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Linking EU ETS with other carbon pricing mechanisms

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List of abbreviations

AFLOU	Agriculture, Forestry and Other Land Use
BAU	Business-as-Usual
CAKE	Centre for Climate and Energy Analysis
CARB	California Air Resources Board
CBAM	Carbon Border Adjustment Mechanism
CCER	Chinese Certified Emissions Reduction scheme
CCR	Cost containment reserve
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CGE	Computable General Equilibrium
CLF	Carbon Leakage Factor
COATS	CO_2 Allowance Tracking System
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPI	Carbon Pricing Instruments
CREAM	Carbon Regulation Assesment Model, computable general equilibrium model used and developed by CAKE
CSCF	Cross Sectoral Correction Factor
DNAs	Designated National Authorities
EC	European Commission
EEA	European Economic Area
EEB	Ecology and Environment Bureau
EITE	Emissions-intensive, trade-exposed
ERU	Emission Reduction Unit
ETS	Emissions Trading System
EU ETS	European ETS
ETS1	EU ETS for Power Generation, Industrial Manufacturing, Aviation and Maritime
ETS2	EU ETS for Transport and Buildings
G20	Group of Twenty
GECO	Global Energy and Climate Outlook
GGRs	Greenhouse Gas Removals
GHG	Greenhouse Gas
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
I-O	Input-Output
IEA	International Energy Agency
IMF	International Monetary Fund
ITMOs	Internationally Transferred Mitigation Outcomes
JCM	Joint Crediting Mechanism

JRC	Joint Research Centre
K-ETS	Korea Emissions Trading Scheme
KCUs	Korea Credit Units
KOCs	Korean Offset Credits
LTS	Long-Term Strategies
LU	Livestock unit
LULUCF	Land Use, Land-Use Change and Forestry
MRV	Monitoring, Reporting, Verification
NDCs	Nationally Determined Contributions
PACM	Paris Agreement Carbon Mechanism
RBPs	Results-Based Payments
REDD+	Reduced Emissions from Deforestation and Forest Degradation
RES	Renewable Energy Sources
RGGI	Regional Greenhouse Gas Initiative
SEMARNAT	Mexican Ministry of Environment and Natural Resources
UK ETS	United Kingdom Emissions Trading Scheme
US EPA	US Environmental Protection Authority
WCD	World Commission on Dams
WCI	Western Climate Initiative

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Main conclusions

EU ETS is in need of reform: Several solutions are currently on the table.

- As the EU ETS evolves to meet more ambitious climate policy targets, the market faces challenges such as price volatility and expected depletion of emission allowances (EUAs) by 2040. Additional challenges include concerns about industrial competitiveness, limited social acceptance and the intricacy of extending ETS coverage to new sectors (such as transport and buildings) or implementing significant reforms.
- These issues could destabilise the market, hinder emission reduction efforts, and increase the risk of carbon leakage, where companies relocate to regions with less stringent regulations. Linking ETS systems, the use of offsets and establishing the European Central Carbon Bank could mitigate these risks by managing supply and demand in the carbon market and serving as a stabilising force to ensure the effectiveness and longevity of the system.

CBAM and ETS linking can help mitigate competitive disadvantages faced by EU industry and reduce incentives for companies to relocate to regions with lower climate standards.

- The CBAM mechanism and ETS linking both aim to mitigate carbon leakage and facilitate cost-effective emissions reductions. ETS linking can complement the objectives of CBAM and support a more coherent approach to global emissions reductions. Together, these mechanisms can help countries meet their climate goals more efficiently while minimising cross-border competitive disadvantages.
- Although, primary goal of CBAM is to prevent carbon leakage, it can also incentivise EU trading partners to invest in low-emission technologies in exchange for a level playing field for their final products. The third country producers exporting to Europe can reduce CBAM charges by reducing their emission intensity of production. In addition, if third country producers already bear the cost of greenhouse gas emissions, this will be taken into account in the CBAM charges.
- CBAM is currently in its preliminary phase and still has several areas for improvement, such as providing adequate protection for exporters.

Linking ETSs across regions increases market liquidity, leading to more competitive carbon pricing, technology transfer and lower overall compliance costs.

- Linking offers considerable cost savings by allowing emissions reductions to take place where they are most economically efficient. ETS linking lowers carbon prices in high price regions such as the EU and the UK. Under a linked system, as considered in this report, the EU would likely purchase a notable amount of allowances from other regions, particularly China.
- A global computable general equilibrium (CGE) model CREAM has been used to quantitatively assess the macroconomic impacts of (a) linking the EU ETS (comprising of ETS1 and ETS2) with counterpart systems in the UK, Mexico, USA, Canada, Korea and China, and (b) utilizing emission offsets from countries of the Global South. These potential policies have been assumed to be implemented in 2035, while simulation horizon extending to 2050.
- The baseline carbon price projection for the EU ETS (comprising ETS1 and ETS2) is approximately 180 EUR/t in 2040 and 460 EUR/t in 2050. In comparison, carbon prices in other countries, with the exception of South Korea, are lower, reflecting either less stringent emission reduction targets or greater reduction potential. ETS linking is expected to reduce EU carbon prices by approximately 40-60 EUR/t.
- The global welfare gain from ETS linking, approximated by increase in real household consumption, is estimated to range from around 25 billion EUR in 2035 to 40 billion EUR in 2050. These gains reflect a more efficient distribution of emission reduction efforts among countries participating in the shared carbon market. Most countries experience consumption gains across most years, although GDP may decline at the same time in countries where carbon prices increase following the linkage. An exception is South Korea, where welfare losses due to deteriorating terms of trade outweigh the efficiency gains from reduced abatement costs.
- Changes in the GDP are primarily influenced by shifts in exports resulting from carbon price adjustments. In the EU, GDP consistently increases, compared to baseline, throughout the simulation period by approximately 0.2-0.3% (50 billion EUR). In contrast, in most non-EU countries GDP generally decreases compared to baseline.
- The impact on production of selected individual sectors is much stronger than the aggregate GDP outcome. In the EU, output of ferrous metals, air transport and water transport sectors increase from 2% to nearly 4% in some periods. In Mexico, decreases in output of energy-intensive industries (ferrous and non-ferrous metals, non-metallic minerals) are of the order of 15%-20% in 2050. In China, most industries in most years'

experience output reductions between 0.2% and 0.4%, with the exception of ferrous metals, air transport and water transport, where these reductions are deeper. Changes in sectoral output are mostly driven by adjustments of exports.

- The use of offsets in the EU ETS could reduce compliance costs and address emissions from sectors with limited decarbonisation options.
  - Offsets generated by projects (voluntary, CDM or Article 6 of the Paris Agreement) can also be used in emissions trading systems, allowing emitters to compensate for their emissions by investing in projects that reduce emissions elsewhere (e.g. reforestation, renewable energy or removals projects) and obtain cheaper carbon credits to meet adopted targets.
  - To ensure that back-up measures are in place during the transition period, it is necessary to consider some options for reopening carbon markets, including the EU ETS, for international offsets to allow industry to account for the remaining emissions that cannot be reduced.
  - According to the results of the analysis of using offsets in the EU ETS the consumption gain in the EU is accompanied by GDP increase of 0.15-0.20% (30-45 billion EUR per year). Whereas in Global South countries the GDP decreases by around 0.05% (10 billion EUR per year), driven primarily by exports contraction.
  - Both parties of the offset mechanism experience slight increases in household consumption, by a little more than 0.1% (between 10 and 20 billion EUR per year) in the EU in the years 2040-50, and around 0.05% in Global South countries (around 6-7 billion EUR per year) in the same period.

- The European Central Carbon Bank (ECCB) could manage supply and demand in the carbon market, acting as a stabilising force to ensure the system's effectiveness.
  - The proposed European Carbon Central Bank offers a strategic solution for managing the EU carbon market as it transitions to more ambitious climate targets. By centralising control over allowances, removals and offsets, the ECCB would promote a stable and reliable carbon market environment that supports the EU's climate goals and contributes to global emissions reduction efforts. This new model of the climate policy not only strengthens the role of the EU ETS in achieving climate neutrality by 2050, but also

positions the EU as a leader in carbon market governance, setting a new standard for other regions to follow or join.

- The ECCB could purchase offsets generated under Article 6 of the Paris Agreement. The offset units can be purchased at a price set by the various global carbon pricing initiatives. The ECCB could add a margin above the purchase price to incentivise sellers of offset units (to sell units to the EU rather than use them within its own carbon pricing framework). This would help finance low-carbon initiatives and provide a way for these countries to participate effectively in the global carbon market.

- The findings of the analysis support the need for extensive international policy cooperation and coordinated carbon pricing to achieve climate goals efficiently and equitably.

- The complex and interconnected nature of global emissions reduction efforts underscores the necessity of robust international collaboration. Effective policy coordination, particularly in carbon pricing mechanisms, can help bridge disparities in ambition and capability between regions, ensuring that the burden of climate action is shared more equitably. Enhanced cooperation can lead to the harmonization of carbon markets, driving technological innovation, cost reductions, and a level playing field for industries across borders.

- Additionally, integrated approaches that combine mechanisms like ETS linking, CBAM, and the use of offsets can amplify their collective impact. For instance, linking ETS systems not only lowers compliance costs but also fosters knowledge and technology exchange, benefiting participating countries. Similarly, CBAM and offsets create financial incentives for global investments in low-carbon solutions, extending the reach of EU climate policies while respecting the diverse economic contexts of trading partners.

- Achieving such synergies requires transparent governance structures, trust-building among nations, and the establishment of institutions like the European Central Carbon Bank to oversee market stability. These coordinated efforts can ensure that the global carbon market becomes a key instrument in meeting climate neutrality targets by 2050, paving the way for a resilient, sustainable, and inclusive low-carbon future.

Summary

The newest CAKE report conducted within the LIFE VIIEW 2050 project provides an in-depth analysis of key mechanisms to enhance the EU Emissions Trading System (EU ETS) and support global climate goals. The report examines the implications of EU ETS linking with other ETS frameworks, the introduction of the Carbon Border Adjustment Mechanism (CBAM), the role of offsets in reducing compliance costs, and the potential establishment of a European Central Carbon Bank (ECCB). Primarily through macroeconomic analysis, the report assesses how this integration could affect carbon pricing, emissions reductions and economic indicators in different regions. Presented measures aim to improve market stability, mitigate carbon leakage, foster international cooperation, and ensure a cost-effective path toward achieving climate neutrality by 2050.

1) Background - the carbon pricing mechanisms

- Emissions trading systems allocate a limited number of emission allowances to covered installations (e.g. large emitters). These entities can buy or sell allowances on a market. Total emissions are capped, ensuring overall reductions. The EU ETS is a prominent example of this approach.
- National and regional emissions trading systems can be linked to increase the size of the compliance market and reduce costs. In addition to increasing market liquidity, linking emissions trading systems can be used to address the issue of carbon leakage.
- The EU's Carbon Border Adjustment Mechanism (CBAM) is the EU's policy instrument to put a fair price on the carbon emitted in the production of carbon-intensive goods entering the EU market. The CBAM is designed to safeguard internal EU ambitious climate policy and encourage cleaner industrial production in non-EU countries.
- Offsets generated by projects (voluntary, CDM or Article 6.4 mechanisms, which are still largely under development) can also be used in emissions trading systems, allowing emitters to compensate for their emissions by investing in projects that reduce emissions elsewhere (e.g. reforestation, renewable energy and removals projects) and obtain cheaper carbon credits to meet adopted targets.

2) Policy Framework

- The analysis is based on EU policies to achieve climate neutrality by 2050, in particular through the EU ETS, a key instrument in the EU's climate strategy. The primary legal basis includes the EU's climate policies under the 'Fit for 55' package and the European Green

Deal, which set ambitious targets for reducing greenhouse gas (GHG) emissions by 2030 and achieving climate neutrality by mid-century. In addition, the document refers to international agreements, notably the Paris Agreement, which promote cooperative mechanisms such as ETS linking to enhance global emissions reduction efforts.

3) Objective and the scope of the analysis

- The main purpose of the analysis is to assess the impact of linking the EU ETS to emissions trading schemes in countries such as the UK, US, Canada, Korea and China. This linkage could lead to a more harmonised approach to carbon pricing, potentially reducing carbon leakage (when companies relocate to regions with less stringent climate policies) and achieving emission reductions more cost-effectively. By examining multiple scenarios,

  the analysis aims to provide insights into the most feasible pathways to achieve the EU's climate change targets. In addition, the study uses a CGE model called CREAM to simulate economic and environmental outcomes, including macroeconomic factors such as GDP, trade and investment, of different emissions scenarios and policy implementations.

4) Policy scenarios

Three primary scenarios were analysed, each reflecting different levels of ETS integration and policy mechanisms:

- Baseline Scenario: This scenario assumes that the EU ETS operates in its current form, with the CBAM in place. It incorporates the EU's emissions targets and GHG reduction outcomes based on existing policies.
- Scenario 1 (ETS Linking): This scenario explores the potential impacts of linking the EU ETS with other international ETSs, such as those in the UK, US, and Canada. Linking would create a larger, more liquid carbon market, enabling cost-effective emissions reductions across regions with aligned carbon pricing.
- Scenario 2 (Offsets): This scenario includes limited use of offsets in the EU ETS. Investments are made in countries in the Global South and the offsets are then sold to the EU ETS. This mechanism could reduce compliance costs and address emissions from sectors with limited decarbonisation options.

5) Results

a. Baseline Scenario

In the Baseline Scenario, ETSs operate independently with no allowance trading between regions. Each system is analyzed with specific emission targets for 2050, compared to 2020, which vary significantly:

- Korea has the most ambitious target, aiming for an 89% reduction, followed by the EU with a 78% reduction and China (76%).
- The targets in ETS in USA and Canada are both around 65% emission reduction, while Mexico is the least ambitious (40%).

This scenario highlights expected rises in carbon prices as regions individually strive to meet their goals, with projected prices reaching 460 EUR/t in the EU by 2050 due to stringent reduction requirements.

b. Scenario 1 (S1 - Linking ETS)

Scenario 1 simulates a hypothetical linking of the EU ETS with other national or regional ETSs, allowing free trading of allowances to equalise carbon prices across participating regions.

- ETS linking lowers carbon prices in high price regions such as the EU and the UK by 40-60 EUR/t, while raising prices in low price regions. Under linked systems, the EU would likely purchase significant allowances from other regions, particularly China, which would help offset its emissions deficit. Linking offers significant cost savings by allowing emissions reductions to take place where they are most economically efficient. It is estimated that the EU could save around EUR 2-4 billion per year in abatement costs by purchasing allowances from lower-cost regions.
- Linking the ETS affects trade and economic growth through shifts in carbon prices and export dynamics. Lower carbon prices in the EU make exports more competitive, leading to an increase in export volumes of 1-2%. Conversely, in countries where carbon prices rise, such as Mexico and Korea, exports fall. GDP in the EU and other regions with high carbon prices increases due to the cost efficiencies from the link, leading to a small but steady GDP growth (0.2-0.3%). Household consumption also benefits from the reduced cost pressures associated with lower carbon prices.

c. Scenario 2 (S2 - Offsets)

In scenario S2, the EU ETS includes offsets from regions in Africa and Eastern Europe and Central Asia (Global South countries) from 2035. Offset purchases are assumed to account for up to 10% of the EU cap and are priced at a 25% premium over the marginal abatement costs in these regions.

- The availability of offsets reduces the EU carbon price by 25-55 EUR/t, providing a less volatile compliance cost structure.
- Payments for offsets benefit regions in the Global South to the tune of some EUR 3-5 billion annually, providing resources to support climate initiatives and low-carbon development.
- EU offset purchases create a profitable margin, with revenues from offset resale potentially reaching EUR 10-20 billion per year, although EU ETS revenues may decline slightly due to lower carbon prices.

6) Conclusions

- Linking ETSs and implementing CBAM together could create a more cohesive global carbon market. This approach could lead to significant cost savings by allowing emission reductions to be made where they are most affordable and reducing carbon leakage by aligning carbon prices between trading partners.
- In addition, linking the EU ETS to other global schemes or integrating offsets could bring significant economic and environmental benefits by reducing compliance costs, stabilising carbon prices and enhancing international cooperation on climate change. While linking promotes a more balanced global market for emission allowances, offsetting scenarios provide additional flexibility, making carbon neutrality targets more achievable for the EU and its partners. Both approaches underline the importance of flexibility,
- The findings support the need for extensive international policy cooperation and coordinated carbon pricing to achieve climate goals efficiently and equitably. The report recommends the further development of ETS linkages, taking into account the different economic conditions in the participating countries. The proposal of establishing the European Central Carbon Bank offers a strategic solution for managing the EU carbon market as it transitions to more ambitious climate targets.

Introduction

This report examines the potential for linking the EU Emission Trading System (EU ETS) with similar systems in other countries. It aligns with the objectives of the LIFE VIIEW project, which seeks to analyze challenges, prospective extensions, and reforms of the EU ETS.

The report is structured in two main sections. Part I explores how emissions trading systems (ETS) fit within the broader context of climate policies. It begins by outlining the global climate policy landscape and then details the current ETS frameworks in selected countries, including the EU, UK, Mexico, USA, Canada, South Korea, and China. This section focuses on ETS sectoral coverage, emission reduction targets, current carbon price levels, allowance distribution methods, and other institutional arrangements. It also reviews relevant aspects of the Paris Agreement, particularly those related to the shared mitigation of greenhouse gas emissions, such as carbon market integration and the use of emission offsets. Additionally, it examines the past attempts at linking ETS. Part I concludes with a review of scientific literature on the challenges and economic impacts associated with carbon markets integration.

Part II provides a quantitative assessment of the macroeconomic impacts of integrating the EU ETS with other systems, using simulations on a computable general equilibrium (CGE) model of the global economy. Two policy scenarios are analyzed, extending to the year 2050. Scenario 1 considers the linking of the EU ETS with systems in the UK, Mexico, USA, Canada, South Korea, and China, allowing for cross-border trading of allowances. Scenario 2 explores the use of offset credits within the EU ETS from emission reduction projects in Global South countries. This quantitative analysis examines the implications for carbon prices, as well as broader macroeconomic and sectoral outcomes. The results shed light on the costs and benefits of carbon market integration and contribute to the discussion on the future development of the EU ETS.

Outline of the analysis:

Objectives:	A review of the current state of emission trading systems in selected countries and their role within the global climate policy framework. A quantitative assessment of macroeconomic effects of ETS linking and the use of emission offsets.
Topics:	Paris Agreement EU climate policy, including 'Fit for 55' ETS regulations in selected countries and regions CBAM Offsets Concept of European Central Carbon Bank
Geografical scope:	EU UK Mexico South Korea Canada USA China Global South countries
Scenarios:	Baseline Scenario Scenario 1 (Linking ETS) Scenario 2 (Offsets)

I. Policy Framework

1. Global climate policy background

1. Ten years ago in Paris (in 2015), at COP21, the Parties to the United Nations Framework Convention on Climate Change unanimously adopted an agreement, now known as the Paris Agreement, to strengthen global efforts to combat climate change. This international treaty has been ratified till now by 194 sovereign countries and the European Union to strengthen international cooperation in pursuit of the long-term goal of limiting the increase in global temperature to well below 2°C, while pursuing efforts to limit the increase to no more than 1.5°C above pre-industrial levels.

2. According to the IPCC 1.5 SR,[1] net-zero CO_2 emissions are a prerequisite for stopping warming at any level. For the world to achieve net-zero emissions by mid-century and meet the IPCC's long-term global temperature goal of 1.5°C, global greenhouse gas emissions must be reduced by 43% by 2030 compared to 2019 levels, while deforestation must be halted. This means that global net reductions between 2019 and 2030 must reach 23 Gt CO_2eq.[2] In its latest report, the IPCC estimates that around 6 Gt CO_2eq of emission per year will need to be reduced by 2050 to meet the 1.5°C temperature target for this century.[3]

3. The Paris Agreement commits all countries, developed and developing, to climate action through the implementation of their Nationally Determined Contributions (NDCs). The countries that signed the Paris Agreement have agreed to pursue the domestic actions set out in their NDCs, which will be updated every five years, in order to raise global ambition and collectively achieve a balance between anthropogenic emissions and removals of all greenhouse gases by the second half of the century at the latest.

4. The Agreement recognises that countries may wish to cooperate through market and non-market approaches to accelerate progress towards their goals and establishes an accounting system to help track internationally transferred mitigation credits. It also establishes an enhanced transparency framework to track the implementation of NDC actions and support to developing countries, and to enable global stocktakes to assess collective progress towards the Agreement's long-term goals and to inform Parties in updating and strengthening their NDCs and international cooperation on climate action. Countries are free to decide in their NDCs on measures they will pursue to reach their domestically set targets as well as on how they intend to cooperate to

[1] IPCC, Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5 °C, 2018. https://www.ipcc.ch/sr15 (access: 04.09.2022).
[2] *Taskforce on Scaling Voluntary Carbon Markets. Final Report, January 2021,* p. 4 (access: 04.09.2022).
[3] IPCC Sixth Assessment Report (AR6) Working Group 3 (WG3) published in April 2022.

strengthen global efforts in combating climate change and adapting to the unavoidable climate change impacts.

5. In line with the 'polluter pays' principle, carbon emitted into the atmosphere should be priced to reflect the social and economic costs of climate change, so that it leads to a shift away from a fossil fuel-based economy towards a low-carbon economy. It should be part of a wider range of policy instruments to meet domestic targets, including regulatory instruments, investment in climate-friendly technologies, capacity building and education. Carbon is priced through taxation and emissions trading, which can take the form of cap-and-trade systems set by jurisdictions, in other words compliance markets[4], and carbon credit mechanisms dominated by voluntary markets[5].[6] To date, carbon pricing has been implemented mainly in high-income countries at the national, sub-national or regional level. However, the World Bank reports increased interest in carbon pricing in the Middle East and Africa.[7]

6. In addition to compliance markets, there are large voluntary markets that have developed in response to voluntary carbon reductions and net zero pledges by private companies. Although the environmental effectiveness of voluntary markets is debatable, voluntary credits compete on price with the international crediting mechanisms established by the Kyoto Protocol and the Paris Agreement, the Clean Development Mechanism (CDM) and the Paris Agreement Carbon Mechanism (PACM) under article 6.4.

7. Governments are guided by national circumstances when deciding on the approach to carbon pricing. A carbon tax provides a carbon price guarantee and is easier for the government to administer, with revenues going into the budget or a dedicated carbon fund that can be spent by the government on carbon reduction policies and the just transition measures. Emissions trading, on the other hand, does not guarantee a fixed price, although a minimum or maximum price can be set by regulation for the emissions units traded, and gives participants in emissions trading greater flexibility in how they meet targets. Countries that choose to price carbon through emissions trading rely on carbon markets to achieve environmental goals in the most flexible

[4] Compliance carbon markets are regulatory frameworks that require certain industries to limit or decrease their greenhouse gas (GHG) emissions.
[5] Voluntary carbon markets enable businesses and individuals to offset their emissions by buying carbon credits on a voluntary basis, often driven by corporate social responsibility (CSR) objectives or to meet sustainability targets.
[6] See, for example: World Bank, Carbon Pricing Dashboard, What is Carbon Pricing? | Carbon Pricing Dashboard (worldbank.org) (access: 02.08.24)
[7] World Bank, State and Trends of Carbon Pricing 2023, Executive Summary, p.8, (http://documents.worldbank.org/curated/en/099805106052321586/IDU0df4b14850029d0403c0811b0f1575605c07a).

and cost-effective way. Emissions trading can also generate direct revenues for governments that choose to auction allowances, which can be used for green investments and addressing social issues in line with the just transition principles.

