricing Revenue

Figure 3.62. reflects the revenue from jurisdictional governments. It was noted that some revenues are collected by government, however it is later dispatched to other jurisdictions. The price of the carbon in importing have been calculated depending on allowances expressed in USD or EURO/tonne of CO_2 emitted.

Figure 3.64. Carbon Pricing Revenue, by Instrument in 2022 (Billion USD)



(Source: *The World Bank Carbon Pricing Dashboard*)

3.4.3. GDP

Table 3.9. represents GDP and total value of imports of six carbon intensive goods to top largest countries which import six carbon intensive goods. These countries have carbon pricing for six carbon intensive goods. For a country's overall economy, GDP is solely measurement with the total value at constant prices of final services and goods produced during one year.

Table 3.7. Top Largest Importers which Have Carbon Pricing, GDP, Total Value of Imports of Carbon Intensive Goods and Carbon Emissions

	Year 2022			Year 2021			Year 2020			Year 2019			Year 2018		
	GDP	Total Value of Import*	Carbon Emissions by Importers ***	GDP	Total Value of Import	Carbon Emissions by Importers	GDP	Total Value of Import	Carbon Emissions by Importers	GDP	Total Value of Import	Carbon Emissions by Importers	GDP	Total Value of Import	Carbon Emissions by Importers
EU	16.746.545	25.476	27.957	17.315.219	9.534	27.829	15.381.174	3.591	26.440	15.693.433	4.335	27.508	15.980.992	4.856	27.201
Switzerland	818.427	8.778	22.624	813.409	4.209	22.799	741.999	1.272	21.719	721.369	1.414	22.555	725.569	1.884	22.399
US	25.439.700	5.932	20.480	23.315.081	3.907	20.676	21.060.474	2.930	19.690	21.380.976	3.272	20.152	20.533.057	3.636	20.016
China	17.963.171	5.356	15.141	17.820.460	5.816	14.896	14.687.744	4.081	14.009	14.279.969	2.202	15.371	13.894.908	2.147	15.500
Canada	2.161.483	4.244	25.016	2.007.472	3.576	24.890	1.655.685	2.881	23.615	1.743.725	3.356	24.607	1.725.329	4.507	24.448
UK	3.089.073	4.134	19.960	3.141.506	4.143	19.965	2.697.807	1.085	18.999	2.851.407	1.586	19.634	2.871.340	2.062	19.486
South Africa	405.271	1.023	21.024	420.118	916	20.771	338.291	700	19.817	389.330	810	20.533	405.261	971	20.340
Australia	1.692.957	416	25.223	1.559.034	322	24.851	1.330.382	236	23.638	1.394.671	248	24.695	1.429.734	244	24.497

(Source: *The World Bank Organization – Development Indicators*)

* Total value of imports of six carbon Intensive Goods (cement, steel, aluminium, fertilisers, electricity, hydrogen) to top largest importers (EU, Switzerland, US, China, Canada, UK, South Africa, Australia), US$

*** Carbon emitted by importers of six carbon intensive goods to top largest importers, millions tones

There are 57 countries which export six carbon intensive goods as cement, steel, aluminium, fertilisers, electricity and hydrogen to top largest countries with carbon pricing as Australia, Canada, China, European Union, South Africa, Switzerland, UK and US.

Total value of imports of six carbon intensive goods were 17.5b USD in 2018, 15.1b USD in 2019, 14.8b USD in 2020, 30.2b USD in 2021 and 5312b USD in 2022. It was noted that fluctuations in imports resulted from covid-19 pandemic period, especially year 2019 and 2020. Total value of imports were decreased by 14% from 2018 to 2019. Addition to this, total were decreased by 2% more after year 2019. On the other hand, there was a huge increased by 105% in 2021 and 76% in 2022.

It was observed that total of carbon emissions were increased at an average change of 4.2% compared to the corresponding period previous year (2019) in top largest exporter countries. There were approximately 7.2 billion tonnes of carbon emitted less than previous year during covid-19 pandemic year. After only a year, 8.7 billion tonnes of carbon were emitted at the end of year 2021.

EFFECT ON IMPORT OF CARBON BORDER RESTRICTIONS

4.1. Literature Review

Measurements of global warming are essential to accelerate the transmission of fossil energies. Many studies as a part of major works of literature are mostly trying to find out more about a way how to countries migrate from non-renewable energies to renewable energies. As recently, researches are mainly on energy policies since restrictions on carbon emissions are underway globally. How energy policies progressively impact on economic developments is very important for governments and authorities. Therefore, the connection between energy consumption and economic growth have been an issue with a great importance among economists, researches who find out the causal relationship of energy and growth. Some studies showed conflicting results such no causality and, on other hand others tried to prove the opposite.

