REPORT . 2023

OPPORTUNITIES FOR BRAZIL IN CARBON MARKETS

ICC Brasil | WAY CARBON

SUMMARY OF PREVIOUS EDITIONS

2021

The first report **Opportunities for Brazil in carbon markets**, besides introducing important concepts about carbon markets, focused on opportunities related to productive sectors in the mechanisms of Article 6 of the Paris Agreement and in the voluntary market. The study reviewed the Forestry, Agriculture, Energy, Transport, and Industry sectors in terms of emission reduction technologies, socio-economic benefits and opportunities for the production chain. It also presented the potential supply of credits generated in Brazil and estimates of demand for these credits. Based on the identified opportunities and barriers, and considering the sectors to be prioritized, recommendations for the Brazilian government and the business sector were presented.

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2022

The study **Opportunities for Brazil in carbon markets 2022** presented progress on the definitions of the new carbon market mechanisms under Article 6 post-COP 26 and an updated overview of the regulated markets and the voluntary market. This report also provided an unprecedented mapping of the current national carbon market ecosystem with important definitions of the types of players and their participation in the market and presented a national overview of the projects registered in the country since 2003. Based on interviews with market players, it was possible to identify the main barriers and opportunities for operating in these markets in Brazil. Based on the specific barriers and opportunities for market players, recommendations were made to the different players and to the Brazilian government.

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COVER LETTER

Gabriella Dorlhiac

Executive Director of ICC Brasil

Since the launch of the last edition of the study in 2022, carbon markets have experienced important developments. From the voluntary markets and the growing pressure for greater transparency and quality of credits to the progress made in the negotiations on Article 6 of the Paris Agreement, the debates have become increasingly relevant and have brought more clarity to important aspects for the effective functioning of these markets.

In recent months we have also seen the start of the implementation of carbon adjustment mechanisms at the border and the progress of discussions on the establishment of a regulated carbon market in Brazil.

The latter is the focus of this third edition of the study, which seeks to understand the potential impacts of the Brazilian regulated market and analyze how the competitiveness of Brazilian products in the international market can be affected by the border adjustment rates of foreign regulated markets, investigating whether the regulation of our national market would be a potential risk mitigation instrument.

It is important to note that it is expected that there will be interaction between the Emissions Trading Systems (ETS) and the global carbon markets regulated by the United Nations Framework Convention on Climate Change (UNFCCC) and with the voluntary market, but that it is up to national governments to decide how this connection window and the voluntary market credits will be used and to be selective when authorizing credits that will or will not contribute to their respective Nationally Determined Contributions (NDCs). It's worth remembering that although accepting carbon credits can reduce compliance costs, caution is needed to avoid flooding the market and reducing the effective result of emissions reductions. In other words, it's not a simple process.

Although this year brings a new look at the subject, the study "Opportunities for Brazil in carbon markets" continues with the aim of raising updates and recommendations for the evolution of the carbon market, contributing to the qualified debate on this transition mechanism that can leverage Brazil's sustainable development.

In this sense, the report anticipates several points that will remain open for infralegal regulation and the design of the national carbon market after the enactment of the Legal Framework and highlights the crucial role of using revenues to mitigate the negative impacts of the ETS and border adjustment mechanisms with the aim of reducing economic impacts, especially to avoid worsening social inequality.

I hope that the study will provide relevant information and that the conclusions presented here will be useful to decision-makers in the private and public sectors, negotiators, experts and society as a whole.

I would like to take this opportunity to thank the supporters of the 2023 edition - AES, Demarest Advogados, Indústria Brasileira de Árvores (Ibá), Itaú, KPMG, Marfrig, Natura &Co, Santander, Schneider Electric, Shell, Tauil & Chequer Advogados in association with Mayerbrown and Trench Rossi Watanabe Advogados - whose contributions have been essential for the publication and who, once again, have believed in this initiative.

Good reading!

ICC Brasil, one of the national committees of the International Chamber of Commerce (ICC), was created in 2014 with the mission of bringing the private sector to the center of the international trade agenda and amplifying the voice of the Brazilian business community with governments and international organizations, in the elaboration of projects aimed at economic and social development and improving the business environment.

From a multi-sectoral approach, we produce knowledge through advocacy projects and initiatives, seeking to approach the private sector to government bodies and global debates in multilateral organizations such as the UN, WTO and G20, providing subsidies for the development of public policies that are beneficial to business and society.

We also disseminate locally the content developed by the global ICC in its 12 areas of activity, organize events on topics of relevance to the country's economy, give a voice to companies based in Brazil at the global level and convey to the relevant government authorities the ICC's positions on key issues for a good, healthy and sustainable business environment.

ICC was founded in 1919 with the mission of promoting more open, fair and transparent international trade. Today, ICC represents the voice of business at the highest levels of intergovernmental decision-making, whether at the World Trade Organization, the G20 or the United Nations, and is the first private sector organization with observer status at the UN General Assembly. It is this ability to connect the public and private sectors that sets ICC apart as a unique institution, responding to the needs of all stakeholders involved in international trade and the issues surrounding it, such as innovation and sustainability.

To find out more, visit iccbrasil.org

WayCarbon is a global company, a reference in solutions focused on the transition to a low-carbon economy. Founded in Brazil in 2006, WayCarbon employs scientific and business knowledge leveraged by technology to support companies and governments in their climate change and ESG strategies. In 2022, WayCarbon was acquired by Santander Spain, which envisioned the opportunity of accelerating the adoption of solutions to tackle climate change by companies globally.

WayCarbon has served over 500 private sector clients, besides having an extensive experience in projects for multilateral organizations (Global Compact, UN, BID) in the areas of mitigation, adaptation, and compensation. It´s technological solutions are currently being employed by customers in 40 countries.

WayCarbon's consultancy services, specialist software and high quality carbon projects are designed to help companies on their decarbonization journeys. It´s forest preservation and reforestation projects value biodiversity and local communities. WayCarbon is the perfect partner to trace a holistic strategy when the subject is climate change.

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MESSAGES FROM SUPPORTERS

aes Brasil

“AES Brasil generates energy from 100% renewable sources, acting as an integrated platform adaptable to the demands for reducing carbon emissions into the atmosphere. More than that, the company focuses its entire strategy on accelerating global decarbonization through new technologies that help in this mission. A study like this, carried out by ICC Brasil, in partnership with WayCarbon, helps us on the necessary journey towards the energy transition that the planet is seeking.”

Rodolfo Lima, Executive Director of Customer Relations at AES Brasil

Itaú

“Itaú aims to be the climate transition bank and to support real economy corporations on their decarbonization paths. Carbon pricing is an essential step for climate transition to become a reality. The third edition of the study effectively translates the regulatory scenario, as well as Brazil's challenges and potential. The study gains even more relevance by addressing the impacts of instruments such as CBAM for the country.”

Luciana Nicola, Director of Sustainability and Institutional Relations at Itaú Unibanco

DEMAREST

“The update of this study carried out by ICC Brasil in partnership with WayCarbon is essential for assessing the structure of the carbon market, especially the potential impacts of establishing a regulated carbon market in Brazil. For us at Demarest Advogados, it is a great pleasure to support and contribute to such a complete study, which reflects Brazil's potential as a leading player in the climate agenda.”

Fernanda Stefanelo, Environmental and ESG Partner at Demarest Advogados

KPMG

“This is an important study on the potential impacts of regulating the carbon market in Brazil. The processes of adapting to climate change and mitigating emissions must be accelerated if ecosystems are to stabilize. In this sense, this publication presents fundamental information and analysis for Brazilian companies to ensure their competitiveness in this new scenario.”

Felipe Salgado, Partner at KPMG

iba – indústria brasileira de árvores

“The cultivated tree sector, through sustainable practices, has established itself over the decades as a large-scale bioeconomy business model. It contributes to climate change mitigation by removing and storing carbon, reducing emissions in its production processes, increasing circularity and its mostly renewable electricity matrix.”

Renata Nishio, Director of Corporate Affairs

Marfrig

“Brazil is vital for the global climate agenda and, consequently, for strengthening the global regulated carbon market. This new ICC report contributes to pushing for the much-needed decarbonization of industry by collecting, organizing and making available up-to-date and in-depth information. The study represents a leap forward on this urgent issue and will help increase the competitiveness of Brazilian products.”

Paulo Pianez, Director of Sustainability and Corporate Communication South America at Marfrig

MESSAGES FROM SUPPORTERS

Natura &Co

"Natura&Co, as one of the pioneering companies in the carbon agenda in Brazil, believes that the consolidation of the Brazilian carbon market has enormous potential for the development of the bioeconomy. This new edition of the study will be fundamental in guiding the implementation of public policies and helping to direct business strategies that unlock new business opportunities and promote paths to climate resilience."

Fernanda Facchini, Head of Climate Change and Circularity

Santander

"This edition of the study comes at an opportune moment to broaden the debate on the implementation of actions by the private sector and the carbon market in Brazil, while the country develops its regulatory framework for the segment. Santander has made a commitment to become net zero by 2050, and believes that the financial sector has a key role to play in stimulating this market, by providing liquidity and structuring financing instruments for decarbonization projects."

Luiz Masagão Ribeiro Filho, Treasury Partner

Schneider Electric

"The regulated carbon market is a catalyst for accelerating the ecological transition in Brazil at maximum speed, stimulating, through the pricing of emission permits, the sectors with the greatest impact to adopt solutions and technologies already available today, such as energy efficiency, electrification and digitalization, which are relegated to the background due to the lack of attractiveness in business cases."

João Carlos Souza, Sales Manager, Sustainability Solutions | Schneider Electric

"Shell is supporting this study for the third consecutive year because it believes that it helps to qualify the debate and advance policies and regulations for the implementation of a regulated carbon market, at the same time as the voluntary carbon market grows, gains strength and international credibility, positioning Brazil as one of the leading countries in the low carbon economy."

Flávio Rodrigues, Vice President of Corporate Relations, Shell Brasil

TAUIL | CHEQUER
MAYER | BROWN

"For us, it is an honor to be able to support a study of such relevance, a real service to Brazilian society. We believe that the next steps in the construction and improvement of carbon pricing instruments, especially with the development of carbon markets, will be decisive in helping Brazil to play a leading role in the new low-carbon world economic order."

Luiz Gustavo E. Bezerra, Partner / Head of the Environmental & Climate Change practice at Tauil & Chequer Lawyers associated with Mayer Brown

Trench Rossi Watanabe.

"The new edition of the study comes at a decisive moment for the development of a Brazilian carbon market and proves to be an important tool for expanding knowledge on the subject and improving the quality of ESG decision-making. Trench Rossi Watanabe has advised major companies on projects and transactions related to the generation of carbon credits and recognizes the relevance of this agenda for business, communities, and the planet."

Renata Amaral, Partner of the Environment, Climate Change and Sustainability group at Trench Rossi Watanabe

ACRONYM LIST

A6.4ER - Article 6.4 Emission Reduction
AFOLU – Agriculture, Forestry and Other Land Uses
BC – Low Carbon Scenario
BC0 – Low Carbon Scenario with price US$ 0/tCO_2
BC100 – Low Carbon Scenario with price US$ 100/tCO_2
BC25 – Low Carbon Scenario with price US$ 25/tCO_2
BECCS – Biomass Energy with Carbon Capture and Storage
BEN – National Energy Balance
CBAM – Carbon Board Adjustment Mechanism
CBIO - The Decarbonization Credit
CCUS – Carbon Capture, Utilization and Storage
CER/VER – Certified or Verified Emission Reduction
CF – Carbon Footprint
CH_4 – Methane
CMPD – Carbon Market Policy Dialogue
CO_2 – Carbon dioxide
COP – United Nations' Conference of Parties
CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
CPS – Current Policy Scenario
CVM – Securities and Exchange Commission
DDS – Deep Decarbonization Scenario
DEGEE – Greenhouse Gas Emissions Rights
E&P – Extraction & Production
ETS – Emission Trading System
EU – European Union
EU CBAM – European Union Carbon Board Adjustment Mechanism
EU ETS – European Union Emission Trading System
FCC – Fluid Catalytic Cracking
FEBRABAN - Brazilian Federation of Banks
GATT - General Agreement on Tariffs and Trade
GDP - Gross Domestic Product
GHG - Greenhouse Gases
HFC – Hydrofluorocarbons
ICAP - Research and Training Institute
ICC - International Chamber of Commerce
ICROA – International Carbon Reduction and Offsetting Accreditation
IEA – International Energy Agency
IETA – International Emissions Trading Association
ILPF – Crop-Livestock-Forest Integration
IPCC - Intergovernmental Panel on Climate Change
ISIC – Standard Industrial Classification of All Economic Activities
ITMOs – Internationally transferred mitigation outcomes
LCA – Life Cycle Assessment Evaluation
MAC – Marginal abatement cost
MBRE – Brazilian Emissions Reduction Market
MCER - Mitigation Contribution Emission Redutions
MCTI – Ministry of Science, Technology and Innovation
MMA - Ministry of the Environment
MP – Provisional Measure
MRV – Measurement, Registration and Verification
NDC – Nationally Determined Contributions
OECD – Organization for Economic Cooperation and Development
PL – Bill
PMR – Partnership for Market Readiness
PNH2 – National Hydrogen Program
PNMC – National Policy on Climate Change
REDD+ – Reduction of Emissions from Deforestation and Degradation
REF – Reference Scenario
RGGI - Regional Greenhouse Gas Initiative
RVE – Verified Emissions Reductions
R&D – Research and Development
SBCE – Brazilian Emissions Trading System
SCN – National System of Accounts
SH – Harmonized System
SIN – National Interconnected System
SNIC – National Cement Industry Union
tCO_2e – Ton of carbon dioxide equivalent
Twh – Terawatts-hour
UN – United Nations
UNFCCC – United Nations Framework Convention on Climate Change
VAT – Value Added Tax

SUMMARY

1. INTRODUCTION

After the success of its publication in 2021 and 2022, the "Opportunities for Brazil in carbon markets study" presents a new publication in 2023 updating the market on the topic. The previous years' studies presented opportunities focusing on action in the mechanisms of Article 6 of the Paris Agreement and in the voluntary carbon market. However, last year's report found that the absence of a regulated carbon market in Brazil has a direct impact on other barriers to voluntary market participation in Brazil (ICC Brasil & WayCarbon, 2022). In this way, the development of the Brazilian carbon market ecosystem as a whole depends directly on an analysis of the development of a regulated carbon market in Brazil and its implications.

Therefore, this study, with a different focus from previous editions, **aims to conduct an analysis of the potential impacts of the establishment of a regulated market in Brazil**. To this end, we have first presented an overview of trends in the implementation of new markets, the possible ways in which a national regulated market could interact with the market under Article 6 of the Paris Agreement and with the voluntary carbon market. It also identified the possible impacts on the international competitiveness of Brazilian products in the face of exposure to border adjustment charges from foreign regulated markets, and sought to understand whether the implementation of a regulated market in Brazil could minimize them. It also analyzed the country's policy and regulatory updates on carbon markets, the costs and opportunities of reducing emissions in the sectors to be regulated, and the socio-economic impacts of implementing the system in Brazil. These costs and opportunities show that carbon pricing may not be so painful for sectors as there are mitigation measures with negative costs. It is also noteworthy that there are few studies that bring out the possible socioeconomic impacts related to carbon pricing in the country. This analysis leads to the suggestion of actions that can minimize negative impacts and maximize positive ones.. As in previous editions, the study concludes with recommendations for the Brazilian government and the business sector to establish a regulated market in Brazil and to operate in the carbon markets.

It is important to emphasize that even if the regulated carbon market in Brazil is created soon, the relevance of this study remains since the analyses lead to recommendations that are not limited to the market implementation stage. There is a need for periodic assessments of the impacts of the system's operation, infra-legal aspects that will be defined after the law that will create the market and other fundamental elements that will be defined over time.

It should also be noted that, as the bills currently being considered in the country to regulate a carbon[1] market consider the formation of an Emission Trading System (ETS)[2], as well as the Partnership for Brazil Market Readiness (PMR) Project, which recommended an ETS as the most suitable instrument for Brazil[3] , this study will focus specifically on the structuring of this type of market in Brazil and the elements of its design.

1. See chapter 4.
2. ETSs are systems regulated at international, national or regional level where, through a regulatory framework, a maximum GHG emission limit (cap) is established and agents who emit below this limit can trade their emission allowances with those who emit above this limit(ICC Brasil & WayCarbon, 2022).
3. Under the coordination of the Ministry of Finance and the World Bank, this project aimed to discuss the convenience and opportunity of including carbon pricing in the package of instruments for implementing the National Policy on Climate Change (PNMC) in the post-2020 period.

2. UPDATED GLOBAL OVERVIEW

Several jurisdictions made internal progress on climate action in 2022, setting new targets or developing policies to reduce emissions. By the end of 2022, 89 countries, representing 86% of global emissions, had adopted net-zero[4] commitments with a time horizon between 2035 and 2060. Despite these efforts, the global ambition of climate policies still falls far short of what is needed to meet the goals of the Paris Agreement. The new and updated Nationally Determined Contributions (NDCs[5]), if implemented, project global warming of between 2.4°C and 2.6°C by 2100[6]. To get on track for 1.5°C, as pursued by the Paris Agreement, the world must cut current emissions by 45% by 2030 (World Bank, 2023b).

Therefore, it is necessary for countries to continue presenting increasingly ambitious NDCs, to devise cost-effective strategies to achieve them and to make the necessary investments, which can often be considerable. **The need to develop economic strategies for the implementation of the NDC and the demonstrated effectiveness of carbon pricing in reducing emissions are therefore increasing the chances of making it a central element for many countries to meet the Paris targets** (World Bank, 2023b).

Considering carbon pricing mechanisms, it can be said that there are three different carbon market environments: the international regulated market under the Paris Agreement, which is being structured with Article 6 mechanisms; the regulated carbon markets at regional, national and sub-national level, in which companies in sectors follow specific arrangements in each jurisdiction; and the voluntary market, in which companies make voluntary climate contributions. Following the focus of this study, this chapter will present an overview of regulated markets and their interaction with other markets.

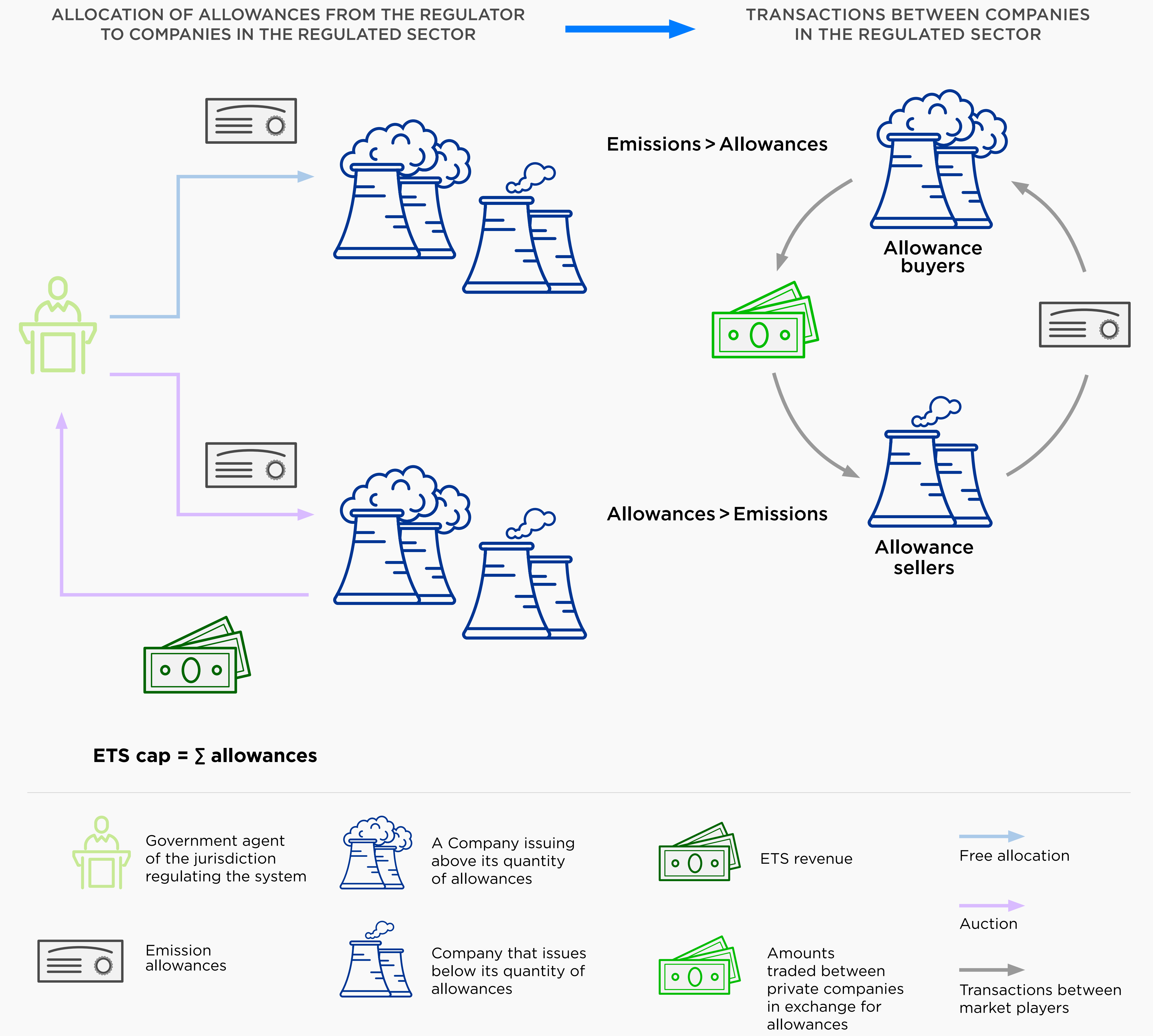
2.1. REGULATED CARBON MARKETS AT REGIONAL, NATIONAL AND SUB-NATIONAL LEVEL

There are two economic carbon pricing mechanisms regulated at regional, national and sub-national level: the carbon tax and the ETS. A carbon tax directly establishes a price for carbon by setting a tax on greenhouse gas emissions or - more commonly - on the carbon content of fossil fuels. It differs from an ETS in that the emissions reduction result of a carbon tax is not predefined, but the price of carbon is (World Bank, 2023d).

ETSs, on the other hand, are systems in which their regulator allocates or auctions **emissions allowances**[7], which are rights to emit a certain amount of greenhouse gases (GHG) considering a cap (the system's emissions ceiling, which is equal to the total number of allowances in a jurisdiction/sector), to companies in the regulated sectors. Thus, the result of reducing emissions is predefined and the price of carbon is not. Those companies that emit below their allowances can trade their excess allowances with a company that emits above. The scarcity of allowances circulating on the market encourages investments in decarbonization, so that the emission reductions from these investments will provide a greater quantity of allowances available to be traded. Figure 1 shows how allowances are allocated and traded in an ETS.

4. Net-zero refers to a zero balance between emissions and removals of greenhouse gases from the atmosphere. The Paris Agreement instructs states to achieve a balance between emissions by anthropogenic sources and removals by greenhouse gas sinks from 2050 onwards.
5. It is a climate action plan to reduce emissions and adapt to climate impacts. Each Party to the Paris Agreement is obliged to establish an NDC and update it every five years (United Nations, 2022).
6. In practice, the difference in temperature increase scenarios has severe consequences for global ecosystems and human well-being. The higher the temperature rise, the greater the risks of severe weather events such as extreme heat, drought, river and coastal flooding and crop failures. In the scenario of an increase of between 2.4°C and 2.6°C, it is estimated that there will be a 100% increase in the frequency of extreme heat events compared to 2021 and these would be around 120% more intense; there would also be a 40% increase in droughts, which would be around 100% more intense (IEA, 2021).
7. It can be seen that these allowances can be allocated by the regulator free of charge and/or through auctions. Generally, if a company over-allocates its allowances, it must pay a fine. These forms of allocation will be discussed in the chapter 4 of this report.