8. According to the World Bank, carbon taxes may be more effective in smaller economies and jurisdictions with well-established and transparent tax frameworks, while emissions trading may be more appropriate in larger economies or economies with political barriers to tax reform.[8]

9. Emissions trading systems from different jurisdictions can be linked into single carbon markets, in order to reduce costs, giving participants greater flexibility in managing their businesses and achieving carbon reduction targets.

10. The introduction of a price on GHG emissions (taxes or trading systems) may lead to carbon leakage, meaning the relocation of production or investment to regions with lower climate ambitions. Therefore, protective measures are often implemented to prevent this effect. The CBAM (Carbon Border Adjustment Mechanism) is a new policy instrument specifically designed to prevent carbon leakage from industries covered by the EU ETS. Other current emissions trading schemes generally attempt to prevent carbon leakage by incorporating features that reduce the additional costs incurred by industrial installations in sectors covered by emissions trading.[9] One of the most common methods to prevent carbon leakage is the allocation of free allowances (a mechanism also currently in place in the EU ETS, although its significance will decrease over time).

2. ETS systems in selected countries

11. Emissions trading as a government-supported carbon pricing option is expanding globally. As reported by the World Bank and ICAP in their annual reports on carbon pricing and emissions trading respectively, there are currently 36 emissions trading systems in operation in different parts of the world, with a further 22 under development.[10]

12. In the analysis of the effects of ETS linking, the following systems will be considered, in addition to the EU ETS:: Mexican ETS, UK ETS, Korea Emissions Trading Scheme, China National Emissions Trading System, Regional ETSs in China, Québec's Cap-and-Trade System in Canada, California Cap-and-Trade Program and Regional Greenhouse Gas Initiative (RGGI) in USA. These countries were chosen based on the

[8] World Bank Group, Carbon Pricing for Climate Action, p.1
[9] IEA, Implementing Effective Emissions Trading Systems. Lessons from International Experiences, 2020 (Implementing Effective Emissions Trading Systems – Analysis - IEA: dostęp: 29.07.2024)
[10] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

availability of comprehensive data, their representation of different global regions, the maturity of their ETS implementations, and the similarity of their cap-and-trade systems to EU ETS regulations.

2.2. Mexico

GHG Reduction Targets in Mexico

13. The objective of Mexico is to reduce its greenhouse gas emissions to 35% below the business-as-usual (BAU) baseline by 2030, as stated in its updated NDC ,and to achieve 50% reduction in GHG emissions compared to 2000 levels by 2050 (aspirational, included in the "General Law of Climate Change").[11]

Mexican Emissions Trading System

14. The Mexican Emissions Trading System (ETS) was designed to progress through three stages. The pilot phase (2020-2021) aimed to test the system's design and build capacity among participants. It covered the energy sector (electricity generation, transmission and distribution, as well as fossil fuel extraction, production and transport) and industrial sector (encompassing automobile manufacturing, cement, lime, chemicals, food and beverages, glass, iron and steel, metallurgical industry, mining, petrochemicals, pulp and paper industries, as well as other industrial sub-sectors that generate direct CO_2 emissions from stationary sources). Currently, the Mexican ETS includes approximately 295 entities, each emitting at least 100,000 t CO_2 annually. These entities account for about 40% of Mexico's total greenhouse gas emissions, which were approximately 714 Mt CO_2eq in 2021, excluding LULUCF.[12]

15. In 2020, the cap for emissions under the Mexican ETS was set at 271.3 Mt CO_2, increasing slightly to 273.1 Mt CO_2 in 2021. The increase was due to an expanded sectoral allocation for regulated entities classified as "other". -The ETS includes three reserves of allowances in addition to the cap: an auction reserve (5% of the cap) for planned regular auctions that have not yet occurred, a new entrants reserve (10% of the cap) for new participants and production increases of existing regulated entities, and a general reserve (5% of the cap) for ex-post adjustment of allocations to entities with emissions higher than their baselines. Allowances are currently allocated free, with plans to reduce allocation starting from the first year of the operational phase in 2024, though this mechanism has yet to be officially implemented. As of the end of

[11] Ibid.

[12] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

2023, transactions are only possible through direct negotiation between participants due to the absence of a secondary market for trading allowances, and no auctions have been conducted. However, the Mexican Ministry of Environment and Natural Resources (SEMARNAT) is in the process of developing an auction mechanism.[13] SEMARNAT is also establishing institutional arrangements to manage revenues during the operational phase.[14]

16. A tool has been developed to calculate installation-level allocations under various parameters and allocation methods tailored to the Mexican context, using data reported by operators. Allocation methods can be based on either grandfathering (using historical emissions) or benchmarking. If the allocation rules result in a total allocation exceeding the allowances available for free allocation, a Cross-Sectoral Correction Factor (CSCF) is applied to scale allocations proportionally within the budget.[15]

17. SEMARNAT plans to establish a domestic programme for generating offset credits that can be used for compliance within the ETS. Offset credits from mitigation projects initiated before the start of the pilot phase in 2020 may be eligible for use in the system, with these projects expected to continue producing credits during the operational phase. Participants in the ETS will be permitted to use offsets or early action credits to fulfil up to 10% of their compliance obligations.[16]

18. Annual self-reporting relies on electronic templates provided by SEMARNAT, with verification conducted by independent accredited verifiers and required by the end of June of the following year. All regulated entities are expected to monitor their emissions throughout the operational phase.[17]

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[13] ICAP (2022), Mexican Emissions Trading System, https://icapcarbonaction.com/en/ets/mexican-emissions-trading-system (access 30.08.2024)

[14] Ibid.

[15] Distributing Allowances in the Mexican Emissions Trading System: Indicative Allocation Scenarios, SEMARNAT, GIZ, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany, https://www.gob.mx/cms/uploads/attachment/file/505767/Distributing_Allowances_in_the_Mexican_ETS.pdf (access 30.08.2024)

[16] ICAP (2022), Mexican Emissions Trading System, https://icapcarbonaction.com/en/ets/mexican-emissions-trading-system (access 30.08.2024)

[17] Ibid.

2.3. United Kingdom

GHG Reduction Targets in United Kingdom

19. The UK has committed in its NDC to reduce GHG emissions by 68% by 2030 compared to 1990 levels. The 2035 target set out in the Carbon Budget Order 2021 is to limit net GHG emissions to below 965 Mt CO_2eq in the period 2033 to 2037, which represents a reduction of around 77% from 1990 levels, including emissions from LULUCF and international aviation and shipping. The net-zero emissions level, including emissions from LULUCF and international aviation and shipping, is to be achieved by 2050 (Climate Change Act 2008 [2050 Target Amendment] Order 2019).[18]

UK Emissions Trading Scheme

20. The UK ETS covers: power sector, energy intensive industry and aviation[19]. As part of the integrated Single Electricity Market with the Republic of Ireland, electricity generators in Northern Ireland are still covered by the EU ETS. The intention to extend the scheme to cover emissions from domestic maritime from 2026 and emissions from waste incineration and waste from energy from 2028 was announced by the UK ETS authorities in 2023. GHGs covered by the UK ETS include CO_2, NO_2 and PFCs. Approximately 25% of the total 429.5 Mt CO_2eq GHG emissions (including indirect CO_2, excluding LULUCF) in the UK in 2021 were covered by the system. In 2022, 1,429 entities will be required to participate in the UK ETS.[20]

21. The cap for 2024 was set at 92.1 Mt CO_2eq, with the total cap for the first (2021 to 2025) and second (2026 to 2030) allocation periods set at 633 Mt CO_2eq and 303 Mt CO_2eq respectively (to be adjusted to account for hospital and small emitter opt-outs). The free allocation in the UK ETS is designed to mitigate the risk of carbon leakage in the industrial sector. The number of free allowances an installation receives is determined by historical activity levels, an industry-specific benchmark, and a carbon leakage (CL) factor. The CL factor and benchmarks applied since the scheme's inception in January 2021 align with those used in phase 4 of the EU ETS. There is a maximum number of allowances that can be allocated for free, known as the 'industry cap'. From 2024, the industry cap will be set at 40% of the total cap and will decrease annually in line with the cap trajectory. The primary method for distributing

[18] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)
[19] Activities in scope of the UK ETS are listed in Schedule 1 (aviation) and Schedule 2 (installations) of the Greenhouse Gas Emissions Trading Scheme Order 2020.
[20] ICAP (2022), UK Emissions Trading Scheme, https://icapcarbonaction.com/en/ets/united-kingdom

allowances in the UK ETS is through auctioning. Allowances are not permitted to be sold below the Auction Reserve Price (ARP). Auctions proceed even if not all allowances are sold, with any unsold allowances being rolled over to the next four auctions, up to a maximum of 125% of the original number intended for sale. If all four subsequent auctions reach this limit, the remaining unsold allowances will be transferred to the market stability mechanism account. In 2023, the average auction price was GBP 53.36 (EUR 61.10[21]) and the average secondary market price was GBP 55.54 (EUR 63.59).[22]

22. The use of offset credits is not allowed, but the UK is considering the introduction of greenhouse gas removals (GGRs) to be used for compliance within the scheme. The UK is also considering how the UK ETS should interact with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).[23]

23. Total revenues from the UK ETS reached GBP 4.2 billion (EUR 4.76) in 2023 and GBP 14.6 billion (EUR 17.13) since the start of the system in 2021. Revenue from the UK ETS auctions goes to the general budget, including debt reduction, but is not earmarked for any particular use.[24]

24. Covered entities must surrender one allowance per t CO_2eq emitted for all their covered emissions. Covered entities must surrender allowances by the end of April of the following year. Verification is carried out by independent accredited verifiers before the end of March each year. The UK ETS has adopted the EU ETS Phase 4 Monitoring, Reporting, Verification (MRV) framework.[25]

2.4. South Korea

GHG Reduction Targets in South Korea

25. There are two laws that define the emissions to be reduced in South Korea by 2030. The Carbon Neutral Framework Act commits to reducing emissions by 35% below 2018 emissions and the updated NDC commits to reducing emissions by 40% below

[21] Based on the average EUR/USD exchange rate for November 5, 2024 (1 EUR = 1.0918 USD or 1 USD = 0.9160 EUR).
[22] ICAP (2022), UK Emissions Trading Scheme, https://icapcarbonaction.com/en/ets/united-kingdom
[23] Ibid.
[24] Ibid.
[25] Ibid.

this level. The target to be achieved by 2050 is only set by the Carbon Neutral Framework Act and commits to achieving carbon neutrality.[26]

Korea Emissions Trading Scheme

26. Each phase of the Korea Emissions Trading Scheme (K-ETS) has expanded the scope of covered industries. Phase 1 (2015-2017) covered 23 subsectors from the following sectors: power, industry[27], buildings, waste and transport, aviation, maritime and waste. The greenhouse gases covered by the K-ETS are CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. The K-ETS covers approximately 89% of South Korea's 676.6 Mt CO_2eq national GHG emissions (including indirect CO_2, excluding LULUCF), with 804 companies emitting more than 125,000 t CO_2 per year and facilities emitting more than 25,000 t CO_2 per year participating in 2023.[28]

27. The caps for 2024 and 2025 (excluding reserves) are both set at 567.1 Mt CO_2eq. There are plans to develop a roadmap and align the cap with the Republic of Korea's updated NDC. Allocation will be either through auctioning or free allocation with grandfathering and benchmarking. Less than 90% of the free allocation will go to entities in sub-sectors subject to auctioning; 100% for Emission Intensive, Trade Exposed (EITE) sectors. The share of sector-specific benchmarking is to reach 60% and has been expanded to a total of 12 sub-sectors: grey clinker, oil refining, domestic aviation, waste, industrial parks, electricity generation and district heating/cooling, with the addition of steel, petrochemicals, buildings, paper and wood processing. EITE sectors receive 100% free allocation if they meet certain criteria. Both benchmark and grandfathering allocations are calculated using a correction factor and a carbon leakage factor. Participation in the auctions (which will start regularly in 2019) is limited. Only companies that do not receive all their allowances for free are eligible to bid, with a list of eligible bidders published by the Ministry of the Environment. Bidders can purchase a maximum of 15% of the allowances in each auction. At least 10% of the allocation goes to companies in sub-sectors subject to auctioning. Companies from 41 sub-sectors (excluding EITE sectors) are eligible to participate in the auctions. For 2023, around 19 million allowances were allocated, representing around 3% of the cap of 589.3 Mt CO_2eq (excluding reserves). In 2023, the average auction price was KRW 10,672 (EUR 7.48) and the average secondary market price

[26] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

[27] KETS requires mandatory participation from all companies within the covered sectors with average annual GHG emissions equal or greater than 125,000 t CO_2eq over 3 consecutive years, or business sites with annual average GHG emissions equal or greater than 25,000 t CO_2eq over 3 consecutive years.

[28] ICAP (2022), Korea Emissions Trading Scheme, https://icapcarbonaction.com/en/ets/korea-emissions-trading-scheme (access 30.08.2024)

was KRW 9,999 (EUR 7.01). In 2021 and 2023, the government set a price floor for allowances. There will be eight K-ETS market makers from the beginning of 2024.[29]

28. Domestic offset credits, i.e. Korean Offset Credits (KOCs), were allowed in Phase 1. International credits (subject to qualitative criteria) have been allowed together with KOCs since phase 2. Both domestic and international credits have to be converted into Korea Credit Units (KCUs) in order to be used for compliance. An increase or decrease in the offset limit is included in the stabilisation measures.[30]

29. Since the start of -ETS in 2015, KRW 1,176.75 billion (EUR 825.44 million) in revenues have been collected and KRW 84.18 billion (EUR 58.99 million) in revenues will be collected by 2023. The revenue is invested in the Climate Response Fund, which supports emission reduction infrastructure, low-carbon innovation and technology development for small and medium-sized enterprises covered by the K-ETS.[31]

30. Entities are required to report their emissions for the previous year by the end of March each year. Independent verificators review emission reports. The reports are reviewed and certified by the Certification Committee of the Ministry of Environment by the end of May. Companies are required to revise and resubmit emissions reports that are found to be inaccurate.[32]

2.5. China

GHG Reduction Targets in China

31. The reduction target to be achieved by 2025 is to reduce carbon emissions per unit of GDP by 18% from 2020 levels (14th Five Year Plan). China is committed to reducing CO_2 emissions per unit of GDP by more than 65% from 2005 levels by 2030 ("1+N"

[29] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)
[30] ICAP (2022), Korea Emissions Trading Scheme, https://icapcarbonaction.com/en/ets/korea-emissions-trading-scheme (access 30.08.2024)
[31] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)
[32] Ibid.

policy framework[33]; updated NDC) and achieving carbon neutrality by 2060 ("1+N" policy framework; updated NDC).[34]

China National Emissions Trading System

32. Only emissions from the power sector remain covered by the ETS, but the system is expected to be expanded to include seven other sectors, with no specific timetable for expansion. Only CO_2 emitters are covered by the Chinese ETS. It is the largest ETS in the world in terms of covered emissions, with 5,000 Mt CO_2 covered, representing 40% of 13,035 Mt CO_2eq of national emissions (excluding LULUCF). The inclusion threshold for 2021 to 2022 was annual emissions of 26,000 t CO_2 or more in any year from 2013 to 2019, which 2,257 power companies met.[35]

33. Allowances are allocated free of charge on the basis of grandfathering and benchmarking. A pre-allocation method is applied annually and then adjusted ex-post to reflect actual production in the relevant compliance year. Benchmarking based on output is used as the main allocation method, with four different benchmarks: conventional coal-fired power plants below 300 MW, conventional coal-fired power plants above 300 MW, unconventional coal and natural gas. There is no auctioning mechanism, but this will be introduced in the announced interim regulations.[36]

34. The use of offset credits in China has been permitted since January 2024, when the country launched its domestic offset scheme, the Chinese Certified Emissions Reduction scheme (CCER), after a six-year suspension during which it underwent reform.[37]

35. The average price on the secondary market in 2023 was CNY 68.35 (EUR 8.84).[38] There are currently no arrangements for the use of revenues generated by the ETS.[39]

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[33] According to Centre for Research on Energy and Clear Air (2022), '1' refers to combating climate change and 'N' refers to to solutions to achieve peak carbon emissions by 2030.

[34] Ibid.

[35] ICAP (2022), China National ETS, https://icapcarbonaction.com/en/ets/china-national-ets (access 30.08.2024)

[36] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

[37] ICAP (2022), China National ETS, https://icapcarbonaction.com/en/ets/china-national-ets (access 30.08.2024)

[38] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

[39] ICAP (2022), China National ETS, https://icapcarbonaction.com/en/ets/china-national-ets (access 30.08.2024)

36. Covered entities are required to prepare monitoring plans and monitor their emissions based on these plans. They must submit the previous year's emission reports by the end of April each year. Provincial ecological and environmental authorities organise the verification of GHG reports. They can hire technical service agencies to provide verification services. The verification process for the power sector must be completed by the end of June. Verification of the cement, electrolytic aluminium and steel industries should be completed by the end of September. Other "key industries" should be verified by the end of the year. Eight sectors expected to be covered by the ETS will be provided with MRV guidelines, supplementary data sheets, verification guidelines and other guidance. Changes to MRV will be made annually by the MEE.[40]

Regional ETSs in China: Beijing, Chongqing, Fujian, Guangdong, Hubei, Shanghai, Shenzhen, Tianjin

37. China has also introduced pilot ETS frameworks in several regions or cities, including Beijing, Chongqing, Fujian, Guangdong, Hubei, Shanghai, Shenzhen and Tianjin. All regional ETSs use different types of allowance allocation methods: free allocation based on grandfathering and benchmarking, and auctioning. Chongqing remains the only Chinese pilot to cover both CO_2 and non-CO_2 gases (CH_4, N_2O, HFCs, PFCs, SF_6). The regional ETS are not linked to other ETS markets, but there are plans for expansion.[41]

Beijing Pilot Emissions Trading System

38. The Beijing ETS covers emissions from: power sector, industry, buildings and transport. In 2022, total GHG emissions, including indirect CO_2 and excluding LULUCF, will be 132.1 Mt CO_2eq. The cap has been set at around 50 Mt CO_2 in 2020 and 44 Mt CO_2 in 2022. There are 909 entities required to report their emissions and 388 others with reporting obligations covered by the pilot system. In 2020, 30% of urban emissions were covered by the system (total emissions of 132.1 Mt CO_2eq in 2020, including indirect CO_2, excluding LULUCF).[42]

39. In 2023, the average auction allowance price was CNY 115 (EUR 14.89) and the average secondary market price was CNY 90.96 (EUR 11.76). Beijing is the only regional pilot ETS in China to use floor and ceiling prices (CNY 20, EUR 2.58 and CNY 150, EUR 19.39 respectively). The total revenue generated since the start of the system in 2013 is CNY 274 million (EUR 35.42 million) and the revenue for 2023 is CNY 161 million (EUR 20.81 million). The revenue is allocated to the municipal treasury and used for general budget purposes, including debt reduction.[43]

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[40] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

[41] Ibid.

[42] Ibid.

[43] Ibid.

Chongqing Pilot Emissions Trading System

40. Unlike most other Chinese pilots, Chongqing does not pre-determine which sub-sectors will be covered by its ETS. Instead, it sets a threshold that applies to all industrial sector entities. The cap for 2020 was set at 78.39 Mt CO_2eq. The total emissions cap is currently established using a bottom-up approach, by summing the emission levels derived from the outputs of each individual covered entity. Previously, the Chongqing ETS used absolute caps that decreased annually at a predetermined rate. The annual reduction rate was 4.13% until 2015 and increased to 4.85% from 2016 onwards. Until 2020, the inclusion threshold was 26,000 t CO_2 per year or energy consumption of 10,000 tonnes of coal equivalent (tce)[44] per year. From 2021 to 2022, the threshold was lowered to 13,000 t CO_2 per year or energy consumption of 5,000 tce per year. The number of industrial installations with emissions above the threshold from 2021 to 2022 was 308. In 2020, the ETS covered 40% of total GHG emissions from Chongqing region (where total GHG emissions amounted to 188.1 Mt CO_2eq, including indirect CO_2 and excluding LULUCF).[45]

41. The average secondary market price for 2023 was CNY 29.82 (EUR 3.75). Revenue raised since the start of the system in 2014 amounts to CNY 336 million (EUR 43.45). The proceeds are allocated to the city treasury and used for the general budget, including debt reduction.[46]

Fujian Emissions Trading System

42. The Fujian provincial ETS covers industry and domestic aviation. Electricity generation was covered until 2019 and then transitioned to the national Chinese ETS. The cap for 2022 was set at 116.2 Mt CO_2. Emitters with an annual energy consumption of 5,000 tce or more are included in the system, and the total number of GHG emitters in 2022 was 293. In 2020, the ETS covered 38% of total CO_2 emissions from Fujian region (where total CO_2 emissions in 2021 amounted to 299.81 Mt CO_2, excluding LULUCF).[47]

43. The average secondary market price in 2023 was CNY 23.25 (EUR 3.00). The total revenue generated since the start of the system in 2016 was CNY 1.25 million (EUR 169,881). The proceeds are allocated to the central treasury and used for the general budget, including debt reduction.[48]

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[44] 10,000 tonnes of coal equivalent is approximately 293,900 GJ.
[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] Ibid.

Guangdong Pilot Emissions Trading System

44. The Guangdong provincial ETS covers industry[49] and domestic aviation. The cap for 2023 was set at 297 Mt CO_2. The number of entities covered in 2023 was 417 (391 existing and 26 new entrants). In 2022, the lower bound conditions for an entity to be covered was to reach at least 10,000 t CO_2 emissions per year or 5,000 tce of energy consumption per year. In 2020, the ETS covered 40% of total CO_2 emissions from Guangdong region (where total CO_2 emissions amounted to 693.5 Mt CO_2, excluding LULUCF).[50]

45. The average secondary market price in 2023 was CNY 75.01 (EUR 9.69). The total revenue collected since the start of the ETS system in 2013 is CNY 815.5 million (EUR 105.4 million). The revenues are allocated to the provincial treasury.[51]

Hubei Pilot Emissions Trading System

46. Unlike most other Chinese pilots, Hubei does not pre-determine which sectors will be covered by its ETS. Instead, it sets a threshold that applies to all industrial sector entities. The cap for 2022 has been set at 180 Mt CO_2. The threshold for all 343 entities covered by the ETS in 2022 was an energy consumption of more than 10,000 tce in one of the last two years, which applies to all industrial sectorsIn 2020, the ETS covered 50% of total CO_2 emissions from Hubei region (where total CO_2 emissions amounted to 350.5 Mt CO_2eq, excluding LULUCF).[52]

47. The auction and secondary market price levels in 2023 were CNY 42.73 (EUR 5.52) and CNY 38.78 (EUR 5.01) respectively. The revenue generated since the start of the system in 2014 is CNY 432.75 million (EUR 55.96 million) and the revenue for 2023 is CNY 46.59 million (EUR 6.03 million). The revenue is allocated to the central treasury and used for the general budget, including debt reduction.[53]

Shanghai Pilot Emissions Trading System

48. In phase 2 (2016-present), the Shanghai ETS covers the following sectors: power (oil-fired generators), industry[54], buildings, domestic aviation and maritime. The cap for 2022 has been set at 100 Mt CO_2. There are different inclusion thresholds depending on the sector, ranging from 10,000 t CO_2 to 100,000 t CO_2 of annual emissions or

[49] Industry sectors includes: petrochemical, chemical, building materials, iron and steel, nonferrous metals, paper and ceramics.
[50] Ibid.
[51] Ibid.
[52] Ibid.
[53] Ibid.
[54] Industry sectors includes chemical fibers, chemicals, commercial, water suppliers, hotels, financial, iron and steel, petrochemicals, ports, non-ferrous metals, building materials, paper, railways, rubber, and textiles.

from 5,000 tce to 50,000 tce of energy consumption. In the power and industry sectors, the threshold for companies participating in Phase 1 was lower and therefore more stringent. There were 357 companies participating in the ETS in 2022. In 2020, the ETS covered about 36% of total GHG emissions in Shanghai (where total emissions amounted to 244.0 Mt CO_2eq, excluding LULUCF).[55]

49. The average auction price in 2023 was CNY 70.90 (EUR 9.16) and the average secondary market price for the same year was CNY 66.96 (EUR 8.66). The total revenue collected since the start of the ETS in 2013 was CNY 456.4 million (EUR 59.00 million), and the revenue for 2023 was CNY 191.5 million (EUR 24.76 million). The revenue is allocated to the provincial treasury and used for the general budget, including debt reduction.[56]

Shenzhen Pilot Emissions Trading System

50. The Shenzhen ETS covers the industry, buildings and transport sectors. The cap for 2023 has been set at 28 Mt CO_2. In addition to the cap, the government sets aside reserves for new entrants (2%) and market stability measures (2%). Enterprises with annual emissions above 3,000 t CO_2, confirmed by the local Ecology and Environment Bureau (EEB), participate in the ETS. In 2022, 680 entities were covered by the Shenzhen ETS. In 2020, the ETS covered 50% of total CO_2 emissions in Shenzhen (where total emissions amounted to 45.42 Mt CO_2, including indirect CO_2, excluding LULUCF).[57]

51. For 2023, the average secondary market price was CNY46.37 (EUR 6.00) and the total revenue generated since the start of the system in 2013 was approximately CNY27.9 million (EUR 3.57 million). The revenues are used for climate change mitigation and general budget purposes, including debt reduction. Auction revenues will be allocated to the city treasury (according to the 2014 Shenzhen ETS regulation). The city will improve the transparency of revenue use and establish a new Carbon Emissions Trading Fund to support the ETS and other GHG reduction programmes (as stated in the 2022 revision).[58]

Tianjin Pilot Emissions Trading System

52. The Tianjin ETS covers the industry sector (including iron and steel, petrochemicals, chemicals, oil and gas exploration, paper, aviation and buildings). Electricity generation was also covered until 2020, when it transitioned to China's national ETS.