Studies mostly recommends different hypotheses such as growth, conservation, feedback and impartiality. In growth recommendation, it is noted that there is one-sided relationship from energy consumption to economic growth. An increase or a decrease in energy consumption triggers an increase and a decrease in economic growth respectively. Conversation hypothesis implies that there is one-sided relationship from economic growth to energy consumption. On the other hand, when an increase in economic growth, energy consumption rises and, vice versa. According to impartiality hypothesis, there is no causality between energy consumption and economic growth. It is noted that a decrease or an increase in energy consumption does not trigger a decrease or an increase in economic growth respectively and that an increase or a decrease in economic growth does not trigger an increase or a decrease in energy consumption respectively.

There are many studies on relationship between carbon emissions, energy consumption and economic growth. However, the studies have different results, ranging from data and econometric analysis. The different results are due to sample selection inquiring different countries, different time range and various econometric analysis. This may cause conflicting results in terms of since the estimation results are very sensitive to data selections and other parameters.

Kraft and Kraft (1978) discussed the relationship between energy consumption and economic growth for the United States within the period of 1947-1974. They implied that there is a one-sided causality from Gross National Product growth to energy consumption.

Akarca and Long (1980) tried to analyse the connection between economic growth and energy consumption in the US for the period of years 1950-1970 with the SIM method. They did not reach a relationship in terms of causality.

In the study by Stern (1993) there are variables such as workforce, capital, energy and GDP for the US with the data between 1947 and 1990. Toda-Yamamoto and Granger causality test were used for this analysis. As a result of the Stern's study, it was noted that there is a one-sided relationship between economic growth and energy consumption.

Cheng (1995) applied Granger causality test with two and more variables model by using the US data of energy consumption and economic growth for the time period between 1947 and 1990. It was assessed that there is one-sided relationship among variables. Also, there is a causal relationship between energy consumption and industry production. Changes in both energy based on services and economy may cause a poor impact on growth. Cheng (1995) stated that an energy saving policy may not result in negative impact on economic growth.

Soytas and Sari (2009) examined long-run causal relationship among energy consumption, carbon emissions and economic growth in Türkiye for the years between 1960 and 2000 with the method of Toda and Yamamoto‘s version of the Granger causality. The results showed that there is a causal relationship between energy consumption and economic growth.

Apargis ve Peyne (2009) found out causal relationship among carbon emissions, energy consumption and economic growth variables for six Central America countries between years 1971-2004. It was noted that there is two-sided relationship between economic growth and energy consumption and that there is one-sided relationship from economic growth and energy consumption to carbon emissions.

Halıcıoğlu (2009) analysed a causality among energy consumption, carbon emissions, per capita GDP and foreign trade in Türkiye, for the time period of years 1960-2005. Halıcıoğlu used the cointegration and Granger causality test together with autoregressive distributed lag. It was noted that there is one-sided relationship from carbon emissions to per capita GDP, and vice versa. Secondly, Halıcıoğlu (2009) stated that there is no supporting evidence to verify a relationship between energy consumption and economic growth.

Zhang and Cheng (2009) implemented a multivariate model of economic growth, energy consumption, carbon emissions and capital based on urban population. They used the data for the period for years 1960-2007 for China. The study aimed to ascertain the direction of the a relationship among energy consumption, carbon gas emission economic growth, It was verified with the evidence that there is no causal relationship directionally. However, Zhang and Cheng (2009) found results supporting a relationship between carbon emissions and energy consumption.

Pao ve Tsai (2010) found out two-sided causal relationship between energy consumption and carbon emissions by using the data for the period between 1971 and 2005. They carried out the study for the BRICS (Brazil, Russian Federation, India, China Republic and South Africa).

Panel Cointegration and Panel Vector Error-Correction Model were used in Lean ve Smyth (2010) study for ASEAN regions with the time period of years 1980-2006. It was identified that there is one-sided a relationship from energy consumption and carbon emissions to economic growth.

Menyah and Wolde-Rufael (2010) aimed to identify a relationship between carbon emissions, energy consumption and economic growth in South Africa. They used the data for the time period between 1965 and 2006 by using cointegration and Granger causality test. They found cointegration relationship among time series. It was noted that there is one-sided relationship from carbon emissions to economic growth and, vice versa.

Güvenek and Alptekin (2010) tried to verify relationships between energy consumption and economic growth for twenty five OECD countries. They used the data for the period of years 1980-2005 by using the method of Panel Data Analysis. As a result of the study, it was implied there is no causality between energy consumption and economic growth.

Çınar (2011) carried out an analysis for the OECD countries by using data between 1971 and 2007. The study aimed to find out a causal relationship between per capita GDP and per capita carbon emissions together with unit root and cointegration tests. Çınar (2011) reached a logical linear coefficient statistically between income and carbon emissions. It was noted that increase in income cause increase in carbon emissions correspondingly.