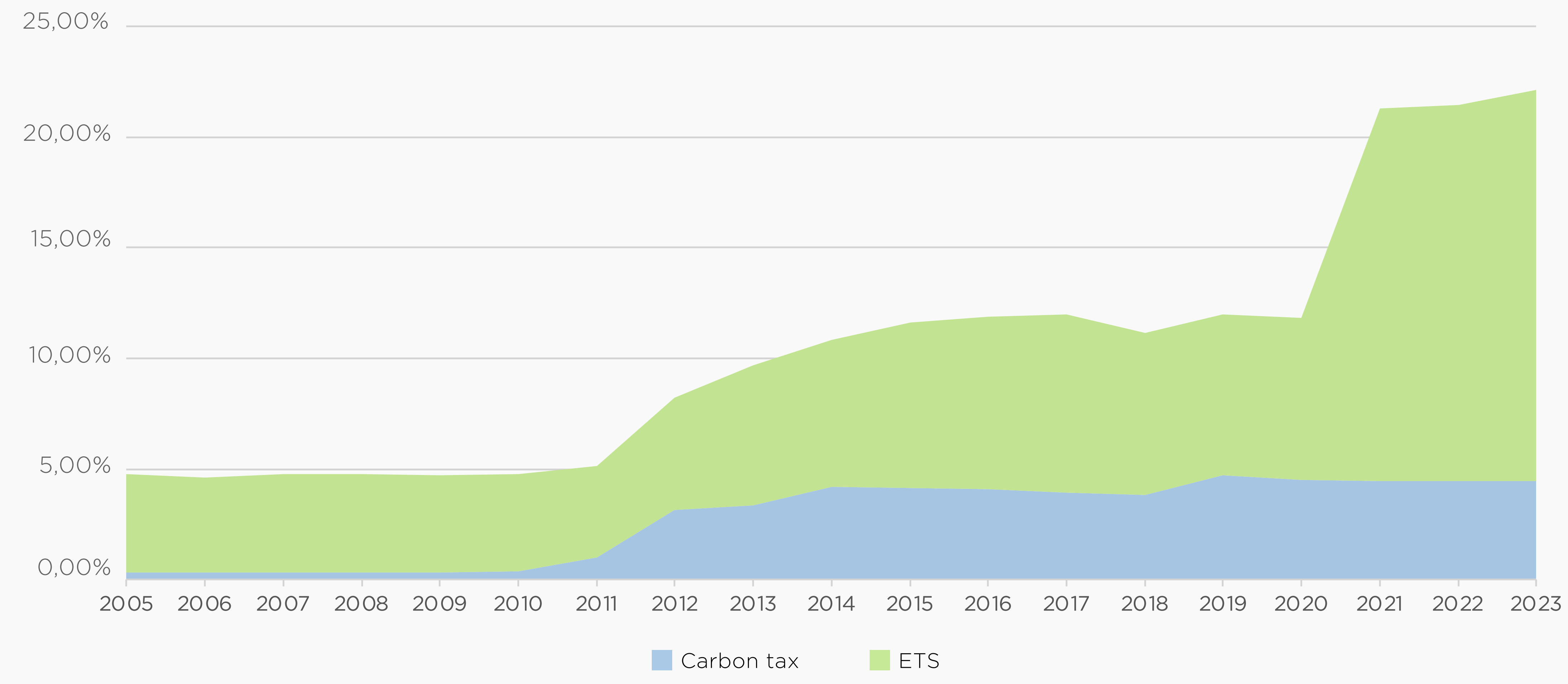
Figure 1 - How an ETS works



Source: Own elaboration.

The share of global GHG emissions covered by one of these two instruments - taxes or ETSs - is almost 23% (World Bank, 2023b). Figure 2 shows the growth in emissions coverage, with the share covered by ETSs growing significantly in recent years and currently standing at over 17%[8].

Figure 2 - Coverage of greenhouse gas emissions by the regulated carbon market



Source: Own elaboration based on World Bank (2023c). Data extraction on June 15, 2023.

In the last year, new ETSs have emerged in Austria and Washington state in the United States, and new carbon taxes in four states in Mexico – Querétaro, in the State of Mexico, Yucatán and Guanajuato. In June 2023, there were a total of 74 carbon pricing instruments in operation, 28 of which were ETSs[9]. In addition to these, eight others developing ETSs have been mapped that are due to come into operation in the next few years, including Colombia, Indonesia and Vietnam. There are also 12 jurisdictions that are considering the implementation of an ETS, including Brazil (the Chapter 4 in this report discusses the political and regulatory updates for the establishment of this ETS) and Nigeria, the first African jurisdiction to announce that it is considering the implementation of an ETS (ICAP, 2023a; Plataforma Mexicana de Carbono, 2023; World Bank, 2023b).

A new ETS in European Union (EU) is to be launched by 2028, with a more ambitious climate target of at

8. There are 40 jurisdictions that have carbon taxes, according to data extracted on June 15, 2023.
9. Guanajuato was launched after the publication World Bank (2023a) of Plataforma Mexicana de Carbono (2023). Thus, counting it and the 73 of April 2023 (World Bank, 2023b), there are 74 carbon pricing instruments. The report ICAP (2023a) states that in January 2023, there were 28 ETSs.

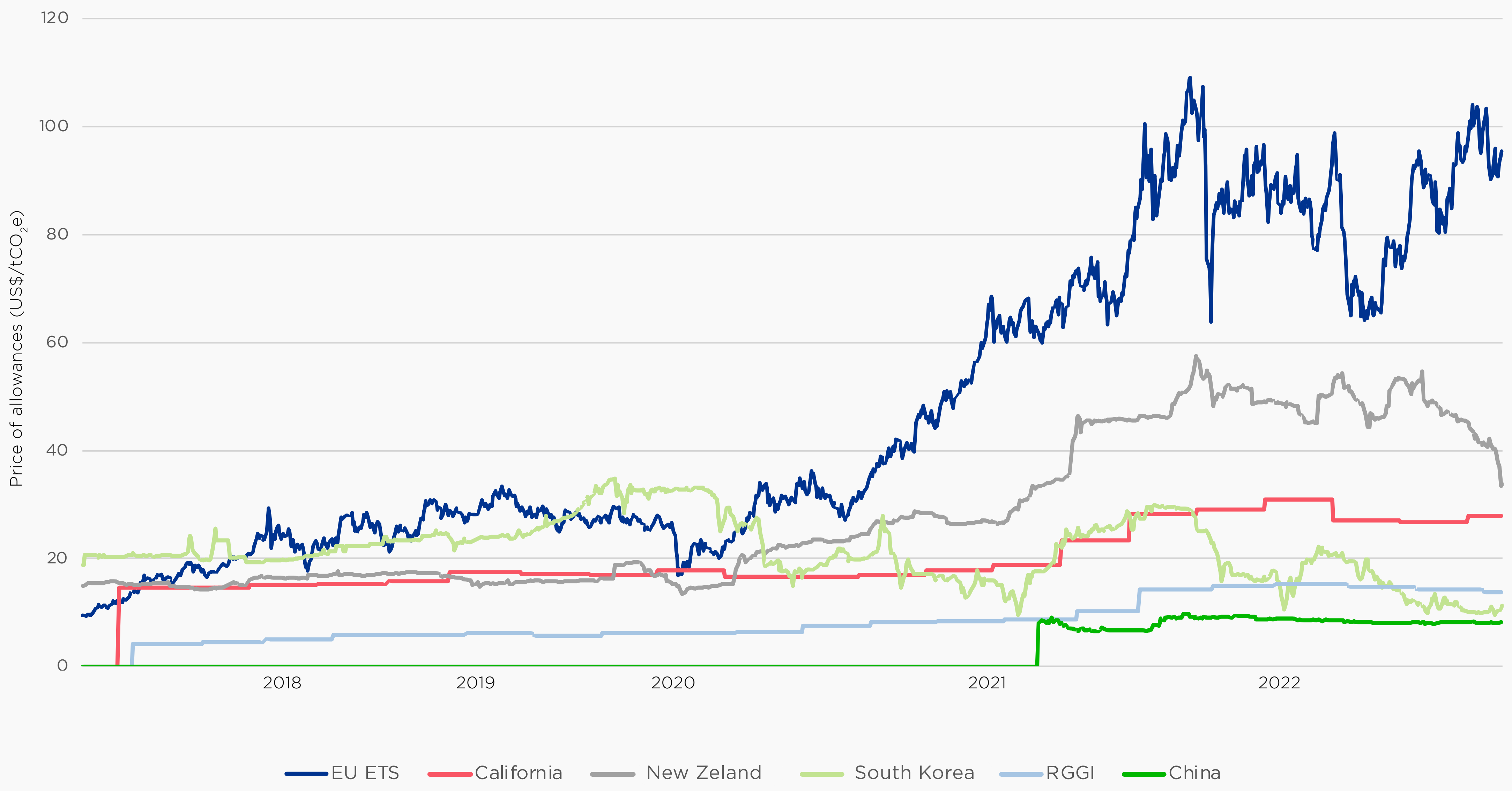
least a 55% net reduction in emissions by 2030 compared to 1990. To achieve this, the new ETS is expected to include emissions from fuels used in buildings, road transport (regulating fuel suppliers rather than end consumers) and industrial sectors not yet covered by the current EU ETS. Currently, the most regulated sectors in ETSs are energy and industry (ICAP, 2023a). The systems generally establish stages for the inclusion of new sectors. Germany's ETS, for example, recently extended its coverage to include coal-derived fuels used in installations not covered by the EU ETS (World Bank, 2023b). Figure 3 shows the regulated sectors in various ETSs.

Figure 3 - Regulated sectors in ETSs

Source: ICAP (2023a).

The evolution of allowance prices is driven by factors such as: changes in the current and expected future scarcity of allowances in either the short or long term; marginal abatement costs of technologies in the regulated sectors; variations in general economic conditions, such as the energy crisis resulting from the war in Ukraine; revisions to system rules; and interactions with other climate and energy policies. Despite significant volatility, prices in the EU ETS, the first to be implemented, have continued to rise over the last 12 months. Against the backdrop of the energy crisis, allowance prices in the EU ETS increased by 8.6% between June 2022 and May 2023, reaching a peak of € 100.34/tCO_2 in February 2023 (IETA, 2023a). Most jurisdictions are following this trend. Among the exceptions is South Korea's ETS, possibly due to the increase in cap due to the transition between phase 2 and phase 3 with the inclusion of more sectors (ICAP, 2023a). Figure 4 shows the variation in the price of allowances for the following ETSs: European Union (EU ETS), China, New Zealand, California[10], RGGI[11] and South Korea.

Figure 4 - Price of allowances 2018-2023 in the main ETSs



Source: Own elaboration based on data from ICAP (2023b). Data extraction on: 03/15/2023.

10. The Quebec ETS uses the same price as the California ETS for its allowances.
11. The Regional Greenhouse Gas Initiative (RGGI) is a cooperative market-based effort between the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and Virginia to limit and reduce CO_2 emissions from the electricity sector. It represents the first regional initiative implemented in the United States with auctions in which participants can choose to submit a single bid for all the allowances they want or a series of bids for groups of allowances at different prices.

Despite this growth, most of the emissions covered by the ETS are in systems where average prices were below US$ 10 in 2022, while around a fifth of this total is in systems where the average price of allowances in 2022 was above US$ 70. Differences between the prices of allowances from different ETSs are driven by various factors. These include variations in abatement costs among different countries, differences in the ambition levels of the systems (determined through the cap), changes in the current and expected future scarcity of allowances in each system, variations in general economic conditions, system design and policy reforms (Gusmão *et al.*, 2015; Hof *et al.*, 2017; ICAP, 2023a).

Although allowance prices have risen in all ETSs involved in the Carbon Market Policy Dialogue (CMPD)[12] during 2021, reaching the US$ 100/tCO_2e needed to achieve the Paris Agreement's 2°C scenario remains a major challenge (Galdi *et al.*, 2022). It is believed that prices need to increase globally in the long term to achieve climate neutrality on the scale and at the pace required, being between US$ 61 and US$ 122 (excluding the effect of inflation) by 2030. However, less than 5% of global GHG emissions will be covered by a carbon price equal to or higher than this by 2030, most of which will be in Europe (World Bank, 2023b).

As for revenues, there was a growth of more than 10% in 2022, reaching almost US$ 95 billion globally, with 69% coming from ETSs and 31% from carbon taxes. Different regulatory design features affect the amount of revenue generated by a carbon tax or ETS, including which emissions sources are covered and how the price is set, as well as the level of baselines or free allocations, the use of auctions, rebate schemes and offsets (World Bank, 2023b).

It should also be noted that, after years of planning and negotiations, in April 2023, the European Parliament and Council approved the regulation establishing the European Union's Carbon Border Adjustment Mechanism (EU CBAM). CBAM's main objective is to guarantee the competitiveness of local industry, preventing carbon leakage and encouraging comparable levels of climate action globally, particularly, with regard to emission-intensive products traded internationally. This mechanism, whose transition phase will begin in October 2023, provides for a tax on imports of aluminum, cement, iron and steel, electricity, fertilizers and hydrogen into the EU. China, the United States, Canada and the United Kingdom are trading partners that are likely to establish a similar mechanism in response to the European Union's CBAM (IETA, 2023a).

2.2. INTERACTION BETWEEN MARKETS

Each carbon market environment has a different transaction unit. In ETSs, regulated carbon markets at a regional, national or sub-national level, the transaction is for **emissions allowances**. In the international market regulated under the Paris Agreement, there are two mechanisms: the units traded under **Article 6.2** and **Article 6.4** are, respectively, (i) Internationally Transferred Mitigation Outcomes (ITMOs), in which emission mitigation outcomes from one country can be traded for compliance with another country's NDC; and (ii) Article 6. 4 Emission Reductions (A6.4ER), emission reductions generated by a country's private sector carbon projects that can be traded by the company responsible for the project or the host country for compliance with another country's NDC or to foreign private companies. The **voluntary market**, on the other hand, trades certified or verified emission reductions (CER/VER) known as carbon credits generated by carbon projects that can be used to offset emissions (ICC Brasil & WayCarbon, 2021).

In all these markets, although the origin of the unit traded is different, the unit of measurement is the same: tons of carbon dioxide equivalent (tCO_2e)[13]. Generally speaking, the term "carbon price" is used for the same unit of measurement. In this way, given the allowances of the systems' regulators, interaction between regulated markets and the voluntary market is possible. **The inclusion of voluntary market credits on a limited basis can be used as a system flexibility mechanism to help meet the goals of a regulated market.**

2.2.1. INTERACTION BETWEEN REGIONAL, NATIONAL AND SUB-NATIONAL REGULATED MARKETS AND THE VOLUNTARY MARKET

Carbon credits generated in the voluntary market can serve not only voluntary climate contribution purposes but also compliance in domestically and/or internationally regulated markets, as long as they are authorized by the regulations. There are ETSs and carbon taxes that allow some use of additional GHG reductions produced by those outside the cap (nationally or internationally). ETSs already give companies a certain amount of flexibility, as they can choose between reducing their own emissions and buying allowances from the market. In addition, offsets with carbon credits can further increase this flexibility to meet climate targets (La Hoz Theuer *et al.*, 2023). Generators of carbon credits can sell them to producers of GHGs covered by the ETS. However, there are ETS-specific rules that limit the amount and types of offsets that will be used to comply with the ETS (ISDA, 2021).

Offsets with carbon credits can reduce compliance costs by providing additional, potentially lower-cost abatement options for companies and, at the same time, encourage mitigation activities from other sectors and/or regions (La Hoz Theuer *et al.*, 2023). As cheaper abatement costs tend to be concentrated in less developed economies, emissions offsets have the potential to provide a platform for international cooperation (Galdi *et al.*, 2022). While there are advantages to

12. Composed of the EU ETS and the ETSs of California, China, New Zealand, Quebec and Switzerland, this group aims to deepen cooperation between the ETSs.
13. For the same unit of measurement, the term carbon price is often used generically.

using carbon credits in regulated markets, experience suggests that the use of offsets can also pose risks to the objectives of an ETS (La Hoz Theuer *et al.*, 2023).

The first experience of ETSs with emission offsets was the EU ETS. Offsets under the EU ETS were intended to be supplementary to domestic abatement, acting as a cost containment measure in the event of a shortage of domestic allowances that would make them too expensive. During phase II (2008-2012), the EU ETS already had a considerable surplus of allowances, making the use of offset credits essentially unnecessary. Even so, many credits were still given away as a cheaper option for compliance, with surplus allowances deposited for later years. Thus, the high imports of international credits added to the effects of the economic crisis experienced at the time led to an oversupply of allowances by 1 $GtCO_2e$. As a result, the price of allowances fell, damaging the cost-benefit ratio of the system in the long term, since it was not worthwhile for companies in the regulated sectors to invest in mitigating their emissions (Galdi *et al.*, 2022). Currently, the EU ETS no longer accepts offsets and there are still other jurisdictions that have chosen - either from the outset or subsequently, due to unfavorable experiences - not to accept offsets (Asian Development Bank, 2016).

Dependence on offsets can therefore discourage mitigation and low-carbon investments in regulated sectors (La Hoz Theuer *et al.*, 2023). With this dependence on offsets, regulated sectors in the ETS tend to be locked into high-carbon technologies, delaying effective action and making emissions reductions more expensive in the future. Thus, it can be said that in the long term, as the market matures, dependence on the use of offset credits can delay domestic action to reduce emissions and the low-carbon transformation of the sectors covered by the ETS. On the other hand, in the short term, with the system in its early stages, the flexibility to meet commitments through offset credits is particularly useful for ETS participants to minimize the economic cost of GHG mitigation (Asian Development Bank, 2016). Thus, it can be inferred that **if an ETS begins by accepting offsets, it is necessary that, as it matures, there is a reassessment of the inclusion of offsets, identifying whether their impacts are still advantageous for the system**. Currently, the ETSs that do not include compensation are: Austria, Germany, China, Massachusetts (USA), Montenegro, New Zealand, Oregon (USA), UK, EU ETS, New Scotia (Canada) and Switzerland. China is considering whether to include it.

Colombia and Vietnam, still developing their ETSs, are already considering integration with offsets[14] in the development of their respective systems (ICAP, 2023a). In addition, it is important to note that even if countries do not currently accept offsets, this limitation can be reviewed. For example, the UK government has indicated that it is open to reviewing this restriction as the system evolves, especially to decide how to implement obligations under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)[15] alongside the aviation ETS. Frame 1 shows which ETSs currently have offset participation and what the restrictions are for this inclusion.

14. In Vietnam, international and domestic offsets. In Colombia, only projects registered in a specific national registration program.
15. Carbon offset system for aviation.

Frame 1- ETSs with offset participation and their restrictions for inclusion

ETS	Geographical restriction	Offsets restriction	Other types of restrictions
Canadá	No	No	There are other requirements, but they have not been specified
Kazakhstan			Not specified
Saitama (Japão)			Type of project
South Korea		5%	For CDM projects, there are limitations on the origin of the company responsible for the project
California (EUA)	Yes, only credits generated in the country.	4% (until 2025) and 6% (from 2026 to 2030)	Not specified
Mexico		10%	GHG types and others yet to be specified
Shenzhen (China)		10%	Type of project
Quebec (Canada)	Yes, credits generated in the country or from a linked jurisdiction (California).	8%	There are other requirements, but they have not been specified
RGGI (USA)	Yes, only credits generated in the jurisdiction	3.30%	Types of project
Washington (EUA)		No	There are other requirements, but they have not been specified
Chongqing (China)		8%	Timing and type of project
Fujian (China)		5% (non-forestry credits) or 10% (mix of forestry and non-forestry credits)	Type of project
Guangdong (China)		10%	Types of GHG
Shanghai (China)		1%	Type of project
Tianjin (China)		10%	Timing and type of project
Tokyo (Japan)		No	Type of project
Beijing (China)	Yes, only credits generated in the country, with at least 50% within the jurisdiction.	5%	Timing depending on each type of project
Hubei (China)	Yes, projects must be located in key counties under the national or provincial poverty alleviation plan in the jurisdiction.	10%	Timing and type of project

Source: World Bank (2023c).

It can be seen that in the jurisdictions that have restrictions on the inclusion of offsets, there are no percentages higher than 10%. Most jurisdictions require that the credits to be included be generated in the national territory or jurisdiction, and there are other forms of restriction, the most common being the acceptance of only certain types of specific projects. In the Tokyo ETS, for example, the use of carbon credits has been restricted to those of domestic origin that are traded at high prices. This has shown that **strategic design and integration of offsetting measures may be necessary to help installations achieve emissions reductions, bypassing problems faced in other systems associated with reliance on and extensive use of offsets** (Asian Development Bank, 2016).

Therefore, **it is important to understand what types of credits are included to provide better value for money while protecting the environmental integrity, which is associated with their ability to represent real, lasting, incremental, and verifiable emissions reductions** (Galdi *et al.*, 2022). It should be emphasized that it is the responsibility of jurisdictions to ensure the environmental integrity of the offsets included in the ETS, in particular with regard to their additionality[16] , baseline value[17], and risk of non-permanence[18] (La Hoz Theuer *et al.*, 2023).

In addition, **the desire to reduce compliance costs may increase over time, regardless of considera-**

16. The concept of additionality requires that any mitigation measure considered for a market-based mechanism demonstrates that the corresponding emission reductions would not have occurred without the support of such a mechanism. Additionality is key to ensuring that units that do not represent real emissions reductions do not undermine carbon markets. If these units are used to meet mitigation (offset) obligations, this would result in an overall increase in emissions rather than a reduction. Additionality is therefore a safeguard for environmental integrity (Michaelowa *et al.*, 2019).
17. The baseline is a scenario defined as reasonable and conservative that would exist in the absence of the carbon project. When defining the baseline, the project developer must consider the applicable legislation and the effectiveness of its application (Gold Standard, 2022).
18. The risk of non-permanence is the risk that carbon avoided or removed by a project will not be sustained over the specified time period (BeZero Carbon, 2022).

tions for international cooperation and of support in developing countries, which may lead ETS regulators to decide to include offsets in their systems. Carbon credits from the voluntary market can therefore play an important role for the future of ETSs and global emissions reduction (Galdi *et al.*, 2022).

2.2.2. INTERACTION BETWEEN THE MARKETS REGULATED BY THE PARIS AGREEMENT, JURISDICTIONAL MARKETS, AND THE VOLUNTARY MARKET

Following negotiations at the 26th Conference of the Parties (COP26) on the relevant adjustments[19], the relationship between the market regulated by the Paris Agreement and the voluntary markets remains uncertain, and therefore various supervisory measures are already underway to help reduce this uncertainty and provide greater clarity for users of these markets. Although the text adopted in Glasgow does not regulate the voluntary market, it is possible that the sale of these credits will be influenced by decisions under the Paris Agreement[20] (ICROA, 2021).

In this scenario, there is an inevitable tension between promoting carbon markets to raise funds, regulating and monitoring these markets to ensure environmental integrity, and achieving the sustainable development goals demanded by investors. There is also a risk that increasing regulatory and oversight efforts will lead to further uncertainty about which regulations will ultimately be enforced. Furthermore, the credits offered in the voluntary markets predominantly come from avoided emissions, particularly from Reduction of Emissions from Deforestation and Degradation (REDD+), which do not actually reduce countries' emissions (Fattouh & Maino, 2022). According to Climate Focus, approximately, 78% of credits issued between 2002 and 2022 come from avoided deforestation or forest conversion (Climate Focus, 2022). Therefore, the agenda for integrating markets should be to promote convergent mechanisms, exploit cost-effective opportunities, create relevant investment flows for the transition, and harmonize regulations to ensure the integrity of these markets.

Box 1

REDD+ PROJECT CREDITS

Despite the popularity of REDD+ project credits in the voluntary market, there is still no clarity about their role in the carbon markets regulated by Article 6. The payment-for-results model is covered in Article 5 of the Paris Agreement, which also covers the REDD+ mechanism.

However, because the definition of ITMOs includes emission reductions and removals without explicitly including or excluding specific sectors, there is an expectation that emission reduction activities such as REDD+ can become ITMOs. Based on this, it is expected that high-quality REDD+ programs at jurisdictional level that meet all other requirements of Article 6.2 can be used to achieve NDCs and other international mitigation goals (Ecosystem marketplace, 2021; UN-Redd Programme, 2022).

However, institutions such as the International Emissions Trading Association (IETA) and the International Carbon Reduction and Offsetting Accreditation (ICROA) have already raised concerns about the overlap between the concepts of REDD+ under Article 5 of the Paris Agreement and verified credits. This is because there are significant differences between verified carbon credits generated using independent standards recognized for carbon markets and mitigation outcomes generated under the Warsaw Framework[21]. Although the Warsaw Framework provides the basis for REDD+ programs, it was not created to act as a standard or mechanism for carbon credits (IETA, 2023b).