[55] Ibid.
[56] Ibid.
[57] Ibid.
[58] Ibid.

The cap for 2023 was 74 Mt CO_2. The inclusion threshold for companies is 20,000 t CO_2 per year, taking into account both direct and indirect emissions. In 2023, there were 154 entities in the system. In 2020, the ETS covered around 50% of Tianjin's total CO_2 emissions (total CO_2 emission amounted to 183.14 Mt CO_2, excluding LULUCF)[59]

53. The average 2023 secondary market price was CNY32.20 (EUR 4.16). The total revenue raised since the start of the system in 2013 was CNY148.18 million (EUR 19.16 million). The revenue is used for climate change mitigation and general budget purposes, including debt reduction. The revenue is allocated to the municipal treasury.[60]

2.6. Canada

GHG Reduction Targets in Quebec, Canada

54. Quebec's goal is to reduce greenhouse gas emissions by 37.5% in 2030 compared to 1990 levels (Order in Council 1018-2015) and to achieve carbon neutrality by 2050 (2030 Plan for a Green Economy).[61]

Québec's Cap-and-Trade System

55. The sectors covered by the Québec ETS are power generation, industry[62], buildings and transport. The system covers seven greenhouse gases, namely CO_2, CH_4, N_2O, SF_6, NF_3, HFCs and PFCs. The inclusion threshold for companies is at least 25,000 t CO_2eq of emissions per year or at least 200 litres of fuel distributed for fuel distributors. From 2019, emitters from capped sectors with emissions between 10,000 t CO_2eq and 25,000 t CO_2eq can voluntarily join the trading system. They can receive free allocations if they meet the eligibility requirements for the production activity. In 2022, there were 132 covered entities representing 174 facilities (84 industrial facilities, 51 fuel distributors and 39 opt-in emitters). In 2021, the Québec ETS covered 78.5% of the region's total GHG emissions, which amounted to 77.6 Mt CO_2eq, (including indirect CO_2 and excluding LULUCF).[63]

56. The cap for 2024 is set at 51.6 Mt CO_2eq. There are two mechanisms for allocating allowances: free allocation based on benchmarking, and auctioning. New rules

[59] Ibid.
[60] Ibid.
[61] Ibid.
[62] Industry sectors include producers and importers of electricity and industrial facilities.
[63] Ibid.

adopted in September 2022 reduce the level of free allocation from 2024. The rate of reduction is determined by three additional parameters: the cap decline factor of 2.34%; an additional expected effort based on the risk of carbon leakage and the proportion of fixed process emissions; and a modulation adjustment factor that reduces the rate of reduction in the early years and increases it later, with no net effect over the period 2024 to 2030. Some of the emission units resulting from the reduction in the free allocation will be auctioned on behalf of emitters. The proceeds from the auctioning of these units will be set aside on behalf of each company to finance projects related to climate change mitigation.[64]

57. In Québec's Cap-and-Trade System it is possible to use domestic offsets, which increase the overall cap. Offset credits generated in Québec from eligible projects are fungible in the Western Climate Initiative (WCI) carbon market (WCI manages the California-Québec emissions trading market). The ministerial regulations allow the following types of offset projects: landfill methane reclamation and destruction, halocarbon destruction, carbon sequestration through afforestation or reforestation on private land, and anaerobic digestion of manure.[65]

58. In 2023, the average auction price was CAD 44.46 (EUR 30.16), while the average secondary market price was CAD 45.57 (EUR 30.92).[66] The auction reserve price, a part of the market stability mechanism (so called Market Stability Provisions), is the minimum price at which allowances are available at auction. It is equal to the previous year's annual reserve price plus 5% and an indexation rate based on the Consumer Price Index (CPI). For 2024, it is set at CAD 22.93 (EUR 15.55) for Québec and USD 24.04 (EUR 22.02) for California, with which Québec's cap-and-trade system has been linked since 2014. For joint auctions with California, the reserve price is the highest value in USD between the Québec and California auction reserve prices, based on the Bank of Canada exchange rate on the day before the auction. An allowance reserve was created by Québec to sell to entities that do not have enough allowances to meet their obligations ("mutual agreement sales"), and is filled with fixed portions of the annual cap (4% for 2021 and beyond).[67]

59. Total revenues generated since the start of the ETS in 2013 were CAD 8,419.1 billion (EUR 5,920.1 billion), and revenues for 2023 were CAD 1,419.3 billion (EUR 963.1

[64] Ibid.
[65] ICAP (2022), Canada - Québec Cap-and-Trade System, https://icapcarbonaction.com/en/ets/canada-quebec-cap-and-trade-system (access 30.08.2024)
[66] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)
[67] ICAP (2022), Canada - Québec Cap-and-Trade System, https://icapcarbonaction.com/en/ets/canada-quebec-cap-and-trade-system (access 30.08.2024)

billion). The revenue goes into the Electrification and Climate Change Fund, which replaced the Green Fund in November 2020, and is used to implement climate change mitigation and adaptation measures included in the 2030 Green Economy Plan. Implementation includes energy efficiency, electrification and public transport.[68]

60. Covered entities must report surrendered emissions annually. All covered entities are required to have their emissions reports verified by an independent third party. The mandatory reporting of certain emissions of pollutants into the atmosphere is regulated by the Environmental Quality Act.[69]

2.7. USA

California Cap-and-Trade Program

61. The sectors covered by California's cap-and-trade system are the same as those covered by Quebec's system, with which it has been linked since 2015. They are: power, industry[70], buildings and transport. In addition to the seven GHGs covered by Québec's system (CO_2, CH_4, N_2O, SF_6, HFCs, PFCs and NF_6), California's ETS also covers other fluorinated GHGs. Facilities emitting 25,000 t CO_2eq or more per year are included in the ETS. All imported electricity from specified sources associated with a specified generating unit that emits more than 25,000 t CO_2eq per year is covered. Emissions associated with imported electricity from unspecified sources have a zero threshold and all imported electricity emissions are covered using a default emission factor. An installation in one of the covered sectors that emits less than 25,000 t CO_2eq per year can participate in the system on a voluntary basis. Voluntary participants (known as opt-in entities) are subject to all registration, reporting, verification, compliance and enforcement obligations applicable to covered entities. The number of covered entities averages 400. In 2021, the California ETS will cover 76% of the state's total GHG emissions of 381.3 Mt CO_2eq (including indirect CO_2, excluding LULUCF).[71]

62. The cap for 2024 has been set at 280.7 Mt CO_2eq. Allowances are distributed through free allocation, free allocation with consignment and auctioning. The auctioned portion of the cap represents 50% of the total available cap. In the case of free allocation, the amount of allowances is determined by product-specific benchmarks, production volumes, a cap adjustment factor and a support factor based on an assessment of the risk of leakage. There is no cap on the total industrial allocation,

[68] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership [Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com)](icapcarbonaction.com) (access 28.07.2024)
[69] Ibid.
[70] Industry sectors include cement, glass, hydrogen, iron and steel, lead, lime manufacturing, nitric acid, petroleum and natural gas systems, petroleum refining, and pulp and paper manufacturing
[71] Ibid.

but the allocation formula includes a declining cap adjustment factor to gradually reduce the allocation in line with the overall cap trajectory. Free allocation with consignment means that electricity distribution companies and natural gas suppliers receive free allocation on behalf of their ratepayers. Natural gas and electric utilities are required to use the allowance value to benefit ratepayers and to reduce greenhouse gas emissions. All allowances allocated to investor-owned electric utilities and an annually increasing percentage of allowances allocated to natural gas utilities must be consigned for sale at the state's regular quarterly auctions, while publicly-owned electric utilities may choose to consign freely allocated allowances to auction or use them for their own compliance needs.[72]

63. Approximately 70% of total vintage 2023 allowances were made available through auction in 2023, including allowances owned by the California Air Resources Board (CARB) (~41%) and allowances submitted for auction by utilities (~29%). The auction volume is 197,368,635 (2023 vintage) and 25,400,000 for the advance auction (2026 vintage). Unsold allowances from previous auctions will be gradually released for sale in the auction after two consecutive auctions with a clearing price above the minimum price. If any of these allowances remain unsold after 24 months, they will be placed in CARB's price cap reserve or the two lower reserve tiers.[73]

64. Compliance offset credits issued by CARB or the authority of a linked cap-and-trade system are compliance instruments under the California cap-and-trade system. Offset credits from projects implemented under one of six compliance offset protocols are accepted as compliance instruments: US forest projects; urban forest projects; livestock projects (methane management); ozone depleting substance projects; mine methane capture projects; and rice cultivation projects. For emissions generated between 2013 and 2020, companies can use offset credits to meet up to 8% of their obligations, with lower limits after 2020.[74]

65. The average auction price for 2023 was USD 32.93 (EUR 30.16). The total revenue generated since the start of the system in 2012 was USD 26.97 billion (EUR 24.70 billion) and the 2023 revenue was USD 4.72 billion (EUR 4.32 billion). Revenues will be used for: climate change mitigation; other development objectives such as education and health; support for individuals, households and businesses; and low-carbon innovation.[75]

66. Except for the year following the last year of a compliance period, compliance instruments equal to 30% of the previous year's verified emissions shall be surrendered annually by the beginning of November. Compliance instruments for all

[72] Ibid.
[73] Ibid.
[74] ICAP (2022), USA - California Cap-and-Trade Program, https://icapcarbonaction.com/en/ets/usa-california-cap-and-trade-program (access 30.08.2024)
[75] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

remaining emissions shall be surrendered by the beginning of November of the year following the last year of a compliance period. Emission data reports and their underlying data are verified annually by an independent third party for all entities covered by the system. Most emitters whose emissions are equal to or greater than 10,000 t CO_2eq per year are required to report. They must implement internal audits, quality assurance and control systems for the reporting system and the reported data.[76]

Regional Greenhouse Gas Initiative (RGGI)

67. The Regional Greenhouse Gas Initiative (RGGI), launched in 2009, is the first mandatory greenhouse gas ETS in the United States. It started with ten states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont) and its composition remains the same until 2024 (Virginia joined in 2021 but left in 2024, New Jersey left in 2011 during the control period but rejoined in 2024). Pennsylvania's RGGI scheme is currently under court injunction and the state will not release any allowances for the time being.[77]

68. The GHG reduction target is a 30% reduction in power sector emissions compared to the 2020 CO_2 cap, but participating states also have their own emissions targets. There are no economy-wide targets set at the RGGI level.[78]

69. RGGI only covers CO_2 emissions from the power sector. In 2021, the share of covered emissions was 14% of total CO_2 emissions of 631.8 Mt CO_2 (form states covered by RGGI, including Virginia but excluding Pennsylvania, including indirect CO_2, excluding LULUCF).[79] Most RGGI states cover units with a capacity of at least 25 MW. There are 195 units participating in the system (excluding both Virginia and Pennsylvania).[80]

70. The cap for 2024 has been set at 63 Mt CO_2. Allowances are allocated by auction only, and auctions are held quarterly. Since 2014, RGGI has operated with a cost containment reserve (CCR), which consists of a number of allowances in addition to the cap that are held in reserve and released to the market only when certain trigger prices are reached. From 2021, the CCR will hold allowances equivalent to 10% of the regional cap. The trigger price will be USD 15.92 (EUR 14.58) in 2024 and will

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[76] Ibid.
[77] RGGI, The Regional Greenhouse Gas Initiative: an initiative of Eastern States of the USA, https://www.rggi.org/program-overview-and-design/elements (access 30.08.2024)
[78] ICAP (2022), USA - Regional Greenhouse Gas Initiative (RGGI), https://icapcarbonaction.com/en/ets/usa-regional-greenhouse-gas-initiative-rggi (access 30.08.2024)
[79] Ibid.
[80] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

increase by 7% per year. It had previously increased by 2.5% per year between 2017 and 2020, from an initial value of USD 10 (EUR 9.16).[81]

71. Currently, the ETS allows offset credits from three types of offsets located in RGGI states: the capture and destruction of methane from landfills; carbon sequestration through reforestation, improved forest management, or avoided conversion; and the avoidance of methane emissions from agricultural manure management. A company's emission can be covered by offset credits up to 3.3%, and this limit will remain unchanged between 2021 and 2030. Despite this possibility, no CO_2 offset credits were deducted between the first and fourth monitoring periods (2009 to 2020) and in the fifth monitoring period (2021 to 2023).[82]

72. The average auction price for 2023 was USD 12.81 (EUR 11.73). Total proceeds raised since the inception of the system in 2009 were USD 7,160 million (EUR 6,558.6 million). Revenue in 2023 was USD 1,265 million (EUR 1158.7 million). The proceeds will be used for climate change mitigation and support for individuals, households and businesses. In 2020, the distribution of RGGI investments was: energy efficiency (51%), direct bill assistance (13%), beneficial electrification (13%), greenhouse gas reduction (11%), and clean and renewable energy (4%).[83]

73. Participants in the system are required to report on a quarterly basis. Emissions data reports and the underlying data are subject to regular quality assurance and quality control procedures in accordance with US Environmental Protection Agency (US EPA) regulations. Emissions data are recorded in the database of the US EPA's Clean Air Markets Division in accordance with the rules of the state CO_2 budget trading systems and agency regulations. The regulations are based on US EPA monitoring requirements. The data is then automatically transferred to the RGGI CO_2 Allowance Tracking System (COATS) electronic platform, which is publicly accessible.

3. CBAM

74. Emissions trading systems are a key element of climate policy, aiming to reduce greenhouse gas emissions by imposing costs associated with emissions. In practice, however, imposing such financial burdens on regulated sectors risks distorting competitive conditions. Companies operating in countries with strict climate regulations may face higher production costs than their competitors in countries with more lenient environmental regulations, encouraging "carbon leakage" - the relocation of production/investment to countries with lower climate standards.

[81] Ibid.
[82] ICAP (2022), USA - Regional Greenhouse Gas Initiative (RGGI), https://icapcarbonaction.com/en/ets/usa-regional-greenhouse-gas-initiative-rggi (access 30.08.2024)
[83] ICAP (2024), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership Emissions Trading Worldwide: 2024 ICAP Status Report | International Carbon Action Partnership (icapcarbonaction.com) (access 28.07.2024)

75. In response to these challenges, most emissions trading systems include mechanisms to mitigate the financial impact on sectors, such as free allocation of allowances (many examples of which were described in the previous chapter). An additional strategy to protect competitiveness is the introduction of a carbon border tax, which helps to level the playing field. The European Union has decided to introduce such a mechanism, creating a framework for fairer economic competition and reducing the risk of carbon leakage.

76. The EU's Carbon Border Adjustment Mechanism (CBAM) is the EU's policy instrument to put a fair price on the carbon emitted in the production of carbon-intensive goods entering the EU market. The CBAM is designed to encourage cleaner industrial production in non-EU countries.

77. The CBAM is a global climate policy that directly affects EU-based producers and indirectly affects producers in third countries. This mechanism imposes additional charges on goods imported into the EU that are produced in countries with lower greenhouse gas emission standards. By ensuring that imported goods are subject to the same carbon costs as those produced within the EU, the CBAM supports global efforts to reduce carbon emissions and promotes fair competition.

78. The EU CBAM will apply in its final form from 2026, while the current transitional phase runs from 2023 to 2025. This phased introduction of the CBAM is in line with the phasing out of free allowances issued under the EU ETS to support the decarbonisation of EU industry.

79. The CBAM will ensure that the carbon price of imports is equivalent to the carbon price of domestic production and that the EU's climate change objectives are not compromised.

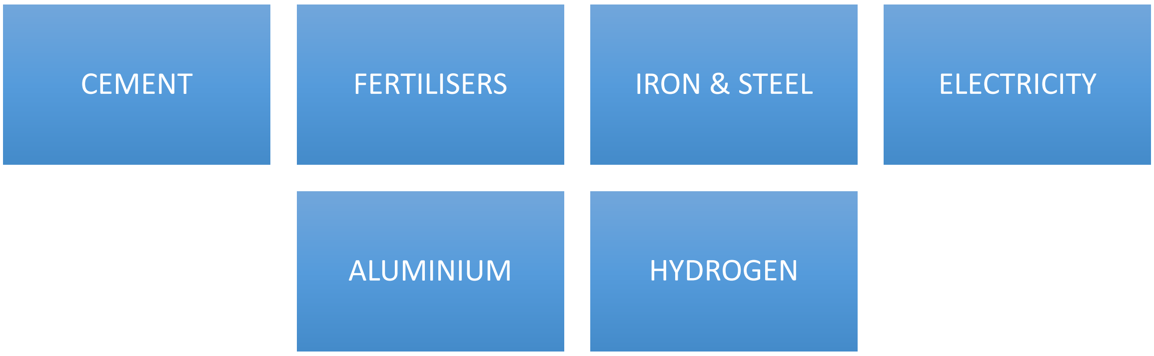
80. The CBAM is divided into two main phases: a transitional phase and a definitive phase. The transitional phase started on 1 October 2023 and will last until the end of 2025. During this period, importers of goods covered by CBAM are required to report the greenhouse gas emissions associated with their imported products on a quarterly basis, but are not yet required to purchase CBAM certificates. The purpose of this phase is to allow companies and third countries to adapt to the new requirements and to collect the necessary data for the full implementation of the mechanism.

81. From 2026, when the final phase begins, EU importers of goods covered by the CBAM will be required to register with national authorities to obtain CBAM allowances. The cost of these certificates will be determined by the average weekly auction price of emission allowances under the EU ETS, expressed in euros per tonne of CO_2 emitted. Importers will also be required to declare the greenhouse gas emissions associated with their imports and surrender a corresponding number of allowances each year. Crucially, if importers can demonstrate that a carbon price has already been paid in the country of origin for the imported goods, they will be able to deduct this amount from their CBAM obligations, thus avoiding double taxation of emissions. The gradual

implementation of CBAM will allow a predictable transition for EU and non-EU companies and authorities.[84] Failure to comply with these requirements may result in significant penalties, including revocation of authorised declarant status and the inability to import CBAM covered goods into the EU market.

82. Initially, the CBAM will apply to sectors with a high risk of carbon leakage, such as cement, iron and steel, aluminium, fertilisers, hydrogen and electricity. As the system evolves and adapts to both market needs and EU climate policy, the mechanism may be extended to other sectors. The sectors covered in the first phase of the CBAM are shown in the Fig. 1.

Figure 1. Sectors covered by Carbon Border Adjustment Mechanism (CBAM) in the EU



Source: CAKE/KOBiZE.

83. Other countries are following the logic of the CBAM approach. As recently announced, Chile intends to implement domestic emissions trading in its energy sector, which accounts for 75% of national emissions, and intends to study the implementation of the Chilean CBAM to protect its emissions-intensive industries exposed to foreign trade from carbon leakage through a potential impact study by the Ministry of Economy.

84. The United States is also considering the introduction of a similar system. The US Senate is debating four major bills: the Prove It Act, the Foreign Pollution Fee Act and the Market Choice Act. Each of these bills has different provisions.[85]

85. The Prove It Act would not impose any fees, but only require the disclosure of emission intensity information from foreign and domestic producers. This

[84] European Commission, Carbon Border Adjustment Mechanism, (Carbon Border Adjustment Mechanism - European Commission) (access: 14.08.2024).

[85] World Resources Institute, 4 New Carbon Border Adjustment Bills in the US, (4 New Carbon Border Adjustment Bills in the US | World Resources Institute) (access: 14.08.2024).

transparency would allow importers and consumers to make informed decisions about greenhouse gas emissions.

86. The Foreign Pollution Fee Act proposes to impose a fee on certain industrial and energy products imported into the U.S. This approach would increase the competitiveness of U.S.-made goods because the bill would not impose taxes on U.S. manufacturers, nor would it require reporting of emissions intensity from them.

87. The Clean Competition Act would impose a tax on certain goods produced by both foreign and domestic manufacturers if their emissions exceed a certain benchmark. In addition, this bill would require emissions intensity reporting, similar to the Prove It Act.

88. Finally, the Market Choice Act would replace federal taxes on motor vehicles and aviation fuel with a broader tax on greenhouse gas emissions. In addition, the bill would adjust the emissions tax by imposing a fee on certain imported goods while reducing the tax on exported goods. Unlike the Clean Competition Act, the Market Choice Act would impose a fee on all emissions, regardless of whether they exceed a certain benchmark.

4. Paris Agreement mechanisms

4.1 History of ETS linking

89. Linking regional emissions trading systems can lower the global costs of emission mitigation. In addition to increasing market liquidity, linking emissions trading systems can be used to address the issue of carbon leakage. It is expected that linking could be the answer to some countries' carbon border adjustment policies, allowing those countries that have implemented or plan to implement domestic emissions trading schemes to avoid the need to address carbon leakage through such border adjustments. There are already some linkage agreements in place between sovereign states or at the sub-national level. The Swiss ETS has been linked to the EU ETS since 1 January 2020. Although the systems remain separate, allowances from both systems can be used for compliance, allowing emissions in either system to be offset. In contrast, other European countries that are not part of the EU, such as Norway and Iceland, have directly implemented the EU ETS rules and have become part of the EU carbon market, and therefore fully participate in the EU ETS. Other linking arrangements have been adopted at regional and sub-national levels, such as the linkage between Quebec and California's systems.

90. The linking arrangements between the EU ETS and the Swiss ETS took 10 years to negotiate. This is an exemplary case of linking, with full fungibility of units, allowing Swiss ETS participants to access EU allowances to meet their targets. Linking has led

Switzerland to expand the scope of its ETS to include domestic and foreign aircraft operators operating domestic flights in Switzerland and flights within the European Economic Area (EEA). To enable the transfer of allowances, the Union registry and the Swiss registry have been linked. The Swiss ETS manages the MRV and compliance of 100 stationary emitters and about 200 aircraft operators. In 2022, the EU ETS covers 8 640 installation operators and 390 aircraft operators. The economic consequence of this link for EU operators is limited (it does not increase significantly the supply of allowances in the EU ETS). However, the linkage between the EU ETS and the Swiss ETS demonstrates that fully integrating systems is both feasible and effective.