Farhani ve Rejeb (2012) applied Panel Cointegration and Granger Causality test for MENA region for the period of years 1973-2008 in their study. It was identified that there is one-sided relationship from economic growth and carbon emissions to energy consumption.

Ergün and Polat (2015) investigated whether or not there is a relationship between carbon emissions, energy use and economic growth for thirty OECD countries. They applied Panel Cointegration and Panel Correction Models for the time period of years 1980-2010. It was noted that there is a cointegration among carbon emissions, energy use and economic growth. There is one-sided causality between carbon emissions and economic growth in the short run. On the other hand, there is two-sided causality between economic growth and energy consumption.

Topallı (2016) examined a relationship between carbon emissions and economic growth for Brazil, India, China Republic and South Africa countries. Topallı (2016) applied Panel Cointegration and Panel Causality test with the data for the period of 1980-2010. As a result of the study, an increase by 1 percent in economic growth causes an increase 0.55% in carbon emissions. It was identified that there is one-sided causality from economic growth to carbon emissions for both short run and long run.

4.2. Data and Methodology

4.2.1. Data

The ratio of total imports of carbon-intensive products to GDP and the carbon emissions from the countries exporting to six countries is taken as dependent variables. Also, the status of carbon restriction is taken as dummy variable. If a country had a carbon restriction for certain year, its value is stated with 1. If not, it is zero.

The study is based on annual data on total value (US$) of imports of six carbon intensive goods to top eight largest importer countries, total quantity (millions tones) of carbon emissions (CO_2) of the exporters to top eight largest importer countries, nominal GDP (current US$) for top eight largest importer countries between the year 2018 and year 2022.

It was identified with regulatory guidelines that the restrictions have applied to imports of certain goods whose production is carbon intensive and at most significant risk of carbon leakage: cement, steel, fertilisers, electricity, aluminium and hydrogen. These goods are sampled since they emitted approximately 40% of carbon in the Earth.

Australia, European Union, Canada, China, South Africa, Switzerland, the United Kingdom, the United States are sampled as top largest importer countries of six carbon intensive goods since they have border restrictions on carbon emissions.

The study mainly involved the collection data from both World Development Indicators which is databank of the World Bank Organization, U.S Energy Information Administration (EIA), World Population Review database and Eurostat were used in the study. Supportive data were obtained by the EU International Carbon Action Partnership database, the US Congressional Research Service, the United Nations Climate Change, the US Environmental Protection Agency databank and IMF.

In Table 4.1. the key variables are used in order to study the impact of the restrictions on carbon emission in the international trade of carbon intensive goods and the production of emissions.

Table 4.1. Variables

Variables	Explanation	Scope	Time Period	Source
Total Import Value of Carbon Intensive Goods	Amount US$	Imports of Six Carbon Intensive Goods (Cement, Steel, Aluminium, Fertilisers, Electricity, Hydrogen) to Top Largest Exporters Country (EU, Switzerland, US, China, Canada, UK, South Africa, Australia) with Carbon Pricing	Annual	• The World Bank DataBank • International Energy Agency
GDP	Amount US$	Top Largest Exporters Country (EU, Switzerland, US, China, Canada, UK, South Africa, Australia) with Carbon Pricing	Annual	• World Development Indicators which is databank of the World Bank Organization • IMF Library
Total Quantity of Carbon Emissions (CO2)	Tonnes	Carbon Emissions (CO2) of the Exporters to Top Eight Largest Importer Countries with Carbon Pricing	Annual	World Development Indicators which is databank of the World Bank Organization

The years between 2018 and 2022 are selected as sample for the time period used since there were no carbon border adjustments before year 2018. It was noted there are some environmental tax in-country, however, carbon border adjustments were not in effective, regardless of small example within a few of jurisdictions.

Total value of imports of six carbon intensive goods included all exporters sold the goods to top largest countries mentioned above. For example, it was noted there are 32 different exporters sold the six carbon intensive goods to the European Union. The US and China have 21 and 25 different exporters for same goods respectively. All are used in data analysis.

Table 4.2. Descriptive Statistics of Variables

	Total Value of Import / GDP	Carbon Emissions by Importers (millions tones)
Average	0,001343	21.774.283.937
Median	0,000553	21.371.578.326
Maximum	0,010725	27.957.381.977
Minimum	0,000139	14.008.762.975
Standart Deviation	0,001853	3.603.236.844
Skewness	3,394092	-0,289399
Kurtosis	16,080172	-0,350064

The negative skew commonly indicates that the tail is on the left side of the distribution, and positive skew indicates that the tail is on the right. Total value of import to GDP has positive skew (3.3) and carbon emissions by importers (-0.2) has negative skew in above.