Following a debate between the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), there was no consensus that Article 5 outcomes were eligible for market-based approaches, so further consideration should be given to the review modalities before allowing this. The relevant United Nations (UN) decision states that moving to a market-based approach - carbon trading - for the Warsaw Framework would require additional guidance for governments, particularly with regard to verification.

In addition, the quality of REDD+ credits in the voluntary market is often questioned because of evidence that deforestation would be avoided in the project area even without them, or that the risk of deforestation is overestimated. A recent article published in The Guardian newspaper again questioned the quality of REDD+ credits based on studies that sought to assess the effectiveness of projects in avoiding deforestation, claiming that most credits are useless in addressing deforestation (The Guardian, 2023). However, Verra, the largest certifier in the voluntary market, claims that the methodology used in the studies is not suitable for analyzing the effectiveness of REDD+ projects, since the location of the projects is not random, a factor that would affect the analyzes using the synthetic control methods used in the studies published by The Guardian (Verra, 2023)
.

19. It consists of a mechanism to avoid double counting of traded credits, whereby the buying country receives a "credit" in its NDC, while the selling country "debits" its NDC with the corresponding sold credits.
20. This is due to the emission reduction accounting requirements to meet NDCs and the need to make appropriate adjustments in international trade.
21. The Warsaw Framework created at COP 21 established a structure for the implementation of REDD+ activities aimed at environmental integrity and tangible results. A crucial element of the framework is the modalities for measurement, reporting and verification (MRV) of greenhouse gas emissions and removals, as an essential tool for linking REDD+ activities with results-based financing (Voigt & Ferreira, 2015).

However, given the uncertainty surrounding the relationship between the voluntary market and Article 6 carbon credits, it may be necessary to align the voluntary market rules with those of Article 6, in particular with regard to the corresponding adjustments. For example, the Gold Standard has already announced that it will allow the issuance and trading of Article 6 approved credits through its registry and that it will provide tags for approved credits and track whether the appropriate adjustments have been made. In 2022, the Gold Standard has also entered into a partnership with the Swedish Energy Agency, which will adapt the credit trading verifier's infrastructure to facilitate Article 6 credit transactions (Leugers, 2021). Since emissions claimed as offset by private companies are not included in the host country's NDC, there would be no need for Verra to make a corresponding adjustment, since the national accounts of the host country are not affected by voluntary measures. Therefore, in Verra's view, the corresponding adjustment should not apply to credits traded solely in the voluntary market (Verra, 2021). This would not apply when credits are traded between voluntary and regulated markets.

Under Article 6.2, countries can authorize the use of mitigation outcomes in three main ways: 1) to comply with NDCs; 2) for international climate change purposes other than compliance with NDCs, such as CORSIA; or 3) for "other purposes" – concepts that are not defined but are assumed to be used by ITMOs for corporate climate commitments and other voluntary commitments (VCM Primer, 2021).

These ITMOs, when used by companies in countries other than the transferring country, either on a voluntary basis or in the national regulated market, would be subject to the appropriate adjustment, although the timing at which the parties must make the adjustments may differ, giving them more options (UNDP, 2022). **This allows the generation of "adjusted" carbon credits that can be traded for voluntary offsets, thereby avoiding double counting**. For this to happen, the receiving country must authorize the use of ITMOs, giving countries more control over how mitigation results can be used and which can be transferred abroad. **This could create incentives for host countries to transfer mitigation results from projects to sectors that are difficult to abate – with higher marginal abatement cost (MAC) – attracting finance to these sectors, and use the mitigation results of low abatement cost projects to meet their own NDCs** (Fattouh & Maino, 2022).

Article 6.4 could also be relevant to the voluntary market, as credits issued through the mechanism could be traded and withdrawn by voluntary market participants such as project developers, intermediaries, and companies. Some Emission Reduction credits under Article 6.4 (A6.4ERs) may be approved by the host country of carbon projects to be used for compliance purposes in nationally regulated markets in other countries. Since the use of these A6.4ERs would reduce the host country's emissions, this requires a corresponding adjustment to the selling country's GHG emissions inventory at the time of the initial international transfer and a further adjustment to the GHG emissions inventory of the country where the purchasing company is located. On the other hand, Article 6.4 credits that are not approved for international use in other NDCs were designated as Mitigation Contribution Emission Reductions (MCERs) at COP 27 and do not require corresponding adjustments, as the mitigation impact continues to accumulate in the country, as they already contribute to the host country's NDC. However, the debate is ongoing and such unapproved MCERs can only be used for certain purposes, as the list of use cases agreed in the text of Article 6.4 of COP 27 was deliberately left open (IETA, 2023c).

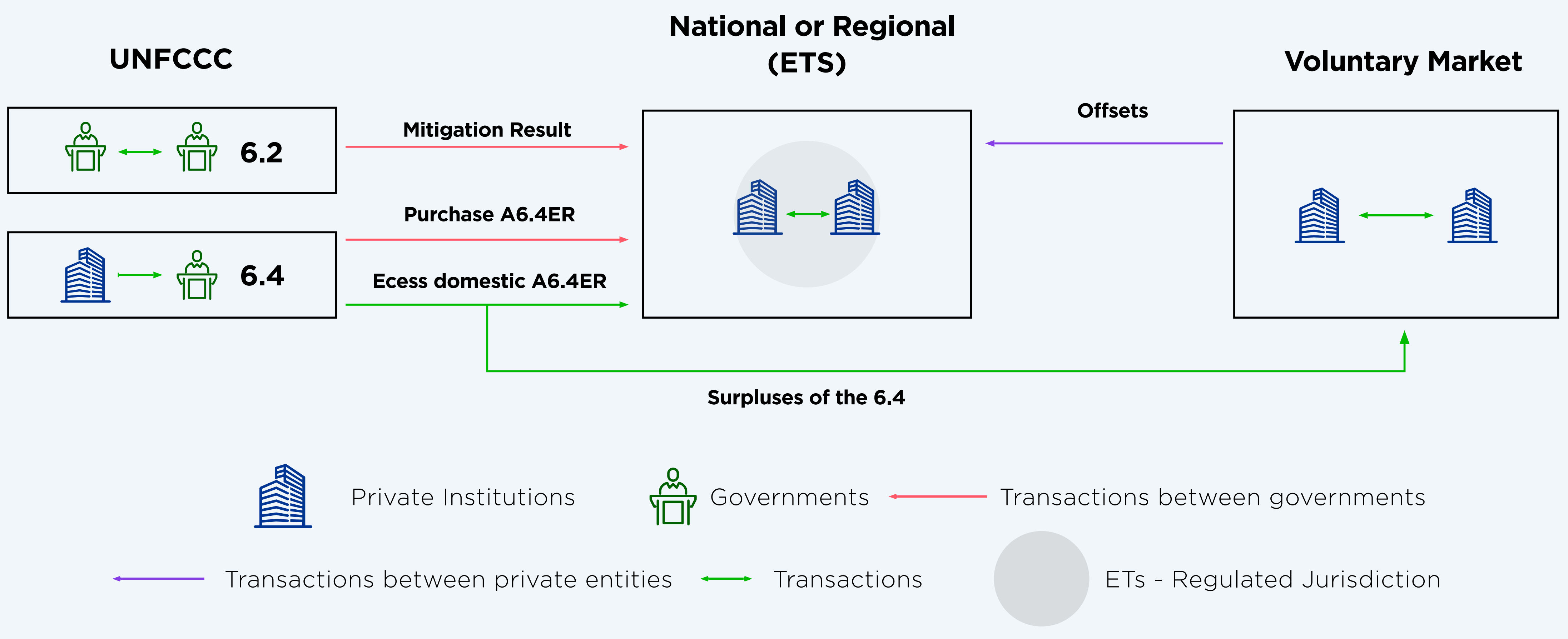
As a result, the use of credits for offsetting purposes could take various paths, mainly depending on whether the host country of the project accepts the sale of credits and the appropriate adjustment. Governments, for their part, will have to decide how to use the voluntary market and be selective in approving credits that contribute or do not contribute to the NDCs. **It can be beneficial for the host country to attract funds from the private sector to collectively achieve emissions reductions, and it is important to identify priority sectors where the voluntary market can fund mitigation actions that would otherwise be more expensive**.

2.3. KEY MESSAGES

1 Interaction flows between trading environments in carbon markets:

- Figure 5 illustrates these flows and the entities involved.

Figure 5 - Interaction between carbon market environments



Source: Own elaboration[22].

2 Prices of allowances:

- Although there was a sharp increase in the price level for allowances at the end of 2021, the increase did not continue at the same pace in 2022. However, it is assumed that prices will continue to rise worldwide in the long term to drive investments towards climate neutrality at the required scale and pace.

3 Border adjustment mechanisms:

- Not only the European Union with CBAM, but also other countries such as China, the United States, Canada, and the United Kingdom are working on introducing carbon taxes on imported products (border adjustment) instead of exemptions for exported products. Therefore, exporting country governments need to be vigilant and prepare for possible taxes that the countries in question may impose in their export agenda.

4 System maturation:

- In regulated markets, the number of regulated sectors increases, typically starting with fuels and industry, and moving to more sectors as the system matures.

- In more mature systems, such as the EU ETS, there is a tendency toward greater restrictions on the use of offsets. In the short term, the ETS strategy should be to include offsets to reduce corporate compliance costs and promote decarbonization in other sectors and/or regions. In the long term, as systems mature, the strategy is to limit the use of offsets with domestically generated credits – or even not use carbon credits at all – so that the dependence on offsets does not unduly discourage climate protection and low-carbon investments in the regulated sectors.

5 Regarding the mechanisms under Article 6

- Decisions under the Paris Agreement are expected to impact the international trade of carbon credits. It will be necessary to harmonize the rules of the markets, in particular regarding the relevant adjustments.

- Although there is still no specific definition of the types of projects that will be accepted under the Paris Agreement mechanisms, since the definition of ITMOs includes emissions reductions and removals without explicitly including or excluding specific sectors, it is expected that emissions reduction activities, such as REDD+, could be included in the Article 6.2 mechanism.

22. This figure is an updated version of a similar figure presented in the first edition of this report. The understanding of the interaction flows between trading environments has changed since the development of the documents dealing with the functioning of the mechanisms of Article 6 of the Paris Agreement.

3. POTENTIAL IMPACT OF THE EU CBAM ON SELECTED BRAZILIAN PRODUCTS

As national climate policies become more ambitious, the question of border adjustment mechanisms comes into focus. As carbon pricing faces the fundamental problem of the "free-rider", where each country has an incentive to leave the climate change challenge to others, these instruments may be one way to improve carbon pricing internationally. In December 2022, the European Union announced its Carbon Border Adjustment Mechanism (CBAM), and other countries such as Canada, the United Kingdom, and the United States are considering implementing similar systems (Canada, 2021; US Trade representative, 2021; UK Government, 2023).

A border adjustment mechanism for carbon pricing consists of a levy on the carbon content of imported products from which it is expected to provide equivalent treatment to the domestic price of carbon, possibly combined with rebates on the carbon content of exports[23]. However, in the case of the EUCBAM, the adjustment mechanism is intended to replace free allocation to exporters (European Comission, 2023) and introduce market control measures considering environmental aspects.

The EU CBAM has another purpose. This standard aims to prevent European companies from relocating their production to countries where there is no obligation to offset greenhouse gas emissions or even a loss of competitiveness of European products compared to cheaper imports, as there are no costs to offset emissions. On the other hand, the EU CBAM brings the argument of encouraging the reduction of emissions in exporting countries, although this purpose is questioned by these directly impacted countries.

According to Keen, Parry e Roaf (2021), countries typically introduce these mechanisms for three main reasons:

- **To maintain the competitiveness of domestic industries in the face of domestic carbon pricing** by trying to avoid distortions in the relative prices of domestic and foreign goods and to avoid discrimination – which may also contribute to the acceptability of carbon pricing policies**;**
- **To reduce the risk of carbon leakage,** i.e., to partially offset the increase in emissions abroad caused by national climate change policies, which is a sign of addressing the effects of climate change not only at the national level but also beyond borders; •
- At the international level, border adjustment mechanisms can **increase the incentives for carbon pricing**, since there is a direct fiscal incentive to the extent that countries that do not participate in the mechanism in practice forego the revenue from their exports that the importing country receives through the mechanism.

Although they are related, Keen, Parry e Roaf (2021) emphasize that these goals are different. For example, it is possible that emissions leakage is significant even if the impact of carbon pricing on competitiveness is small, and vice versa. Accordingly, policymakers should pay attention to three key points depending on the desired goal: 1) how to structure this mechanism well, i.e. define sectoral coverage, how to measure carbon content of traded goods, how to treat exports etc.; 2) whether the border adjustment mechanism is preferable to other instruments such as free allocation; and 3) it is also recommended that the integrity of the CBAM and the ETS be maintained through equivalent constraints, such as requiring measurement of indirect emissions, ensuring equal treatment, and avoiding flexibility. This approach would ensure compliance with General Agreement on Tariffs and Trade (GATT) Article 3 and promote a level playing field and nondiscrimination in international trade. In making these decisions, policymakers must also consider the preservation of domestic incentives for GHG mitigation, the revenue implications of the pricing instrument, and the administrative and compliance costs of the system.

Under the EU CBAM, which is in force in the transition period from October 2023, in the final phase of the mechanism[24], EU importers of goods covered by the CBAM will have to purchase CBAM certificates, the price of which is based on the average weekly auction price for EU ETS allowances, expressed in €/ton of CO_2 emitted.

If importers are able to demonstrate not only payment of a carbon price in the production of imported goods, but also prove the carbon footprint of their products to avoid taxation based on the EU averages, the corresponding amount could be deducted from the total amount payable (European Comission, 2023).

23. Remission of export duties is treated as an optional feature - and indeed many proposals do not provide for such a rebate (Keen *et al.*, 2021).
24. From January 2026.

3.1. AN OVERVIEW OF THE POSSIBLE IMPACTS OF A CBAM

The CBAM has established itself as a tool to reduce the risk of carbon leakage and create a level playing field for industry in decarbonizing the economy. However, questions still remain about the potential impact of the CBAM on exports and the competitiveness of developing countries, established methodologies, and the creation of trade distortions through the introduction of the mechanism, bringing up discussions about the need to support low and middle-income countries. There is a consensus that these countries need support to introduce green technologies into their production processes and thus reduce associated CO_2 emissions.

Therefore, the impact of the CBAM can be assessed from two main perspectives. The first concerns the effectiveness of the mechanisms in reducing emissions and carbon leakage. The other concerns the potential macroeconomic impact of carbon pricing on imports from countries that adopt the mechanism[25]. The macroeconomic impact approach requires identifying the impact of these instruments on welfare and employment (UNCTAD, 2021).

When analyzing these two perspectives, considering carbon pricing with and without the simultaneous implementation of a CBAM, it is important to note that most studies, including those of UNCTAD (2021), reach consistent conclusions: carbon pricing leads to carbon leakage, while the introduction of a CBAM mechanism leads to a significant reduction in this leakage[26]. Pricing encourages CO_2 emission reductions while mitigating carbon leakage through the CBAM and changing trading patterns in favor of countries where production is relatively more efficient in terms of GHG emissions[27].

3.1.1. REDUCING EMISSIONS AND CARBON LEAKAGE

Various studies[28] have examined the efficiency of CBAM in minimizing carbon leakage and reducing CO_2 emissions. Böhringer, Carbone e Rutherford (2014) estimate that the reduction in carbon leakage is between 2% and 12%. However, the experience with a CBAM in the electricity sector in California, a jurisdiction with an ETS, has proven less effective in reducing carbon leakage due to the limited scope of the policy and the Pauer (2018) so-called "resource shuffling". This happens when electricity importers replace carbon-intensive sources with low-carbon ones while the replaced facility continues to produce carbon-intensive electricity, which is ultimately consumed by other users in jurisdictions with more permissive regulations, reducing global CO_2 reduction efforts.

In the specific case of the European scenario with the introduction of the carbon pricing, the magnitude of emission reductions is considered significant by UNCTAD, and without the synchronized implementation of a CBAM, the EU would suffer a significant carbon leakage. And in a scenario with a US\$ 44/tCO_2 tax on imports of electricity and energy-intensive industrial products[29], leakage is reduced by more than fifty percent (from 13.3% to 5.2%), suggesting that the CBAM can be an effective tool (UNCTAD, 2021)[30]. The actual impact of the EU CBAM will need to be assessed and monitored over time to allow a proper evaluation of its evolution.

Markkanen *et al.*, (2021) reached similar conclusions, emphasizing that the reduction in carbon leakage would be partially offset by a slight increase in EU emissions, but overall global emissions would fall. If other countries took more ambitious climate policy measures in response to the EU proposal, an even greater reduction in global emissions would be possible. This underlines the importance of international coordination and cooperation in combating climate change to maximize the impact of the actions taken by the EU.

3.1.2. MACROECONOMIC IMPACTS

The macroeconomic impacts of a CBAM depend on how the instrument is designed and how it is analyzed. Modeling studies suggest that the EU CBAM could lead to a slight increase in EU Gross Domestic Product (GDP), 0.2% by 2030 and 0.4% by 2050, and create an additional 600,000 jobs (Markkanen *et al.*, 2021). Other studies suggest that tariffs could create negative distributional effects for countries affected by the measure and may increase inequality among nations (Böhringer *et al.*, 2014).

Estimates also suggest that if the EU CBAM were applied to all goods covered by the ETS, there could be additional costs for exports from developing countries (Lowe, 2021). The Boston Consulting Group calculated that the steel sector, for example, could be hit hardest in China and Russia due to the high carbon intensity of the production process, while Turkey and India could become more attractive due to cleaner processes (Aylor *et al.*, 2020).

As for the Brazilian context, 10.4% of Brazilian exports are destined for the EU and are now subject to the CBAM. As a result, Oliveira and Santos (2022) estimate that in a scenario where the sector reduces its emissions by 45%, the impact on the added value of steel exports to the EU would be at least 15%, considering that the entire amount corresponding to the CBAM fees would be absorbed by the sector. If no measures are taken to reduce emissions, the impact on the added value of the sector's imports could reach

25. For example, in the case of the EU, India, Brazil and South Africa would be the most affected developing countries, while Mozambique would be the most affected least developed country, considering the volume of imports from the sectors covered by the EU CBAM (UNCTAD, 2021).
26. There is no clear evidence of a significant carbon leakage in the EU ETS (Verde, 2020). However, the lack of evidence can be attributed to the fact that the analyses focus on the early stages of the EU ETS and require follow-up as the systems mature.
27. For example, a domestic carbon price of \$ 88 would result in carbon leakage of 15.1%. The introduction of the CBAM would reduce carbon leakage to about 6.9% UNCTAD (2021), p. 18. Accessed on July 31, 2023.
28. Namely, Bao *et al.* (2012), Monjon e Quirion (2011), Weisbach *et al.* (2013).
29. Cement, glass, steel, aluminum, paper and pulp, petroleum and coal derivatives, chemicals, and fertilizers.
30. The analyzes presented by UNCTAD (2021) were carried out before the launch of the EU's plan for the CBAM and therefore do not reflect the detailed specifications of what is currently being implemented.

28.5%. The latter is a low-probability scenario, largely due to the commitments already made by several steel companies to reduce emissions.

The analysis of UNCTAD (2021) highlights the potential impact of the EU CBAM, particularly in developing countries. The average decline in exports of these countries in carbon-intensive sectors is only 1.4% with a tax of US$ 44/tCO_2 and just under 2.4% with a tax of US$ 88/tCO_2. In both scenarios, developed countries do not suffer declines in exports, suggesting that the CBAM may widen the gap between developed and developing countries.

This gap stands out when analyzing the impact of this mechanism on income. With a carbon tax of US$ 44/tCO_2, the income of developed countries increases by $ 2.5 billion, as these countries tend to have less carbon-intensive production. On the other hand, the income of developing countries decreases by US$ 5.9 billion[31], since a large proportion of these countries are fossil fuel exporters. In Brazil, the loss of income could reach US$ 444.3 million, with exports of energy-intensive products falling by 1.49% compared to a scenario without the CBAM (UNCTAD, 2021). For Xiaobei, Fan e Jun (2022), the introduction of a CBAM also represents net losses for developing countries, particularly for those dependent on carbon-intensive exports.

The impact on employment and wages is negligible in most economies, remaining well below 0.1%. The CBAM may increase unemployment in countries whose exports to the EU consist predominantly of products covered by the mechanism[32]. On the other hand, unemployment is falling in countries that produce energy-intensive products with relatively low CO_2 emissions (UNCTAD, 2021).

In this context, the role of multilateral institutions in supporting risk analysis and mitigation and improving trade policy responses is relevant. Xiaobei, Fan e Jun (2022) discuss the possibility of establishing an Equitable Decarbonization Fund using CBAM's resources. This could mitigate the risks and impacts caused by the mechanism if the resources are used to promote green investments and provide financial and technological support for mitigation and adaptation in low- and middle-income countries.

In this way, the tax revenues raised by the CBAM, which come mainly from developing countries, would largely flow back to these countries and could be used to stimulate and make their economies greener, thus largely offsetting the negative effects of implementing the mechanism or even achieving a net positive effect (Xiaobei *et al.*, 2022). Furthermore, recycling revenue to support climate action in less developed countries can increase the political acceptance of the EU CBAM outside the bloc and also reduce the risk of trade distortions and retaliation (Markkanen *et al.*, 2021).

Overall, while the data suggests that the macroeconomic impact of a CBAM is likely to be smaller, the potential environmental benefits from reducing CO_2 emissions - both within and outside the country of origin - can be significant. Therefore, in addition to the United Kingdom, which recently launched a public consultation on implementing a similar legislation, it is likely that other countries with ambitious climate targets will follow the EU CBAM's lead, such as the aforementioned Canada, China, and the United States[33].

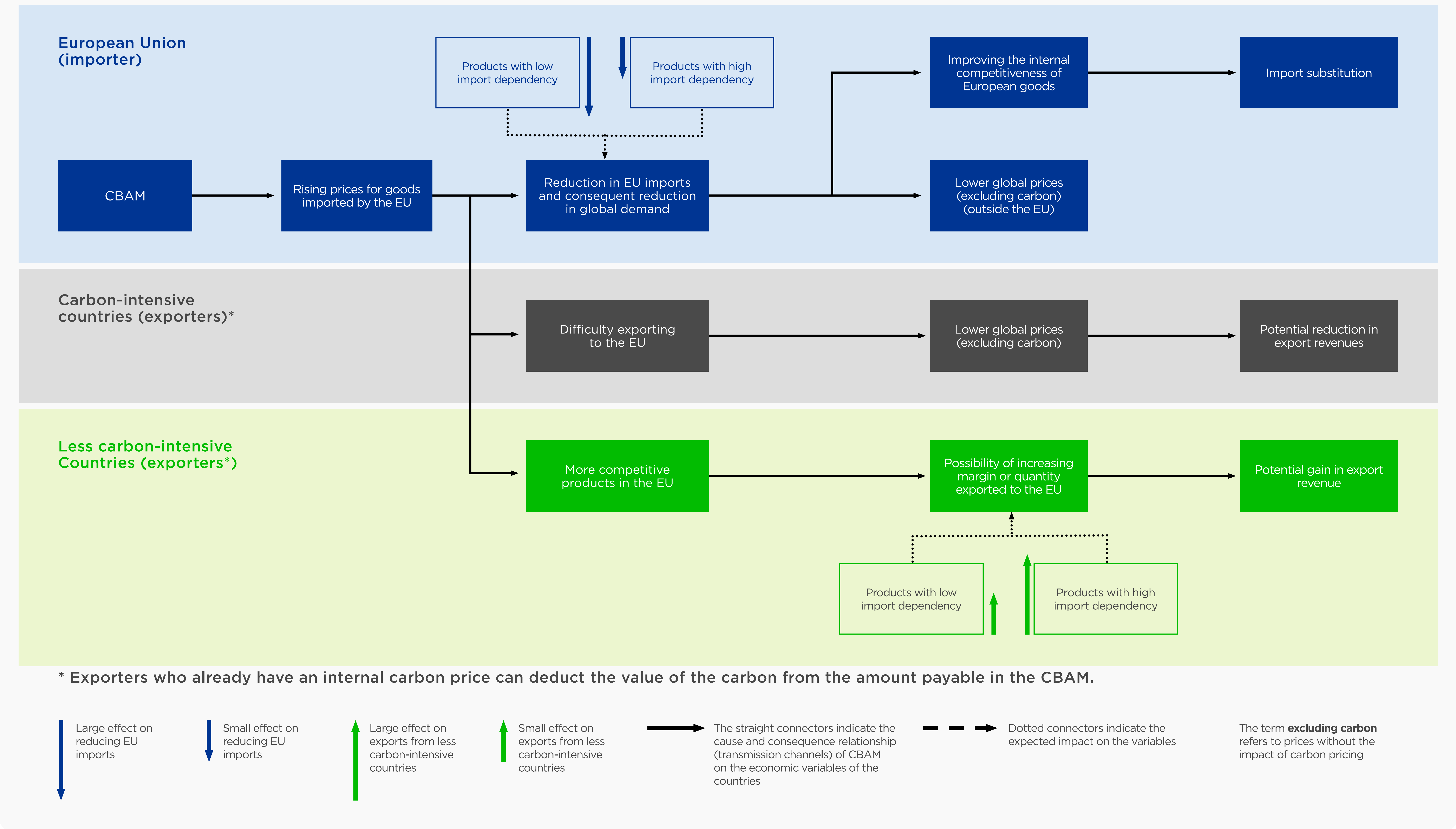
It is important to emphasize that the actual impact of a CBAM depends mainly on the level of carbon emissions included in trading partners' exports, as well as carbon prices already paid in source countries, if any. It is therefore important to implement the mechanism carefully, considering the different economic and industrial contexts of the countries involved, and to look for solutions that support the transition to cleaner technologies in developing countries.