91. Prior to the link with the Swiss ETS, the EU ETS was partially linked to the flexible mechanisms of the Kyoto Protocol through the provisions of the Linking Directive adopted in 2004.[86]. It allowed operators of installations participating in the EU ETS to use fixed amounts of carbon credits generated from Joint Implementation (JI) and Clean Development Mechanism (CDM) project activities for compliance purposes until 2020.[87] In phase 2 of the EU ETS, which ran in parallel to phase 1 of the Kyoto Protocol, Member States decided on the limit of Certified Emission Reductions (CERs) and Emission Reduction Unit (ERUs) to be used for compliance, subject to confirmation by the European Commission. The maximum amount of CERs that operators could use for compliance during phase 3 of the EU ETS (2013-2020) was 11% of their verified emissions during phase 2 of the EU ETS (2008-2012), and the maximum amount of ERUs was 3.5% of installations' verified emissions during phase 2 of the EU ETS. Aircraft operators could use up to 2.5% of the average annual emissions of covered flights (inbound and intra-EU). The use of carbon credits for compliance was limited not only quantitatively, but also qualitatively, by excluding credits from certain activities such as nuclear energy projects, afforestation and reforestation activities and destruction of industrial gases (HFCs and N_2O), while credits from large hydroelectric projects above 20 MW installed capacity were accepted under certain additional conditions, such as compliance with the World Commission on Dams (WCD) criteria.[88]

4.2 Linking under the Paris Agreement

92. Countries that have linked their emissions trading systems in the past may wish to account for the results of linking at the international level, while new linking arrangements may be used to support the achievement of the Paris Agreement NDCs. Flows of emission reductions between Parties are regulated and must be recorded in

[86] Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms)TEXt with EEA relevance), OJ, 338, 13.11.2004, p. 18-23. Directive - 2004/101 - EN - EUR-Lex (europa.eu) (access: 01.08.2024)
[87] Articles 6 (JI) and 12 (CDM) of the Kyoto Protocol.
[88] European Commission, Use of international credits. (https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/use-international-credits_en, access: 01.08.2024).

the international registry managed by the UNFCCC Secretariat. The regulatory framework is set out in Article 6 of the Paris Agreement. Transfers of carbon units between sovereign countries under the Paris Agreement can only be accounted for in the national emissions balance of the participating countries if both countries meet the criteria for Article 6 participation. Both countries engaging in Article 6 activities must be Parties to the Paris Agreement, have prepared, communicated and are maintaining their NDCs, provide their latest national inventory reports and their Article 6 participation contributes to their NDCs, LT-LEDS and the long-term goals of the Paris Agreement.

93. The emission reductions achieved domestically are called mitigation outcomes and become internationally transferred mitigation outcomes (ITMOs) when they are transferred from one country to another or when they are earmarked for other mitigation purposes such as CORSIA. The emission reduction flows resulting from the linking of emissions trading systems would be reflected in corresponding adjustments to the NDCs of countries participating in the linking scheme (and reported under the enhanced transparency framework).

94. The linking of domestic emissions trading systems at the international level will be recognised as a cooperative approach by the countries exchanging the ITMOs. The terms of cooperation under Article 6.2 will be determined by the countries, not by the CMA.[89] However, the linking agreement will need to coordinate the design and management of the linking process.

95. Parties to the Paris Agreement using cooperative approaches will need to report on ITMO flows in accordance with the reporting requirements approved by the CMA and adjust their inventories accordingly. If linking at the subnational level is not accounted for as a cooperative approach, countries would not be able to report the results of these actions to the UNFCCC.

96. Article 6.2 allows Parties to the Paris Agreement to cooperate in the joint implementation of their NDCs and to account for the results in their NDCs through the transfer of international mitigation obligations from one country to another. To avoid double counting of the same emission reductions/removals, the Paris Agreement requires Parties participating in cooperative approaches to make "appropriate adjustments", i.e. to adjust the balance of their emissions or removals covered by their NDCs to reflect internationally transferred mitigation outcomes. Article 6.2 allows Parties to approve mitigation outcomes other than those implemented through NDCs (outside the scope of NDCs), including voluntary use by private entities. Transfers between Parties to the Paris Agreement will be reported under the enhanced transparency framework.[90]

[89] UNFCCC, Conference of the Parties serving as a Meeting of the Parties to the Paris Agreement
[90] UNFCCC, Decision 18/CMA1.

97. Linking regional emissions trading schemes can also be achieved through participation in the Article 6.4 mechanism (Paris Agreement Carbon Mechanism, PACM). To ensure the environmental integrity of Article 6.4 credits, Parties have negotiated the application of appropriate adjustments to Article 6.4 projects approved by host countries. Article 6.4 will operate in a manner similar to the CDM.

98. In addition to the conditions for participation in Article 6.2, countries participating in the Article 6.4 mechanism will be required to appoint a Designated National Authority (DNA) to facilitate the domestic implementation of the Article 6.4 mechanism and cooperation with the Article 6.4 Supervisory Body. Through its DNA, each country will indicate to the A6.4 SB the types of A6.4 activities it will consider approving and provide the A6.4 SB with information on how these activities will contribute to the implementation of its NDCs and its long-term strategies, sustainable development and the long-term goals of the Paris Agreement. A6.4 ERs can only be transferred between countries as ITMOs in accordance with Article 6.2 Cooperation Agreements between Parties and reflected in the NDC emissions balance through appropriate adjustments. For this purpose, the A6.4 registry will be linked to the Article 6.2 international registry. Mitigation outcomes generated through the A6.4 mechanism will come from baseline and crediting activities.

99. All MOs (from A6.2 Cooperative Approaches) and A6.4 ERs will also have unique identifiers to enable them to be tracked after the first transfer until they are cancelled. The CMA5 has not adopted a decision clarifying, inter alia, the characteristics of the unique identifiers to be used for each MO issued.

100. Interoperability with the future A6.4 registry will require A6.4ERs to be transferred to the host country international registry account for conversion to ITMOs. These converted A6.4ERs will then be transferred to the registry account of the purchasing country. The registration of the purchased ITMOs in the buyer's account reduces the emissions in the national inventory of the buyer country and increases the emissions in the national inventory of the host country. All information on ITMOs related to first transfers, transfers, acquisitions, holdings, cancellations and cancellations for OMGE and the use of ITMOs by participating Parties is collected by the UNFCCC Secretariat.

101. However, if ITMOs from baseline-and-crediting mechanisms are used for compliance in the buyer's domestic emissions trading, the domestic reduction in the ETS sectors allowed to use offsets is slowed down, as the imported offsets increase the liquidity of the ETS while the corresponding reductions are achieved abroad. This was the effect of the Linking Directive adopted by the EU in 2004. Installations were allowed to keep their EU allowances or sell the amount that could be replaced with foreign offsets to meet ETS targets.

4.3 Linking using offsets

102. Linking can also be achieved indirectly through carbon offsets. However, voluntary credits cannot be taken into account under the Paris Agreement unless both countries agree to make the appropriate adjustments to their NDCs.

103. Several countries that are Parties to the Paris Agreement plan to use carbon offsets to partially meet their mitigation targets. To name a few, Japan, South Korea, Singapore, Switzerland and Norway plan to engage in cooperative approaches under Article 6 with other countries. Japan has its own purchasing programme called the Joint Crediting Mechanism (JCM) and has signed Joint Crediting Mechanism partnerships with 24 countries. Japan uses the JCM as a means to export its technologies, e.g. CCS, hydrogen or ammonia production. Over 500 Japanese companies will participate in a domestic voluntary carbon market and will be able to use either domestic J-credits or offsets generated under the JCM to meet their targets.

104. Another country preparing to purchase offsets to partially meet its NDC target is South Korea. Korea plans to reduce its 2030 GHG emissions by 40% below 2018 levels and will partly meet this target by purchasing around 35.5 million carbon credits from other countries. Korea has already signed bilateral Memoranda of Understanding with several countries, including Peru, Sri Lanka, Myanmar and Vietnam. Other countries, such as Singapore and Switzerland, are also buying credits through cooperative approaches that will be registered in the International Registry as ITMOs. Singapore has already signed Memoranda of Understanding with countries such as Morocco, Cambodia, Colombia, Vietnam and Thailand to work together to achieve joint mitigation outcomes that can be used to meet NDC targets.

5. Literature review

105. The climate change policy that has been most studied in the economic literature is probably carbon pricing, whether in the form of a carbon tax or a cap-and -trade system. It is considered by many economists to be the most efficient instrument for reducing greenhouse gas emissions. Setting a cap on emissions and allowing emitters to trade them has the potential to reduce them at minimum cost. This logic can also be applied to linking existing schemes into a single large emissions trading system. Research indicates that linking emissions trading systems (ETS) can yield both economic and environmental benefits, which is the primary motivation for pursuing such integration.

106. The body of literature on the various aspects of linking emission trading systems is extensive, encompassing both quantitative and qualitative research. Linking ETS is a complicated process and many of its elements cannot be easily quantified or modelled. When considering the linking of ETS, it is important to take into account the existing design of the systems involved (cf. Kaichi et al., 2015), such as: a) scope and

coverage – encompassing sectors, GHGs and thresholds; b) caps and targets; c) – allowance allocation versus auctioning; d) compliance dates and trading periods, including banking and borrowing issues; e) price support and mitigation measures, f) monitoring, reportin and verification; g) registries and compliance mechanisms; h) the use of offsets; and i) market oversight. Flachsland et al. (2009) point to the various economic mechanisms that can shape the outcomes of linking, emphasizing the importance of considering dynamic efficiency, short-term gains versus global general equilibrium effects, distributional consequences, and policy and regulatory implications. Ranson and Stavins (2015) highlight similar points, including distributional effects, international coordination and strategy, geographical proximity, and other related factors.

107. The issue of linking has also been analysed using simplified quantitative models that highlight the main economic channels and conditions determining how and when the benefits and costs of linking emerge and how they are distributed. There is a general consensus that the primary economic benefit of linking is straightforward price arbitrage; however, for this to occur, the linking countries must differ, at least in terms of their level of ambition and the price of allowances. On the other hand, when such differences exists, there if often redued political willingness tu pursue linking. For this reason, economists also quantitatively examine other mechanisms through which different types of economic benefits might arise.

108. One of the earliest significant contributions to the topic of linking ETS systems is by Helm (2003). The author presents a stylized model in which countries choose the optimal level of emissions that balances the marginal benefits and costs associated with emissions, both in a system with and without international emission trading. They find that, depending on a country's level of environmental awareness, it may choose to increase or decrease the number of emissions allowances after a multilateral link is established, and that the overall effect on total emissions is ambiguous.

109. This model has since been extended and used as the basis for developing more sophisticated models of linkage, incorporating additional mechanisms involved in the linkage process. Doda et al. (2019) apply a modelling approach to quantify efficiency gains from risk and effort sharing. The former relates to due to the uncertain number of emission allowances each region will require, while the latter arises from heterogeneity of abatement technology options available in different regions. The authors calibrate their model using data from Australia, Canada, the EU, South Korea and the US, finding that linking could result in annual gains of USD 3.26 billion (EUR 2.99 billion). In a related study, Doda and Tascini (2017) analyse how the efficiency gains from linking carbon markets depend on factors such as uncertainty, market size and sunk costs. In a similar quantitative analysis, Cheng (2004) emphasizes the role ofcapital mobility in the dynamics of linking ETS markets, concluding that capital mobility can hinder global emission reduction efforts and that maintaining separate systems may be preferable to linking. The issue of linking has also been examined

within a CGE (computable general equilibrium) framework, as opposed to smaller, typically game-theoretic stylized models, in Carbone et al. (2009). They show that the most significant benefits of linking occur when developed and developing countries are paired and highlight notable general equilibrium effects, such as increased demand for fossil fuels as due to lower global prices.

110. In most models and under most assumptions, the economic benefits arise mainly from the ability to exploit differences between countries and the prices of emissions trading schemes. However, Holtsmark and Midttømme (2021) show that countries can benefit from linking even if they are very similar. They develop a dynamic model with endogenous technology development to show that, under such assumptions, global innovation in green technologies brings additional benefits to both countries. The second key assumption is that countries set their emission caps non-cooperatively before linking and then in each period. Such an arrangement leads to more overall investment in green technologies and countries setting lower emission caps.

111. There are also several publications on the current status of ETSs around the world. One of the most comprehensive, annually updated summary of carbon pricing instruments is published by the World Bank. The annual State and Trends of Carbon Pricing report provides a taxonomy of carbon pricing approaches and concise information on the types of carbon pricing instruments operating around the world. In 2024, there were 75 carbon pricing systems in operation around the world, with two new carbon pricing instruments launched in the last 12 months. Carbon pricing is seen as a cost-effective way to achieve decarbonisation targets. The World Bank (2024) categorises carbon pricing instruments (CPIs) as taxes, emissions trading and carbon crediting mechanisms. The World Bank also distinguishes between direct carbon pricing, which includes ETS, carbon taxes and carbon credits, and indirect carbon pricing, such as fuel excise taxes, fossil fuel subsidies or differentiated VAT rates. Key topics covered in the 2024 World Bank report include the uptake of ETS and carbon taxes in low- and middle-income economies, sectoral coverage of ETSs and carbon taxes, and the use of crediting mechanisms as part of the policy mix.

112. The report signalled progress in the implementation of carbon pricing in Brazil, India and Turkey, as well as further progress in the implementation or development of multilateral sectoral initiatives such as the CORSIA offsetting scheme for international aviation managed by the International Civil Aviation Organization (ICAO) and a potential carbon pricing instrument for international shipping being considered by the International Maritime Organization (IMO). The report notes the importance of the EU's Carbon Border Adjustment Mechanism (CBAM) for reporting embedded emissions in imported projects. Carbon pricing covers about 24% of global emissions, and with further instruments in the pipeline, this could rise to nearly 30%. However, price levels are too low to support the ambition needed to meet the Paris Agreement targets. The World Bank report also found that governments are increasingly using

multiple carbon pricing instruments, in parallel with extending carbon price signals to uncovered sectors.

113. The Fortune Business Insights market research report on carbon offsets provides an analysis of carbon offset markets by type (compliance and voluntary markets), by project type (avoidance/reduction and removal/sequestration projects) and by end user (sectors), with regional forecasts for 2023-2030 covering the period 2017-2030 based on historical data for 2017-2021 and 2022 as a base year.

114. According to several experts, e.g. Parry (2021), carbon pricing should be coordinated internationally through carbon price floors. These could be set between groups of countries, for example the EU and three top emitters: China, India and the United States, which account for 64% of global emissions, or at the level of the Group of Twenty (G20) major economies, which account for 84% of global emissions. The International Monetary Fund (IMF) projects that carbon pricing limited to the highest emitting countries could achieve the long-term goal of below 2 degrees, provided that all G20 economies implement their (2030) NDCs.

115. Limiting carbon pricing to the European Union, the United States, the United Kingdom, Canada, China and India, and setting floor (minimum) prices at domestic levels of 75 USD/t CO_2eq (68,70 EUR/t CO_2eq) for advanced economies, 50 USD (45,80 EUR/t CO_2eq) for high-income emerging economies such as China and 25 USD (22,90 EUR/t CO_2eq) for low-income emerging economies such as India, would deliver the necessary abatement. This suggests that the current EU ETS price would fall if linkages with the UK, US and Canadian carbon markets could be achieved. In addition, carbon price floors would provide minimum carbon prices that could be raised above the set levels by cooperating countries to accelerate decarbonisation and, if necessary, meet the ambition of their NDCs. This proposal does not take into account the time needed to negotiate and implement the link, even for the most advanced economies. Based on the experience of the EU-Swiss link, which took over 10 years to achieve despite the similarities between the two ETSs and the common economic framework provided by the EEA, we do not have the time to do this.

116. Linking heterogeneous carbon markets is motivated by the need to increase market liquidity and the efficiency of carbon financing. However, it is associated with a lower level of ambition. The alignment of carbon prices would enable countries to address the competitiveness concerns among jurisdictions. The IMF (IMF 2021) advocates simultaneous increases in carbon prices as the most effective way of addressing that issue.

117. Domestic carbon schemes based on voluntary standards are described in I4CE (2019).

118. Important insights into the development of carbon pricing instruments (CPIs) around the world can be found in the PMR (2021) report, which argues for a careful assessment of the impact of different design features of the envisaged CPI on

competitiveness and jobs. The choice of CPI should be carefully considered and assessed with the support of decision support tools such as modelling. The PMR (2021) report points out that the use of models already in use in the country, adjusted with updated information, may yield better results than searching for a new model to assess the CPI options. Where possible, a set of complementary models should be used to compare different modelling results to confirm the findings on the impact of the CPI. The report also points out that CPI design choices can influence the complexity of the chosen instrument in terms of capacity and implementation costs (administrative and compliance).

119. In summary, according to the literature review the carbon pricing plays a crucial role in achieving environmental objectives by internalising the external costs of emissions and encouraging cleaner development.

II. Insights from Modelling of ETS linking

120. The study's findings were generated using a Computable General Equilibrium (CGE) model called CREAM[91], applies in its recursive dynamic version. CREAM is a global, multi-sector model, built upon the economic Input-Output (I-O) table, which is used in the Global Energy and Climate Outlook (GECO) report for the year 2020 published by the Joint Research Centre (JRC) of the European Commission (EC)[92]. A detailed description of the model can be found in Annex I.

6. Objective and scope of the analysis

121. Objective: The primary objective of this analysis is to provide comprehensive impact assessment on macroeconomic effects, and the costs of decarbonization under various international scenarios of climate policy. The report will evaluate the effects of linking emissions trading systems (ETS), adopting alternative policy measures (CBAM) and use of carbon credits, with the aim of identifying the most politically feasible and cost-effective solutions for reducing greenhouse gas (GHG) emissions in alignment with the commitments of the Paris Agreement and the latest IPCC recommendations.

122. This report will explore several key aspects of emissions trading and international climate policy mentioned below.

123. Scenario Development: The analysis will develop a set of politically feasible scenarios, including baseline scenario with CBAM, ETS linking and carbon credits use. These scenarios will be informed by policy trends, stakeholder consultations, and a review of existing literature, with input from climate negotiators, global ETS administration and representatives of CBAM sectors.

124. Modeling Framework: The macroeconomic model from the Centre for Climate and Energy Analysis (CAKE) will be expanded to evaluate the implications of different ETS linkages and alternative policies. The model will incorporate detailed features of the EU ETS, including free allowances, the sectoral scope, providing a robust foundation for analyzing the impacts of different policy options.

125. Projections: The report will generate detailed projections of emissions, GDP, trade, and marginal abatement costs across regions, with a time horizon to 2050.

[91] CREAM - Carbon Regulation Emission Assessment Model.
[92] Garaffa, Rafael; Ordonez, Jose; Vandyck, Toon; Weitzel, Matthias (2023): Baseline GECO 2022. European Commission, Joint Research Centre (JRC) [Dataset] doi: 10.2905/DF6CFD52-EE0C-4647-A2B3-5FA56B8B5AB0 PID: http://data.europa.eu/89h/df6cfd52-ee0c-4647-a2b3-5fa56b8b5ab0 .

These projections will cover various scenarios, including linking ETS systems and the use of carbon credits.

126. Policy Insights: The analysis will assess the costs and benefits of CBAM, linking ETS systems and carbon credit use, both unilaterally and multilaterally. The impact of linked ETS systems and Nationally Determined Contributions (NDCs) on long-term economic and environmental outcomes will be evaluated. This will include consideration of sectoral and macroeconomic impacts, such as decarbonization costs, emissions reduction potentials, and risks of carbon leakage.

127. Recommendations: Based on the analysis, the report will provide policy recommendations for decision-makers negotiating the linking of ETS systems. It will offer insights into the most effective mechanisms to achieve global GHG reductions while minimizing economic disruptions, ensuring the analysis supports transparent, credible, and actionable policy decisions.

7. Theoretical assumptions

7.1 Overview of modelling assumptions

128. Equalization of prices of emission allowances (carbon prices) is the primary effect of linking emission trading systems, from which other effects derive. Therefore quantitative assessment of the macroeconomic impact of such a policy crucially depends on the projected levels and differences in carbon prices between the systems under the no-linking scenario.

129. A similar conjecture applies to the effects of international offsets. In this case, there is no equalization of carbon prices, but the use of offsets by a buyer country is expected to bring down its carbon prices. Like with the ETS linking, quantitative effects hinge on projected levels and changes in carbon prices.

130. Historical experience with emission trading systems is still limited, and it is not representative of future emission reduction targets. Consequently, the evolution of carbon prices is subject to immense uncertainty, especially when looking far into the future (e.g. to 2050), as required by the climate policy planning perspectives. Available long-run projections of carbon prices come from various numerical models, rooted more in theory than in the very scarce empirics.

131. Carbon prices depend on a number of factors: (a) the stringency of emission reduction targets, (b) the costs and potentials of various technical emission mitigation options (including their future evolution, due to technical progress etc.), (c) the rate of GDP growth, (d) responses of consumer demand and foreign demand to changes in prices of commodities (in particular, emission-intensive goods), (e) other existing

climate-and-energy policies, (f) behaviour of emission allowance markets, and other factors.

132. The CGE model employed in this study takes into account effects (a) through (d). However, regarding factor (b), unlike specialized sector models (such as those used for power or transport sectors), it does not contain information on detailed technologies, asset lifetimes, investment cycles and various related constraints. Instead, it relies on approximations of the aggregate effects of climate-related policies on industry costs, energy mix and emissions. Our strategy is to calibrate CGE model parameters in such a way that it mimics some aspects of a "better informed" energy system model. That approach will be laid out in more detail in the following sections.

133. In the CGE model carbon prices are assumed to equal the current marginal cost of emissions abatement (marginal abatement cost, MAC). It alludes to the arbitrage mechanism: given a carbon price, agents (firms and households) are motivated to undertake any abatement actions that are cheaper than the cost of emissions. However, in reality, one can imagine frictions and delays in that process, non-compliance etc. Agents may take actions based not on the current, but expected future prices, with various patterns of expectation formation, leading to short-run carbon price volatility. Those factors are not taken into account in the model. Instead, carbon price paths projected in the model can be viewed as a smoothed-out version of actual market price dynamics.

134. This study is based on the CGE model named CREAM (Carbon Regulation Emission Assessment Model). The model distinguishes 20 industries, plus household and government sectors. It also distinguishes 4 energy forms (coal, gas, refined oil products and electricity). Final energy users (industries and households) can substitute between energy forms, as well as between energy bundles and capital (consumption of non-energy goods, in the case of households). Similarly, the electricity sector can substitute between 8 power generation technologies: coal-fired, gas-fired, oil-fired, nuclear, biomass, hydro-electric, wind and PV. CO2 emissions are linked to the use of fuels. Non-CO2 emissions (CH4, N2O, F-gas) are proportional to the output of the emitting sectors. Non-CO2 abatement technologies are not incorporated directly into CREAM; instead, the emission intensities of production are determined externally. Carbon pricing within emissions trading systems is the sole policy modeled in this study.

135. The CREAM model distinguishes the 9 world regions/countries: EU27, United Kingdom, USA, Canada, China, Korea, Mexico, Africa and ECA countries, and the Rest of World. The selection of individual countries in this disaggregation is dictated by the choice of existing emission trading systems to be linked with the EU ETS (spanning ETS1 and ETS2) in the simulation experiment. More information on the model can be found in Annex I.

136. Sectoral scopes of the ETSs differ by country (see Chapter 1.1 and Table 2 for the detailed mapping). Individual sectors have been either fully assigned to an ETS, or are fully left outside. Given such an assumption and the relatively coarse-grained model representation of economic activities imply that emission volumes falling under an ETS are only approximately matched between the model and reality.