Total value of import to GDP (16.08) is leptokurtic and carbon emissions by importers (-0.35) is platykurtic. It is common to compare the excess kurtosis of a distribution to 0.

Total quantity of carbon emissions for the importers of carbon intensive goods are taken as dependent variable. The emissions are the sum of carbon dioxide emissions from energy, in carbon dioxide equivalent associated with the production, transportation and distribution of fossil fuels, and carbon dioxide emissions from industrial processes. There are uncertainties with respect to the global warming potential of emissions. IEA database have estimated of total GHG emissions from energy in use and related indicators, recommended by the IPCC.

4.2.2. Methodology

Hypothesis is that current carbon constraints have a significant impact on carbon emissions and the international trade of carbon intensive goods. The effects of these carbon adjustments are analysed with a regression analysis on panel data from the six importers for the years 2018-2022. In order to evaluate the impact of carbon restrictions on the imports of carbon intensive goods, data of countries with the largest import volumes are used to measure the international trade of these goods.

Here is the variables as follow in Table 4.3. In order to mitigate the effect of economic growth, the ratio of total imports of carbon-intensive products to GDP is used as the first dependent variable. As the second variable, the carbon emissions from the countries exporting to six countries is taken. The policy initiative on carbon constraint is received a dummy variable. The effects of the restrictions were analysed by using regression on panel data from the six countries for the years 2018-2022.

Table 4.3. Variables

Total Import Value of Carbon Intensive Goods To GDP	Dependent
Total Quantity of Carbon Emissions	Dependent
Carbon Restriction for Importers (0 or 1)	Dummy
Carbon Restriction for China (0 or 1)	Dummy

China is also selected as separate dummy variable since they are bigger exporter for carbon intensive goods. At the same time, they have applied the carbon border adjustment as well other top largest importers which have carbon pricing.

A regression model with one variable is established to identify the relationship between total value of import to GDP, index of carbon emissions as dependent variables and the status of carbon restriction as dummy variable. Ordinary Least Square (OLS) is applied in the regression models formed in the study.

In the study, time series are total import of six carbon intensive goods, GDP of top largest exporter countries which have carbon pricing and total quantity of carbon emissions of importer countries, started from year 2018 to year 2022 with total observations of approximately 40 for each variable from official sources mentioned in section 3.2.1.

The reason why regression is established in this study was to determine how well the effect of carbon emissions could be explained by different variable/s. The regression which consisted of one variable (i.e carbon restrictions) could give a definite picture on several factors which could affect carbon emissions and total import. Significance of the carbon restrictions on total import to GDP is key to understand.

4.3. Findings

In order to test whether there was any significance in the carbon restrictions to the imports of goods, the top eight largest importer countries which have imposed the border restrictions on carbon emissions were sampled. It is sampled that cement, steel, hydrogen, fertilisers and aluminium due to high carbon intensity. The analysis is supported by annual data, between years 2018 and 2022, especially it is concentrated mainly in last five consecutive years since carbon pricing adjustments were newly started in this period.

The regression model is implemented by OLS procedure. The estimation results for the regression model is presented in Table 4.4. and Table 4.5. The raw data in the use of regression is represented in Appendicies.

The null hypothesis is that the imports of carbon intensive goods have not been affected by the carbon restrictions. Test rejects the null hypothesis that the coefficients of total import to GDP are jointly equal to zero at 10% significance level. It was examined at significance level such as 1%, 5% and 10% whether there is a relationship from the carbon restrictions to total import to GDP and, vice versa. The weakness of data set requires higher level of significance such as 10% in order to decrease the quantity of evidence.

Table 4.4. represent the result between dependent variables such as total value of import of carbon intensive goods to GDP and total quantity of carbon emissions by importers and the dummy variable for the carbon restrictions by all top largest importers.

Table 4.4. Regression Output for Top Largest Exporters with Carbon Restrictions

C	0.00081
	(0.00446)*
Carbon Restrictions	0.00092
	(0.00058)*
R^2	0.06106

The values in the parentheses are standard deviations of corresponding coefficient estimates.

*, **, *** indicates the significance at 1%, 5%, and 10% respectively.

Based on Appendix-2, the p-value (0.12) is higher than the significance level 10%. It means that there is no assumption for the null hypothesis. It indicates an increase in carbon emission have not any impact on total import to GDP at significant level.

The following regression model for Top Largest Exporters which have Carbon Restrictions is estimated in this study:

$$CRI_{it} = \beta_0 + \beta_1 * CR_{it} + \varepsilon \quad (4.1)$$

Table 4.5. Regression Output for Top Largest Exporters which Have Carbon Restrictions and China

C	0.001
	(0.00047)*
Carbon Restrictions	0.00082
	(0.00059)*
Carbon Restrictions for China	-0.00109
	(0.00088)*
R^2	0. 09842

The values in the parentheses are standard deviations of corresponding coefficient estimates.