From the perspective of domestic industry competitiveness, global carbon pricing in conjunction with border adjustment mechanisms can be viewed in two ways: while the absence of a domestic carbon price may benefit companies in the short term, it may also weaken their competitive position in the medium to long term, as they are less able to compete in a market environment where carbon emissions are limited (World Bank, 2015). In this way, less carbon-intensive countries such as Brazil can benefit from production costs associated with GHG emissions in manufacturing activities that are relatively low compared to their global peers and can even attract foreign companies.

It should be noted that these effects must be considered along with several other factors. Overall, the cost of carbon emissions will be a factor in many production and investment decisions, including those in emission-intensive sectors. In general, the impact of carbon policies on competitiveness is often less than other more influential factors, such as changes in input costs, overall quality of institutions, levels of education, financial and labor market efficiency, and the quality of the business environment (World Bank, 2015). Figure 6 shows the potential impacts of the CBAM on economies involved in the transactions.

31. Regions that will suffer loss of income due to the introduction of the CBAM include Oceania (with Australia dominating this region), India, Serbia and Bosnia and Herzegovina, the Russian Federation, Ukraine, Saudi Arabia, South Africa, and other Middle Eastern countries, as well to a lesser extent Brazil, Canada, China, and Turkey (UNCTAD, 2021).
32. Such as Kazakhstan, Serbia and Bosnia and Herzegovina, Saudi Arabia, and Ukraine, as well as the countries of the North Africa and Central Asia regional groups.
33. Available at: https://www.gov.uk/government/consultations/addressing-carbon-leakage-risk-to-support-decarbonisation. Retrieved on July 31, 2023.

Figure 6 - Potential impacts of the CBAM on economies involved in the transactions



Source: Own elaboration.

3.2. ANALYSIS OF THE POTENTIAL IMPACT OF THE EU CBAM ON SELECTED BRAZILIAN PRODUCTS

This section assesses the potential impact of border adjustment taxes, based on the case of the European Union CBAM, on the products of the sectors likely to be covered by a regulated market in Brazil. This assessment was made based on the carbon footprint of these products. Currently, the methodology requires the measurement of direct and indirect emissions from the production process for most of the covered sectors, calculated in accordance with Annex IV of the CBAM Regulation (European Comission, 2023). However, the calculation methodology is not yet fully defined and it is planned to consider the inclusion of a product life cycle assessment (LCA) requirement in a future regulatory review. Based on this premise, the methodology used in this chapter evaluates the carbon footprint of the most common products currently exported to the EU.

3.2.1. PRODUCTS

The selection of products was done in three steps. First, Brazilian industrial sectors potentially involved in the carbon market were identified, in accordance with the recommendations of the PMR Brasil project and current draft legislation, in addition to the fact that these are generally the first sectors to be regulated in the initial phases of already implemented pricing systems, namely: fuels and industry (chemicals, paper and pulp, steel, aluminum, cement, lime, glass, food and beverages, textiles, mining, and ceramics). Next, the sectors currently covered by the CBAM were analyzed[34], as well as those included in the European Union list of sectors and subsectors considered at risk of carbon leakage (European Comission, 2019). Finally, the sectors' exposure to international trade was examined, i.e., which sectors account for the largest share of Brazilian exports to the EU and which fall into the steps described above. In this step, the following sectors were identified: manufacture of basic iron and steel, manufacture of vegetable and animal oils and fats, and extraction of crude oil.

The export values of products from these sectors were obtained from the Comex Stat platform of the Brazilian Ministry of Development, Industry, Trade and Services (MDIC). The products were selected based on the consistency of the codes[35] used in the different databases. The goal was to achieve the highest possible level of detail of the product representing each subsector. This process of breaking down the products that make up the sectors was necessary because it was important for selecting a single product that represented the entire sector and also for assessing the carbon footprint (CF).

In addition, the selected product needed to be available in the Ecoinvent database, which was used to assess the emissions associated with its production (Ecoinvent, 2023). With granularity as a criterion, Ecoinvent is the largest and best-known database where life cycle assessments (LCA) for various products can be accessed and which also offers support for sustainability assessments (ECOINVENT, 2023).

The following frames describe each selected sector and the products (most frequently exported from Brazil to the EU) in the Standard Industrial Classification of All Economic Activities (ISIC) and in the Harmonized System (in Portuguese, *Sistema Harmonizado* - SH), as well as the dollar value of exports of the main products in each selected sector in 2022.

Frame 2- Export data, from Brazil to EU, for the main products of the Iron and Steel industry sector (manufacture of basic iron and steel)

ISIC Class Code	ISIC Class Description	SH4 Code	SH4 Description	2022 - FOB Value (Million US$)
2410	Manufacture of basic iron and steel	7207	Iron or non-alloy steel; semi-finished products thereof	5,589.16
		7202	Iron-alloys	4,081.94
		7201	Pig iron and spiegeleisen in pigs, blocks or other primary forms	2,384.46
		7208	Iron or non-alloy steel; flat--rolled products of a width of 600mm or more, hot-rolled, not clad, plated or coated	1,233.68

Source: MDIC (2023).

Frame 3 - Export data, from Brazil to EU, for the main products of the foods and beverages industry (Manufacture of vegetable and animal oils and fats)

ISIC Class Code	ISIC Class Description	SH4 Code	SH4 Description	2022 - FOB Value (Million US$)
1040	Manufacture of vegetable and animal oils and fats	2304	Oil-cake and other solid residues; from the extraction of soya-bean oil	10,335.94
		1507	Soya-bean oil and its fractions; whether or not refined, but not chemically modified	3,930.09
		1508	Ground nut oil and its fractions; whether or not refined, but not chemically modified	275.01
		1502	Fats of bovine animals, sheep or goats, other than those of heading 1503	136.32

Source: MDIC (2023).

34. In its transition period, the mechanism will cover imports from the following sectors: iron and steel; cement; aluminum; fertilizers; hydrogen; and electricity.
35. The ISIC correspondence, which is the reference economic activity classification used to classify productive economic activities and a correspondence was made with the classifications of the National System of Accounts (in Portuguese, *Sistema de Controle de Numerações* - SCN), with the codes in the SH, which is the international classification of goods, so that it was possible to obtain a more broken-down classification.

Frame 4 - Export data, from Brazil to EU, for the product that makes up the Fuel sector (Extraction of crude oil)

ISIC Class Code	ISIC Class Description	SH4 Code	SH4 Description	2022 - FOB Value (Million US$)
0610	Extraction of crude oil	2709	Petroleum oils and oils obtained from bituminous minerals; crude	42,553.77

Source: MDIC (2023).

After selecting the products according to their business activity, the availability of information in the Ecoinvent database was checked. Frame 5 lists the representative product of each selected subsector as well as the main inputs used in the respective production processes. The assessment of these inputs sought to ensure that the data selected by Ecoinvent best represents each of the sectors examined."

Frame 5 - Selected products from each subsector and their main inputs

Sectors (ISIC Class)	Product	Main inputs
Manufacture of basic iron and steel	Steel production, converter, low alloy	• Pig iron • Iron-nickel • Carbon dioxide, fossil
Manufacture of vegetable and animal oils and fats	Soybean meal and crude oil production	• Soybean
Extraction of crude oil	Oil and gas production	• Natural gas • Heavy fuel oil

Source: Ecoinvent (2023).

3.2.2. CARBON FOOTPRINT

This section provides information on the direct and indirect CO_2e emissions associated with a product/process, i.e., emissions that occur at all stages, from the supply chain – such as the energy used to transport and produce raw materials – to direct emissions from production (cradle-to-gate analysis), such as the combustion of fossil fuels in vehicles and appliances. This measurement, determined by LCA, is called a Carbon Footprint ("CF") and is based on the methodology that GHG Protocol (2011) follows the guidelines of ISO 14067 (FOOTPRINT) and ISO 14040/44 (LCA) (Shabir *et al.*, 2023).

The CF was quantified for the three products selected in the previous section, considering their production in Brazil, Europe and on average in the rest of the world, as well as the production data available in the literature. This quantification was carried out to assess the "climatic competitiveness" of domestic and foreign products by comparing the footprints of these products manufactured in different locations and assessing the result of emissions per kilo of product. Through this assessment it is possible to gain an understanding of the impact that domestic products could have in a scenario where the EU CBAM is in force. This is followed by an analysis of Brazil's main competitors in the EU for the selected products and the implications of this analysis for the discussion on border adjustment taxes.

ASSUMPTIONS

For the assessment of specific embedded emissions, the EU CBAM divides products into two groups: simple and composite products. Simple products are those that are produced from a single raw material and fuels with zero implicit carbon emissions (European Comission, 2023). Composite products are those whose production involves the combination of several different raw materials and require complex transformation processes. In this case, the calculation of embedded emissions considers a larger number of variables[36] .

The software used for the calculation was openLCA® with the Ecoinvent v3.9.1 database (Ecoinvent, 2023) and the Intergovernmental Panel on Climate Change (IPCC) 2021 impact calculation method for converting greenhouse gas emissions to CO_2e, evaluating the production of 1 ton of each product. Based on the original data sets (see Annex A), adjustments were made to the database to calculate the CF of these products. This included adjusting emissions factors for the rest of the world to more accurately reflect Brazilian reality. The electricity consumption of Brazil's National Interconnected System (in Portuguese, *Sistema Interligado Nacional* - SIN) was considered, due to the contribution of the individual energy sources from the National Energy Balance (in Portuguese, *Balanço Energético Nacional* - BEN) 2022 (EPE, 2022), while for fuel consumption in the upstream production chain the factors were adjusted according to the

36. In this calculation, besides the emissions from the manufacturing and assembly process of the product, the emissions generated during the extraction of each raw material used are also considered.

national data sets. In the absence of such data, data sets for the Latin American region were used. This was possible because the CBAM offers the possibility of making these types of changes to the emissions calculations to demonstrate that the production facilities and/or processes in a given geographical area are less emissions intensive than the reference and/or European values. It is important to highlight that for this type of change it is necessary that the data are reliable and that alternative adjustments specific to the region follow the guidelines established in the regulations, as per item 7 of Annex IV (European Comission, 2023).

RESULTS

The results obtained for the CO_2e emissions included in the selected products are presented in Table 1. It can be seen that the selected national products are less carbon intensive than the "rest of the world" profile, but not compared to the EU. In the case of steel production in Brazil, the adjustment of the data started from the production process with the profile of the rest of the world (same input and output flows and in the same quantity), changing only the electrical mix and the fuel production profile of both the main product production process and the production of the most representative inputs (those that represent more than 80% of the total emissions). For steel production, in addition to direct production, which accounts for 3% of total emissions, pig iron and iron-nickel were included in the adjustment, accounting for 67% and 18% of total emissions, respectively.

Despite these adjustments, emissions from the combustion of fossil fuels in steel production are significant, and regionalization shows practically no significant changes since emissions from combustion have not changed. Therefore, in general, it can be said that products with higher energy consumption in the production process should have higher emission levels and, consequently, a larger carbon footprint than products manufactured in the EU, which generally have more technological processes with lower consumption. This results in higher taxes being levied on these products. The same applies to the production of oil and gas, where fuel consumption plays a larger role in the footprint than electricity consumption. It should be added that for this last case, the data originally used already applied to Brazil, without the need for additional adjustments.

On the other hand, the soybean process is one and a half times less carbon intensive than its international competitors. This is probably due to the fact that the production processes used in Brazil produce fewer emissions than those used in the rest of the world, including the European Union. This should include the adoption of modern conservation agriculture techniques such as direct farming, crop rotation, and the use of crop-livestock-forest integration (in Portuguese, *integração lavoura-pecuária-floresta* - ILPF) techniques, which have helped reduce emissions from land use change (Estevam *et al.*, 2022; Garofalo *et al.*, 2022).

Table 1 presents the calculation of the carbon footprint in the production of 1 ton of selected products for Brazil, Europe and the rest of the world.

Table 1 - Calculation of carbon footprint in the production of 1 ton of selected products for Brazil, Europe and the rest of the world

Sectors (ISIC Class)	Product	Brazil (tCO_2e)	EU (tCO_2e)	World (tCO_2e)
Manufacture of basic iron and steel	Steel production, converter, low alloy[37]	2.14	2.08	2.18
Manufacture of vegetable and animal oils and fats	Soybean meal and crude oil production	3.04	7.60	7.82
Extraction of crude oil	Oil and gas production[38]	0.34	0.18*	0.39**

FSource: Own elaboration based on data from Ecoinvent (2023).
* Emission calculated considering the average oil production in the Netherlands, Germany, Norway, and Romania.
** Emission calculated considering the average oil production in Russia and Saudi Arabia.

Finally, according to the EU CBAM proposal, tariffs will be levied based on the difference in emissions between imported and European products. Countries exporting to the EU will have to declare the carbon emissions embedded into their products. A benchmark will be set for the emissions allowed in products similar to those produced in the EU and an adjustment fee will be applied based on the average weekly price of EU ETS allowances, expressed in €/tons of CO_2 emitted. As described in Regulation (EU) 2023/956 of the European Parliament (European Parliament & Council of the European Union, 2023), importers must collect a levy as part of the import process to offset the additional emissions and level the playing field for European companies.

In this way, the presence of less emission-intensive products compared to international competitors represents a new element of competitive advantage, since the EU is not self-sufficient in a number of products such as those analyzed in this study.

37. The purpose of the adjustment process is not to change the categories of inputs included in the original data set, but rather to put the relevant input into a regional context. Therefore, the use of Natural Gas rather than charcoal was considered. However, this inclusion was regionalized according to the production profile of Natural Gas in Brazil.
38. This data set represents the life cycle inventory of offshore oil and gas extraction using conventional extraction methods. These figures correspond to the national production average over a time. Therefore, there may be discrepancies regarding the latest information released. Petrobras, for example, reports a footprint of 15.8 kg CO_2e per barrel of oil equivalent, but details of this data are not disclosed.

3.2.3. ANALYSIS OF THE IMPACT OF BORDER ADJUSTMENT TAXES ON BRAZILIAN PRODUCTS

The EU CBAM consists of a tariff on imported products based on their embedded emissions. According to the European Union's argument, the adoption of the CBAM originates in the search for ambitious measures to face the climate challenge in its borders.. To understand the potential impact on Brazilian exports and the impact on the competitiveness of domestic products, it is necessary to understand emissions and the possible inclusion of carbon prices in products from countries that compete directly with Brazil in the European market. This is because, to avoid double pricing, agents who import products that are already subject to a carbon pricing system at their point of origin can have the corresponding payment deducted from the tax payable in the CBAM.

It is clear that there is a fundamental loss of competitiveness for products with the same embedded emissions, as Brazilian products exported to the European Union may become more expensive than products from countries that have already integrated a carbon price into their products, because they are already subject to a pricing system at the place of origin and these costs are therefore already included in the value of their exports before they are submitted to the CBAM, and no new "costs" arise that correspond to the value of the tax payable to the CBAM. This is because although the importer is responsible for the payment, the exporter may be forced to reduce its price by the same amount as the CBAM tax to remain competitive. Frame 6 shows the countries that export the most of the selected products to the world and the countries that export the most to the EU.

Frame 6 - List of the main exporting countries for the selected products in 2022

Subsector	Code (SH4)	Main countries exporting to the EU	Main countries exporting worldwide
Manufacture of basic iron and steel	7202	• Brazil • South Africa • Russia	• Indonesia • South Africa • Brazil
Manufacture of vegetable and animal oils and fats	2304	• Brazil • Argentina • Netherlands	• Argentina • Brazil • United States
Extraction of crude oil	2709	• Saudi Arabia • Russia • United States	• Saudi Arabia • Russia • Canada

Source: Eurostat (2023) e OEC (2023).

Frame 7, in turn, presents overviews of the pricing systems of the countries that export the products included in the CF assessment. It is important to highlight that the adoption of pricing systems in other regions creates economic pressure for Brazil to also adopt emission reduction measures. This should be a point of attention for the Brazilian industrial sector, which must adapt to these changes. It should be noted that since its introduction, the EU CBAM has not only prevented carbon leakage and protected local industry, but has also had the expectation of encouraging countries outside the EU to adopt decarbonization solutions, including carbon pricing.

Frame 7 – Pricing Systems in the countries of origin of imports

Countries	Are there pricing systems? (Carbon tax or ETS)?	Details
South Africa	Yes	• The carbon tax applies to all types of fossil fuels burned by large companies in the industrial, energy, and transport sectors.
Saudi Arabia	No	--
Argentina	Yes	• The carbon tax applies to CO_2 emissions from all sectors with some exceptions, e.g., for the export of the covered fuels, the biofuel content of liquid fuels, and the use of fossil fuels as raw materials in chemical processes. • The tax applies to most liquid fuels (except fossil gas) and some solid products (coal and petroleum coke).
Canada	Yes	• The tax applies to 21 types of fuels and fuel residues burned to produce heat or energy in these jurisdictions.
United States	Yes, for some states	• California - cap-and-trade system for greenhouse gas emissions from industry, energy, transportation, buildings, and industrial processes. • Massachusetts - ETS applied to CO_2 emissions from the energy sector. • RGGI - cap-and-trade program to limit carbon dioxide from the energy sector. It covers 12 states.
Netherlands	Yes	• The "Minimum price of carbon for electricity" applies to the direct CO_2 emissions of all generation sources (including cogeneration in industrial plants) covered by the EU ETS. • The "Minimum price of carbon for industry" applies to the direct CO_2 emissions of all industrial plants that are also covered by the EU ETS, as well as waste incineration.
Indonesia	Yes	• Indonesia has a mandatory domestic ETS for the energy sector as one of the policy mechanisms to achieve its NDC targets.
Russia	No	--

Source: Adapted from World Bank (2023d).

On the other hand, one of the advantages of products manufactured in Brazil over their international competitors is the cleaner electricity mix. While many countries are still heavily dependent on fossil fuels, Brazil is characterized by an electricity mix with a high share of renewable energies. According to the National Energy Balance (2022), hydroelectric power plants account for 56.8% of domestic electricity supply, while wind power accounts for 10.6%, solar power for 2.4%, and biomass for 8.2%. The non-renewable share consists of coal and derivatives (3.9%), natural gas (12.8%), petroleum derivatives (3.0%), and nuclear energy (2.2%)(EPE, 2022).

According to Neto (2021), the average GHG emissions per unit of energy in Brazil are 141,305 tons of CO_2e per TWh (terawatt hour), while the world average is 230,697. In addition, CO_2 emissions per MWh produced in Brazil in 2022 were about 75% lower than those of the European countries of the Organization for Economic Cooperation and Development (OECD) (EPE, 2023).

However, it is important to highlight that this competitive advantage should not be seen as a reason for Brazil not to pursue other initiatives related to climate issues. On the contrary, it is an opportunity for the country to position itself as a leading producer of low carbon intensity products and to further improve its attractive practices. Moreover, the aforementioned advantage is even more evident in processes with high energy consumption. However, as previously noted, emissions from industrial processes themselves[39] can be preponderant in the CF. Therefore, it is equally important to look for initiatives that considering less carbon-intensive processes, such as the introduction of Industry 4.0 technologies that can improve the management of industrial processes to minimize their emissions.

Finally, the introduction of the CBAM could stimulate greater international dialogue on measures to combat climate change with the European Union and other countries. The impact could vary depending on what measures Brazil takes to reduce its emissions and how the CBAM is implemented by the EU. Nevertheless, Brazil can see the situation as an opportunity to improve its competitiveness and promote more sustainable practices in its economy, thus strengthening its position in global discussions on climate change.

39. Emissions from the process stages include heavy oil burned in a refinery furnace and natural gas burned in a gas turbine.

3.3. KEY MESSAGES

1 The purpose of the CBAM:

- The CBAM is a mechanism to address the loss of competitiveness and the increasing carbon leakage as a result of carbon pricing schemes.
- However, caution is needed in assessing the configuration of this mechanism and its ability to impact key trading partners involved.

2 Key implications and considerations:

- Despite the lack of practical experience and recent implementation of the EU CBAM, there is consensus that its impact depends on the carbon emissions of trading partners' exports and the carbon prices paid in their countries of origin.
- The risks of macroeconomic and distributional losses, particularly for developing countries, can be mitigated if CBAM revenues are used for green investments and financial and technological support for mitigation and adaptation. However, without such measures, it is possible that economic inequality between countries will increase.

3 Brazil's competitive advantage:

- If the EU CBAM regulations include life cycle analysis, it will be possible to consider carbon removal through processes involving forestry inputs or raw materials, which would be a positive point for industries that use this type of process, especially when international competitors do not use them, as is the case with charcoal in the steel industry, where fossil fuels are more commonly used.
- Looking at the profile of the products analyzed in this chapter, Brazil has less carbon-intensive processes compared to its international competitors that also export to the EU, which means a competitive advantage in the short term.
- Compared to local production, although Brazil has a cleaner electrical mix, some products proved to be more carbon intensive than those in the EU, since emissions from the industrial process itself predominate in the carbon foot.
- In assessing the impact of the EU CBAM, it should be noted that while some products of European origin may have lower embedded emissions, the EU is not self-sufficient in the production of all products, which opens space for the entry and continued import of Brazilian products. This condition must be studied as part of a strategy to strengthen Brazil's position in the European market, including with the EU CBAM.
- Compared to other developing countries, Brazil has a competitive advantage because it has a renewable energy mix and the potential to reduce emissions with financially viable and innovative technologies such as Carbon Capture, Utilization and Storage (CCUS) and green hydrogen[40].

4 The importance of introducing a regulated carbon market:

- The EU CBAM imposes a pro-rata tax on products imported from countries that already have an emissions pricing system.
- To create sectoral reduction targets and improve emissions accounting, Brazil must advance the creation of a regulated carbon market (ETS) to exempt products and sectors from the EU CBAM.
- In this context, a Measurement, Reporting and Verification (MRV) system would also help reduce uncertainties associated with measuring emissions throughout the production chain.

5 Relevance of the MRV system:

- A standardized MRV system can enable national industry to adequately report the carbon content of its exports.
- MRV system compatibility is also critical for connecting markets in different jurisdictions.
- Interoperability between markets is a common proposal in bills being considered in Congress and requires that the Brazilian market be comparable to other markets.

6 Importance of Brazil's continued evolution toward decarbonizing its economy:

- As climate policy ambitions increase globally, CBAMs have the potential to be widely adopted in countries' climate strategies.
- Climate policy must focus on the main goal of a real and efficient reduction in global carbon emissions, while ensuring economic sustainability and equity between nations.
- Brazil has competitive advantages that make the country a key player in global efforts to combat climate change. If the country takes a proactive stance to accelerate the decarbonization of its production processes, it can take advantage of the identified opportunities to remain competitive with the major players.