137. In the case of the USA, Canada and China the emission trading systems cover selected regions only. However, our database does not include data for country regions. We took a simplified approach and artificially split those countries in the database using the proportions of emissions covered by the respective ETS to total country emissions. The implicit assumption is that the economic structure (industry shares etc.) of the ETS region is identical to that of the whole economy.

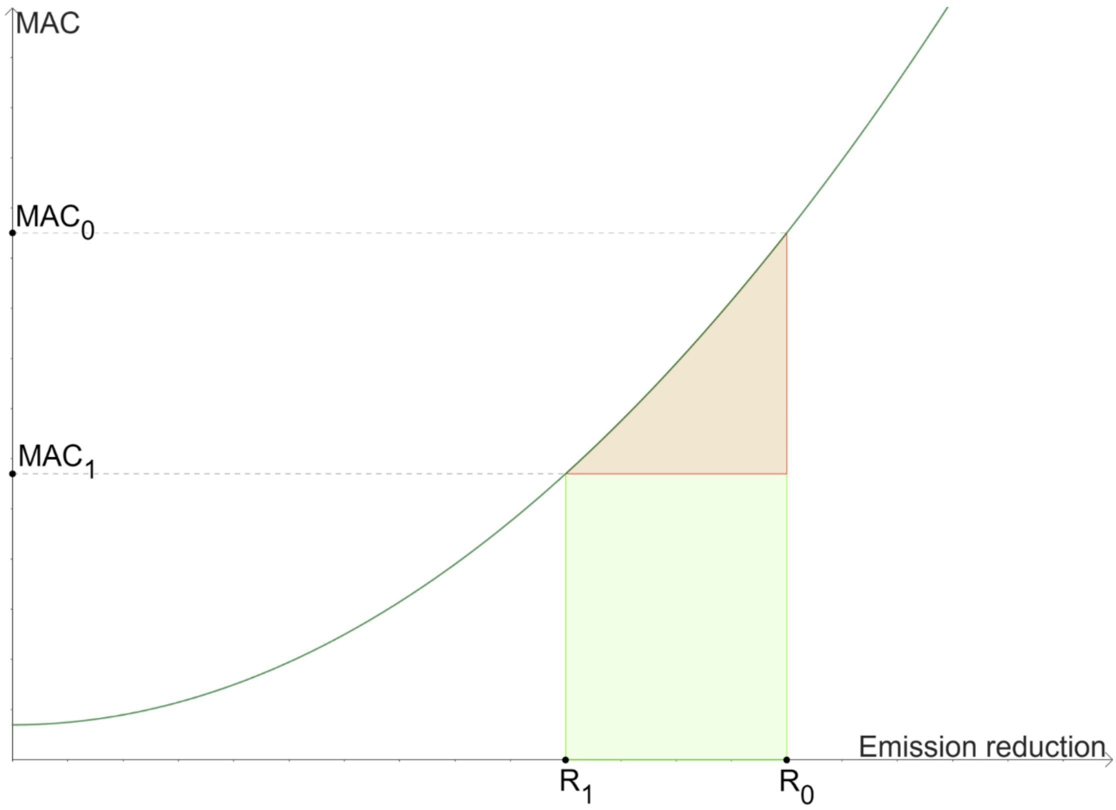
7.2 Macroeconomic effects of ETS linking: a theoretical perspective

138. It is useful to consider the effects of ETS's linking for a two-country example. Assume these countries differ in carbon prices if they have separate emission trading systems – let's refer to them as a high-price and a low-price country. Upon ETS linking, a uniform carbon price settles at a level between prices found in the separate systems. Consider the direct effects of linking from each country's perspective.

139. The high carbon price country perspective is illustrated in Figure 2. The ETS prior to linking features emission reduction target of R_0, which yields a carbon price (marginal abatement cost) equal to MAC_0. More specifically, R_0 represents a reduction in annual emission volume compared to some baseline. Consequently, the area under the MAC curve, from $\mathbf{0}$ to R_0, represents an annual cost that needs to be incurred to maintain the reduced emission levels. This cost is permanent in that it needs to be incurred each year to maintain the reduction.

140. In the ETS's linking scenario, carbon price decreases to MAC_1, which leads to a more moderate emission reduction, R_1. The red+green area represents savings on total annual abatement cost resulting from systems linking. At the same time, the green area shows the cost of purchasing additional emission allowances from abroad. The net benefit of ETS's linking is therefore depicted by the red area.

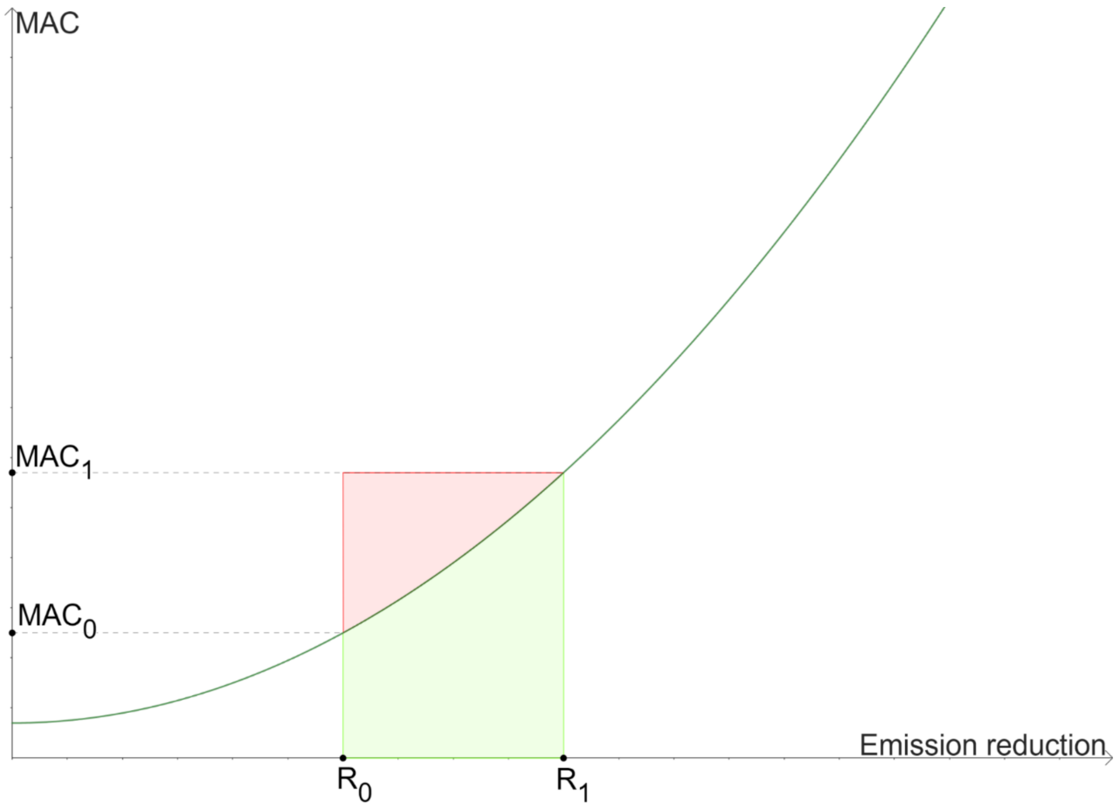
Figure 2 . Direct effects of ETS linking: the high carbon price country perspective



Source: CAKE/KOBiZE

141. The low carbon price country perspective is illustrated in Figure 3. In this case, ETS's linking leads to a carbon price increase (from MAC_0 to MAC_1) which results in more emission reduction (increase from R_0 to R_1). The green area represents the increase in the annual cost of maintaining lower emission levels, whereas the red+green area shows revenue from the sales of excess emission allowances abroad. The net benefit is represented by the red area.

Figure 3. Direct effects of ETS linking: the high carbon price country perspective



Source: CAKE/KOBiZE

142. From the above analysis it follows that, considering direct effects only, both countries should benefit from the ETS linking. This stems from the opportunity of shifting a part of emission abatement from a country characterized by higher MAC to one with lower MAC, thus utilizing the "where-flexibility" in allocating emission reduction efforts. Nevertheless, the situation is not entirely symmetric. In the high-MAC country the net benefits from ETS linking stay in firms and households which can now avoid the most costly abatement projects. Instead, in the low-MAC country firms and households are pushed towards greater emission reduction, thus moving to more costly emission abatement options, while the compensation, in the form of revenue from sales of emission allowances abroad, accrues to the government which emits and auctions the allowances. In the latter case, it is therefore the role of the government to distribute that revenue when the policy goal is to have all the agents better off upon systems linkage.

143. Another important channel of the macroeconomic impact of ETS linking is terms of trade adjustment. Terms of trade are defined as the ratio of export prices to import prices. When this ratio increases (that is, terms of trade improve), the quantity of export goods that are exchanged for a unit quantity of import goods decreases, allowing to divert some labour and capital resources from export-related activities to

the production of consumption and investment goods, thereby increasing welfare. The opposite happens when terms of trade deteriorate.

144. By assumption, a country that runs into a deficit of emission allowances after systems linking (this is the case of high carbon price regions, such as the EU and UK), must compensate that deficit by an equal increase in the trade balance – that is, either increase exports value, or decrease imports value, or both. Otherwise, we would see the effects on GDP, consumption, investment etc. partly due to an increase in foreign lending or borrowing, of which trade balance is indicative in the model.

145. According to GTAP-type CGE models, to which category the CREAM model belongs, changes in exports are driven by (other exogenous shocks aside) the changes in export prices of a given country relative to prices of exports of other countries. To increase export volumes, in order to compensate for the allowances deficit, export prices need to go down. This is already largely facilitated by a decrease in carbon price in such a region as the EU, upon linking carbon markets. Possible additional adjustments of export prices happen via changes in the primary factor prices (wages and capital rental rates). At the same time, import prices are less sensitive to the policy in question, largely because a significant portion of imports comes from countries that are not subject to policy change. As a result, terms of trade (ratio of export to import prices) deteriorate in high carbon price regions.

146. The possibility of expanding exports by decreasing export prices (or – on the flipside – exports of a good not being ruled out when raising prices even slightly above the level of world markets) is interpreted in terms of domestic producers having a degree/some market power. It can be attributed to distinguishing qualities of goods from a given country, as well as to various rigidities that make it costly for purchasers to switch to different supply sources. An alternative view would be that domestic producers are price-takers in the world market, and need only adjust to the given price. However, empirical results, in the form of substitution elasticities of imports from different sources (regions), support the former view. We use the elasticities from the GTAP database. They tend to be relatively high, implying that a region's impact on world prices is small, but nevertheless non-negligible.

147. One way of looking at the effects of terms of trade in the context of carbon pricing is as follows. With some amount of market power in the world markets, the emission cost embedded in exported goods is partly shifted to foreign purchasers, thus contributing to some welfare gain for the exporting country (which is not to say there aren't welfare losses elsewhere – we just focus on a particular channel for exposition purposes) – foreign purchasers effectively pay a part of the cost of domestic climate policy. In such a case, a decrease in carbon price limits the aforementioned gain, thus being negative for welfare.

148. The effects of emission offsets are similar to those of ETS linking. A major difference is in that carbon prices (marginal abatement costs) do not equalize between

the countries, because the volume of emission offsets is arbitrarily constrained (rather than allowing free trade of allowances, in which case the volumes of emission reduction shifted between countries are determined by the market). However, in the offset scenario the difference between carbon prices in both countries shrinks, invoking impact through the same impact channels as is the case of ETS linking.

8. Policy scenarios and results

149. The analysis considered a baseline scenario and two analytical scenarios: linking ETS and using offsets. The details of the scenarios are described below. Under each scenario main assumptions and results are presented.

8.1 Baseline Scenario

8.1.1 EU emissions targets

150. The EU's scenarios, reflecting its climate commitments set out in line with the ‘Fit for 55’ package and the European Green Deal, assume a net GHG emissions reduction of 55% by 2030 compared to 1990 levels, putting the Union on track to achieve climate neutrality by 2050. This 2030 target is based on the net reduction of GHG emissions, including both reductions and removals. Without considering removals, the estimated emissions reduction for 2030 is 53% compared to 1990 levels. For 2050, the emissions reduction target, excluding removals, is set at 90%, with the EU expected to achieve a 75% reduction by 2040 relative to 1990 levels. The 2030, 2040, and 2050 targets apply to the entire economy and are then allocated between the EU ETS (ETS1, ETS2) and non-ETS sectors.

151. The assumed reduction effort in the EU for 2030, 2040 and 2050 excluding removals in the EU ETS and non-ETS, is shown in Table 1 below.

Table 1. GHG emission targets for 2030, 2040 and 2050 in the EU (excluding the LULUCF sector)

Year/ Sectors coverage	Total (vs. 1990)	EU ETS (vs. 2005)			non-ETS (vs. 2005)
		ETS1+ETS2	ETS1	ETS2	
2030	53%	54%	62%	43%	36%
2040	75%	77%	82%	68%	64%
2050	90%	92%	95%	87%	82%

Source: CAKE/KOBiZE

152. It is assumed that from 2030 onwards, there will be no distinction between emission allowances in the ETS1 and ETS2 systems, effectively merging these two systems in the EU. Full integration of ETS1 and ETS2 would imply that emission targets for extended EU ETS are adjusted to 54% in 2030 and to 92% in 2050, compared to the 2005 emission level. After integration the emissions from ETS2 (buildings and road transport sectors) are excluded from non-ETS, and new targets and limits are set for the rest of the non-ETS sectors.

8.1.2 CBAM and free allocation of allowances in the EU

153. The scenario also incorporates a carbon border adjustment mechanism (CBAM), which adjusts prices at borders to account for CO_2 emissions. It is assumed that by 2030, the CBAM will cover the import of petroleum products (refined oil products and coke), ferrous metals (iron and steel industry), non-ferrous metals (aluminium production), the chemical industry (chemical production), the paper industry (paper production and printing), the mineral industry (cement, lime, gypsum, and glass), and electricity imports. After 2030, the CBAM mechanism will be expanded to include all sectors currently under ETS1.

154. In the scenario we proposed that the value of carbon border tax will depend on of the fee rate and the volume of imports (tax base) from a specific region of the world to the EU. The fee rate reflects the difference in emission costs paid by producers in the EU and other regions of the world, multiplied by the emission intensity of production. The emission intensity of production in a given sector includes both direct emissions (Scope 1) and indirect emissions associated with electricity and heat consumption (Scope 2).

155. To better reflect current climate policy, the scenario initially includes the free allocation of allowances under ETS1, serving as a form of production subsidy (for

industrial sectors excluding electricity generation). The implementation of CBAM in the EU implies a gradual phase-out of free allocation, following the trajectory: 2026: 97.50%, 2027: 95.00%, 2028: 90.00%, 2029: 77.50%, 2030: 51.50%, 2031: 39%, 2032: 26.5%, 2033: 14%, and 0% from 2034 onwards. This indicates that from 2034, full auctioning will be in place in the EU's emissions trading systems, with all allowances being sold at auction.

8.1.3 Emission reductions in non-EU regions

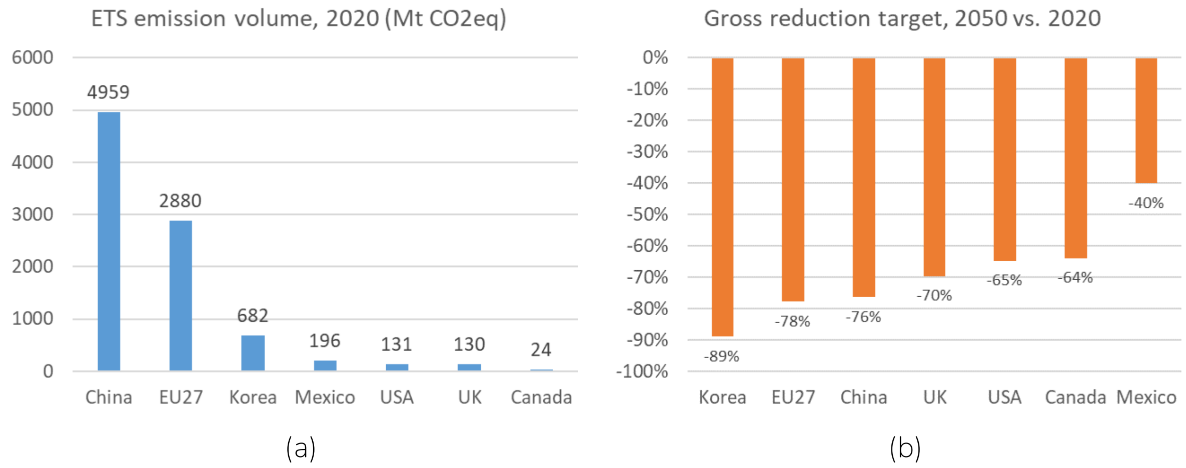
156. In non-EU countries and regions, it is assumed that emission reductions will follow the Nationally Determined Contributions (NDCs) submitted under the Paris Agreement, Long-Term Strategies and other national documents connected to climate policy. The emission reduction pathway for non-EU regions is based on the projected GHG emissions for the period 2020-2050 from the European Commission's GECO2023 projections for the "NDC" scenario[93].

8.1.4 ETS assumptions

157. In the baseline scenario there are separate ETS's with individual targets (see section 2.4.1. EU emissions targets for details). Figure xx (a) compares the volumes of emissions in those systems. These volumes have been calculated based on emission data from Global Energy and Climate Outlook input-output tables (Baseline GECO 2022), serving as the CREAM model's database. In each country and sector, emissions from different sources (fuels and process emissions) have either been fully included or excluded from respective country's ETS, based on the mappings shown in Table 2. Therefore, the model representation of ETS emissions is approximate and need not exactly match official figures. In that sense ETS emission volumes are also a backward projection for the year 2020, given that some systems have been started after that year. In the case of the EU, the reported figure relates to a hypothetical merger of ETS 1 and ETS 2 in that year. Figure 4 (a) displays a substantial diversity in ETS sizes, where China, EU, and – to a lesser extent – Korea will be the major parties of carbon market linking.

[93] GECO 2023 Global Energy and Climate Outlook 2023: Investment Needs in a Decarbonised World, https://joint-research-centre.ec.europa.eu/scientific-activities-z/geco/geco-2023_en

Figure 4. ETS emission volumes and reduction targets



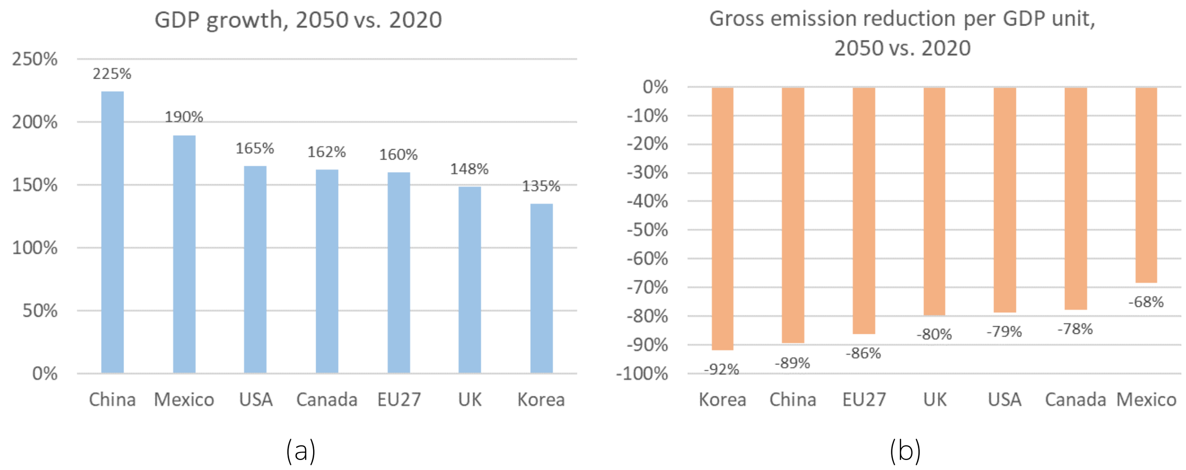
Source: CAKE/KOBiZE

158. Emission reduction targets for 2050, compared to 2020, differ significantly between the countries (see Figure 4 (b)), Korea being the most ambitious (89% reduction), followed by the EU (78%) and China (76%), and UK (70%). The targets in ETS in USA and Canada are both around 65% emission reduction, while Mexico is the least ambitious (40%). Importantly, these targets are reported in gross terms, whereas in net terms they are in fact more ambitious. For example, the target for the EU actually implies net zero emissions in 2050. The difference between net emissions and gross emissions are the removals, including those from BECCS and DAC technologies, as well as natural removals in the LULUCF. Removals volumes are treated as exogenous, that is in analytical scenarios of this report they are the same as in the baseline scenario. Baseline removal volumes are taken from GECO NDC scenario (GECO 2023).

8.1.5 Baseline scenario: Results

159. Economic effects of emission mitigation policies depend not so much on the nominal reduction target, but on that target in comparison with the GDP growth. Such a perspective is shown in Figure 5. Our baseline GDP growth is consistent with the GECO NDC scenario, according to which China and Mexico grow significantly faster than the other economies with cumulative growth from 2020 through 2050 of 225% and 190%, respectively. Korea with cumulative growth of 135% in that period occupies the other end of the spectrum. Nevertheless, Korea's ETS is still characterized by the highest ambition of emission reduction per GDP unit (92%), followed by China (89%) and the EU (86%) ETS's. Mexican ETS remains the least ambitious (68%) among the systems considered, but it is nevertheless substantially higher than the nominal target.

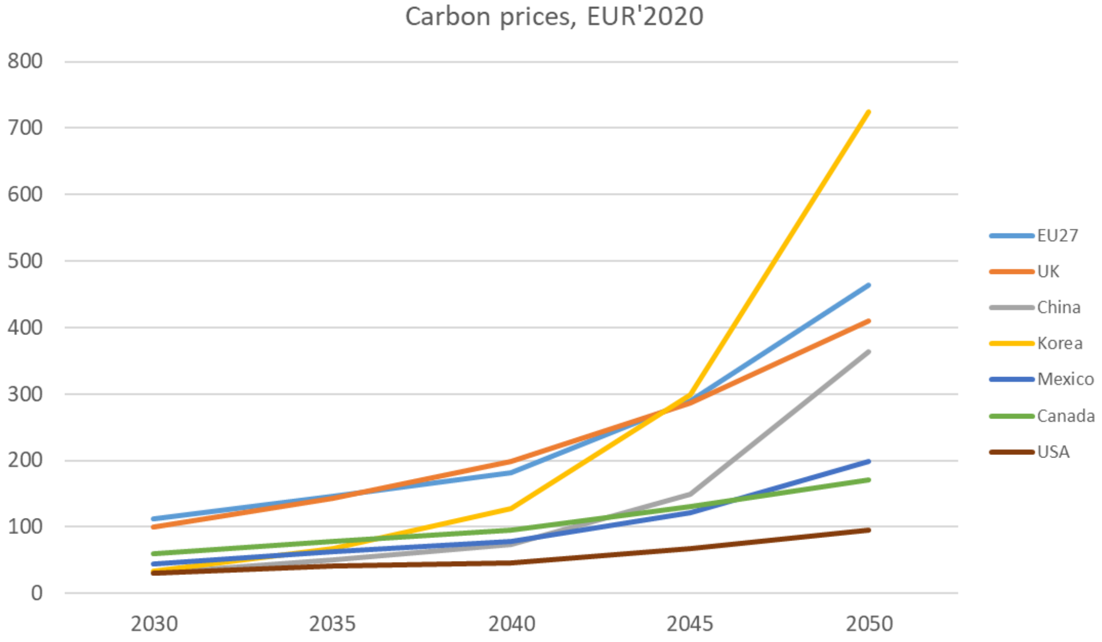
Figure 5. Baseline GDP growth rates and reduction targets per unit of GDP



Source: CAKE/KOBiZE

160. The quantitative effects of the policies under consideration crucially depend on carbon price levels and adjustments invoked by the regulation. Figure 6 shows carbon price projections from the CREAM model for the baseline scenario, for individual country (or regional) systems. In the case of the EU, the price relates to the merged ETS 1 and ETS 2 systems. CREAM has been fine-tuned, by adjustment of key model elasticities, for approximate consistency of carbon price projection for the EU with the one from NECP (PRIMES) WAM scenario (according to European Commission guidelines on the carbon cost path in the EU ETS sent to Member States). According to that projection, the carbon price will be around 100 EUR/t in 2030, reaching the level between around 450 EUR/t in 2050. Carbon prices for the systems in other countries result from applying the model with the same fine-tuned parameters (assumptions) as in the case of the EU, but for different emission reduction targets, different GDP growth rates an different initial economic structures in the base year 2025 (in particular, different structures of the power mix, energy efficiency and energy mix by sector, sector shares in overall economic output, etc.). Note that, while we present emission reduction and GDP growth relative to the year 2020, the CGE model was calibrated to GECO economic projections for 2025. This approach avoids biases associated with COVID-19 effects in 2020 data, such as underestimations in air transport demand.