*, **, *** indicates the significance at 1%, 5%, and 10% respectively.

The following regression model for Top Largest Exporters which have Carbon Restrictions with China together is estimated in this study:

$$CRI_{it} = \beta_0 + \beta_1 * CR_{it} + \varepsilon \quad (4.2)$$

$$CRIC_{it} = \beta_0 + \beta_1 * CR_{it} + \beta_2 * CHINA_{it} + \varepsilon \quad (4.3)$$

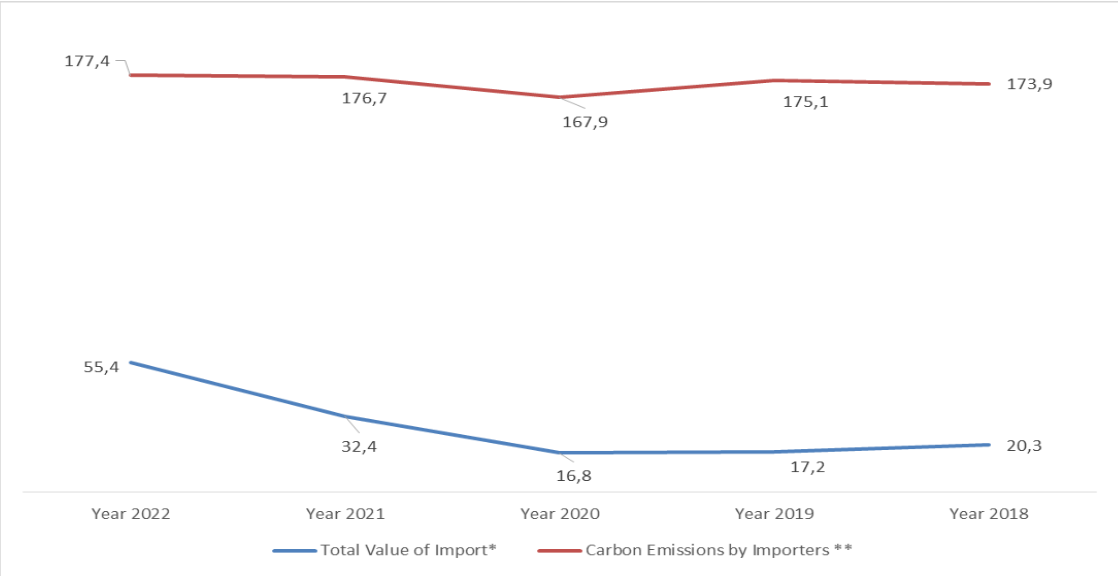
Table 4.5. represents the result between dependent variables such as total value of import of carbon intensive goods to GDP and total quantity of carbon emissions by importers and the carbon restrictions. Adding to the restriction of six importers, China restrictions is taken solely dummy variable since it was assumed that there could be a significance to total import to GDP as a biggest carbon emitter.

The result was not likely to be true since p-value for the carbon restrictions for all exporters was 0.16 in Appendix-4. Addition to this, the p-values for carbon restrictions for China only is still higher than the significance levels. It was seen that total value of imports to GDP have not significance to carbon restrictions in China.

It was intended that a full of panel data analysis is applied for this study. The data for both carbon restrictions and carbon emissions is inadequate and they have not same long period of the imports of carbon intensive goods. It was ensured that there are not sufficient detailed statistical data for carbon related information such as emissions and carbon restrictions.

On the other hand, Figure 3.60. and Figure 4.1. represent country specific total carbon emissions and the trends for both total imports and total carbon emissions together. It was explicitly seen that there is a decreasing trend in the quantity of carbon emissions until year 2022, excepting China. But, there was a pandemic covid-19 effect in year 2020. The influence of pandemic covid-19 caused a large deferred demand for these goods in international trade and, this caused an increase in carbon emission after 2020.

Figure 4.1. Trend in Total Value of Imports and Total Quantity of Carbon Emissions (Billions, US$, Tones)



(Source: *The World Bank Organization – Development Indicators*)

In brief, the results represent that the current carbon constraints do not have a significant impact on carbon emissions and the international trade of these products. The reason why there are no verified as statistically significant is resulted from inadequate set of data. There are a narrow range of data since the carbon restrictions were newly effective.

A few of countries have started to impose restriction on carbon emissions in recent years. The conflicts are due to the fact that each analyses handle different countries for both different time sequences and various statistical data. For countries, energies used in the production of carbon intensive goods were indispensable to keep their growth of economy. Therefore, countries did not accelerate to cut GHG emissions.