40. See Section 4.1, where we explain the costs and opportunities for reducing emissions in more detail.

4. BRAZIL'S POLICY AND REGULATORY UPDATES ON CARBON MARKETS

In Brazil, several Bills are being processed in the Chamber of Deputies and the Federal Senate, which are usually merged or processed together. Nevertheless, there is no forecast for the passage of a law regulating the regulated carbon market. The creation of the Brazilian Emissions Reduction Market (MBRE) was originally formalized in 2009 by the National Policy on Climate Change (PNMC), which aimed, among other things, to create a market that would operate on commodity and futures exchanges, stock exchanges, and organized over-the-counter companies authorized by the Securities and Exchange Commission (SEC), where securities representing **"certified avoided greenhouse gas emissions"** would be traded[41] .

However, according to the legal analysis conducted by the PMR Brasil Project (World Bank, 2020a), the definition of these securities representing avoided emissions could differ from the concept of emissions allowances in a regulated market. Allowances are not synonymous with avoided emissions from a project with additionality, as is the case in the voluntary market, but with **emission rights** that correspond to the legal obligations of operators to bring their emissions into compliance.

Since it creates obligations for the regulated companies, which must bring their emissions into line with the emission rights and are obliged to purchase these rights if they exceed the set limit, **the establishment of a regulated market in Brazil must be established by law** as it constitutes a restriction on the free economy according to Article 170 of the Federal Constitution. In addition, the introduction of an Emissions Trading System may require the establishment of an implementing or regulatory body and institutional arrangements which, due to the principle of legality[42] governing public administration, can only be established by law.

It is also necessary to create a regime that ensures the certainty of emission allowance transactions and creates trust in contracts, which can be an opportunity to ensure autonomy, transparency, and credibility in the administration of price incentives. In this sense, according to the PMR analysis, a regulatory structure for carbon market creation must include the following (World Bank & Vivid Economics, 2018):

1, the general principles and guidelines to guide the allocation of carbon allowances – such as regulated sectors, limits, scopes etc. – with price control criteria and measures to protect competitiveness;

2. the frequency of reviewing the rules, with criteria that consider national mitigation objectives;

3. trading practices, penalties, registration of emission rights, financial and carbon accounting rules, MRV standards, and use of financial derivatives;

4. maximum percentage allowed for the use of voluntary market carbon credits (offsets);

5. identification of the executive government body, at the federal level, to implement and coordinate the regulatory framework; and

6. the rules for the accreditation of private entities that manage the market, such as exchanges, brokers, operators, and MRV bodies.

In general, the regulated sectors and emission limits are not specified in the regulatory proposals currently being processed. For example, for PL 2,148/2015 and its appendices and PL 412, this would be at the discretion of the National Allocation Plan (NAP) established by the Executive Power (Brasil, 2022a, 2022b). The latest version of the substitute bill for PL 412, which considers the draft prepared by the federal government working group, already includes thresholds for the entities to be monitored – emission sources above 10,000 tons of CO_2e – and for regulated sources, i.e., those sources with emissions of more than 25,000 tons of CO_2e per year.

However, the bills currently being processed provide for price control mechanisms and measures to protect competitiveness, such as free allocations or border adjustment mechanisms, but without specifying concretely how these will be implemented.

In theory, the sectors covered by an adjustment mechanism should be those that have high carbon intensity and are exposed to international trade. **To promote greater acceptance and reduce controversy over the parameters used to define these sectors, we propose to identify sectors with competitive risks in the first pricing phase in Brazil using indicators similar to those used in the EU ETS, but with a less restrictive gradation, considering the initial pricing phase and the degree of competitiveness of the sector in Brazil** (World Bank & Vivid Economics, 2018). The compatibility of these indicators could become even more interesting with

41. Pursuant to Law 12,187 of December 29, 2009 ((Brazil, 2009).
42. This principle states that the public administration can restrict a right only if it is supported by a law that grants the authority this power. The principle of legality is set in Article 5, II of the Constitution, according to which no one is obliged to do or refrain from doing anything except by law (Di Pietro, 2017).

the implementation of the EU CBAM, since Brazilian exporters will have to report the emissions contained in their products to European importers.

For the pricing system to truly reflect actual emissions, an MRV system including a national database of emission factors must be created to ensure consistency of factors used in the calculations. The specific emission factors must be checked by a competent body. Ideally, the MRV system should be introduced before the market system to collect data that allows a realistic calculation of the fulfillment target.

To achieve this, it is also necessary to define the institutional arrangements and the governance flow for the market, which must be established by a law (World Bank, 2020a). The PMR proposes two possible institutional arrangements, distinguished by the presence of a private entity for supporting the implementing body throughout the compliance cycle of the Trading System. The bills currently being processed in the Brazilian Chamber of Deputies and Federal Senate propose different arrangements. Frame 8 summarizes the governance structures proposed for the MBRE.

Frame 8 - Proposed governance structures for the Brazilian market

Governance Structure Proposed by PMR	Governance Structure Proposed by PL 2148 and its appendices	Governance Structure Proposed by Substitute Bill for PL 412
• **Interministerial Committee:** committee responsible for the structural and strategic coordination of the system. • **Regulatory Body:** it would be responsible for the macro regulatory aspects, e.g., for setting targets based on criteria established by the Interministerial Committee or its own regulations. • **Advisory/Implementing Body:** a body with the technical mandate and structure to coordinate and monitor the system, which could be a public administrative body linked to a ministry or a regulatory agency established for this purpose. • **Verifying Agent:** a private entity engaged by the regulated agent and accredited by the accreditation body to verify compliance with the regulated agent's obligations. In this case, an arrangement could be considered whereby the advisory body centralizes the engagement and allocation of verifying agents, which could reduce the risk of conflicts of interest between regulated agents and verifying agents. • **Operating Platform:** Platform authorized by the Securities and Exchange Commission (SEC) to sell emission rights. • **Accreditation Body:** Government body with technical capacity to accredit verifying agents.	• **Higher Body:** composed of members of the highest body of the National Financial System, with the authority to set strategic guidelines on issues related to the impact of the SBCE on monetary and credit policy, as well as to set standards to improve assets and financial instruments related to the efficient operation of the System. • **Deliberative and Appellate Body:** composed of the Interministerial Committee on Climate Change and Green Growth and institutions representing the regulated sectors to, among other things, draw up the National Allocation Plan and evaluate and approve the Sectoral Agreements. • **Consultative Body:** composed of representatives from government and civil society who provide technical input to the Deliberative Body's decisions. • **Competent Authority:** the public body designated to manage the SBCE, which would coordinate the institutions responsible for the system's Operational Reporting Register and the Regulated Carbon Market; issue rules for regulated sectors in the event that a sectoral agreement does not exist or is not followed; enforce administrative sanctions for regulated entities; and implement and manage the SBCE's Operational Reporting Register.	• **Interministerial Committee on Climate Change:** has the task of establishing the general rules of the SBCE; approve the National Allocation Plan; establish technical groups to provide subsidies and submit recommendations to improve the SBCE; and approve the annual plan for the use of funds from SBCE collections. • **Managing Body:** constitutes the executive body responsible for: regulating the market, complying with the guidelines of the Interministerial Committee, regulating the presentation of information on GHG emissions; defining the activities, facilities, sources, and gases to be regulated; defining the annual GHG emission level above which operators of facilities or sources must submit a monitoring plan and report GHG emissions and removals, in addition to periodic reconciliation of obligations. In addition, the Managing Body is responsible for establishing the requirements and procedures for MRV and the requirements for the procedures for periodic information comparison, as well as the requirements for the production of Certificates of Verified Emission Reduction or Removal; establishing rules and managing procedures to link the SBCE with emissions trading systems in other countries or international organizations, etc. • **Technical Group:** the consultive body of the SBCE responsible for providing technical input and making recommendations to improve the SBCE.

Source: Own preparation based on World Bank (2020b) e Brasil (2022a, 2022b).

Emissions trading, on the other hand, must be set with a reduction target or an overall budget of carbon to be distributed and sold. In most cases, part is allocated for free and another part is auctioned. At the end of each commitment period, each regulated source must reconcile the total number of allowances issued with the total number of free and purchased allowances.

These free distributed allowances can be distributed based on historical indicators (grandfathering) or sectoral performance indicators (benchmarking). It is considered that grandfathering allocations tend to benefit sectors that are lagging behind in terms of controlling their emissions. On the other hand, this is a simpler metric to implement since it basically depends on historical data, emission reduction targets, and a protection factor for sectors with a competitiveness risk (World Bank & Vivid Economics, 2018).

Also according to World Bank (2018), to recognize previous control efforts, the benchmarking metric may be more appropriate because the initial level of free allocation of each regulated entity is proportional to an indicator of the emissions intensity of the product considered efficient. In this way, an intra-sector benchmark is defined by observing the technological developments and the different products within the same sector. To estimate the emission intensity factors (emission per production), a measure of the intensities observed in the sector is first used, usually in consultation with the regulated bodies. However, this measure requires greater effort to define the industrial products to be regulated, to estimate the emission intensity of these products and the costs of reducing the emissions of each product, and thus to establish the criteria for free allocation.

Given the lack of data and its simplicity, the grandfathering criteria is recommended at the initial stage in Brazil, with a free allocation of 50% for all sectors with competitiveness risk. For emissions not covered by free allocations, the allocation would be through auctions, reconciling emissions with the purchase of emission rights (World Bank & Vivid Economics, 2018).

The allowances in mechanisms with a high proportion of free allocations tend to have lower liquidity because fewer companies will actively engage in the market when their needs for allowances are more or less covered by the allocations. Since companies implicitly disclose their assessment of the abatement costs in the trading process, inhibiting trading creates barriers to price discovery.

The purchase of emission rights takes place at auctions (primary market), which are usually held quarterly and allow for the auctioning of future emission allowances to facilitate planning by companies. **There must also be a minimum price for allowances auctioned**. To increase the cost-effectiveness of the system, it must be possible to save allowances for later use (banking).

The auction involves the allocation of allowances through a competitive bidding process, which allows for price discovery and strong incentives for carbon reduction. **The predictability of auction events allows for transparency and a stable price signal for participants and consumers, and can reduce volatility in emissions prices**. In addition, this mechanism creates a revenue stream for the government that can be distributed to a wide range of potential beneficiaries (ICAP & World Bank, 2021).

Participation in auctions may or may not be limited to regulated agents. According to the International Organization of Securities Commissions (IOSCO), some markets allow financial institutions and other non-regulated participants to participate in auctions. In the European Union, around 30% of auction participants are financial institutions. It is also important to note that regulated agents may choose to hedge their risk by taking positions on the derivatives market rather than purchasing allowances directly through auctions or on the spot market to reduce their capital costs and mitigate the financial liquidity restrictions associated with the allowances. In this particular context, financial institutions may decide to participate in auctions and instead purchase these quotas and, for example, take positions sold in the derivatives market (IOSCO, 2023).

Financial institutions and other non-regulated agents can also participate in the secondary market, which promotes market development, especially by increasing the liquidity of allowances. Additionally, they can enable protection against price fluctuations and increase price signaling, which allows companies to make more informed investment decisions about their GHG emissions (IOSCO, 2023). It is understood, therefore, that the solidity of primary and secondary markets for emissions allowances would help to reduce information asymmetries and market opacity, one of the main market barriers raised by the previous edition of this study (ICC Brasil & WayCarbon, 2022)[43].

43. Increasing liquidity as well as reducing opacity and informational asymmetry about prices can also help in financing decarbonization projects, as the cash flows of these projects can be estimated with greater precision and, therefore, contribute to credit risk assessment for these projects. If financial institutions participate in the market, they may eventually accept emissions allowances as financing guarantees, thus reducing the cost of credit.

Box 2

LEGAL DEFINITION OF CARBON UNITS TRADED IN THE REGULATED AND VOLUNTARY MARKET

One of the obstacles to the operation of the carbon market in Brazil is still its legal definition. While some texts, such as the National Policy on Climate Change, treat emissions allowances as securities, others treat them as financial assets, such as the bills currently being processed in the House of Representatives and the Federal Senate.

From the perspective of the Securities and Exchange Commission (SEC), the allowances would not be securities as they do not qualify as Collective Investments or Derivatives. Thus, the SEC even issued some technical notes on this classification, considering that the allowances would not be securities. In 2022, Resolution 175 was issued, which considers carbon credits traded on the regulated market and Biofuel Decarbonization Credits (CBIOs, in Portuguese) as financial assets (Resolução CVM 175, 2022).

For the Central Bank, however, carbon credits and CBIOs are seen as Sustainability Assets. The definition was published in Regulatory Instruction 325/2022 which, among other things, had the goal of regulating the accounting record of these assets in financial institutions. The Instruction also deals with accounting at market prices or at purchase amount, depending on the purpose of purchasing the credits, which in turn may also affect the taxation resulting from the gain on the negotiation of the credits.

Therefore, there is still no agreed classification on the legal definition of emissions allowances in the regulated market. It is understood that this is a significant obstacle to the full operation of the market since for these securities to be traded on a regulated securities market, it is required to create a new specific trading environment that allows the trading of emission rights with a safe and compatible structure to the structures currently used (World Bank, 2020a). Additionally, it is still required to define the market's regulatory entity, which will address the technical and procedural issues related to the creation of this trading environment (World Bank, 2020a).

For the voluntary market, the uncertainty is even greater, given that neither the SEC nor the Central Bank acknowledges credits as securities or financial assets. Despite this, the bills currently being processed in the House of Representatives and the Federal Senate, PL 2148 and PL 412, respectively, consider credits from the voluntary market, called Verified Emissions Reductions (CER/VER), as financial assets and as securities, respectively.

Other mechanisms can be evaluated to reduce uncertainty related to allowance prices, such as Market Stabilization Mechanisms. This could be an interesting alternative for Brazil to establish a minimum price for allowances sold at auctions, due to the strong presence of low marginal abatement cost technologies available in the country. Thus, when abatement costs in a system turn out to be cheaper than expected, the supply of allowances may exceed demand, resulting in pressure that reduces allowance prices, weakening incentives for investment in low-carbon technology and in emission reduction actions, since reduction options are relatively more expensive than purchasing emission allowances (Acworth *et al.*, 2020).

Prices that are too high, in turn, can compromise the economic viability of the trading system, which can provide a reason for a price cap. Setting a price cap, however, requires balancing different considerations: a low maximum price may reduce incentives to invest in low-emission technologies; on the other hand, prices significantly higher than marginal abatement costs may compromise the economic viability of the trading system or result in higher prices, affecting consumers and economic activity (Acworth *et al.*, 2020).

Eventually, the national market can be integrated with other world markets. As a result, emission reduction targets can be achieved through the purchase and sale of allowances in jurisdictions outside the country, in the form of tradable units. This decision to promote international integration must evaluate how the effects on demand and supply in the domestic market are estimated in light of the diversity of markets in other jurisdictions. Additionally, international integration presupposes the harmonization of rules for almost all project characteristics that can generate competitive imbalances, from annual targets to the point of regulation, allocation criteria, penalties and, in particular, MRV rules (World Bank & Vivid Economics, 2018).

Regarding the use of offsets, the PMR considered that the use should be limited to 20% in the starting periods, being reduced to 10% in the following periods to prevent carbon prices from being too low, damaging the incentive for decarbonization and sector technological innovation, and to minimize potential leaking effects. It is also worth highlighting, as shown in Chapter 2, that the inclusion percentages in other countries that have restrictions on the inclusion of offsets in the regulated market generally do not exceed 10%. **PL 2,148/2015 and its annexes**[44]**, however, provide that the maximum percentage of VER purchases would be no less than 25% of the total emissions that exceed their allowances**.

In this context of the voluntary market, it is required to establish measures to involve and protect traditional communities and indigenous peoples, hindering abusive and illegal practices in the generation of credit.

For possible non-compliance with obligations, it is also required to establish the penalties applicable to agents. The PMR takes a fine of BRL100,000, which may double in case of recurrence or, at most, 5% of

44. PL 2,148/2015 adds the PLs: 10,073/2018; 5,710/2019; 290/2020 and PL 528/2021.

the annual revenue of the last two years of the company responsible for the regulated source, adjusted by the Broad Consumer Price Index.

In addition to the fine, it is suggested that the obligation to purchase the equivalent of the target not met occurs in the following gradual manner: 1) first year: once the number of credits that were not met; 2) Second and third years: one and a half times the amount not met; 3) Subsequent phases: three times the unfulfilled quantity.

This penalty, however, can be considered mild, especially for the most polluting companies that could decide between purchasing the appropriate emissions allowances or paying the fine, depending on the price of the credit and how the compliance process will be. It is therefore required to develop a penalty system that effectively discourages fraud in the GHG inventories of regulated entities or in other points that affect the market.

PL 412, for its part, provides for the application of: i) a warning; ii) a fine; iii) publication, at the offender's expense, of an extract of the condemnatory decision for two consecutive days, from one to three consecutive weeks, in the means of communication indicated in the decision, in cases of recidivism of serious infractions; iv) embargo of activity, source or installation; v) partial or total suspension of activity, installation and source; vi) restriction of rights which may consist of, among other things, loss or restriction of tax incentives or benefits, loss or suspension of participation in lines of financing with official credit establishments and prohibition of contracting with the Public Administration.

The fine to be imposed will be no less than the cost of the obligations breached, provided that it does not exceed the limit of 5% (five percent) of the company's, group's or conglomerate's gross turnover in the year prior to the initiation of the administrative process, updated by the Special Settlement and Custody System (SELIC) rate, in the case of infractions committed by companies. For other legal entities or individuals, the fine can be between R$ 50,000 and R$ 5 million. As carbon pricing can change the cost structure of some sectors, there must be a schedule for the use of revenues received by the government after implementing the trading system. Firstly, it is required to identify the sources of revenue – such as permit auctions, taxes on secondary market negotiations and, possibly, fines applied. Subsequently, it is required to establish how the government will use these resources, both to maintain the governance required for the system operation, and to offset any adverse economic effects of pricing.

Still according to the PMR, the priority for the use of resources arising from pricing would be tax offset, i.e., a reduction in taxes in the production sectors. The "second priority" would be distribution offset, given that pricing can cause low-income families to bear the costs of mitigation, given that companies can pass on the price of allowances to consumers. The amount to be distributed would be the equivalent of the revenue collected, minus tax offsets (World Bank & Vivid Economics, 2018). Conversely, PL 412, after the operationalization and maintenance of the SBCE, prioritizes the use of resources in research and development activities that seek new solutions for decarbonization in the regulated sectors, support for the implementation of activities related to the National Climate Change Policy and, finally, compensation for the contribution of indigenous peoples and traditional peoples and communities to the conservation of native vegetation and ecosystem services.

As stated, the various proposals for the legal framework of the Brazilian carbon market address the main mechanisms that a regulated market must have. Until this study elaboration, there was a lack of a convergent proposal and the structuring of how the mechanisms will work, which should probably come through president decree.

In this sense, PL 412 incorporated new proposals and is now a convergent proposal, unanimously approved by the Federal Senate. As previously mentioned, the focus is expected to be on industry, regulating sources and installations that emit over 25,000 tons of CO_2e a year, affecting around 4,000 companies. There is also provision for interoperability between the regulated and voluntary markets, in which companies will be able to offset part of their emissions on the voluntary market, and a specific chapter for safeguarding indigenous and traditional peoples. The Interministerial Committee on Climate Change, created by Decree 11.550/2023, remains the SBCE's deliberative body.

The review of the main regulations approved or in progress demonstrates the importance of the carbon market issue for the Executive and Legislative Branches, which generally provide the required mechanisms for the market to operate. More than the presence of these essential elements, however, it is required to think about how these mechanisms will work. Some understandings must already be clear in the initial phases, such as a process on how emissions limits and free allowances will be defined, as well as the provision of sanctions for regulated entities that fail to comply with the law. Additionally, it is required to consider that a national emissions registry will require a high cost of implementation and operation, so that it will be required to seek forms of financing and technical cooperation for the operation of this system (Prolo, 2023).

It should be noted that, in general, the design, the adoption and the operation of carbon pricing arrangements in Latin America are marked by considerable levels of learning in practice (*learning by doing*). It is important that governments in the region, such as Brazil, recognize this possibility and ensure room for maneuver so that corrections and innovations are proposed within the legal framework of a carbon pricing instrument (FGV EAESP, 2019).

4.1. KEY MESSAGES

1 General principles and guidelines to guide the allocation of allowances

- For the regulated carbon market to function efficiently, several mechanisms must work together to encourage the reduction of emissions by regulated agents, taking care to ensure that the sectors most exposed to foreign trade do not lose competitiveness and so that the most vulnerable families do not bear the cost of mitigation.

- It is still required to define the sectors that will be regulated. The Bills do not provide this definition, which must be done through decree. Sector coverage should be as broad as possible.

- Given the lack of available data and its simplicity, the gradfathering criteria is recommended at this initial stage in Brazil, with a free allocation of 50% for all sectors with competitiveness risk. For emissions not covered by free allocations, the allocation would be through auctions, reconciling emissions with the purchase of emission rights (World Bank & Vivid Economics, 2018).

- Allowances sold at auctions must have a minimum price to avoid reducing incentives for decarbonization.

2 Trading practices, penalties, registration of emission rights, financial and carbon accounting rules, measurement, reporting and verification (MRV) standards and use of financial derivatives:

- The distribution of credits can be carried out through free allocations together with auctions, with unregulated sectors, including financial institutions, being able to negotiate allowances in the primary (purchase at auctions) and secondary markets. For this to happen efficiently, it is also required to establish the legal definition of allowances so that accounting and tax rules are also applied in accordance with this definition.

- The MRV system plays a crucial role in the integrity of the national market and in the connection between different international markets.

- Allowing the use of financial derivatives, as well as allowances in other periods (*banking*) can increase the predictability of market prices, enabling companies' risk management.

3 Regarding the frequency of reviewing the rules, with criteria that consider national mitigation objectives:

- It is expected to be established by the National Allocation Plan, which will be defined by the Executive Branch, as well as other rules to be updated more frequently.

4 Maximum percentage allowed for the use of voluntary market carbon credits (offsets):

- It is possible to note some elements present in the legislative proposals that differ from the PMR's technical recommendations, such as the percentage of use of *offsets*. A high percentage of voluntary market credits could discourage emissions reductions by regulated entities. Additionally, it is still required to establish mechanisms to consider the autonomy of original peoples in relation to voluntary market carbon projects.

5 Identification of the executive government body, at the federal level, to implement and coordinate the regulatory framework:

- The Interministerial Committee on Climate Change is expected to be the Executive Branch body to propose and coordinate the regulatory framework, which is already being prepared with the participation of several ministries

- It is required to define which other regulatory, implementing and other bodies will be created to ensure the full operation of the system.

5. COSTS AND SOCIO-ECONOMIC IMPACTS OF MITIGATION IN SELECTED SECTORS

To identify the feasibility, costs, opportunities and public policy options to achieve long-term mitigation goals in Brazil, it is essential to analyze the potential roles of different sectors. The simulations carried out in the PMR Project show that carbon pricing is preferred in strategic sectors, such as fuels and industrial processes. Furthermore, most ETSs in force until 2023 in the world included at least one of these two sectors, and many of them covered both, especially those in the starting phase of implementation (World Bank, 2020b).

On the other hand, the Agriculture, Forestry and Other Land Use (AFOLU) sector is rarely covered by international pricing systems, due to the difficulty of regulation, considering the large number of agents involved. Nevertheless, given the potential of low-carbon agriculture in the country, the sector could contribute to a regulated carbon market, acting as a provider of offsets. Regulation must stay alert to these opportunities. Another point that deserves attention in terms of realizing opportunities is land regularization as a condition of the forest-related market. Based on this, this section will focus on the Industry and Fuel sectors.

5.1 ABATEMENT OPPORTUNITIES AND COSTS FOR THE INDUSTRY AND FUEL SECTORS

The marginal abatement cost (MAC) is a concept commonly used to analyze the economic viability of GHG reduction projects, considering the cost of reducing one ton of carbon dioxide equivalent (tCO_2e) in a project or activity. Costs can be estimated in two main ways. The first is based on individual project assessments, considering investment and operation costs, as well as the difference in corresponding emissions from this project in relation to a project scenario or counterfactual activity, which is generally the technology usually used (Kesicki & Strachan, 2011). In general, this is the way in which companies base their decarbonization strategies: selecting, as a priority, projects with the lowest abatement cost and below the current carbon price.