Figure 6. Prices of emission allowances, baseline



Source: CAKE/KOBiZE

161. Projected carbon prices for the UK are similar to those for the EU. Otherwise the prices differ significantly. A sharp increase in the price of emission allowances in Korea in 2045 and 2050, to the level above 700 EUR/t is related to the stringency of emission mitigation targets and it signals approaching to the bounds of expansion of renewable power and other abatement options. A similar spike in prices can be observed in 2050 in China. Still, even though China's ETS emission reduction per unit of GDP in 2050 is slightly deeper than in the EU and UK, the carbon price is still below the ones in the EU and UK in 2050. This is because in the base year ETS sectors in China are more emission-intensive than in the EU and UK, thus still having access to cheaper abatement options, whereas the EU and the UK start at a point where such options have been already partly utilized. Projected carbon price paths in Mexico and Canada, and especially USA, are markedly lower in 2045 and 2050 than in the other countries. In the years 2030-2035, carbon prices in the EU and UK are in the range of 100-150 EUR/t, while in the other countries they range from 30 to 80 EUR/t.

9. Analytical Scenario 1 – ETS Linking

9.1 ETS assumptions

162. The scenario no 1 models the integration of the European Union Emissions Trading System (EU ETS) with selected Emissions Trading Systems (ETS) currently operational worldwide.

163. The ETS selected for this integration are from five countries: the USA, Canada, Mexico, South Korea, and China. These countries were chosen based on the availability of comprehensive data, their representation of different global regions, the maturity of their ETS implementations, and the similarity of their cap-and-trade systems to EU ETS regulations. The key rules of the implemented ETS pertain to cap limits, levels of free allocation, sectoral scope, and the types of greenhouse gases covered. The assumptions for modelling this scenario are drawn from historical data, current legislation and ETS rules, Nationally Determined Contributions (NDCs), and Long-Term Strategies (LTS). The main assumptions are presented in the Table 1.

164. In this scenario, it is assumed that the EU ETS and the selected systems form a fully linked ETS system. This integration results in a single emissions reduction target and a uniform allowance price across all participating regions. There are no restrictions on the flow of allowances between the countries. For sectors and gases covered by this linked system, the Carbon Border Adjustment Mechanism (CBAM) tax is not implemented. Additionally, there is no allowance for the use of offset credits to compensate for emissions within this integrated system.

Table 2. Assumption for ETS systems in the USA, Canada, Mexico, South Korea, and China

	Mexico	UK	South Korea	China	Canada	USA
ETS included into analysis	Mexican ETS	UK ETS	Korea ETS	China's national ETS Regional ETSs: Beijing, Chongqing, Fujian, Guangdong, Hubei, Shanghai, Shenzhen, Tianjin	Québec's Cap-and-Trade System	California Cap and Trade Program Regional Greenhouse Gas Initiative (RGGI)

Cap limit	The limit correspond the NDC target.	The limit is based on the current regulation in force.	The limit correspond the NDC target.	The cap is sum of all caps. The limit correspond the NDC target.	The limit correspond the NDC target.	California C&T: The "Cap-and-Trade Regulation" sets the limit till 2030 and a formula for declining caps after 2030. RGGI: The cap is calculated based on the assumption from possible scenario: Zero by 2040.
Sectoral scope	Energy Industry	Energy Industry Aviation	Energy Industry Buildings Transport Maritime Aviation Waste	Energy Industry Buildings Transport Maritime Aviation*	Energy Industry Buildings Transport	Energy Industry Buildings Transport*
Gases	CO_2	CO_2	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6**

* not all sectors are in each ETS

** not all gases are in each ETS

Source: CAKE

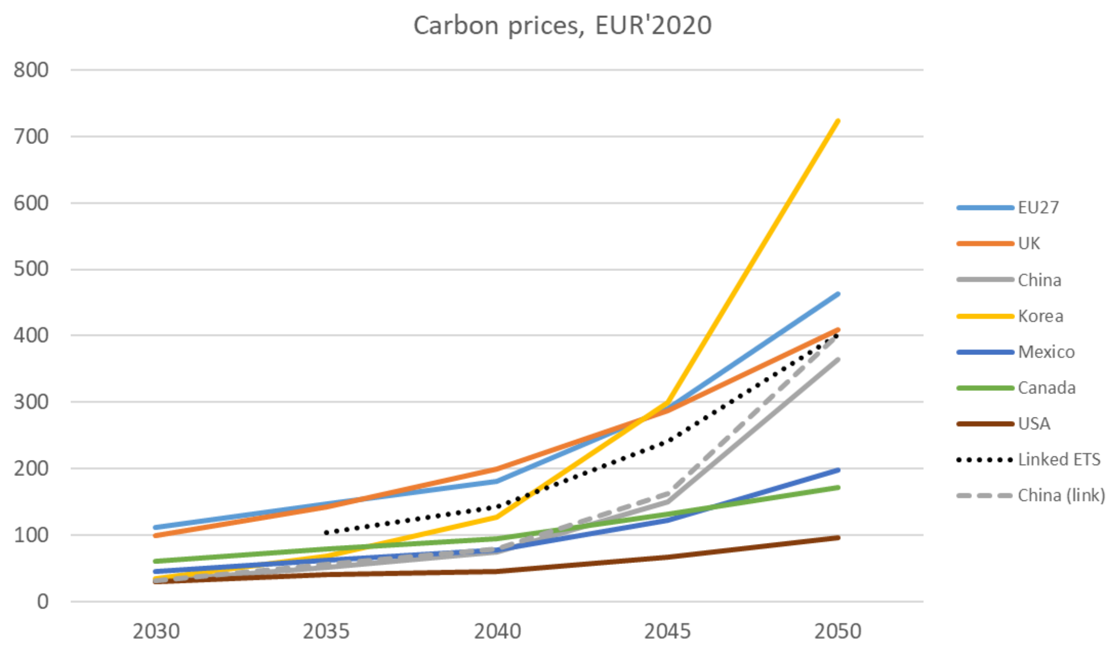
9.2 Effects of ETS linking (scenario S1): simulation results

165. Effects of ETS linking (scenario S1) are assessed against a baseline scenario, in which the emission trading systems function separately. In the S1 scenario, we consider a full link of the EU ETS with its counterparts in the UK, Korea, Mexico, Canada and the USA. Full link implies free trade of emission allowances between the

systems, equalizing their prices. In the case of China, trade volume has been limited to 10% of the EU ETS limit. Simulation experiments assuming a full link with the Chinese ETS indicated that such a policy could be disruptive to the EU climate policy, driving carbon prices in 2030 below their current levels. Systems merger takes place in 2035, as the possibility to occur it befor 2030 is low.

166. Impact of ETS linking on carbon prices is shown in Figure 7. The dotted line shows carbon prices in the linked system, whereas solid lines show baseline carbon prices in separate systems, for a direct comparison. From the EU perspective, linking of the ETS's lowers the carbon price by 40-60 EUR/t, across the whole simulation period. In the case of China, the uniform carbon price for the linked ETS's does not apply, as a result of constrained volume of allowances traded with the common ETS. However, the prices (the new price path being represented by the grey dashed line) increase slightly in the years 2035-2045, by around 5-10 EUR/t. Only in 2050, as a result of the partial linking with the other upon partial systems linking, does the price increase slightly compared to the baseline case in the years 2035-2045 – only in the final year the price match the price hike and is higher, around 40 EUR/t.

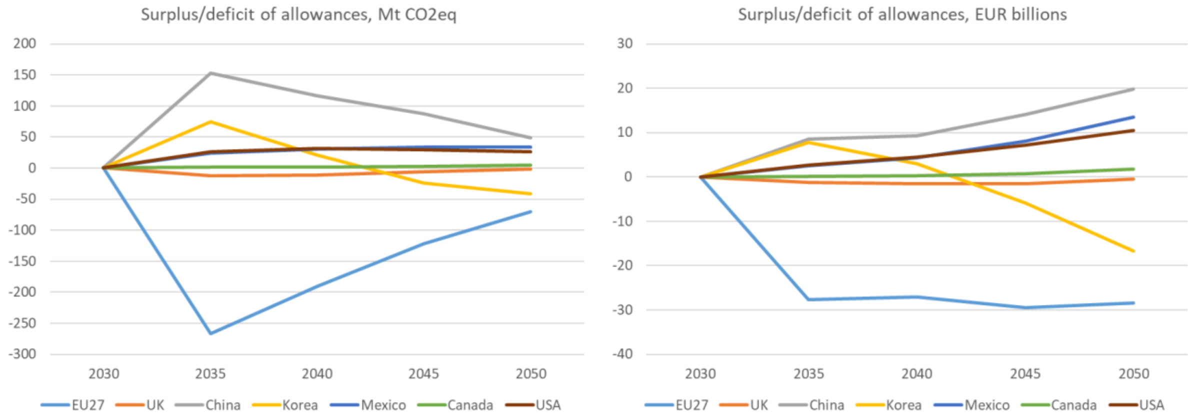
Figure 7. Prices of emission allowances: baseline and S1 scenario, EUR/t



Source: CAKE/KOBiZE

167. Lower carbon prices in the EU lead to an increase in ETS emissions, covered by allowances purchased from other participants of the system. As shown in Figure 8, the EU buys from around 270 mln of allowances in 2035 to 70 mln in 2050, supplied mainly by China and, initially, Korea, as well as, in the longer run, Mexico and USA. In money terms this allowance deficit equals nearly 30 billion EUR per year.

Figure 8. Surplus/deficit of emission allowances, S1 scenario

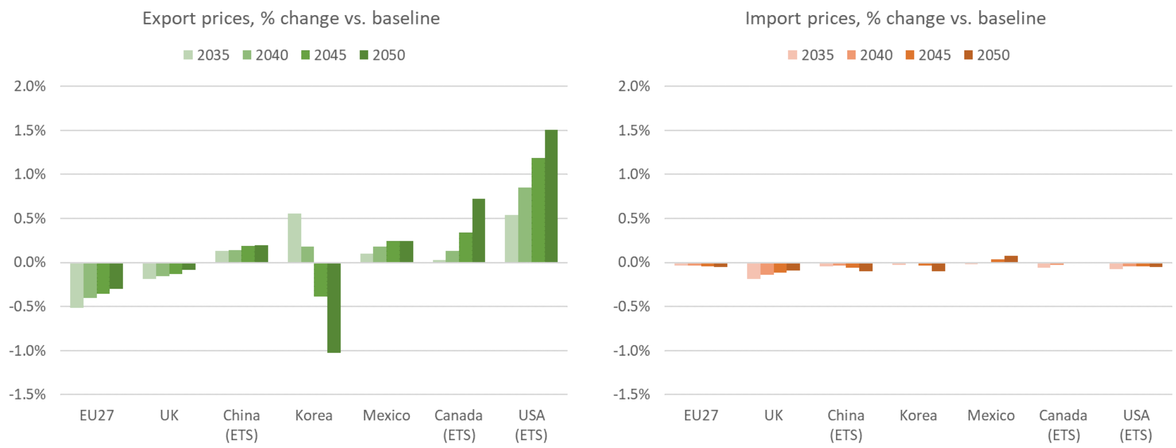


(a) (b)

Source: CAKE/KOBiZE

168. The theoretical analysis in section 2.2 demonstrated that direct savings on abatement costs consistently exceed the cost of purchasing allowances from abroad. The CGE model does cannot isolate the exact savings amount, as it only captures the net effect of economic system interactions. However, a rough back-of-the-envelope calculation suggests that, in the EU, annual savings could be approximately 2-4 bln EUR greater than the cost of the allowance deficit.

Figure 9. Export and import prices, S1 scenario, % differences vs. baseline



(a) (b)

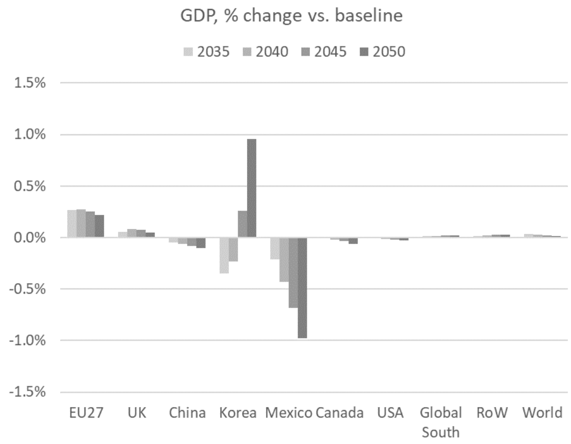
Source: CAKE/KOBiZE

169. An important impact channel of ETS linking is via export prices (see Figure 9). Export prices of emission-intensive products change as a result of changes in carbon prices. Consequently, one can observe decreases in export prices in the EU and UK (by 0.1-0.5% in aggregate, while for individual sectors, such as ferrous metals, non-metallic minerals, as well as air and water transport they may drop by around 1.5-2%), as well as, in the years 2045-50, in Korea (1% decrease in 2050). In the other countries, experiencing increase in carbon prices, export prices also increase,

particularly in the USA region covered by the ETS (California), with an increase of 0.5-1.5%. On the other hand, import prices hardly respond to carbon markets linking.

170. As small as the export price changes may seem, they nevertheless invoke a pronounced adjustment in export volumes (see Figure 10). This effect derives from high sensitivity of foreign trade to price changes, reflecting high competitiveness of world product markets, where participants can easily switch to cheaper supply sources. The most salient changes are observed for the EU (export increase by 1-2%) and Mexico (export decrease by 1-2.5%), as well as Korea (decrease by 1-2.5% in the years 2035-2040, and as much as 3.5% increase in 2050). Export changes in USA and Canada are much smaller only because we are looking at total country results in this case, whereas the effects for ETS regions (California and Quebec) are much stronger. Note that in the case of the EU, export volumes refer to extra-EU exports only, not including bilateral trade between EU Member States. The pattern of import changes is similar to that of exports, but having smaller scale. Import changes are mostly demand driven – increase in production (particularly for exports) increases demand for intermediate inputs and, indirectly, investment goods, including the imported ones.

Figure 10. Real GDP and components, S1 scenario, % differences vs. baseline

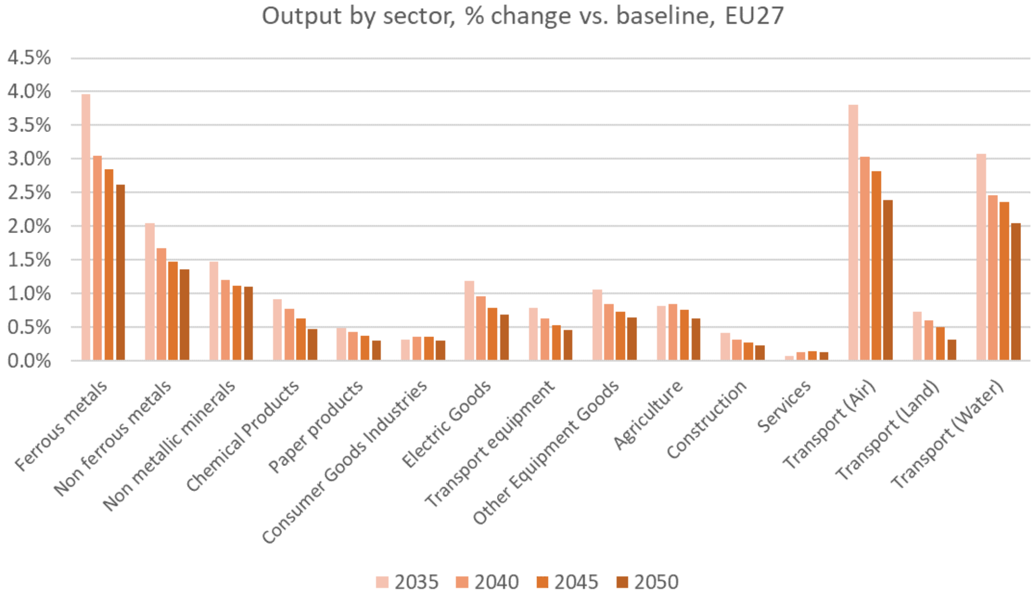


Source: CAKE/KOBiZE

171. Changes in the GDP are largely driven by changes in exports, invoked by carbon price adjustments – they exhibit a similar pattern to export deviations. In the EU, GDP increases consistently throughout the simulation period by around 0.2-0.3%, whereas in Mexico GDP reductions are the highest, topping nearly 1% in 2050. The largest positive GDP change encountered in the simulations is also around 1%, in Korea in 2050.

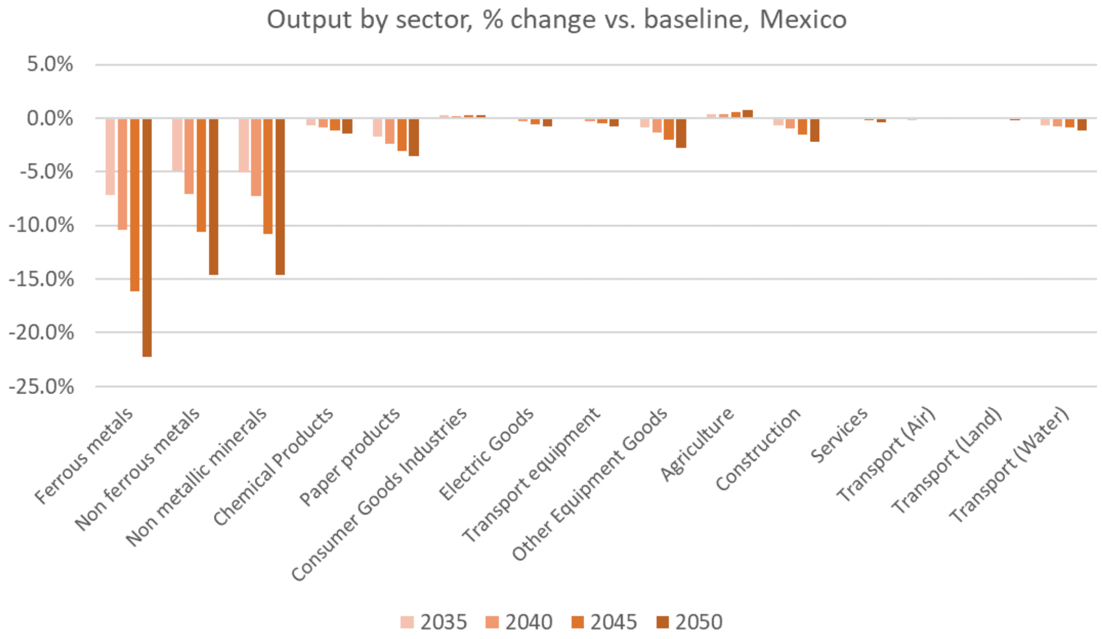
172. The impact on production of selected individual sectors is much stronger than the aggregate GDP outcome (see Figures 11-14). In the EU, output of ferrous metals, air transport and water transport sectors increase from 2% to nearly 4% in some periods. Note, however, that the services sector, where output, increases negligibly, comprises roughly half of the whole economy. In Mexico, decreases in output of energy-intensive industries (ferrous and non-ferrous metals, non-metallic minerals) are of the order of 15%-20% in 2050. In China, most industries in most years experience output reductions between 0.2% and 0.4%, with the exception of ferrous metals, air transport and water transport, where these reductions are somewhat deeper. Importantly, changes in sectoral output are mostly driven by adjustments of exports. Results for Korea indicate that carbon price beyond 700 EUR/t, as in the case of individual ETS, are prohibitive for exports of certain goods, and reducing it to the level of around 400 EUR/t, in the case of carbon markets linking, allows to build up, for example, output of ferrous metals by 30%.

Figure 11. Output by (non-energy) sector, EU27, S1 scenario, % differences vs. baseline



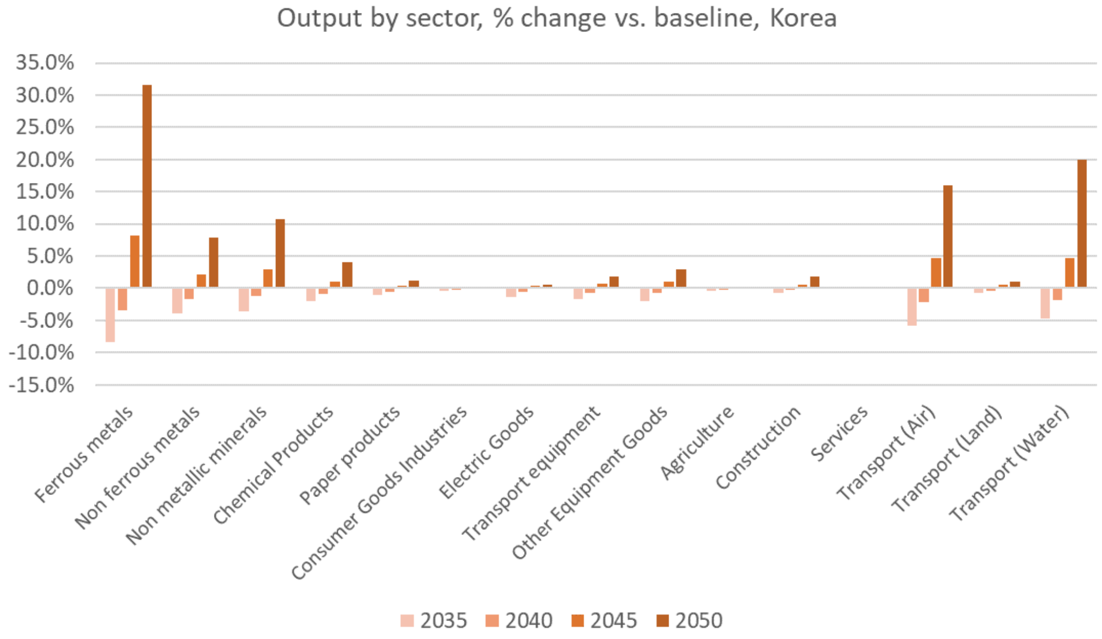
Source: CAKE/KOBiZE

Figure 12. Output by (non-energy) sector, Mexico, S1 scenario, % differences vs. baseline



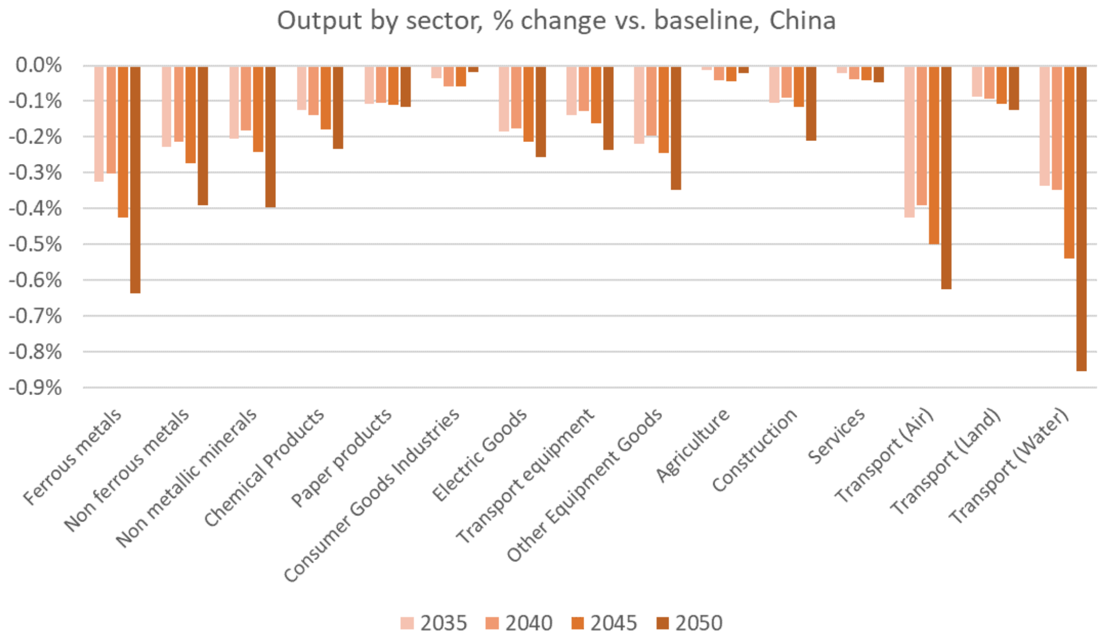
Source: CAKE/KOBiZE

Figure 13. Output by (non-energy) sector, Korea, S1 scenario, % differences vs. baseline



Source: CAKE/KOBiZE

Figure 14. Output by (non-energy) sector, China, S1 scenario, % differences vs. baseline



Source: CAKE/KOBiZE

173. The ultimate metric of policy impact at the macroeconomic level is welfare, most closely approximated by real household consumption in our modelling framework (changes in household consumption are also closely related to changes in real household income). Government consumption is fixed in the policy scenarios (S1 and S2) at baseline levels. This reflects the assumption that ETS linking or emission reduction offsetting do not affect the level of government real expenditure on services supplied to household by the public sector. Consumption improves at the world level, as expected, reflecting the more efficient distribution of emission reduction efforts between countries participating in the common carbon market. Albeit very small in percentage terms, this effect is equivalent to around 25-40 billion EUR (in constant 2020 prices) per year (see Figure 15). Part of that benefit spills over to countries not participating in the common ETS, via cheaper (on average) imported goods as well as increased exports.