CONCLUSION

Global warming has a major impact on economic outcomes such as productivity, output, and investment. Additionally, climate change indirectly affects a range of activities, including energy production, manufacturing, and international trade.

Scientists have been drawing our attention to the economic impacts of global warming for a long time. William Nordhaus, who was the first to investigate the aspects of mitigating carbon emissions, recently stated that our current response to global warming is probably inadequate (Nordhaus, 2016). Kenneth Arrow formed a group of scientists to highlight that the cost of carbon dioxide emissions is being underestimated by existing models (Revesz et al., 2014). The IPCC report in 1995 continuously provided adverse comments on climate change issues (Rogoff, 2016).

Global organizations and governments are aware of the possible economic consequences of climate change and ensure that measures are in place to sustain economic growth. It is observed that a key policy accepted by authorities is to implement a global commitment to reduce carbon emissions to the maximum extent possible. The migration to a lower carbon-intensive economy could result in financial and economic risks if investments are not compliant with strategies aligned with global warming policies.

If the restrictions on carbon emissions are barely adequate to impact economic activities, analysts must be able to model the risks arising from carbon emissions and quantitatively evaluate their impacts on macroeconomic outcomes such as consumption, international trade, and technological progress. Countries face a number of severe challenges from these impacts, which are directly related to their characteristics. Firstly, the causes and outcomes are global. Secondly, the impacts are persistent and long term. Thirdly, there are uncertainties about the economic impacts and, these uncertainties are pervasive. Lastly, there is an irreversible change that carries a serious risk of major consequences.

Firstly, carbon-intensive goods such as cement, steel, aluminium, fertilisers, electric and hydrogen are critical raw-materials used in the manufacturing of intermediate goods. There was a global slowdown in manufacturing, and some countries postponed their needs for these goods in their own industries during the COVID-19 pandemic. Therefore, countries did not decrease their exports after the COVID-19 pandemic period, regardless of the restrictions.

On the other hand, countries engaged in international trade did not prioritize carbon emissions since there were no strict rules and regulations regarding carbon emissions imposed by either the World Trade Organization or other jurisdictions. Additionally, existing restrictions were weak and discretionary. As a result, they did not impose significant costs on international trade. Complying with carbon restrictions in international trade was not sufficient to prevent most countries from experiencing losses due to the production of intermediate goods, as these imports of carbon-intensive goods were crucial for their industries.

There was an element of ambiguity in the implementation of carbon restrictions, as it was not clear how these restrictions could be measured. Although countries agreed to accelerate cuts in their emissions, nearly 20 percent of companies were aware that carbon restrictions must be considered in the process of importing decisions.

According to the World Bank Group's "State and Trends of Carbon Pricing 2023" report, 89 countries, including 13 that produce 86% of global emissions, had accepted net-zero targets by the end of 2022.

In order to obtain a meaningful result, the study should be repeated after new carbon border adjustment mechanism become effective in 2026. The European Union and the United Kingdom will implement their definitive mechanism from 2026 and 2027, respectively, while the existing transitional phase lasts from 2023 to 2025. Additionally, China started a domestic and international certified emissions reduction programme in January 2024. The United States introduced four key bills to prevent carbon leakage starting in 2023. The Australian Government announced a review of carbon leakage commencing in July 2023. Canada has been working on its own carbon adjustment mechanism similar to the EU CBAM.

There has been a gradual progress in the use of low-emission technologies. However, commercial deployment could not be accelerated rapidly in the last consecutive five years. The adoption and readiness of low-carbon intensive technology remained too low across most sectors, such as aluminum. Additionally, the transformation of fuels and recycling efforts could not sufficiently support industries in narrowing the gap until low-emission technologies became available.

Fewer countries, such as Switzerland, avoided the further costs of energy-related emissions since they were partially equipped with low-emission production technologies and competitive with high-emission alternatives. Most countries, however, were adversely affected by the additional costs of energy-related emissions, even if the results of this study could not yet prove this conclusively.

During the transition to de-carbonisation there is likely a supply-side risk resulting from the the trade-off between international trade and economic growth. Investments in de-carbonization technologies can lead to demand-side shocks. Achieving the net-zero target set in the Paris Agreement requires widespread and urgent actions, particularly in countries with a high share of carbon emissions. It is noted that there are mainly three ways to mitigate carbon emissions:

- Decrease the manufacturing production and consumption of carbon intensive goods,
- Advancements in energy efficiency of existing goods, where producers must decrease the level of energy used per unit of energy intensity.
- Transform carbon intensive production by switching to low-carbon energy sources.

In order to meet the commitments at Paris Agreement, there are internalised actions implemented by the signatories. The carbon pricing mechanism aim to discourage the consumption and manufacturing goods with high greenhouse gases emission.