The other way of estimating costs is based on macroeconomic models, which operate with different levels of carbon pricing and record the corresponding reduction in CO_2 emissions, based on the technological level, aggregate productivity and technology costs. Therefore, MAC[45] is commonly used in cost-benefit analyses in which countries' emission reduction targets are achieved at the lowest cost. Furthermore, **the MAC is the main guide for carbon credit trading strategies within the scope of the Paris Agreement, as countries must first adopt the lowest cost activities to comply with their NDCs, making use of carbon markets to subsidize projects with higher abatement cost.**

Therefore, the importance of knowing the marginal abatement costs for different GHG reduction options when defining criteria for a regulated carbon market becomes evident. Some studies seek to estimate these costs in the national scenario, such as the study "Options for Mitigating GHG Emissions in Key Sectors" (Brasil, 2017a), which estimated the potential costs of reducing GHG emissions through an integrated economic-energy analysis. This study served as the basis for the publication, in 2021, of the first edition of this report based on three main scenarios, which differ according to the assumptions adopted for sector trends in technological development and incorporation, carbon price and other public policies until the year 2050 (ICC Brasil & WayCarbon, 2022). The description of this scenarios can be seen in Frame 9.

45. The MAC can show negative or positive values. In the first case, it is an indication that the project is economically viable ("no regret investment"), while the second case means that the project is not economically attractive ("climate justified investment") according to the assumptions considered in the analysis. The presence of negative costs, obtained from economic and engineering studies, may not be directly applicable in reality, in addition to there being possible obstacles that may not be well represented in the analyses, such as: i) competition for low carbon technologies with other sectors, which can change the price of these technologies and consequently the return on investments; ii) adequacy of investment, operation and maintenance costs, obtained in scientific literature, to the country's economic and tax reality; iii) impacts of regulatory gaps, reflected in transaction costs not captured by the methodology; iv) non-additivity and applicability of measures in the face of technical-operational restrictions; among others.

Frame 9 - Scenarios considered in the Mitigation Options study

Scenarios[46]	Description
Reference Scenario (RS)	It shows market-based characteristics, without major qualitative changes and maintains the natural pace of incorporation of technologies in the sector – maintenance of sector and political trends already underway.
Low Carbon Scenario (LC)[47]	It incorporates programs, public policies, actions and strategies that can be developed, given commercial availability and application at an international and/or national level in the sectors, with the goal of reducing GHG emissions.
LC+I Scenario	It adheres to the basic characteristics of the BC scenario, with consideration of the entry of disruptive technologies into the sectors. In other words, technologies that are technically developed, or in development, but prohibitive due to the high cost of implementation and technical restrictions on diffusion.

Source: Brasil (2017l).

5.1.1. INDUSTRY

The scenarios from the "Mitigation Options" study are used to analyze the sector impacts of carbon pricing. In the industry, the segments analyzed are: Food and Beverages; Ceramics; Cement; Pig Iron and Steel; Iron alloys; Non-Ferrous Metals Metallurgy; Mining and Pelletizing; Paper and Pulp; Chemical; and Textile.

In general, the study highlights the low energy efficiency performance of Brazilian industry, which may represent an opportunity to reduce emissions. However, emissions until 2030 may persist for two reasons: the first is linked to the competitiveness of the industry, which leaves little room for negotiation and, therefore, for absorbing additional costs; the second concerns the use of capital-intensive and long-lasting equipment, which delays the implementation of innovative low-emission technologies (MCTIC, 2017).

The industrial segments have a significant potential for reducing 387 $MtCO_2$ in the Low Carbon (BC) scenario by 2050 and the results indicate that the most cost-effective measures are directly related to improving energy efficiency (Brazil, 2017m). In this sense, technologies that reduce emissions throughout the industrial sector's production chain, despite having the year 2010 as a base, already point to the economic viability of mitigation actions. The Table 11 shows the costs and abatement potentials by industry segments for the BC scenario between 2010 and 2050 and the most representative mitigation options.

Table 11 - Total costs and potential abatement by Industry segments for the BC scenario between 2010 and 2050 and most representative mitigation options by segment

Industry segments	Most representative Mitigation Options	Mitigation Potential between 2010 and 2050 ($MtCO_2e$)	Abatement Cost (US$/$tCO_2e$)	
		Low Carbon (BC)	At the social discount rate*	At the market discount rate**
Food and beverages	Flue gas recovery; improving insulation in natural gas boilers.	24.6	-185 to -31	-94 to -2
Ceramics	Optimization of combustion in furnaces through dry route.	25.3	-263 to 84	6 to 368
Cement	Adoption of the dry process with multiple stages of preheaters and pre-calciners; use of slag carbide in cement production.	29.1	8	8,74
Pig iron and steel	Application of Scope 21 furnaces; recovery of sensible heat in the basic oxygen furnace (BOF).	53.9	-	-330 to 150
Iron alloys	Replacement of semi-covered arc furnaces with covered ones; heat and carbon monoxide recovery.	26.1	-667 to -479	-385 to -262
Metallurgy and non-ferrous metals	Heat recovery; furnace insulation.	39.4	0 to 326	8 to 374
Mining and Pelletizing	Use of electric-diesel hybrid vehicles in the extraction segment.	34.7	-286 to -17	-25 to 33
Other industries (lime, plaster, glass)	Replacing coke with natural gas in the lime sector.	14.2	-	-54 to 292
Paper and Pulp	Application of CondeBelt dryers; use of more efficient presses.	16.7	-331 to 930	-88 to 641
Chemical	Efficiency of motor systems; adoption of natural gas in boilers and furnaces to replace more carbon-intensive fuels, such as coke, coal, diesel oil and fuel oil.	46.7	-70 to 81	-14 to 89
Textile	Efficiency of combustion in boilers.	14.7	-1 to 32	11 to 72

Source: Brasil (2017a, 2017b, 2017c, 2017d, 2017e, 2017f, 2017g, 2017h, 2017i, 2017j, 2017n, 2017o).
*Social discount rate is equivalent to 8% p.a.
**Market discount rate varies between 15% and 18% p.a., depending on the activity.

46. To construct the scenarios, the study Options for Mitigating GHG Emissions in Key Sectors uses the base year of 2010. Therefore, it is important to consider that over recent years, technology options and costs may have varied. This is due to increased economies of scale and variations in cost assumptions, which makes these technologies more affordable. Therefore, some technologies included in the BC and BC+I scenarios may already be widely used in some sectors and, consequently, not contribute to additional emissions mitigation.
47. BC Scenario is a Low Carbon Scenario.

It is noteworthy that, in the **Food and Beverages and Cement** sector, all technologies considered in the modeling carried out are economically viable (MCTIC, 2017a). Specially, for the cement sector, another study points out that the potential for reducing emissions in the sector could result in the mitigation of around 421 $MtCO_2$ by 2050 through the replacement of clinker with the use of slag carbide, the replacement of petroleum coke with biomass and waste and measures to improve energy efficiency (SNIC, 2019).

In the **Pig Iron and Steel** sector, it is important to mention that the high potential for mitigating emissions is only inferior to that of the cement sector and represents an emissions reduction of 13% by 2050. Around 12% of Brazilian pig iron production is obtained through the use of charcoal from planted forests, replacing mineral coal, a competitive advantage for Brazil in relation to other countries in the steel sector (Instituto Aço Brasil, 2021). There is still room to increase the production of pig iron with charcoal and, as pointed out in the review of the Steel Plan[48], improving the conversion of wood into charcoal, in addition to being an option to further reduce emissions, also promotes the reduction of costs in the sector (IBRAM, 2021).

However, **the Non-Ferrous Metals Metallurgy** sector – which encompasses aluminum and other non-ferrous metals – presents technological alternatives that are not economically viable at market and social discount rates (MCTIC, 2017d). Although the cost of these technologies is higher, the aluminum subsector is distinguished by its high recycling rate, a comparative advantage that results in lower emissions compared to other countries (MMA, 2022). Another sector with a high recycling rate is Lime and Glass (MCTIC, 2017g). The low technological intensity of lime production processes limits the adoption of low-carbon activities. On the other hand, greater recycling of glass used as a component of the raw material mixture is an excellent opportunity, as it manages to mitigate 1 tCO_2 for every 6 tons of glass recycled and used in production (ABIVIDRO, 2019).

In the **Paper and Pulp** sector, energy efficiency can be improved through greater on-site waste heat recovery and cogeneration (biomass gasification) (EPE & IEA, 2022). The search for the use of renewable energy sources (replacing fossil fuel boilers with biomass) is also important, especially for recycling. In addition to technologies related to advancing operational efficiency, planting and preserving trees removes carbon from the atmosphere, with the potential to store a significant amount of carbon[49].

More recent global studies, such as McKinsey&Company (2022), have evaluated the implementation of mitigation measures, considering the Steel and Cement industries. The paths to decarbonization of the **Steel** sector involve replacing Basic Oxygen Furnaces (BOF), which release carbon through the burning of coke coal. Although there are several promising switching technologies, there is still uncertainty regarding a preferred route. A key strategy for decarbonizing this sector would be to replace blast furnaces (BOF) with electric arc furnaces (EAFs) – fueled by electricity from carbon-neutral sources. The raw material for EAFs consists of scrap-based steel, which would also help reduce emissions. Additionally, natural gas is used in most direct iron reduction processes, replacing natural gas with green hydrogen would make this process virtually emission-free. Another option involves the application of carbon capture, usage and storage (Carbon Capture or Storage – CCUS) in conjunction with traditional steel manufacturing techniques, although this approach remains in its early stages and lacks proof of economic viability (McKinsey&Company, 2022).

According to the same study, the decarbonization route for the **Cement** sector may be less clear in technological terms than in other segments of the Industry. If used together, several already established techniques would have the potential to reduce emissions in the production chain. Energy efficiency measures, also considered in the Mitigation Options study, would be concentrated in furnaces, which use almost 90% of the energy used in cement manufacturing. Switching to alternative fuels such as biomass would also reduce emissions, although their use depends on availability and local supply chains. McKinsey&Company (2022) emphasize the decarbonization potential of measures to replace clinker with materials that do not release CO_2[50]. However, considering that these points provide a global view of the sector, it is likely that conventional strategies alone will enable the cement industry to contribute approximately one third of the reduction in emissions required to contain global warming to 1.5° C throughout the economy. The authors also mention other potential mitigation solutions, such as the use of CCUS, approaches involving recycling technologies and the adoption of alternative construction materials[51] to replace traditional cement.

Following the same line as the "Mitigation Options" study, but with different assumptions, Centro Clima and COPPE/UFRJ (2023) evaluates the adoption of mitigation measures based on new emission scenarios for the Brazilian industrial sector. The exercise carried out by Centro Clima and COPPE/UFRJ (2023) simulates two scenarios in Brazil until 2050, providing a framework to analyze sector and economic indicators in a decarbonization process. The description of the scenarios can be seen in Frame 10.

48. The Sector Plan for Emission Reductions in Charcoal-Steel Industry was launched by the Federal Government in 2010, with the aim of promoting a set of actions that would support the transition to the low emissions scenario.
49. According to IBÁ (2022), the sector was responsible for removing and storing 4.5 billion tons of CO_2 equivalent.
50. Natural and calcined pozzolans, or industrial by-products such as fly ash and blast furnace slag (McKinsey&Company, 2022).
51. Cross-laminated wood, alternative insulation materials (colored glass, double glass, insulation foams) and biocement (McKinsey&Company, 2022).

Frame 10 - Scenarios considered in the Centro Clima and COPPE/UFRJ study (2023)

Scenarios	Description
Current Policy Scenario (CPS)	Follows trends in ongoing mitigation actions. Its emissions are 1.68 $GtCO_2$ in 2030, with no increase in the goal between 2030 and 2050.
Deep Decarbonization Scenario (DDS)	It reaches 0.95 $GtCO_2$ in 2030, going beyond the NDC[52] target and follows an emissions trajectory compatible with the global goal of 1.5°C, reaching net zero emissions in 2050. The scenario considers a strategy for resuming economic and social development, based on two climate policies: - Radical reduction in deforestation and increase in CO_2 sinks; - Carbon pricing, applied to GHG emissions from the use of fossil fuels and industrial processes and product use.

Source: Centro Clima and COPPE/UFRJ (2023).

In the DDS scenario, the implementation of traditional mitigation measures[53] would lead to a 34% reduction in emissions between 2020 and 2050, compared to the CPS scenario. The potential abatement of these measures could reach 91 $MtCO_2$ in 2050 at a carbon price of less than US$ 20/tCO_2 (Centro Clima & COPPE/UFRJ, 2023). These mitigation actions encompass several strategies, such as:

- Significant **gains in energy efficiency**, reducing the energy intensity of industries between 13% and 25% in the period from 2020 to 2050, depending on the industrial sector;
- Replacement of fossil fuels with renewable energy sources, including **increasing the use of charcoal in the production of pig iron and the use of wood and waste in cement kilns**;
- **Expansion of the use of ash and slag as clinker substitutes** in cement composition;
- Almost full completion of the replacement of HFCs (hydrofluorocarbons) with gases with low global warming power by 2050, with a 96% reduction compared to 2020 emissions.

Most traditional technology options with significant abatement potential involve improving energy efficiency and the use of renewable sources in Industry. Promoting decarbonization actions not only helps transform processes aimed at competitiveness and sustainability, but also results in multiple benefits for the sector and society.

Brazilian industry plays a fundamental role in maximizing energy efficiency opportunities, enabling increased competitiveness and driving technological innovation in the use (electrical and thermal energy) and production of products aimed at the energy efficiency market (for example, products related to industrial automation and labeling[54]) (EPE, 2020).

This sector becomes more efficient by reducing energy costs, achieving productivity gains, improving product quality and promoting more integrated management through energy management, in addition to obtaining positive results in other areas, contributing to its institutional image. For society in general, greater energy efficiency brings benefits such as increased energy security, reduced dependence on fuel imports, postponed investments in electrical generation, reduced environmental impacts of energy generation, reduced pollution and GHG emissions, contributing to international commitments to fight climate change, in addition to contributing to the creation of jobs in industry and services related to efficiency (EPE, 2020).

However, the alternatives traditionally used and known by the Industry for mitigating its emissions show a technological and operational limit. Possible obstacles to the adoption of these technologies include: high capital costs; asymmetry and high transaction costs for accessing credit; possible recessive economic and sector situation; restriction on installation due to plant layout; high import costs; and risk of sizing of technologies.

As the Industry approaches these obstacles, the search for long-term disruptive solutions is necessary. Some of them, such as the use of green hydrogen and CCUS, previously mentioned by McKinsey&Company (2022), appear as alternatives in almost all industrial processes. Green hydrogen, for example, can serve many purposes, such as raw material for industry, fuel, or chemical for long-term energy storage.

Despite the level of maturity of innovative technologies, they still tend to have high costs. CCUS and hydrogen in the steel industry have carbon costs above US$ 100/tCO_2. Other limitations are the requirement for transport infrastructure and regulatory frameworks (Centro Clima & COPPE/UFRJ, 2023).

52. The second update of the first NDC, submitted in 2022, aims to reduce emissions by 37% in 2025 and 50% in 2030 compared to 2005, indicating the long-term goal of achieving climate neutrality in 2050.
53. In the DDS scenario, only the use of available technologies was considered, to demonstrate that there is a great potential for mitigation at low costs in Brazil, even before the implementation of disruptive technologies. It is also worth noting that the technology options mentioned in the different studies cannot be directly compared, due to the variability of the assumptions and parameters used in the construction of the scenarios.
54. *"Labeling provides information about the performance of products that can influence consumer choices, who will then be able to make better informed and conscious purchasing decisions"* (EPE, 2020).

Box 3

BOX 3 - NATIONAL OPPORTUNITIES TO DIRECT H2 PRODUCTION

The report "Sustainable Hydrogen: perspectives and potential for the Brazilian industry" highlighted the fast growth of the Brazilian sustainable hydrogen market, driven by foreign private companies interested in exporting. In the country, several projects are being structured to take advantage of competitiveness in the production of renewable electrical energy. At the same time, the federal government launched the National Hydrogen Program (PNH2), establishing guidelines and strategies for sector policy (CNI, 2022).

In the short to medium term (3 to 5 years), low-carbon hydrogen production in Brazil offers business and decarbonization opportunities in industrial sectors such as fertilizers, steel, chemicals, petrochemicals and methanol production (CNI, 2022).

• Production of ammonia and green fertilizers (short term) - Brazilian fertilizer production cannot compete with imported products due to the high price of local natural gas. The production of ammonia from green hydrogen in areas close to agribusiness has promising potential, with demand already existing in the international market.

• Steelmaking (short term) - Green hydrogen can replace coke in the sponge iron production process from iron ore, significantly reducing CO_2 emissions – there is already international demand for green steel. Furthermore, green hydrogen and mineral coal can diversify the steel production chain, as they make it possible to reduce the use of iron ore.

• Methanol production for the chemical and petrochemical industries (medium term) - The conversion of low-carbon hydrogen to methanol is advantageous as it does not require new and expensive infrastructure, nor does it face the safety difficulties associated with direct use of hydrogen.

To boost the production of green hydrogen, the *Hydrogen for Net Zero Initiative* (H2NZ) has been seeking, together with Verra and Gold Standard, to develop the first methodologies for the voluntary carbon market to start generating credits from the production of low carbon hydrogen. Given that the cost of green hydrogen is currently not competitive, it is possible that the carbon market will unlock the potential of this input by allocating resources to subsidize its production (South Pole, 2022).

There is, however, the caveat that in addition to the need to reduce production costs, an obstacle to the use of hydrogen in Brazil is the lack of an appropriate regulatory framework and infrastructure required by the links in the chain. The regulatory effort is important to guide government incentive policies and coordinate the efforts of all agents involved (CNI, 2022).

As traditional and disruptive technologies are adopted, industrial sectors tend to face rising costs resulting from changes in production processes and increased capital investments. As indicated by McKinsey&Company (2022), in sectors such as Cement and Steel, production costs per ton produced could rise by around 45% and 30%, respectively, by 2050 compared to 2020 levels. However, these cost increases can be reduced over time, as they are sensitive to the economies of scale of these technologies and the availability of resources. Managing these rising costs will emerge as one of the key challenges for the industry at large.

Other factors can influence companies' decarbonization routes and operational results, including consumers' willingness to pay a premium for low-emission products and the regulatory dynamics surrounding carbon prices within the country. In this way, sector strategies should probably be shaped by the implementation of government policies, as is the case with the national ETS and CBAMs.

The transition will require a joint effort between regulators, governments and industry *stakeholders* to reshape the production chain, facilitate access to the required capital and stimulate demand. Companies must collaborate with regulators to secure financial support for technologies, which will not only help maintain local jobs but also meet growing demand for low-emission products. Additionally, incentives can come from the financial sector, including investments from venture capital and *private equity* funds, to boost research and development (R&D) and support large-scale implementation (McKinsey&Company, 2022).

From an opportunity perspective, producers who advance these technologies will have a competitive advantage during the transition to a low-carbon economy. The adoption of these technologies can also generate opportunities throughout the ecosystem, including for companies that offer equipment and services aimed at implementing mitigation options[55] (McKinsey&Company, 2022).

5.1.2. FUELS

The scenarios developed by the Mitigation Options study also evaluate mitigation opportunities in the Fuel sector, which include technologies aimed at primary energy production centers, such as distributors and importers of fuel oil, natural gas, coal plants and coke ovens. However, mitigation options related to final energy consumption are not addressed (MCTIC, 2017).

Altogether, the Fuel sector can significantly reduce GHG emissions by 2050 by implementing the best technologies available in the low carbon (BC) scenario, with some of these measures already being adopted with low-cost technologies or even at negative costs. Table 3 shows abatement costs and potentials

55. For example, electrolyzer manufacturers may experience increasing demand for their products due to the essential role they play in the hydrogen value chain (McKinsey&Company, 2022).

by segments of the Fuel sector for the BC scenario between 2010 and 2050 and its most representative mitigation options.

Table 3 – Total abatement costs and potential by segments of the Fuel sector for the BC scenario between 2010 and 2050 and most representative mitigation options per segment

Fuel segment	Most representative Mitigation Options	Mitigation Potential between 2010 and 2050 ($MtCO_2e$) Low Carbon (BC)	Abatement Cost ($US\$/tCO_2e$)*
Oil and natural gas	Flare ignition pilot installation; installation of vapor recovery units in storage tanks; inspection and maintenance of equipment connections, and improvement in sealing and compressor casing.	415.0	10 a 50**
Mineral coal	Removal of methane from ventilation air.	1.5	33
Biofuels	Increased electrical energy generation in distilleries through the use of more severe conditions in the boiler (90 bar, 520°C) and straw co-processing.	35.4	-5.5, in 2030, to -2.3 to 2050

Source: Brasil (2017k, 2017l).

* The referenced source does not present the discount rate used to calculate the abatement costs of the measures presented.

** In the Oil and Natural Gas sector there are many mitigation options, therefore, the referenced source does not specify the cost of each one, it only adds the range per total of measures.

It is observed that intermediate cost measures, between 10 and 50 $US\$/tCO_2$, have the greatest potential in the Extraction and Production (E&P) segment. It is worth noting that many of these technologies provide fuel and electricity savings for refineries, which makes a significant portion with zero or even negative abatement costs (for example, modernization of the *flare* system) (MCTIC, 2017f). In addition to these options, the incorporation of *"all electric"* technology into new maritime platforms stands out among the most effective in the oil and natural gas E&P segment (PETROBRAS, 2021).

From a global perspective, the McKinsey&Company (2022) research presents the improvement of energy efficiency as the most effective solution for reducing emissions in the Fuel sector - a 10% improvement in efficiency could reduce the intensity of emissions in the oil and gas E&P segment by almost 4%. As already mentioned, the electrification of equipment used in extraction and refining would help to decarbonize these activities. In addition, fossil fuel producers could manage fugitive methane emissions with equipment such as vapor recovery units and practices such as leak detection. An important solution in carbon-intensive processes in the value chain is the application of CCUS.

The Climate Center uses the CPS and DDS scenarios mentioned in the previous section to present the abatement potential in the Fuels sector, offering a more up-to-date perspective for Brazil. The main purpose of the mitigation measures is to reduce fugitive emissions from gas flaring in the oil exploration and production process, as well as minimizing leaks at oil refineries and natural gas processing plants and reducing emissions from mining activities and the storage and transportation of natural gas. The importance of technologies aimed at reducing emissions from coal furnaces is also highlighted.

In the DDS scenario, these measures related to energy supply could result in a reduction of approximately 41 $MtCO_2$ compared to the CPS scenario (CENTRO CLIMA & COPPE/UFRJ, 2023). The potential for CO_2 capture from innovative solutions, such as CCUS, could reach 32% of the energy sector's emissions - around 130 million tons per year (CCS Brasil, 2023).

In addition to its potential to decarbonize the energy sector, CCUS can also represent a technology to remove carbon from the atmosphere when combined with renewable energy from biomass, called BECCS. The main applications for BECCS[56] include ethanol plants, biogas purification plants to produce biomethane, and biomass or biofuel thermoelectric power plants. Brazil has one of the largest potentials for BECCS in the world, due to its tradition and participation in the ethanol market, as well as its unexplored - but growing - potential for biogas (CCS Brasil, 2023).

56. CCS processes, when applied to the capture of CO_2 from renewable sources, are called BECCS (Biomass Energy with Carbon Capture and Storage).

Box 4

PETROBRAS' PRE-SALT CCUS PROGRAM

Petrobras' CO_2 capture, use and geological storage program in the pre-salt fields is the largest in the world in terms of volume reinjected annually. According to the Global Status of CCS 2021 report, the capacity of CCUS projects in operation is 36.6 million tons of CO_2 per year. In 2020, Petrobras reinjected 7 million tons, representing around 19% of the total. The company has progressively increased the volume of CO_2 reinjected, reaching 10.6 million tons in 2022.

CCUS technology involves separating CO_2 from natural gas, followed by reinjecting the CO_2 into the reservoir. By reinjecting the gas, there is an increase in production efficiency and a reduction in the intensity of GHG emissions per barrel produced. This solution allows Petrobras to produce oil with relatively low carbon emissions (PETROBRAS, 2023).

Despite the growing literature, few studies estimate the potential and marginal costs of sectoral abatement in detail. Even so, based on the results observed, it was possible to map out mitigation strategies, identifying the oil and gas E&P segment as having the greatest potential for reducing emissions in the Fuels sector and the importance of applying CCUS technologies in this process.