174. The modelling framework allows to highlight the ambiguous correspondence between consumption and GDP changes. For example, in UK and the EU (with the exception of the year 2030), both consumption and GDP increase. In the case of China, Mexico, Canada and USA, consumption improves, but GDP drops. Whereas in Korea, consumption decreases while GDP improves. The underlying effects are most apparent in the results for Korea in the years 2045-50. The net benefits from savings on carbon abatement costs and payments for foreign allowances (see theoretical analysis in section 2.2) is outweighed by negative terms of trade effects. Although such effects exist in other high-carbon-price countries, namely the EU and UK, as well, they turn out smaller because those countries are significantly less export and import dependent than Korea. In Mexico, USA and Canada, the terms of trade are improving, allowing consumption to rise even as output (GDP) falls, as these countries can now get more imported goods in exchange for a given amount of exported goods.

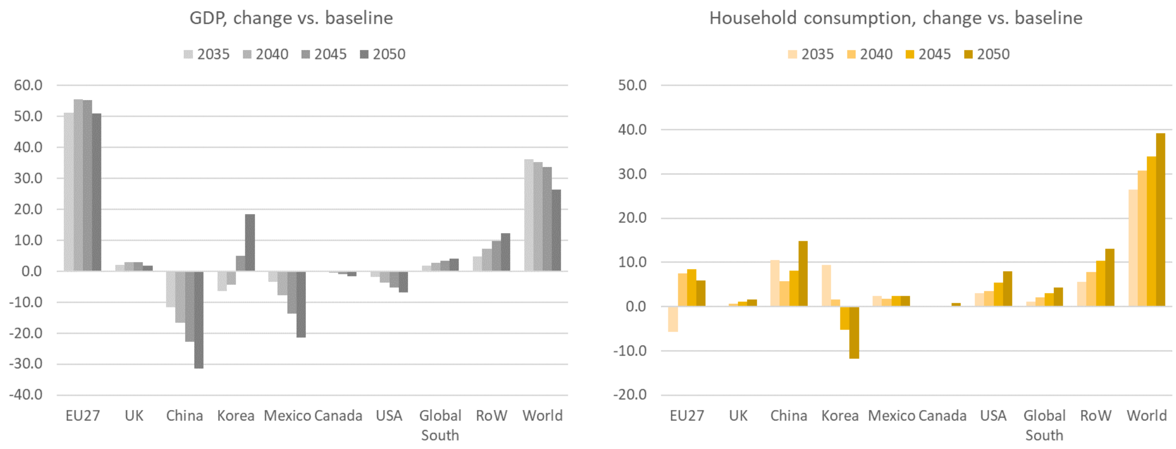
175. With the exception of Korea in 2045-50, and the EU in 2035, the impact on household consumption is positive across all countries, including China. In the case of the EU in 2030, the negative result reflects a trade-off between consumption and investment. As a result of the policy shock which, as explained above, boosts export and output which encourages more investment, via increased profit rate. It is thus profitable to temporarily increase investment at the cost of consumption. This impulse dissipates in subsequent periods, as the economy has restructured its output to conditions. Additional fixed capital created during the investment intensification enhances capacity, thus adding to the GDP in the long run from the supply side.

176. Korea is clearly an outlier in the results, both in the size of macroeconomic effects, and the fact that those effects have opposite signs in different sub-periods (2035-40 and 2045-50). The opposite signs are to the shape of emission reduction path: initially rather flat, then very steep, while in the other countries the reduction paths are more monotonous. As a result, upon systems linking Korea first experiences a drop, and next an increase in carbon prices, compared to the baseline. In reality, market players

in Korea could perhaps incorporate the envisaged specific path of emission reduction in their decision-making. This could lead to intensification of reduction efforts earlier, thus arbitraging between current and future carbon prices. However, the our modelling framework has two limitations that there force us to interpret the results for Korea with caution. Firstly, the model treats agents as myopic ones (more specifically, as having a 5-year planning horizon, given the 5-year jumps in model solution), responding to current carbon prices and complying with the current emission limits. Secondly, fine-tuning of the model was based on external carbon price projections for the EU, whereas Korean ETS emission abatement targets are even more ambitious than the EU. Consequently, the model extrapolates beyond the domain of those projections which increases uncertainty. Therefore it could also be “blind” to specific abatement options that policy-makers in Korea perhaps envisage.

177. Policy design ensures that emissions in the linked ETS equal the sum of emissions in separate ETS’s. Other than that, changes in economic activity by country could have some indirect impact on emissions in the few sectors not covered by the ETS’s, but we have found those effects to be negligible. Consequently, the analysed policy can be considered neutral to global emissions.

Figure 15. Real GDP and consumption, differences vs. baseline, EUR’2020



(a) (b)

Source: CAKE/KOBiZE

10. Analytical Scenario 2 – Offsets

10.1 Assumptions

178. Scenario S2 assumes that, starting in 2035, the EU ETS – operated independently from ETS frameworks in other countries and comprising ETS 1 and ETS 2) – utilizes offsets from Global South countries[94], amounting to 10% of EU ETS emission cap each year. The model implementation is the same as in the case of partial link with the Chinese ETS in scenario S1, wherein offset purchases are conducted centrally by system operators or a specialized carbon bank. The price paid for the offsets equals marginal abatement cost in Global South countries plus an additional 25% (as an example) of the difference between this cost and the EU ETS carbon price. For example, in the offset scenario, the EU emission allowance price in 2035 is projected at 120 EUR/t, while the estimated marginal abatement cost in Global South is 44 EUR/t. Thus, the price paid for offsets would be calculated as follows: 44+(120-44)*0.25=44+19=63 EUR/t. Finally, these offsets are converted into "regular" ETS allowances and auctioned on the European market.

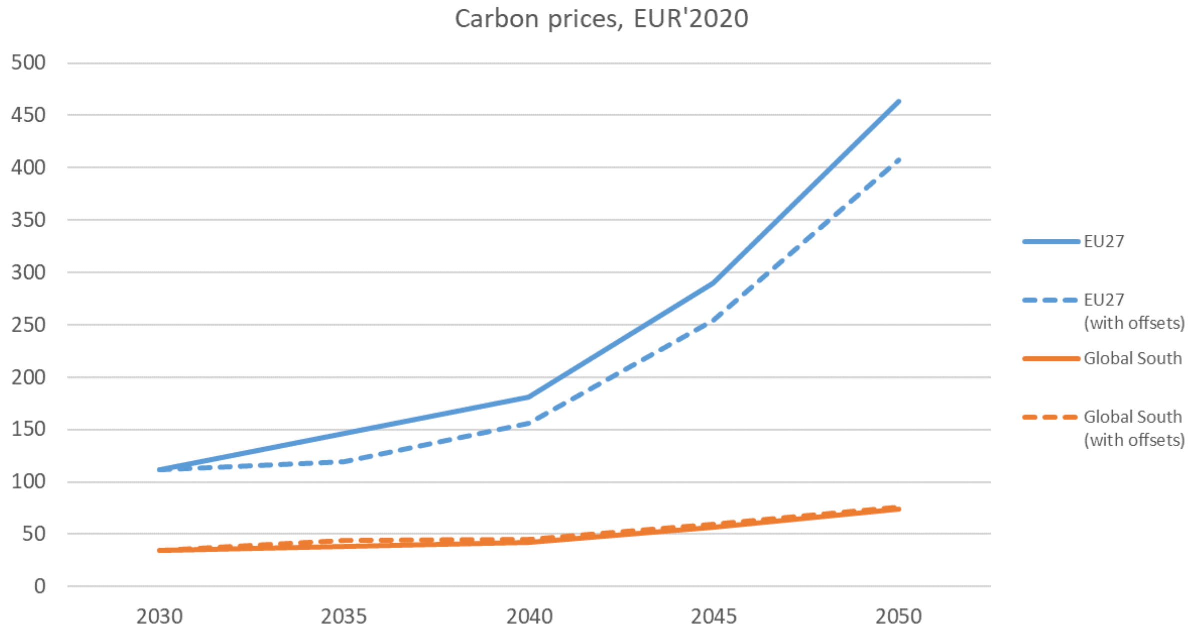
179. In the case of Global South countries, no actual emission trading system is envisaged. Emission abatement efforts in those countries, consistent with their NDC targets, are nevertheless associated with some marginal abatement cost, if not in the form of an explicit market carbon price. However, in the model it is implemented as if a carbon price existed, applying uniformly to all sectors of the economy. In this way we obtain a quantitative assessment of marginal abatement cost, referred to as carbon price for convenience. An implicit assumption is that among potential emission reduction or removal projects being funded under the offset mechanism, the first to implement are the least-cost ones

10.2 Effects of emission offsets (scenario S2): simulation results

180. Additional allowances flowing into the EU ETS decrease its carbon price by around 25-55 EUR (see Figure 16). Whereas in Global South countries, marginal abatement cost increases by as little as 2-5 EUR/t. This asymmetry is mainly due to emission volumes in Global South countries being significantly higher than in the EU ETS (from over 2.5 times in 2035 to almost 7 times in 2050).

[94] The Global South includes countries from Africa, Latin America and the Caribbean, Asia excluding Israel, Japan, and South Korea, and Oceania excluding Australia.

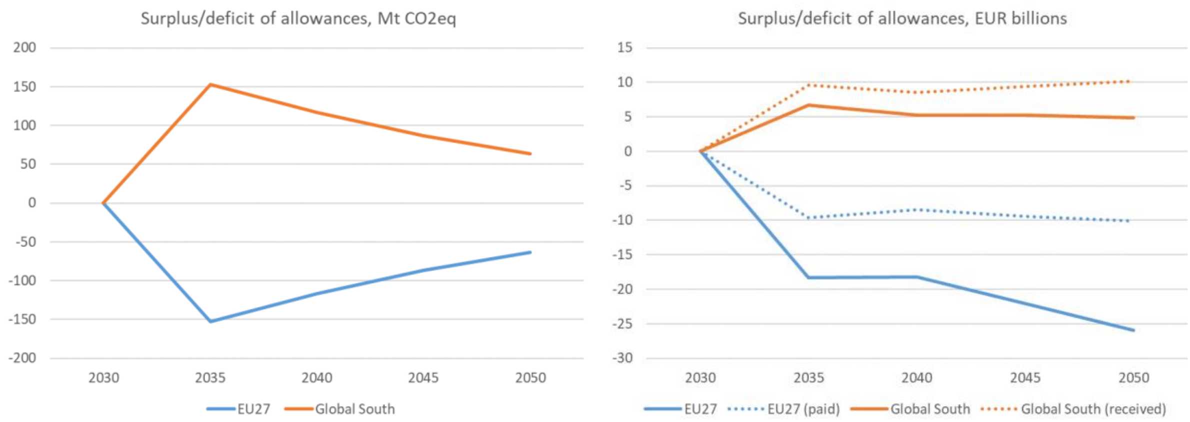
Figure 16. Carbon prices, EU27 and Global South countries, baseline and S2 scenario



Source: CAKE/KOBiZE

181. The initial volume of offsets in 2035 is equivalent to approximately 150 Mt of CO2 equivalent emissions, decreasing to around 60 Mt in 2050 (see Figure 17 (a)). Such a design, in which offset volume is proportional to EU ETS limit, ensures that the deviation of the carbon price from the baseline scenario is relatively stable. However, one could as well envisage a different scenario, for example one in which the offsets volume grows in time, with increasing credibility and experience of the system's participants. In the latter case, one could expect the impact on EU carbon prices increasing rather quickly in time as well.

Figure 17. Surplus/deficit of emission allowances, S2 scenario



(a) (b)

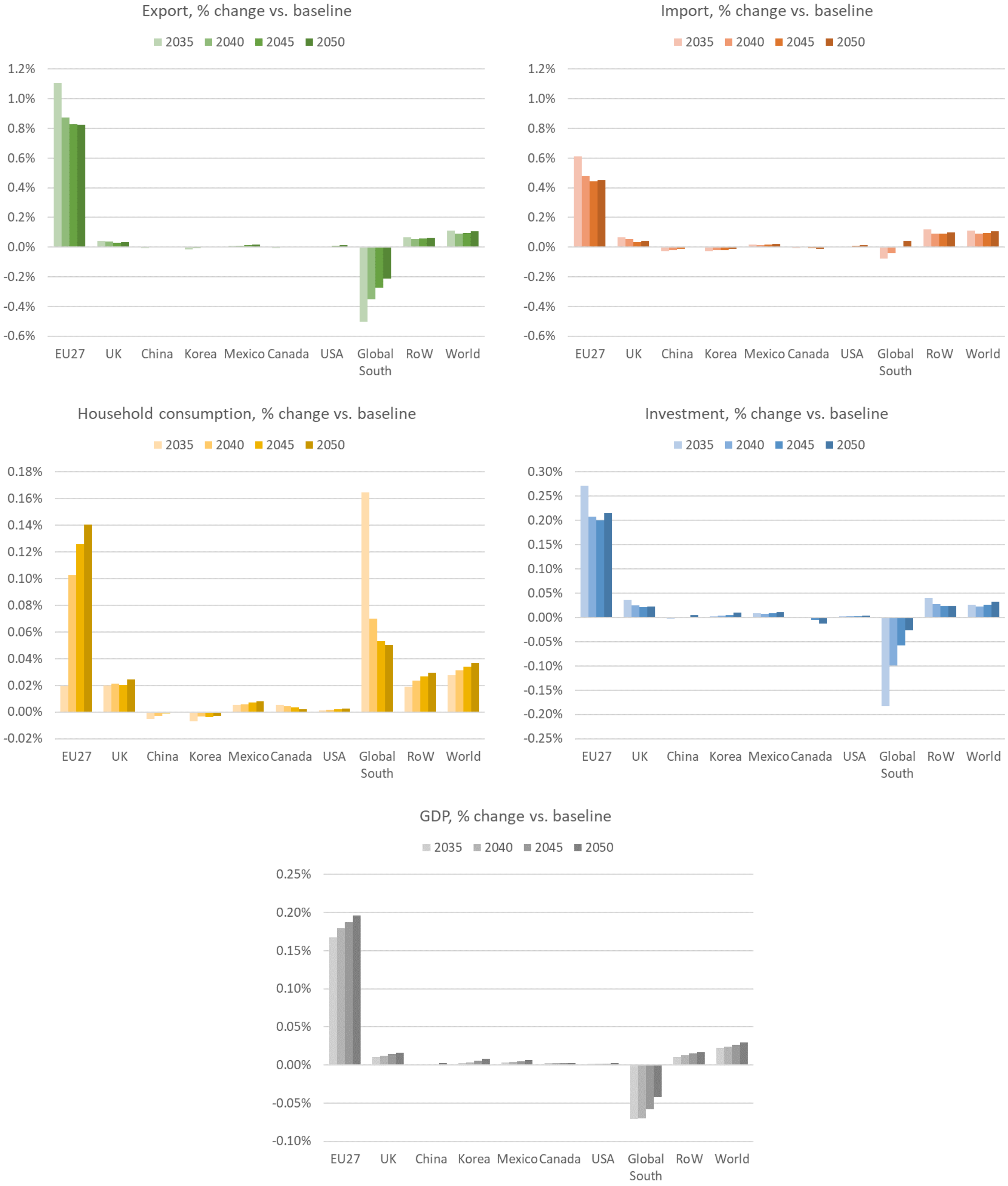
Source: CAKE/KOBiZE

182. Payments for the offsets are stable in time, at around 10 billion EUR per year (see Figure 17 (b), the dotted lines). At the same time, under the pricing scheme explained above, those payments exceed the would-be payments if they were valued at actual marginal abatement cost, bringing additional benefits to Global South countries (3-5 billon EUR per year – the difference between the dotted and solid line for Global South). On the other hand, the value of offsets on the European carbon market is higher that their purchase value, by around 10-20 billion EUR per year, from 2035 through 2050 (see Figure 17 – the difference between the dotted and solid lines for the EU).

183. For the sake of exposition, assume that the 10-20 billion EUR margin, mentioned in the previous point, accrues to a separate entity, such as a "carbon bank". At the same time, the revenues from EU ETS are subject to two opposed effects: on the one hand, the volume of emission allowances increases by 10% due to offsets, and on the other hand carbon price decreases. In our simulation those two effects in fact diminished EU ETS revenues by around 20 billion EUR in 2035, and by around 10 billion EUR per year in 2040-2050. Thus, from the perspective of the joint budget of the carbon bank and the ETS, the impact of offsets is ambiguous (negative in 2035, positive in 2040-50). However, this "budgetary" perspective is not equivalent to welfare perspective. The latter also includes effects such as avoidance of the most costly emission abatement options under lower carbon prices and terms of trade effects.

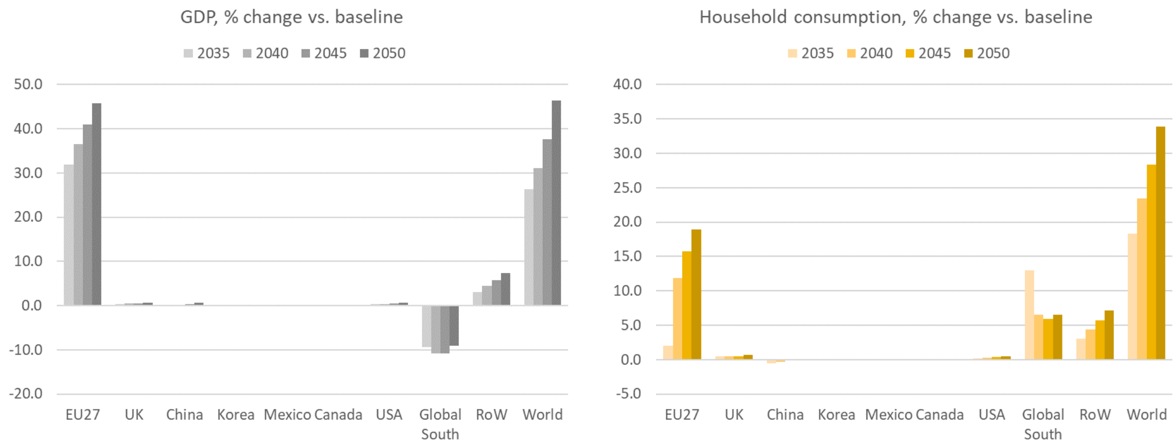
184. It is worth noting that our model does not allocate "carbon bank" or ETS revenues to specific uses. Rather they fall into a common bucket of government revenue, from which any excess revenue above government consumption needs is recycled to the household sector. Since households in the model act both as consumers and business owners, their revenue is used to finance both consumption and investment. In this way, an increase in, say, revenues from carbon pricing, implicitly supports investment. However, investment allocation, whether related to decarbonisation or not, is shaped by their profitability only. From the decarbonisation perspective this investment allocation is driven by carbon price signals, not distorted by policy instruments such as directed investment subsidies. Another implicit assumption in the model is that there are no rigidities in financing the investment – whenever investment is profitable, the necessary funding is provided.

Figure 18. Real GDP and components, S2 scenario, % differences vs. baseline



Source: CAKE/KOBiZE

Figure 19. Real GDP and consumption, scenario S2, differences vs. baseline, EUR'2020



(a) (b)

Source: CAKE/KOBiZE

185. Macroeconomic result of the S2 scenario are in line with the theory (see Figures 18 and 19). Both parties of the offset mechanism experience slight increases in household consumption, by a little more than 0.1% (between 10 and 20 billion EUR per year) in the EU in the years 2040-50, and around 0.05% in Global South (around 6-7 billion EUR per year) in the same period. In the year 2030 these effects are hampered (the EU case) or enhanced (the Global South case) by trading off consumption with investment expenditure. In the EU, consumption gain is accompanied by GDP increase of 0.15-0.20% (30-45 billion EUR per year). Whereas in Global South countries the GDP decreases by around 0.05% (10 billion EUR per year), driven primarily by exports contraction.