Putting a price on carbon encourages firms to modify their production process to reduce carbon emissions. This affects consumer preferences towards to low-carbon intensive goods due to cheaper prices with compared with high-emission alternatives. It is expected that a potential reduction in energy use leads to lower GDP growth until there is a trade-off between clean energy and market price. Carbon taxes and emission trading system are well-known instruments as carbon restrictions.

On the other hand, carbon taxes can be viewed as a means to reflect the expected marginal damage of carbon emissions. However, estimating carbon prices can be challenging, especially in the case of more competitive economies where there is a monopoly on fossil fuel reserves, such as the US, Canada, the Russian Federation, and countries in the Middle East.Owners of fossil fuel reserves can consider carbon pricing as a way of expropriation. This makes them have the incentive to produce more fossil fuel at first. It is a phenomenon known as ‘green paradox’, which highlights the unintended consequences due to a failure to account for supply-side effects (Sinclair, 1994, Sinn, 2008).

In addition to carbon pricing, there are several other policies at mitigating GHGs emissions, including energy efficiency, incentives and subsidiaries for low carbon intensive research and developments, as well as policies encouraging infrastructure in manufacturing.

As a result of de-carbonisation measures, countries have compelled industrial companies to both curb production and allocate resources to emission abatement efforts. This has caused an increase in the price of goods and higher costs, which can adversely impact company profitability. However, policies that incentivize innovation in de-carbonization technologies can have broader positive effects across industries by promoting economic development and growth.

This study explores the impacts and implications for economic growth in countries affected by carbon emissions. The selected countries serve as samples based on two criteria: being economies with the highest energy intensity and being among the top importers of goods with the highest carbon intensity. Through econometric analysis, the study reveals that there is a direct relationship where an increase in energy use correlates with an increase in carbon emissions.

Based on the analysis of time series data, the study concludes that economic growth is indeed influenced by changes in the import of carbon-intensive goods. On the other hand, there is poor and unhealthy results due to the period of time constraints and country specific behavioural production. Countries have put their restrictions on carbon emissions starting in different years. The implications of carbon emissions can differ from one country in their production ability to another. It can be concluded that countries whose production process has been moved to low carbon technology is likely to advance more in international trade.

Renewable energies are permanent solution to both reduce GHG emissions and meet the demand of energy. Until the full migration to the use of renewable energies, the internalised actions such as carbon pricing, subsidiaries, incentives and regulations keeps their own importance and they are still key and vital solutions at mitigating climate change risks.

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APPENDICES

Appendix A. Determinants of Total Import to GDP Using Regression Model

Top Largest Importers which have Carbon Pricing, Real GDP and Total Value of Imports of Carbon Intensive Goods, (US$)	Year	Total Value of Import / GDP	Carbon Emissions by Importers (millions tones)	China Dummy Variable (non-adjusted: 0 adjusted:1)	All Countries Dummy Variable (non-adjusted: 0 adjusted:1)
Australia	2022	0,0002457046	25.223.144.347	0	1
Australia	2021	0,0002066970	24.851.350.541	0	0
Australia	2020	0,0001770360	23.637.552.423	0	0
Australia	2019	0,0001779171	24.695.079.236	0	0
Australia	2018	0,0001706771	24.496.722.424	0	0
Canada	2022	0,0019636836	25.015.814.236	0	1
Canada	2021	0,0017811542	24.890.452.131	0	0
Canada	2020	0,0017399684	23.615.202.346	0	0
Canada	2019	0,0019245585	24.607.470.504	0	0
Canada	2018	0,0026123450	24.448.100.104	0	0
China	2022	0,0002981460	15.140.658.509	1	1
China	2021	0,0003263606	14.896.211.267	1	1
China	2020	0,0002778533	14.008.762.975	1	0
China	2019	0,0001541736	15.370.542.248	1	0
China	2018	0,0001545445	15.499.952.466	1	0
EU	2022	0,0015212409	27.957.381.977	0	1
EU	2021	0,0005505921	27.828.864.779	0	1
EU	2020	0,0002334966	26.440.272.612	0	1
EU	2019	0,0002762054	27.508.013.515	0	1
EU	2018	0,0003038326	27.200.541.820	0	1
South Africa	2022	0,0025242537	21.023.810.258	0	1
South Africa	2021	0,0021815189	20.771.183.020	0	1
South Africa	2020	0,0020696770	19.816.831.465	0	1
South Africa	2019	0,0020796136	20.532.856.345	0	1
South Africa	2018	0,0023956494	20.339.986.782	0	0
Switzerland	2022	0,0107254685	22.623.948.100	0	1
Switzerland	2021	0,0051747327	22.798.521.902	0	1
Switzerland	2020	0,0017146858	21.719.346.394	0	1
Switzerland	2019	0,0019596346	22.554.990.091	0	1
Switzerland	2018	0,0025967311	22.398.513.062	0	1
United Kingdom	2022	0,0013383949	19.960.014.908	0	1
United Kingdom	2021	0,0013186885	19.965.325.707	0	1
United Kingdom	2020	0,0004023361	18.999.324.130	0	0
United Kingdom	2019	0,0005563010	19.634.130.101	0	0
United Kingdom	2018	0,0007182201	19.486.391.796	0	0
United States	2022	0,0002331808	20.479.705.978	0	1
United States	2021	0,0001675797	20.676.235.240	0	1
United States	2020	0,0001391262	19.689.617.214	0	1
United States	2019	0,0001530550	20.152.066.727	0	0
United States	2018	0,0001770739	20.016.467.791	0	0