In a context of energy transition, it is likely that the demand for high-carbon fuels will decrease considerably, while the search for alternative sources of clean energy will increase. In this scenario, the oil and gas E&P segment would retain its importance in the short term as an anchor for ensuring countries' energy security. Even in the long term, a residual demand for fossil fuels would continue, especially those with a lower carbon footprint or higher quality, to meet the needs of sectors facing difficulties in decarbonizing. The combination of the use of technologies that improve energy efficiency and the physical-chemical characteristics of Brazilian pre-salt[57] oil could position Brazil strategically to supply this remaining demand and, at the same time, reduce sectoral emissions (CEBRI *et al.*, 2021).

Furthermore, the biofuel production segment is crucial not only for the decarbonization of the sector, but of the country as a whole. To CEBRI *et al.* (2021), biofuels associated with the use of CCUS could be a major competitive advantage for Brazil, especially considering the availability of land, favorable agricultural yields and domestic experience with the subject. Some advanced biofuels and biomass routes for the production of petrochemicals can contribute to achieving ambitious emission reduction targets[58].

The change in the composition of the energy production mix would have cascading effects on other sectors, which sell and demand products whose use depends on fossil fuels. This observation is important, because the adoption of mitigation technologies should not take place in isolation, but in a coordinated sequence between the strategic sectors. Therefore, efforts to expand biofuel production and adopt low-carbon technologies in the fuel sector will be linked to increased capital investment in industrial sectors aimed at improving energy efficiency and modernizing machinery capacity - this relationship is also valid in the opposite direction.

The Energy sector presents some of the best opportunities for value creation, considering the mitigation options and the increase in capital investments expected. The McKinsey&Company (2022) study estimates that new industries based on hydrogen and biofuel production could grow tenfold by 2050. However, a transition from high-emission to low-emission energy assets must be managed carefully; otherwise, energy costs and fuel price volatility could increase, and ensuring a reliable energy supply could become a challenge.

In the long term, innovation has the potential to significantly accelerate cost reductions. A recent analysis indicates that the costs of producing green hydrogen could fall by up to 60% between 2020 and 2030. At this pace, green hydrogen could become cost-competitive with traditional production methods by 2028, especially in regions favorable to the production of this type of energy (considering an average carbon price of US$ 150/tCO_2e by 2050). Expanding hydrogen production capacity would require an increase in average annual global investment of around US$ 55 billion, which would also result in substantial job creation, with an additional two million jobs related to capital spending on infrastructure by 2050 (McKinsey&Company, 2022).

Increasing biofuel production would also require a significant average annual global investment of around US$ 175 billion. Demand for biomass would grow during the transition to emissions neutrality, mainly due to the adoption of biofuels[59]. The expansion of biofuels could also generate around six million direct and indirect jobs in operations and maintenance by 2050, as well as a further two million jobs related to capital expenditure linked to infrastructure construction (McKinsey&Company, 2022).

In the case of Brazil, an IPEA (2022) study indicates that the country is already attracting a significant amount of investment in hydrogen production projects and the implementation of CCUS. The evolution of these projects and others that promote decarbonization, as well as fluctuations in production costs over time, should influence the decisions made by these sectors and, consequently, drive the country's pace in the transition to a low-carbon economy.

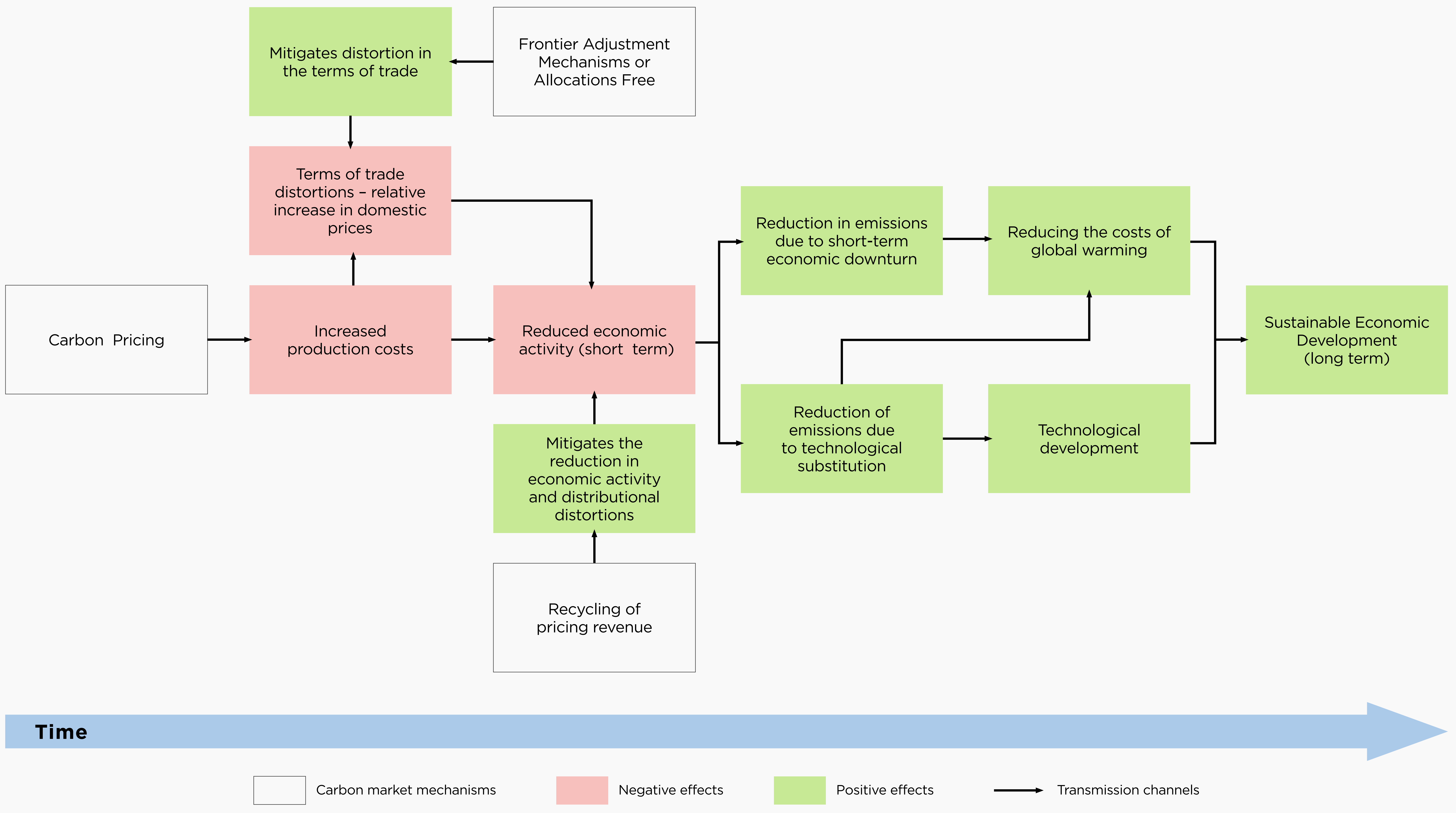
57. Characterized by its medium density and low Sulphur content.
58. CCUS coupled with the biomass conversion chain can achieve negative emissions (CEBRI *et al.*, 2021).
59. Allied to this, issues at stake include the feasibility of producing biomass from waste and the availability of suitable land for growing bioenergy (McKinsey&Company, 2022).

5.2. SOCIO-ECONOMIC IMPACTS OF CARBON REGULATION

Economic theory suggests that the introduction of carbon pricing instruments makes it possible to achieve the best cost-benefit ratio for a national mitigation target. However, in the short-term, pricing GHG emissions has the potential to increase production costs in carbon-intensive sectors, triggering impacts on household income and consumption, prices, the national competitiveness of these products and GDP (Carvalho *et al.*, 2022). These impacts may be unavoidable on the road to a low-carbon economy, and it is necessary to analyze them beforehand to minimize their impacts.

Initially, the internalization of the carbon price has an inflationary impact since production costs increase. The sectoral response to this price increase has knock-on effects throughout the production structure, including endogenous changes in the use of inputs and sectoral production (Brasil, 2017m). **These short-term economic impacts generate strong incentives for technological innovation that increases the cost-effectiveness of emissions control, so that it becomes cheaper to control or emit less per unit produced or consumed** (World Bank, 2020b). These reactions, generated in the short-term, can trigger, in the long-term, a technological lag in economies that delay the adoption of market instruments, since mitigation options are generally intensive in technological content. The Figure 7 presents a simplified summary of the expected transmission channels of the short- and long-term macroeconomic impacts of carbon pricing.

Figure 7 – Simplified summary of the expected transmission channels of the short- and long-term macroeconomic impacts of carbon pricing*



* Expected effects of carbon pricing, keeping all other factors that may affect short-term economic activity and long-term economic development constant.

Source: Own elaboration.

The literature presents various results relationed to these impacts (Carvalho *et al.*, 2022; World Bank, 2020b). Economic impacts can be considered negative for a specific sector or group of consumers, but desirable from the point of view of society as a whole. However, without them, there can be no adjustments in production and consumption to enable low-carbon trajectories. As these impacts are a reflection of the need for adjustments in the economy due to the commitment to an emissions control target, there is no way of zeroing them out, but the cost-effectiveness of economic pricing instruments allows them to be minimized (World Bank, 2020b).

Thus, a carbon pricing policy should be treated as part of a broader fiscal reform, including the possibility of recycling carbon revenues. In addition to cost-effectiveness, well-targeted pricing can generate a "double dividend" by generating net macroeconomic benefits compared to a reference scenario.

For this to happen, the revenues earned by the government through the auctioning of allowances, taxation on trading on the secondary market and possibly penalties applied to agents must be returned to society (recycled) through tax reductions or direct distribution of income to the most vulnerable families.

In short, the introduction of pricing mechanisms makes it possible to achieve national mitigation targets at lower costs and can affect differently agents and sectors of the economy. The effects of these mechanisms can be amplified or nullified within economic interrelationships. A better understanding of these impacts can help reduce uncertainties and encourage timely investments in large-scale low-carbon technologies. It is therefore useful to create scenarios that identify the socio-economic impacts of carbon regulation in Brazil, especially in sectors that are likely to be subject to regulation, such as Industry and Fuels. This section presents some scenarios and results found in recent studies on the impacts of carbon pricing on different economic and social aggregates, such as GDP, unemployment, price levels and income distribution.

5.2.1. SOCIO-ECONOMIC IMPACTS OF CARBON REGULATION IN BRAZIL

The socio-economic impacts of implementing a regulated carbon market in Brazil should be analyzed as deviations from a baseline scenario in which there is no pricing of GHG emissions. These impacts are closely linked to the assumptions adopted in the reference scenario and, therefore, a direct comparison of the results from different models is not recommended since the assumptions and limitations considered in the construction of the scenarios may vary from one model to another. This section therefore provides a specific analysis of the scenarios for each reference.

It is important to note that models do not usually capture the different nuances brought about by pricing instruments. The implementation of a tax or an ETS generates different socio-economic impacts, and it is important to consider these particularities and the specific objectives of the regulated carbon market in Brazil.

Through the scenarios mentioned in section 5.1, the "Mitigation Options" study not only estimated the costs and potential for reducing emissions, but also assessed the impacts that mitigation opportunities would have on different economic and social sectors. The study considered a reference scenario, which reflects current government policy targets, as well as BC scenarios, in which the best available technologies are applied, with different carbon values (BC0, BC25, BC100). Implementing a scenario that internalizes a carbon value of 25-100 US$/t$CO_2$ would **have a low impact on GDP, employment and income indicators by 2050**, with an average annual variation in GDP of -0.10% and -0.83% per year. However, the mining, pig iron and steel, electricity, oil and gas sectors would be significantly affected due to their interdependence with subsequent activities. For this reason, this study argues that carbon revenue recycling mechanisms are essential to counterbalance the negative effect of pricing carbon (Brasil, 2017a).

Along the same lines, the PMR Brazil Project presented different carbon pricing scenarios in Brazil: a reference scenario, which reflects the continuation of current standards and instruments, and six other scenarios with different pricing characteristics. In the main[60], the design of the measures is adapted to national sectoral realities, with a regulated scope that includes Industry (various segments[61]) and Fuels (indirectly regulated users, such as transport and thermoelectric generation) (World Bank, 2020b).

Even with the high ambition of the pricing scenarios[62], **there was no economic damage** compared to the reference scenario. The simulated measures have characteristics that play the expected role, protecting the competitiveness of the regulated sectors while taking advantage of opportunities, either through revenue recycling or incentives for low-cost mitigation via compensation.

As a result, in contrast to the "Mitigation Options" study, the PMR Brazil pricing scenarios are associated with **positive effects on economic activity**. In 2030, GDP growth is approximately 2.25% higher than in the reference scenario. In addition, an increase of around 1.5 million jobs[63] was observed in these scenarios. It is also worth noting that even with avoided mitigation capital expenditure of more than R$ 100 billion, these scenarios have a slightly higher investment rate. Despite the positive balance for the economy, the increase in activity and the cost component generated by the carbon price have an **inflationary impact** in the pricing scenarios compared to

60. The main characteristics of the main scenario, called "baseline", include the use of the ETS as a pricing instrument, with regulatory thresholds covering industrial establishments with annual emissions above 25 ktCO_2, as well as all fuel distributors and importers.
61. The segments considered were the chemical industry, pulp and paper, steel, aluminum, cement, lime, glass, food and beverages, textiles, mining and ceramics.
62. The particular characteristics of the other pricing scenarios are based on deviations from the "baseline" scenario.
63. The jobs in the World Bank (2020b) study refer to full-time jobs, i.e. 44-hour working weeks.

the reference one, which is reflected in a lower trade balance (World Bank, 2020b).

In another paper, the Instituto Talanoa (2021) suggests that the path to decarbonization can be achieved with a carbon price of 9.5 US$/t$CO_2$e in 2025 and 19 US$/tCO_2e in 2030. It considers a reference scenario, with the continuation of ongoing policies and the resumption of economic growth, and more ambitious scenarios, which include carbon pricing and assumptions to achieve climate neutrality by 2030[64].

The higher ambition scenarios are characterized by **higher levels of domestic prices**, which contributes to a deterioration in the terms of trade and results in a larger deficit in the balance of trade compared to the reference scenario in the years 2025 and 2030. On the other hand, for these same periods, a marginally higher GDP is expected (0.04% and 0.30% in 2025 and 2030, respectively), a slightly lower unemployment rate (reduction of 0.1 percentage point in 2030) and a slightly higher average disposable income for the lowest income bracket (0.07% in 2025 and 0.30% in 2030) (Instituto Talanoa, 2021).

These scenarios show that **carbon pricing directly affects the prices** of oil derivatives, leading to an increase in the price of LPG of R$ 2.0 and R$ 3.9 per 13 kg canister by 2025 and 2030, respectively. Gasoline tends to be the most affected fuel (an increase of R$ 0.07 per liter in 2025 and R$ 0.15 per liter in 2030), followed by diesel oil, with increases of R$ 0.06 and R$ 0.13 per liter in 2025 and 2030, respectively. Consequently, carbon pricing has a more significant impact on carbon-intensive sectors and the recycling of revenues from carbon pricing favors job creation, resulting in the creation of more than 150,000 jobs compared to the baseline scenario, mainly in the services, transport, forestry and biofuels sectors (Instituto Talanoa, 2021).

According to the same reference, the pricing scenarios make it possible to strongly reduce emissions in 2030 and put Brazil on the path to neutralizing GHG emissions by 2050, while at the same time, thanks to revenue recycling, mitigating the adverse effects of carbon pricing on poor families. The **gains in disposable household income** in these scenarios are significant compared to the baseline scenario, due to higher levels of activity, lower labor burdens and higher government transfers, which are reflected in more jobs and higher income.

The economic impacts needed to achieve the reduction target required by the Paris Agreement were also analyzed by Carvalho *et al.* (2022). They consider three scenarios between 2022 and 2030: a reference scenario (command and control without negotiation), a broad market scenario (carbon market encompassing all productive sectors) and a restricted market scenario (carbon market only in selected sectors[65]), with variable carbon prices. Based on this approach, the paper identifies that the more sectors participate in the market, the smaller the drop in the level of sectoral activity. This is because, by sharing the reduction target between them, costs are distributed.

However, in the broader market scenario, the inclusion of sectors such as agriculture and food has the potential to have a **significant impact on household** consumption in the case of the lower income brackets. This regressive effect can be explained by the different consumption patterns of each income group. Products from these sectors account for a larger share of the consumption of lower-income families. Therefore, a broad regulated carbon market, which includes all productive sectors, could have negative distributive effects despite reducing the price of the carbon needed to reach the reduction target, requiring compensation mechanisms to be structured to include industry sub-sectors with a large share in the basket of the poorest families.

It is also important to mention that the inclusion of voluntary market credits in the regulated market carries, in addition to the carbon credits, the socio-economic impacts of their generation. It is noteworthy that the local communities of carbon projects, especially in nature-based solutions projects, often include **traditional, indigenous, riverine and *quilombola* populations that are directly impacted** by the projects. For the impact to be positive, these populations must participate effectively in the design of carbon projects and be given due recognition (ICC Brasil & WayCarbon, 2022).

Although there are concerns about the **potential regressive impacts of carbon pricing**, scenarios such as World Bank (2020a), which only include the Industry and Fuels sectors, have shown positive social impacts. Both the real average income and the proportion of real disposable income of the poorest 20% of the Brazilian population have increased and are higher in the scenarios with pricing than in the reference scenario. These results can be attributed to a number of factors, such as the increase in economic activity, the reduction in unemployment, the effective allocation of revenues from carbon pricing and the fact that, unlike in developed countries, Brazil does not have a significant portion of the low-income population's income earmarked for heating homes, reducing possible energy expenses. In addition, Brazil has a clean electricity matrix compared to global standards.

In this way, the **intelligent recycling of revenues** from carbon pricing can result in a reduction in both greenhouse gas emissions and social inequalities. (Instituto Talanoa, 2021). These revenues can be used in various ways, whether for investments in sustainable technologies, reducing taxes, transfers to vulnerable families, increasing government investments, or even paying off government debt.

In practice, ETS revenues are often used to promote climate action or to compensate particularly vulnerable groups. While some jurisdictions have set up separate funds to collect and distribute auction revenues according to a comprehensive investment plan

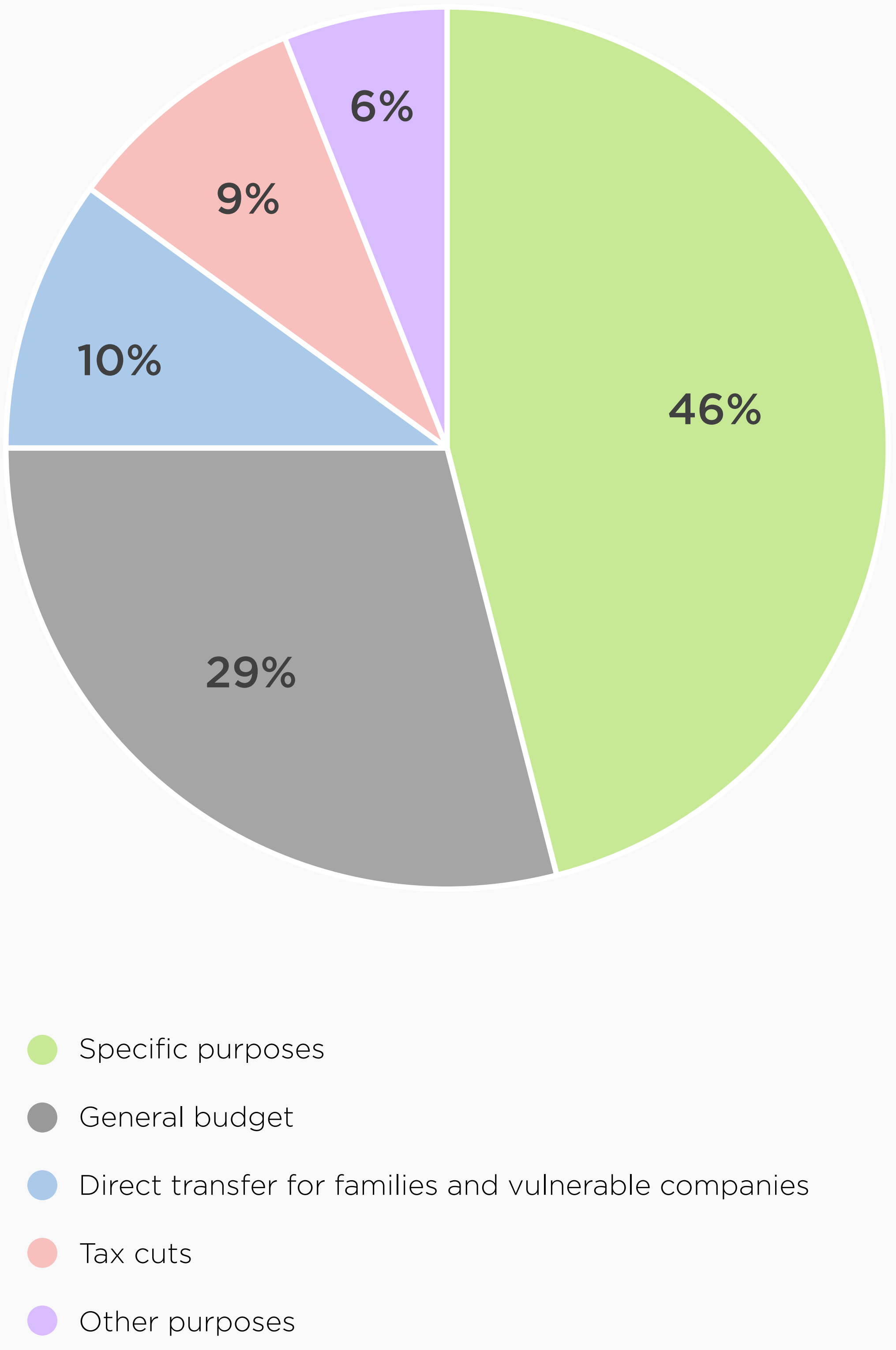
64. This carbon price is introduced through an ETS in industry and a carbon tax on the burning of fossil fuels in other sectors. In addition, an annual rate of Zero Deforestation by 2030 in the Amazon and Atlantic Forest is assumed.
65. Transportation, Thermal Power, Non-ferrous Metallurgy and Cement.

or spending priorities, revenues can also go into the general budget without earmarking (Santikarn *et al.*, 2019). Considering ETS and carbon taxes, most of the revenue goes to specific purposes, in particular spending on green technology, contributing to the increase in emissions reductions in the jurisdiction in the long term. This proportion for specific purposes has been increasing over the years and has been driven **by the increase in revenue in the EU ETS, where most of the revenue (over 50%) is used for climate and energy-related purposes**. It is also important that part of the revenue goes directly to vulnerable families and companies, minimizing the negative distributional effects of carbon pricing (World Bank, 2023b). Figure 8 shows the proportion of each form of revenue allocation.

As well as recycling revenues, **increasing the investment rate** as a proportion of GDP is a fundamental condition for achieving the benefits of pricing and thus sustained economic growth. In Brazil's case, it is estimated that by 2030, low-carbon investments could add R$ 2.8 trillion to GDP and create two million additional jobs compared to the current development model (Romeiro *et al.*, 2021).

On the other hand, the World Bank (2023d) estimated that **investment needs for climate action** represent approximately 1.2% of Brazil's GDP for the period from 2022 to 2050, with around 0.8% of GDP between 2022 and 2030. Most of these investments are related to the transportation system, which requires infrastructure to switch from road to other modes. Although

Figure 8 - Allocation of revenues from ETS and carbon taxes in 2021



Source: Own elaboration based on World Bank (2023a)

large investments are required, these costs are partially offset by savings, such as reduced energy costs in transport and industry, less congestion and less air pollution. These economic benefits represent approximately 0.3% and 0.7% of GDP for the periods 2022 to 2030 and 2022 to 2050, respectively (World Bank, 2023a).

However, there will be **greater public investment needs related to transition**, compensation and social spending. During the period from 2022 to 2050, social spending to facilitate the transition of affected workers and communities is R$ 700 million for the coal sector and R$ 550 million for the gas sector, with these amounts being reduced due to the small number of workers in these areas. Over the same period, compensation costs for asset owners are not significant for the one coal-fired plant that needs to be decommissioned before the end of its useful life (R$ 1.9 billion), but are very high for gas-fired plants (R$ 217 billion). The high cost of shutting down gas-fired power plants between 2022 and 2050 is largely due to the plan to build new plants in the coming years[66] (World Bank, 2023a).