11. Proposal of the European Carbon Central Bank (ECCB)

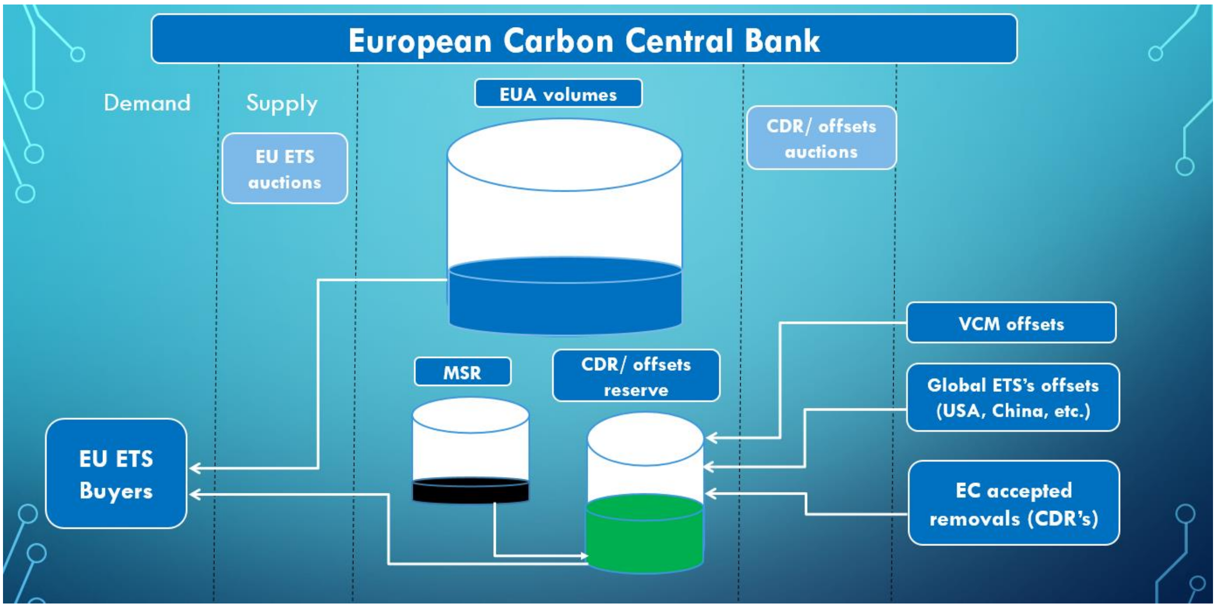
186. The potential changes to the EU ETS that were elaborated in current and previous LIFE VIIEW 2050 analyses (including removals, linking, offsets) would lead to increase complexity of the EU ETS and market behaviour (operating in an increasingly tight market, shifts in hedging strategies) and may require structured governance and efficient management. Governance is now the 'sweet spot' for taking further steps in implementing additional elements of climate policy, such as incorporating removals into the EU ETS. As a solution there is a proposal of introducing the European Carbon Central Bank as the new institution to manage the future EU ETS/ EU carbon market. The European Carbon Central Bank concept is not merely a tool - it is a solution designed not only to provide a clear vision of what the EU ETS could look like after 2030, but also to ensure the continued existence of the EU ETS beyond 2030.

187. ECCB could potentially play a dual role in managing carbon removals (optionally offsets) and regulating the new EU ETS (extension version). This option could potentially replace existing mechanisms within the EU ETS, such as the Market Stability Reserve (MSR)[95] and a "safety valve" mechanism in Article 29a of the EU ETS Directive.

188. Similar to the role of central banks in monetary policy, the ECCB could influence the dynamics of the CO_2 market. Acting as a regulator, it would control basically the supply of EUA allowances and removal units, and intervene to stabilise EUA prices if necessary. In the future, the ECCB would be able to control the distribution of other units originating from ETS systems in other regions linked with the EU ETS or/and offsets from voluntary carbon markets (VCM). Such a mechanism could limited potential market speculation and sudden price fluctuation, ensuring a stable and credible market environment. The decisions of the ECCB could be taken collectively by the Council of Member States, reflecting the principles of central bank governance, thereby enhancing the transparency of the decision-making process.

[95] In light of these considerations, the necessity of the Market Stability Reserve (MSR) becomes subject to scrutiny, particularly given apprehensions about its capacity to release an adequate number of EUA allowances into the market. The recent MSR review fixed supply of only 400 million EUA allowances available to market participants. This quantity may fall short of meeting the market's requirements, potentially exacerbating price instability.

Graph 1. EU ETS governance by ECCB



Source: CAKE/KOBiZE

189. The establishment of the ECCB would support developing countries through targeted funding, thereby facilitating their transition to low-carbon economies. By coordinating the purchase of offsets, managing allowances and directing funds to strategic areas, the ECCB would provide a coherent approach to support both the environmental and economic objectives of the EU and its trading partners.

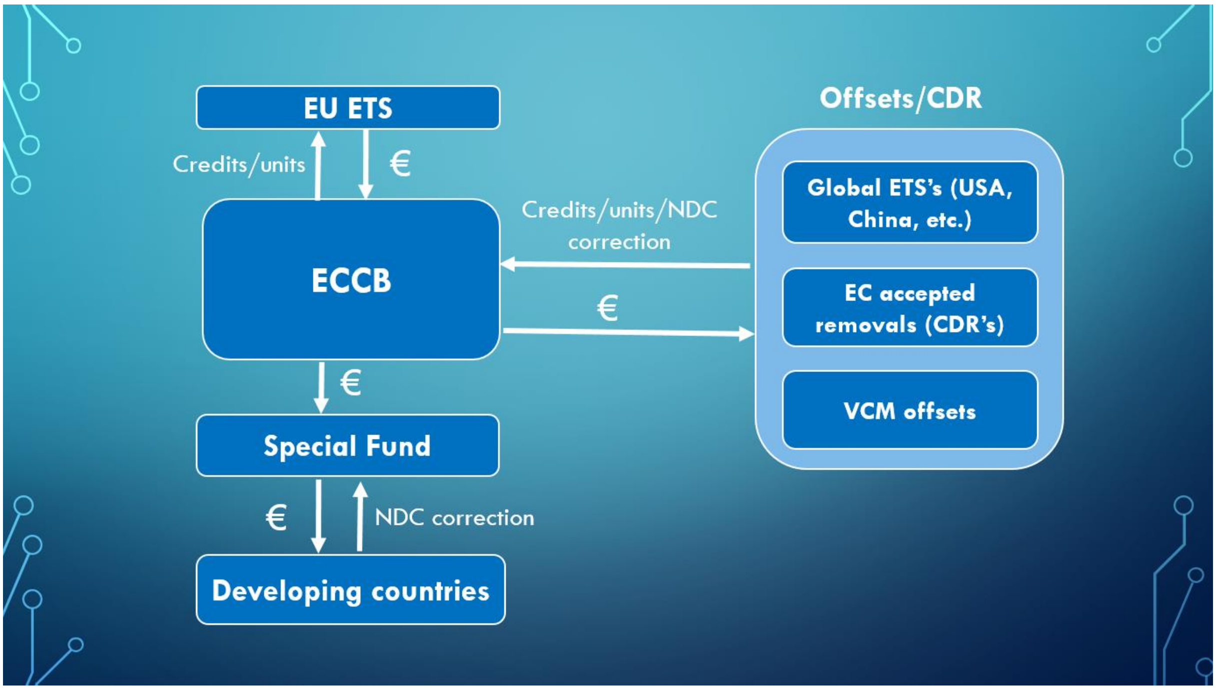
190. The European Central Carbon Bank could have mechanisms in place to regularly review and adjust price targets based on data and market conditions, thereby mitigating the risk of price distortions. The role of the ECCB would be to control the market and safeguard situations where technological progress fails to deliver fast enough reductions, leading to soaring carbon prices. At the same time, cheaper options could arise from sectors not covered by the ETS through sinks and removals. Smoothing out price development behaviour would provide EU ETS participants and Member States with greater stability and room for necessary long-term investments.

191. The ECCB could potentially be the future "Registry" of Carbon Removals and Carbon Farming Certification framework and to create the market for removals (CDRs). The purchase price would depend on the degree of permanence of the removals (e.g. industrial removals would be better priced than nature-based solution), but should not be higher than EU ETS price.

192. ECCB could acquire offsets generated under Article 6 of the Paris Agreement (also as option – VCM offsets). In contrast to removals, the offset units can be bought at a price determined in the various world-wide emissions trading systems (e. g. ETS in USA or ETS in China etc.) or carbon price initiatives. The ECCB could add an extra margin (e.g. 25%) above the purchase price to incentivize offset units sellers (to sell

units to EU rather than using them within their own ETS framework). This would help finance low-carbon initiatives, creating a pathway for these nations to engage in the global carbon market effectively.

Graph 2. CDR and Offset unit flow and revenues generation



Source: CAKE/KOBiZE

193. Removals and offset units would be held in a specially created reserve and released to the market gradually (e.g. by adding them to auction supply) if the situation in the EU ETS required it - e.g. in case of very high prices and a limited supply of allowances.

194. The revenue generated from the difference between the purchase and sale prices of CDRs/offsets units (so called "spread") would be allocated to specific purposes:

a. X% to a Special Dedicated Fund for Developing Countries: A portion of the funds would be allocated to support less developed nations as part of the EU climate finance, to aid in their energy transitions, low-emission technology investments and sustainable economic development. Technical progress greatly reduces emission. Therefore, it is important form climate perspective to support energy-efficient technologies and make them available also to rest of world.
b. X% to EU Member State Budgets: The remaining revenue would contribute to the budgets of EU Member States, providing an additional funding source that could support national climate initiatives or other budgetary goals.

195. Each transaction within the purchase and sale process should be followed by corresponding adjustments to its Nationally Determined Contributions (NDCs) to ensure that emission reductions are only counted once, avoiding "double counting" between countries involved in the trade. Additionally, the mechanism could partially exempt non-EU countries from the CBAM. Under the condition that the EU uses offsets and/or there is a linkage between other ETSs or pricing mechanism and the EU ETS.

196. The proposed European Carbon Central Bank offers a strategic solution for managing the EU carbon market as it transitions to more ambitious climate targets. By centralizing control over allowances, removals, and offsets, the ECCB would foster a stable and reliable carbon market environment that supports the EU's climate objectives and contributes to global emissions reduction efforts. This model not only reinforces the EU ETS's role in achieving climate neutrality by 2050 but also positions the EU as a leader in carbon market governance, setting a precedent for other regions to follow.

References

1. Asian Development Bank, Decoding corresponding adjustments. Understanding the Latest Rules and Guidance in Article 6, v.II, December 2020 (Decoding Article 6 of the Paris Agreement-Version II (adb.org))
2. Carbone, J.C., Helm, C. and Rutherford, T.F., 2009. The case for international emission trade in the absence of cooperative climate policy. Journal of environmental economics and management, 58(3), pp.266-280.
3. Centre for Research on Energy and Clear, Air Lauri M., Xing Z., Liansai D., China's Climate Transition: Outlook 2022, (https://energyandcleanair.org/wp/wp-content/uploads/2022/11/Chinas-Climate-Transition_Outlook-2022.pdf)
4. Cheng, H., 2024. Domestic versus international emissions trading with capital mobility. Resource and Energy Economics, 77, p.101433.
5. D. Hynes and L. Schneider. (2023). Applying Rules under Article 6 of the Paris Agreement to Linked Emissions Trading Systems. Berlin: International Carbon Action Partnership.
6. Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms (TEXt with EEA relevance), OJ, 338, 13.11.2004, p. 18-23. Directive - 2004/101 - EN - EUR-Lex (Directive - 2004/101 - EN - EUR-Lex, access: 01.08.2024).
7. Distributing Allowances in the Mexican Emissions Trading System: Indicative Allocation Scenarios, SEMARNAT, GIZ, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany, (https://www.gob.mx/cms/uploads/attachment/file/505767/Distributing_Allowances_in_the_Mexican_ETS.pdf, access 30.08.2024).
8. Doda, B. and Taschini, L., 2017. Carbon dating: When is it beneficial to link ETSs?. Journal of the Association of Environmental and Resource Economists, 4(3), pp.701-730.
9. Doda, B., Quemin, S. and Taschini, L., 2019. Linking permit markets multilaterally. Journal of Environmental Economics and Management, 98, p.102259.
10. European Commission, Carbon Border Adjustment Mechanism, (Carbon Border Adjustment Mechanism - European Commission, access: 14.08.2024).
11. European Commission, Joint Research Centre (JRC) (2023): Global Energy and Climate Outlook 2023: Investment Needs in a Decarbonised World. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/ab5ad758-8f60-44f9-bf37-1b56d2327e8f
12. European Commission, Use of international credits. (https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/use-international-credits_en, access: 01.08.2024).
13. Flachsland, C., Marschinski, R. and Edenhofer, O., 2009. To link or not to link: benefits and disadvantages of linking cap-and-trade systems. Climate Policy, 9(4), pp.358-372.

14. Fortune Business Insights, „Carbon Offsets Market Size, Share & COVID-19 Impact Analysis, by Type (Compliance Market and Voluntary Market), by Project Type (Avoidance/Reduction Projects and Removal/Sequestration Projects), by End User (Renewable Energy, Forestry and Land, Industrial, Household and Appliances, Transportation, and Others), and Regional Forecast, 2023-2030, Market Research Report. (https://www.fortunebusinessinsights.com/carbon-offsets-market-109080)

15. Garaffa, Rafael; Ordonez, Jose; Vandyck, Toon; Weitzel, Matthias (2023): Baseline GECO 2022. European Commission, Joint Research Centre (JRC) [Dataset] doi: 10.2905/DF6CFD52-EE0C-4647-A2B3-5FA56B8B5AB0 PID: http://data.europa.eu/89h/df6cfd52-ee0c-4647-a2b3-5fa56b8b5ab0

16. Helm, C., 2003. International emissions trading with endogenous allowance choices. Journal of Public Economics, 87(12), pp.2737-2747.

17. Holtsmark, K. and Midttømme, K., 2021. The dynamics of linking permit markets. Journal of Public Economics, 198, p.104406.

18. IEA, Implementing Effective Emissions Trading Systems. Lessons from International Experiences, 2020 (Implementing Effective Emissions Trading Systems – Analysis - IEA, access: 29.07.2024).

19. International Carbon Action Partnership (ICAP), Canada - Québec Cap-and-Trade System, 2022. (https://icapcarbonaction.com/en/ets/canada-quebec-cap-and-trade-system, access 30.08.2024).

20. International Carbon Action Partnership (ICAP), China National ETS, 2022. (https://icapcarbonaction.com/en/ets/china-national-ets, access 30.08.2024).

21. International Carbon Action Partnership (ICAP), Emissions Trading Worldwide. Status Report 2024, Berlin, International Carbon Partnership, (https://icapcarbonaction.com/en/publications/emissions-trading-worldwide-2024-icap-status-report, access 28.07.2024).

22. International Carbon Action Partnership (ICAP), Korea Emissions Trading Scheme, 2022. (https://icapcarbonaction.com/en/ets/korea-emissions-trading-scheme, access 30.08.2024).

23. International Carbon Action Partnership (ICAP), Mexican Emissions Trading Scheme, 2022. (https://icapcarbonaction.com/en/ets/mexican-emissions-trading-system, access 30.08.2024).

24. International Carbon Action Partnership (ICAP), UK Emissions Trading Scheme, 2022. (https://icapcarbonaction.com/en/ets/united-kingdom, access 30.08.2024).

25. International Carbon Action Partnership (ICAP), USA - California Cap-and-Trade Program, (https://icapcarbonaction.com/en/ets/usa-california-cap-and-trade-program, access 30.08.2024).

26. International Carbon Action Partnership (ICAP), USA - Regional Greenhouse Gas Initiative (RGGI), (https://icapcarbonaction.com/en/ets/usa-regional-greenhouse-gas-initiative-rggi, access 30.08.2024).

27. IPCC, Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022. doi: 10.1017/9781009157926.
28. IPCC, Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5 °C, 2018. (https://www.ipcc.ch/sr15, access: 04.09.2022).
29. Jeszke, R., Lizak, S., "Why we need a European Central Carbon Bank within the EU ETS framework", Energypost.eu, (2023), https://energypost.eu/why-we-need-a-european-central-carbon-bank-within-the-eu-ets-framework/
30. Jeszke, R., Lizak, S., Why a European Central Carbon Bank would help stabilise EU climate policy", Euractiv, (2023), https://www.euractiv.com/section/emissions-trading-scheme/opinion/why-a-european-central-carbon-bank-would-help-stabilise-eu-climate-policy/
31. Kachi A, Mooldijk S., Warnecke C., Carbon Pricing Options for International Maritime Emissions, New Climate Institute, 2019
32. Kachi, A., Unger, C., Böhm, N., Stelmakh, K., Haug, C. and Frerk, M., 2015. Linking emissions trading systems: A summary of current research. International Carbon Action Partnership.
33. Keramidas, K., Fosse, F., Diaz Rincon, A., Dowling, P., Garaffa, R., Ordonez, J., Russ, P., Schade, B., Schmitz, A., Soria Ramirez, A., Van Der Vorst, C. and Weitzel, M., Global Energy and Climate Outlook 2023, Publications Office of the European Union, Luxembourg, 2023, doi: 10.2760/836798, JRC136265.
34. OECD, Pricing Greenhouse Gas Emissions. Turning Climate Targets into Climate Action, November 2022, https://www.oecd-ilibrary.org/taxation/pricing-greenhouse-gas-emissions_e9778969-en (OECD Series on Carbon Pricing and Energy Taxation)
35. Partnership for Market Readiness, „From the Ground Up – A Decade of Lessons on Carbon Trading", IBRD/WB 2021
36. Pryor J.D.C., Gadde H., Pigato M.A., Sinha C.S., Timilsina G.R., Carbon Pricing for Climate Action (English), World Bank Group, p.1. (http://documents.worldbank.org/curated/en/725801627450789550/Carbon-Pricing-for-Climate-Action).
37. Pyrka M., Jeszke R., Boratyński J., Witajewski-Baltvilks J., Antosiewicz M., Tatarewicz I., Rabiega W., Wąs A., Lewarski M., Skwierz S., Rosłaniec M., Lizak S., Zborowska I., Chodor M., Kobus P., Cygler M., Gorzałczyński A., Tylka A., Lewarska I., Mzyk P., Sekuła M. (2024). „VIIEW on EU ETS 2050: Exploring synergies between the EU ETS and other EU climate policy measures - carbon removal, hydrogen, and sectoral transport policy", CAKE/KOBiZE, https://climatecake.ios.edu.pl/wp-content/uploads/2024/04/LIFE_VIIEW_EUETS_Exploring-synergies.pdf
38. Ranson, M. and Stavins, R.N., 2016. Linkage of greenhouse gas emissions trading systems: Learning from experience. Climate Policy, 16(3), pp.284-300.

39. Regional Greenhouse Gas Initiative (RGGI), an initiative of Eastern States of the USA, (https://www.rggi.org/program-overview-and-design/elements, access 30.08.2024).

40. Wilfried Rickels, Roland Rothenstein, Felix Schenuit, Mathias Fridahl IN: Energy Research & Social Science 94, 102858; https://doi.org/10.1016/j.erss.2022.102858 .

41. Taskforce on Scaling Voluntary Carbon Markets. Final Report, January 2021, p. 4. (TSVCM_Report.pdf (iif.com), access: 04.09.2022).

42. UNFCCC, Articles 6 (JI) and 12 (CDM) of the Kyoto Protocol, (https://unfccc.int/resource/docs/publications/mechanisms.pdf).

43. UNFCCC, Conference of the Parties serving as a Meeting of the Parties to the Paris Agreement, (https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-serving-as-the-meeting-of-the-parties-to-the-paris-agreement-cma).

44. UNFCCC, Decision 18/CMA1., (https://unfccc.int/resource/tet/0/00mpg.pdf).

45. World Bank, Carbon Pricing Dashboard. (What is Carbon Pricing? | Carbon Pricing Dashboard (worldbank.org), access: 02.08.24).

46. World Bank, State and Trends of Carbon Pricing 2023, Executive Summary, p.8. (http://documents.worldbank.org/curated/en/099805106052321586/IDU0df4b14850029d0403c0811b0f1575605c07a).

47. World Bank, State and Trends of Carbon Pricing 2024. © Washington, DC: World Bank. https://www.worldbank.org/en/news/press-release/2024/05/21/global-carbon-pricing-revenues-top-a-record-100-billion License: CC BY 3.0 IGO

48. World Resources Institute, 4 New Carbon Border Adjustment Bills in the US, (4 New Carbon Border Adjustment Bills in the US | World Resources Institute, access: 14.08.2024).

Annex I. Brief description of the model and assumptions

CGE model – CREAM

CREAM (Carbon Regulation Emission Assessment Model) is global, multi-sector CGE model, based on the economic Input-Output (I-O) table for the year 2020 used in the Global Energy and Climate Outlook (GECO) published by the Joint Research Centre (JRC) of the EC. In a current setting, the model distinguishes 28 sectors and 9 regions (presented in Table 3 and Table 4). The model is solved for the years 2020-2050, in 5 years. The baseline scenario conforms with external projections of GDP growth rates and the emission limits for the EU and rest of the world regions. In its core, CREAM follows standard formulations, with nested Leontief-CES (Constant Elasticity of Substitution) production functions, marginal cost pricing and bilateral trade based on the Armington assumption. Beyond that, several specific features of CREAM have been designed to meet the needs of climate and energy policy analysis. First, greenhouse gas emissions are modelled at a detailed level. Emissions originating from fuel combustion and process emissions are treated separately. The model distinguishes between fuel combustion CO_2 emissions, CO_2 process and non-CO_2 emissions of other greenhouse gases, such as N_2O (nitrous oxide), CH_4 (methane), F-gases (fluorinated gases).

Emission pricing is used as an instrument to facilitate emission reductions, modelled as a cap-and-trade system. By default, revenues from emission prices (taxes), are transferred to the representative household as a lump sum. Industries and consumers adjust their energy mix in response to changes in relative prices of different fuels (including the cost of emissions) and electricity. Additionally, producers may substitute energy for fixed capital (equipment), and thus reduce energy intensity of their production.

In the model fixed capital in each sector follows an accumulation equation – capital stock from previous period is diminished by depreciation and increased by new investment. The old capital remains sector-specific, whereas new investment is allocated freely between sectors. Capital stocks cannot flow between regions. The current model uses a single labor category that can flow freely between sectors, but not between regions. Wage adjustments ensure full employment, leaning to a long-run view on the labor market.

Table 3. The list of sectors in the CREAM model.

Codes in CREAM Model	List of sectors in CREAM model
coa	Coal
cru	Crude Oil
oil	Oil
gas	Gas
ele	Electricity supply
fem	Ferrous metals
nem	Non ferrous metals
che	Chemical Products
pap	Paper products
nmm	Non metallic minerals
elg	Electric Goods
tra	Transport equipment
oth	Other Equipment Goods
cgi	Consumer Goods Industries
con	Construction
atr	Transport (Air)
ltr	Transport (Land)
wtr	Transport (Water)
cof	Coal fired
oif	Oil fired
gaf	Gas fired
nuc	Nuclear
bio	Biomass
hyd	Hydro electric
win	Wind
pv	PV
agr	Agriculture
srv	Services
coa	Coal
cru	Crude Oil

Table 4. The list of regions in the CREAM model.

Modelling Assumption & Aggregation	Code	Aggregation GECO	Countries GECO
EU ETS	EU27		EU27
UK ETS	GBR		United Kingdom
ETS: RGGI, California C&T	USA		United States
Developed	JPN		Japan
Ontario ETS	CAN		Canada
Developed	AUS		Australia
Developed	RUS		Russian Federation
Developed	BRA		Brazil
China ETSs	CHN		China
Developed	IND		India
Korean ETS	KOR		South Korea
Developed	SAU		Saudi Arabia
Developed	TUR		Türkiye
Developed	SAF		South Africa
Mexican ETS	MEX		Mexico
Developed	ARG		Argentina
Developed	IDN		Indonesia
Developed	EFA	EFTA	Iceland, Liechtenstein, Norway, Switzerland
Developed	MEA	Middle East	Rest Gulf (incl. Iraq, Kuwait, Qatar, UAE), Iran, Mediterranean Middle East (incl. Israel, Lebanon)
Developing	AFR	Africa	Egypt, Morocco & Tunisia, Rest Sub Saharan Africa (incl. Kenya, Nigeria), Algeria & Libya
Developing	OAM	Other Americas	Rest South America (incl. Bolivia, Columbia, Venezuela), Chile, Rest Central America (incl. Costa Rica)
Developing	OAS	Other Asia	New Zealand, Rest Pacific (incl. Papua New Guinea), Rest South East Asia (incl. Mongolia, Singapore, Taiwan), Malaysia, Thailand, Vietnam, Rest South Asia (incl. Afghanistan, Bangladesh)
Developed	REA	Rest of Eurasia	Other Balkans (incl. Albania, Serbia), Ukraine, Other CIS (incl. Azerbaijan, Georgia, Kazakhstan)

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