Appendix B. Real Effective Exchange Rate Index

	Australia	European Union	Canada	China	South Africa	Switzerland	United Kingdom	United States
Year 2018	97,00	96,58	95,26	101,72	102,83	98,83	97,64	98,27
Year 2019	96,52	96,81	94,51	100,59	101,67	98,67	96,53	96,97
Year 2020	97,06	94,29	94,08	100,23	102,70	99,25	96,52	95,93
Year 2021	97,28	94,41	94,61	100,61	103,71	99,06	96,95	96,41
Year 2022	95,99	93,74	94,14	96,81	103,94	100,52	96,25	94,30

(Source: *IMF, national currency units/US $*)

Appendix C. Model Summary for Top Largest Exporters with Carbon Restrictions

Regresyon Stats	
Multiple R	0,247116643
R^2	0,061066635
Adjusted R^2	0,036357862
Standart Errors	0,001841730
Number of Observations	40

	Coefficient	*Standart Errors*	*t Stat*	*P-value*	*Lower (d_L) %95*	*Upper (d_u) %95*	*Lower (d_L) 95.0%*	*Upper (d_u)95.0%*
Constant	0,000810562	0,000446685	1,814617209	0,077483039	-9,37042E-05	0,001714829	-9,37042E-05	0,001714829
Carbon Restriction	0,000926070	0,000589071	1,572086390	0,124220836	-0,000266441	0,002118582	-0,000266441	0,002118582

Regresyon Stats	
Multiple R	0,160187634
R^2	0,025660078
Adjusted R^2	1,95538E-05
Standart Errors	3.649.104.123
Number of Observations	40

	Coefficient	*Standart Errors*	*t Stat*	*P-value*	*Lower (d_L) %95*	*Upper (d_u) %95*	*Lower (d_L) 95.0%*	*Upper (d_u)95.0%*
Constant	21.102.914.984	885.037.749	23,84408462	1,83684E-24	19.311.249.729	22.894.580.239	19.311.249.729	22.894.580.239
Carbon Restriction	1.167.598.179	1.167.153.220	1,000381234	0,323454025	- 1.195.179.988	3.530.376.346	- 1.195.179.988	3.530.376.346

Regresyon Stats	
Multiple R	0,313719629
R^2	0,098420006
Adjusted R^2	0,049685952
Standart Errors	0,001828949
Number of Observations	40

	Coefficient	*Standart Errors*	*t Stat*	*P-value*	*Lower (d_L) %95*	*Upper (d_u) %95*	*Lower (d_L) 95.0%*	*Upper (d_u)95.0%*
Constant	0,001003346	0,00047012	2,134236436	0,039515	5,07936E-05	0,001955899	5,07936E-05	0,001955899
Carbon Restriction for China	-0,001092443	0,000882339	-1,238122534	0,223469	-0,002880231	0,000695345	-0,002880231	0,000695345
Carbon Restriction for All	0,000828281	0,000590291	1,403174964	0,168901	-0,000367761	0,002024324	-0,000367761	0,002024324

Regresyon Stats	
Multiple R	0,715355161
R^2	0,511733006
Adjusted R^2	0,485340195
Standart Errors	2617885376
Number of Observations	40

	Coefficient	*Standart Errors*	*t Stat*	*P-value*	*Lower (d_L) %95*	*Upper (d_u) %95*	*Lower (d_L) 95.0%*	*Upper (d_u)95.0%*
Constant	22.455.546.783	672.910.764	33,3707647	3,207813E-29	21.092.100.064	23.818.993.502	21.092.100.064	23.818.993.502
Carbon Restriction for China	- 7.664.913.530	1.262.944.788	-6,069080457	5,062346E-07	-10.223.882.741	- 5.105.944.320	- 10.223.882.741	- 5.105.944.320
Carbon Restriction for All	481.480.600	844.918.872	0,569854237	0,572221	- 1.230.487.651	2.193.448.850	- 1.230.487.651	2.193.448.850