To meet the greater needs for investment in infrastructure and social spending in a limited fiscal context and with pressure from an ageing population, it is essential to create an enabling environment (regulatory certainty and legal security) to **attract private investment in resilient, low-carbon development**. The country's climate strategy must rely on multiple sources of funding, such as redirecting public spending and making strategic use of climate finance opportunities (World Bank, 2023a). In the energy sector, there are still significant subsidies that encourage carbon-intensive and economically inefficient activities. According to the Institute for Socio-Economic Studies (INESC), the government's tax waiver was R$ 99.39 billion in 2019 for fossil fuels, equivalent to 1.36% of GDP in the same year (INESC, 2020). In the case of mineral coal for thermoelectric generation in the south of the country, subsidies reached almost R$ 1 billion in 2020, and were extended until 2040. Incentives for coal-fired power generation could be redirected to support the transition to clean energy sources, reducing the tax burden on the public sector (World Bank, 2023a).

In summary, in the long term, pricing scenarios allow for significant savings in terms of mitigation investments - by optimizing the order of entry of mitigation options - and reduce distortions caused by other taxes, allowing for greater dynamism in the economy, higher GDP and a warmer job market.

Most studies on the possible impacts of a regulated carbon market in Brazil stress the importance of efficient allocation and appropriate use of revenues from pricing instruments as a strategy to mitigate regressive effects on income and sustain long-term economic benefits. This includes the introduction of income transfer programs and the increased investment in the adoption of more efficient and cleaner technologies (World Bank, 2020b).

66. Other transition needs, such as retraining or re-qualification of affected workers in agriculture or industry, have not been estimated.

5.2.2. SOCIO-ECONOMIC IMPACTS OF CARBON REGULATION IN IMPLEMENTED SYSTEMS

The socio-economic impacts of carbon pricing depend on the design of each system. Many jurisdictions have already introduced pricing, some for years, such as the European Union with the EU ETS. With empirical literature, their experiences provide useful lessons to guide the implementation of a Brazilian market. Most jurisdictions have adopted a gradual approach to implementing emissions trading, with the carbon price starting at low levels, possibly reflecting uncertainty about its impacts (SHANG *et al.*, 2023).

As mentioned in the section 5.2 of this report, **one of the main short-term effects is an increase in prices**. Thus, the burden of carbon pricing can be passed on to producers and consumers through higher prices. Ganapati, Shapiro and Walker (2020) concluded that, on average, 70% of the changes in input costs caused by higher energy prices are passed on to consumers in the short and medium term. In the case of the EU ETS, Fabra and Reguant (2014) reported that market costs are almost entirely passed on to prices.

Evidence from the systems already in place also suggests that the **adverse effects on low-income groups**, via higher consumer prices, can be mitigated by allocating the revenues generated by pricing to aid and compensation policies for these groups (Bowen, 2011; Baranzini, 2017; Sager, 2019; Dorband *et al.*, 2019).

As for the impact on jobs, the results of a Computable General Equilibrium model applied to China's ETS show that the ETS **increases the unemployment rate in the short term, but it tends to decrease in the medium to long term**. The ETS leads to a decrease in employment in sectors that consume a lot of electricity, including coal and oil production, manufacturing, mining, construction, transportation and service sectors. In contrast, it provides for increased employment in the electricity sector through the energy transition and in agricultural, water, heat and gas production sectors, since these sectors are complementary to the electricity sectors or are not carbon-intensive (Chen & Wang, 2023). Therefore, there is a job transition from more carbon-intensive sectors to less carbon-intensive sectors.

Job losses and gains can be translated into job transitions, involving the movement of workers between skills, functions, companies, sectors and geographies. The study McKinsey&Company (2022) suggests a net increase of around 15 million jobs associated with changes in the economic activity of specific energy and land use systems resulting from the transition. Historical analyses also recognize that the use of new technologies usually creates far more jobs than it destroys. This includes new jobs in occupations that could not have been envisioned at the outset.

Many studies on carbon pricing have found **no evidence of a negative impact on regulated companies' economic performance and competitiveness** (Dechezleprêtre *et al.*, 2018; Jaraitè & Maria, 2016; Löschel *et al.*, 2019; Richter & Mundaca, 2013; Verde, 2020). On the contrary, some have observed a positive impact on the economic performance of companies regulated by the EU ETS, especially during its Phase I (Alves *et al.*, 2011; Löschel *et al.*, 2019). These results can be explained by the over-allocation of emission allowances, which led to a drop in prices, and by the ability of companies to pass on costs to consumers in certain sectors. These factors have even allowed some companies to generate unexpected profits (Joltreau & Sommerfeld, 2019).

To help mitigate the regressive effects of carbon pricing, the authors evaluate the different impact channels and their attributes based on available evidence. They suggest that measures to contain distributional impacts of consumption should initially focus on short- and medium-term effects to gain political support and protect the well-being of the most vulnerable. In the long term, improved energy efficiency and the transition to less carbon-intensive energy sources incentivized by pricing can help mitigate rising production costs and consumer inflation (Acemoglu *et al.*, 2012).

Sager (2019) argues that the **socio-economic impact of any carbon pricing scheme depends on the use of the revenues**. Raymond (2019) points out the importance of using revenues to promote tangible, widely distributed and easily recognized public benefits, as well as adopting appropriate uses according to local circumstances. As mentioned above in section 2.2, carbon pricing instruments generated US$ 95 billion in revenue in the jurisdictions that adopted them in 2022 (World Bank, 2023b).

ETSs generally produce proportionally less revenue than carbon taxes, despite having a wider coverage, but if the distribution of allowances is done through full auctions, their revenue stream would be higher, and could even be similar to a direct tax. However, it should be noted that, in some cases, increasing revenues in this system may not be advantageous, as political feasibility often favors lower revenues (Carl & Fedor, 2016).

Only a fraction of the pricing systems implemented allocate some portion of the revenue directly to poor families (Carl & Fedor, 2016). In the EU ETS, studies indicate that carbon pricing has neutral or even progressive effects for most EU member states, but the effect for the region as a whole tends to be regressive, mainly due to differences between countries (Feindt *et al.*, 2021). As a result, new regulations on the use of revenues have been incorporated into a broad set of proposals launched by the European Commission through the "Fit for 55"[67] package, which includes the creation of the Social Climate Fund (*Fundo Social para o Clima*).

In other emissions trading systems, only a few countries have implemented measures to support the most vulnerable households, partly due to the very low levels of pricing in some of them (China, Colombia and

67. The package of proposals aims to provide a coherent and balanced framework for achieving the European Union's climate objectives that: ensures an equitable and socially just transition; maintains and strengthens the innovation and competitiveness of European Union industry; and supports the European Union's leading position in the global fight against climate change.

South Africa). On the other hand, almost all of them include measures to mitigate the impact on companies, such as tax cuts (British Columbia), exemptions (Colombia, France and South Africa), free emissions allowances (California) and low initial carbon tax rates (Singapore and Sweden) (Shang *et al*., 2023).

In addition to the socio-economic impacts, to determine **the effectiveness of emissions trading in terms of reducing emissions**, it is crucial to evaluate the results of ongoing markets, even considering the lack of uniformity and the difficulty of accessing data. Regarding the installations covered by the EU ETS, according to the European Commission, there was a reduction of around 41% in emissions between 2005 and 2022. In the case of New Zealand, the amount of emissions reported under the ETS has remained relatively stable since 2015, while in South Korea a reduction in the carbon intensity of regulated entities has been observed in the manufacturing and construction sectors, but not in the energy sector (European Commission, 2019; ICAP, 2021). However, it is difficult to determine what part of these results is attributable to the ETS, due to the numerous factors that influence emission levels and the lack of reliable data to compare current emissions. The complexity of crisis events (such as the Covid-19 pandemic and the Ukrainian War) also makes it difficult to understand the longevity of their impacts.

Furthermore, policies related to the EU ETS can have an economic impact on developing countries. As already mentioned, the implementation of CBAM could affect the exports from several of these countries, causing a significant impact on their economies. However, as the purpose of this mechanism is to encourage cleaner production processes, the European Union says it is ready to collaborate with low- and middle-income countries in decarbonizing their manufacturing industries by providing the necessary technical assistance.

5.2.3. POINTS OF ATTENTION FOR IMPLEMENTING A REGULATED MARKET IN BRAZIL

The impact of carbon pricing in Brazil on the different income strata of society will depend on the productive sectors that will be covered and, above all, the destination of the revenues from this market. Carbon revenues can be used to increase public investment, reduce taxes on private agents, increase income transfers or repay public debt. In the long term, increased investment in infrastructure, more efficient and cleaner technologies should ensure sustained economic growth.

While the destination of revenues is important, the way in which these revenues are managed and used in the long term is even more fundamental – it must be ensured that they are truly effective in mitigating emissions and minimizing socio-economic impacts. Regardless of how carbon revenues are directed, the quality of this public spending requires structuring, rationalizing and prioritizing efficiency. For this to happen, the entity responsible for the market must take a leading role in measuring the results and analyzing the impacts of public policy, whatever it may be.

Before assessing the measures needed to mitigate the possible socio-economic impacts of a regulated carbon market, it is necessary to deal with the challenges of its implementation. Two topics deserve attention here:

1. **The complexity of trading instruments:** the implementation of infrastructures for trading and managing carbon credits can be very complex, which requires a robust financial system;
2. **The engaging role of the public sector:** the public sector must act to create a consensus and circumvent potential political resistance from sectors that may oppose the implementation of the carbon market, especially those who see it as an economic burden.

Finally, even before implementation, it is essential that the public and private sectors are aligned in favor of decarbonization strategies that support the sustained growth of the Brazilian economy. For this to happen, it is up to the government to provide transparency and propose a clear timetable for the phased implementation of the ETS, with specific milestones to evaluate the progress and effectiveness of the actions.

5.3. KEY MESSAGES

1 The purpose is to estimate abatement costs and potentials:

- Estimating abatement costs and potentials is essential for analyzing the economic viability of GHG reduction projects and identifying mitigation opportunities in selected sectors. Based on the marginal abatement costs, it is possible to evaluate the least-cost options for achieving long-term mitigation targets.

2 Opportunities for the industrial and fuel sectors in a regulated market:

- The industrial and Fuels sectors play a strategic role in the decarbonization of the Brazilian production chain. Both are covered by most of the ETSs in force until 2023 and are more likely to be covered by a regulated carbon market in the country.

- Industry can adopt energy efficiency measures with significant potential to reduce GHG emissions at negative abatement costs. In the Fuel sector, mitigation opportunities include the adoption of more efficient technologies at various stages of the production chain, with actions capable of increasing operational efficiency and reducing emissions at low or negative cost.

- Overcoming entry barriers and seeking more disruptive solutions, such as the use of green hydrogen and CCUS, is necessary to achieve more ambitious sectoral goals in the long-term.

3 Socio-economic impacts of carbon pricing in Brazil:

- In terms of modeling, carbon pricing scenarios point to a low impact on macroeconomic indicators, especially when associated with revenue recycling mechanisms.

- Pricing can directly affect the production prices of carbon-intensive sectors, causing a negative distributive effect on income when all sectors are included. However, by including only strategic sectors, this effect can be reversed or even generate positive impacts on income.

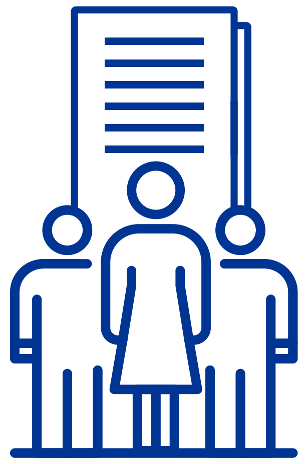
- To sustain positive potential impacts and mitigate the negative ones, it is necessary to allocate revenues effectively and fairly. To this end, it is necessary to study the efficiency of different forms of revenue recycling in minimizing the impacts of implementing a national ETS on the Brazilian population. Among the possible alternatives, consider incentives for the adoption of clean and efficient technologies, tax reductions, support for vulnerable families, increased government investments, among others.

4 Lessons learned from implemented systems:

- There is no consensus on the socioeconomic impacts of pricing in implemented systems, as they depend on the specific characteristics of each instrument, the socioeconomic conditions of the country, and the operating conditions of the regulated sectors.

- Empirical experience shows that the burden of carbon pricing can be passed on to producers and consumers through prices, affecting lower income groups more intensely. There has also been a transition of jobs from more carbon-intensive to less carbon-intensive sectors.

- Despite the importance of recycling income to mitigate the regressive effects of carbon pricing, only a few jurisdictions have adopted measures to support the most vulnerable families.



6. RECOMMEN-DATIONS

Based on the theoretical and empirical research carried out throughout the study and the trends pointed out in the key messages sections of each chapter, it is understood that there are several points of attention that the Brazilian government should consider establishing a carbon market in Brazil and the private sector in relation to the impact of a national market and international border adjustment mechanisms. The study therefore presents the following recommendations with the potential to minimize negative impacts and boost the domestic market.

6.1. TO THE GOVERNMENT

The recommendations to the government are aimed at increasing the country's climate ambition, avoiding possible regressive effects on the most vulnerable populations and enabling a just transition to a low-carbon economy.

FOR THE IMPLEMENTATION OF THE BRAZILIAN ETS:

1. **Ensure transparent and open consultation with the entities to be regulated** and institutions with technical knowledge of carbon markets to design the rules of the Brazilian carbon market during the government's drafting process.

2. **Implement a regulated carbon pricing system (ETS) to ensure that there is an exemption from or reduction in the fees imposed by EU CBAM for exported products**, which can safeguard competitiveness related to the international market.

3. **Define the institution that will be responsible for operating the ETS**, whether it will be a ministry or an independent body to be created, as well as other institutions that could be involved in operating the system, such as regulatory and implementing agencies.

4. **Define the legal nature of the emissions allowances to be traded in the ETS** so that there is legal certainty and tax predictability for the regulated agents and other agents involved. This definition is fundamental in establishing the market regulator, which will deal with the technical and procedural issues related to the creation of this trading environment.

5. **Establish phases for the implementation of the ETS** to:

   5.1. Start implementation by regulating the fuel and industry sectors and expand the number of regulated sectors. To increase the ambition to reduce emissions, distribute sectoral costs and mitigate the fall in the level of sectoral activity, the sectoral coverage of the market should be broader in the coming periods.

   5.2. Gradually reduce the ETS cap to increase climate ambition and support the targeting of investments towards climate neutrality at the scale and pace required.

   5.3. Initially include domestic offsets in the Brazilian ETS for project types that are eligible to reduce compliance costs for companies and encourage decarbonization in other sectors, thus minimizing the impact on emissions mitigation in regulated sectors.

   5.4. Periodically reassess the impacts of the ETS to guarantee the effectiveness of the carbon pricing policy, considering the review of the system and when it will be done. If necessary, include more sectors, the reduction of the cap, greater restriction of the use of offsets and alteration of the use of revenue..

6. **Reconcile free allocations and allocations through auctions considering:**

   6.1. The adoption of the grandfathering criterion, for free allocation of 50% to all sectors with a competitiveness risk;

   6.2. And a percentage of allocation through auctions designed to raise revenue that can boost emissions mitigation actions and minimize the socio-economic impacts of implementing the ETS, such as the increase in the price of inputs that must be passed on to the end consumer. The allowances sold in the auctions must have a minimum price so that the incentive to decarbonize is maintained.

7. **Recycle any revenues effectively and fairly, in order to offset the negative distributive effect on the population's income and on sectors whose competitiveness will be affected by the pricing mechanism, and for investments in decarbonization or R&D projects**. The possible uses of the revenue should be studied, prioritizing, in the long term, increasing the incentive to adopt more efficient, clean and sustainable technologies, using robust targets and metrics for evaluating performance and effectiveness. Recycling revenue can help mitigate the increase in production costs and, consequently, consumer inflation. This allocation of resources should also help catalyze private investment.

8. **Implement a system of stringent penalties to deter potential fraud,** considering that regulated entities will weigh the trade-off between paying fines or acquiring emission allowances.

Regarding the inclusion of compensation:

9. **9.1. Study the types of carbon projects that will be eligible for inclusion as offsets in the regulated Brazilian** carbon market, considering the non-inclusion of types of projects that could flood the market and jeopardize allowance transactions and the effective reduction of emissions in the system.

9.2. Have as a criterion for inclusion in compensation projects that benefit and count on the active participation of local communities - traditional, indigenous, riverine and/or *quilombola* populations - including revenue sharing and income generation.

OTHER RECOMMENDATIONS TO THE GOVERNMENT:

1. **Implement, simultaneously with the adoption of carbon pricing, a robust MRV system for recording and monitoring mitigation results for compliance with the NDC and that integrates with other systems.** For example, public programs and policies linked to the progress of the different sectors in relation to the targets stipulated by the NDC, the ETS and the transactions to be carried out under Article 6, to provide data to guide the national strategy for action in carbon markets. This system, as well as being a prerequisite for the ETS to work, can prove the lower carbon intensity of its exported products compared to international competitors. This strategy would allow Brazil to better prepare itself to deal with the requirements imposed by EU CBAM.

2. **Supporting and directing the private sector in its decarbonization** so that Brazilian companies do not lose competitiveness internationally, since their competitors, who are currently under stricter regulations regarding the climate impact of their activities, are prioritizing this process. This can be done through sectoral trade associations, such as the State Industry Federations and the Brazilian Banking Federation (FEBRABAN).

3. **Strive to fulfill the commitment to zero illegal deforestation and to reduce legal deforestation in the country**, given the representativeness of its emissions for the country and the non-inclusion of the forestry sector in the Brazilian ETS as a regulated sector. Furthermore, it is important to include among its actions the establishment of clear definitions so that the Federative Units (FUs) are able to carry out avoided deforestation projects at the jurisdictional level.

4. **Take a stand for the World Trade Organization (WTO) to guarantee clear rules regarding the equal measurement of the carbon intensity of products and their production processes, so that different production routes and the reality of each country are considered, as well as the electricity matrix**. This would protect national sectors from carbon leakage, provide better results for the footprint of exported products, and ensure Brazil's competitive advantage in terms of its cleaner electricity matrix;

5. **When discussing the methodology to calculate emissions according to the European Union's CBAM guidelines, it is essential to broaden the approach to include not only direct emissions, but also to consider carbon removals from the sustainable implementation of forests**. In the Brazilian context, where vertical companies use these forests responsibly in sectors such as charcoal-fired steel, pulp and paper, flooring and panels, it is crucial that the methodology recognizes this positive contribution to a more complete carbon balance. Therefore, it is recommended to consider the net balance between emissions and removals, promoting sustainable industrial practices and moving towards global carbon emission reduction targets.

6. **Support the debureaucratization and simplification of transaction processes, as well as implement digital technology for the MRV and carbon credit certification processes.**

7. **Enable a series of important institutional measures for the voluntary carbon market to facilitate the interaction of this market** with the Brazilian and international regulated market within the scope of Article 6 and to support the use of carbon credits in the decarbonization process of Brazilian companies:

7.1. Define the legal nature of carbon credits and the roles of financial institutions and the carbon credit asset regulator. In addition, create a trading infrastructure, as well as bookkeeping and create identification codes for the credits.

7.2. Foster the development potential of the voluntary carbon market, considering that its projects can contribute to social equity and ecological balance generated by the protection of biodiversity, equitable access to sustainable development and the eradication of poverty and climate justice, in harmony with the Paris Agreement and the Climate Convention.

7.3. Strengthen the government's technical bodies on carbon projects, local community participation in these projects, REDD+ and Jurisdictional REDD+, for example.

8. **Given the planning for compliance with the NDC, establish the strategy for selling credits through Article 6 mechanisms**, considering the interaction between the regulated and voluntary markets in Brazil.

6.2. TO THE PRIVATE SECTOR

To strengthen national carbon markets and support companies exporting products potentially affected by border adjustment mechanisms and sectors to be regulated under the Brazilian ETS, the following recommendations have been drawn up.

1. **Prioritize decarbonization as an urgent strategy to be implemented, independently and in parallel with the process of creating a regulated market in Brazil**, with the purpose of not losing competitiveness internationally, considering that its competitors are advancing on this agenda due to the more restrictive regulations to which they are subject.

2. **Drawing up a greenhouse gas (GHG) inventory and calculating the carbon footprint of the products produced** is the first step in diagnosing companies' emissions profiles. Calculations and monitoring should be continually improved.

3. **Expand the effort to reduce and remove GHG emissions by investing in technological development and innovation**, as advocated by initiatives such as the Science-Based Targets (SBTi), with a view to contributing to sustainable development and avoiding the loss of competitiveness of its products internationally with the implementation of EU CBAM and other border adjustment mechanisms that may emerge.

4. **Strengthen the involvement of the financial sector to increase market liquidity and the possibilities of financing and financial mechanisms for decarbonization projects**. Pricing economically quantifies the advantage of reducing emissions and therefore contributes to assessing the credit risk of these projects. If emissions allowances can be used as collateral for financing, there is the possibility of reducing the cost of credit for decarbonization projects. Other **financial mechanisms should be developed to reduce the cost of capital for regulated entities**.

5. **Defend the reduction of legal deforestation and zero illegal deforestation in the country and the expansion of reforestation** considering its representativeness of greenhouse gas emissions from the forestry sector as a whole, since more and more trading partners are making demands in this regard.

6. Those involved in the supply of carbon credits, with a view to including **offsets in the regulated Brazilian market, should invest in carbon projects that include the participation of and generate income for indigenous and traditional populations** directly affected by project activities, considering their historic contribution to environmental preservation and ensuring that they have economically viable alternatives for maintaining the forest and their culture.

The establishment of a regulated market in Brazil is urgent, given the climate crisis and the new dynamics of imports and exports that are emerging with border adjustment mechanisms. This market has the potential to put the country on a faster decarbonization path, consistent with the expectations of climate ambition. It is hoped that guidelines will soon be established to support its implementation and guide companies in the sectors to be regulated. Furthermore, at a national level, there are expectations of definitions that will support action in the voluntary market, favoring its growth, and at an international level, updates are awaited on the operation of Article 6 mechanisms. Therefore, considering the changes in the dynamics of carbon markets in Brazil that are currently taking place, we recommend the continued development of studies in the area of carbon markets with the purpose of encouraging and communicating their evolution.

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8. ANNEXES

8.1. ANNEX A: INFORMATION FROM THE ORIGINAL DATASETS TAKEN FROM ECOINVENT FOR SELECTED PRODUCTS

Table A - 1 - Original dataset used to assess the steel footprint

Name of activity	Geography	Classification	Version	$kgCO_2e$ (original)
Steel production, converter, low--alloyed - RER - steel, low-alloyed	Europe	41122: Alloy steel in ingots or other primary forms and semi-manufactured alloy steel products	3.9.1 - Allocation, cut-off	2.08
Steel production, converter, low--alloyed - RoW - steel, low-alloyed	Rest of the world	41122: Alloy steel in ingots or other primary forms and semi-manufactured alloy steel products	3.9.1 - Allocation, cut-off	2.18

Source: Ecoinvent, 2023.

Table A - 2 - Original dataset used to assess the soybean footprint

Name of activity	Geography	Classification	Version	$kgCO_2e$ (original)
Soybean meal and crude oil production - BR - soybean oil, crude	Brazil	21611: Soybean oil, crude	3.9.1 - Allocation, cut-off	3.04
Soybean meal and crude oil production - RoW - soybean oil, crude	Rest of the world	21611: Soybean oil, crude	3.9.1 - Allocation, cut-off	7.82
soybean meal and crude oil production - RER - soybean oil, crude	Europe	21611: Soybean oil, crude	3.9.1 - Allocation, cut-off	7.60

Source: Ecoinvent, 2023.

Table A - 3 - Original dataset used to assess the oil footprint

Name of activity	Geography	Classification	Version	$kgCO_2e$ (original)
Petroleum and gas production, offshore - BR - petroleum	Brazil	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.34
Petroleum and gas production, offshore - RU - petroleum	Russia	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.54
Petroleum and gas production, offshore - SA - petroleum	Saudi Arabia	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.23
Petroleum and gas production, offshore - NL - petroleum	Netherlands	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.12
Petroleum and gas production, offshore - NO - petroleum	Norway	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.10
Petroleum and gas production, offshore - DE - petroleum	Germany	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.19
Petroleum and gas production, offshore - RO - petroleum	Romania	12010: Petroleum oils and oils obtained from bituminous minerals, crude	3.9.1 - Allocation, cut-off	0.30

Source: Ecoinvent, 2023.

SUPPORT: