

A new hope for net-zero?

Insights from the new Brazilian Carbon
Market framework

Public Report | March 2025



- I. Introduction to today's session
- II. Overview of carbon markets
- III. The Brazilian regulated carbon market
- IV. Impact on the Power Market
- V. Key takeaways
- VI. Appendix

Introducing the Aurora team

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With a cap-and-trade system, emission reductions can be targeted better, though leading to lower price security

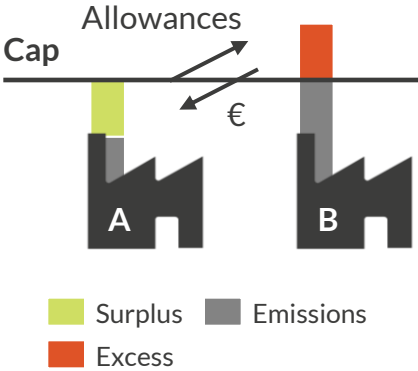
Following the “polluter pay” principle, a carbon price aims at internalising the costs of emissions and hereby reducing them. There are broadly two different systems 1) a carbon tax and 2) a cap-and-trade system

1 Carbon tax

- Carbon price set by the regulator
- Level of carbon emissions set by emitters in response to carbon price
- Leads to higher certainty of prices and investor security
- However, number of emissions cannot be targeted as directly as under a cap-and-trade system

2 Cap-and-trade

- Level of carbon emissions set by regulator in the form of the cap, which defines the number of tradable certificates issued per year
- Carbon price set by market balance of demand and supply
- While a cap-and-trade can lead to higher economic efficiency, it can risk investor security if not designed appropriately



Price vs. emission quantity under carbon tax & cap-and-trade

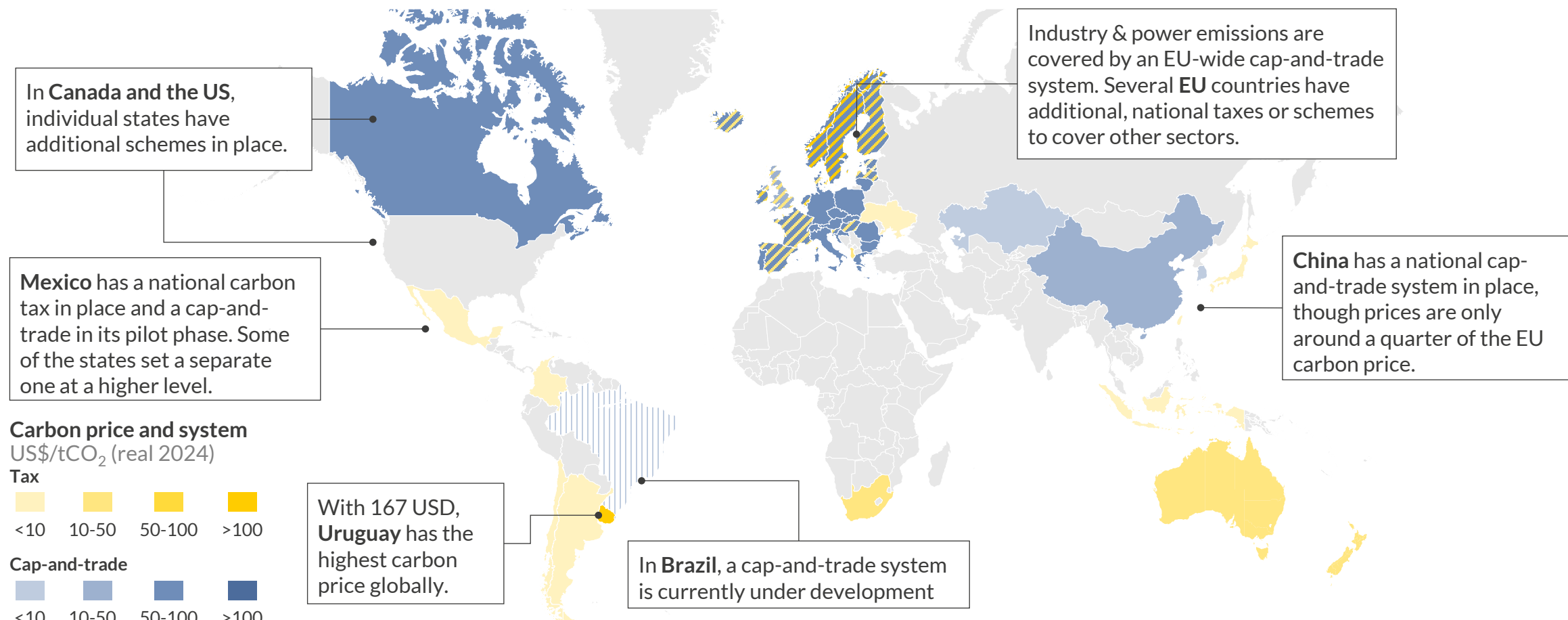
| | 1 Carbon tax | 2 Cap-and-trade |
|--------------------|--------------|-----------------|
| Carbon price | Fixed | Variable |
| Emissions quantity | Variable | Fixed |

Strengths and weaknesses of carbon tax & cap-and-trade

| | 1 Carbon tax | 2 Cap-and-trade |
|------------------------------|--------------|-----------------|
| Targeted emission reductions | - | + |
| Economic efficiency | - | + |
| Investor security | + | - |
| Bureaucratic simplicity | + | - |

Several countries have a carbon tax or cap-and-trade system in place, but price levels vary significantly

Global carbon pricing systems and 2024 price levels



The EU-ETS 1 only led to meaningful carbon prices and emission reductions after several changes to the market design

2005: ETS 1 is launched covering emissions from **industry and energy**

2008-2020: Several reforms to EU ETS incl. revision of free allocations and introduction of **Market Stability Reserve**

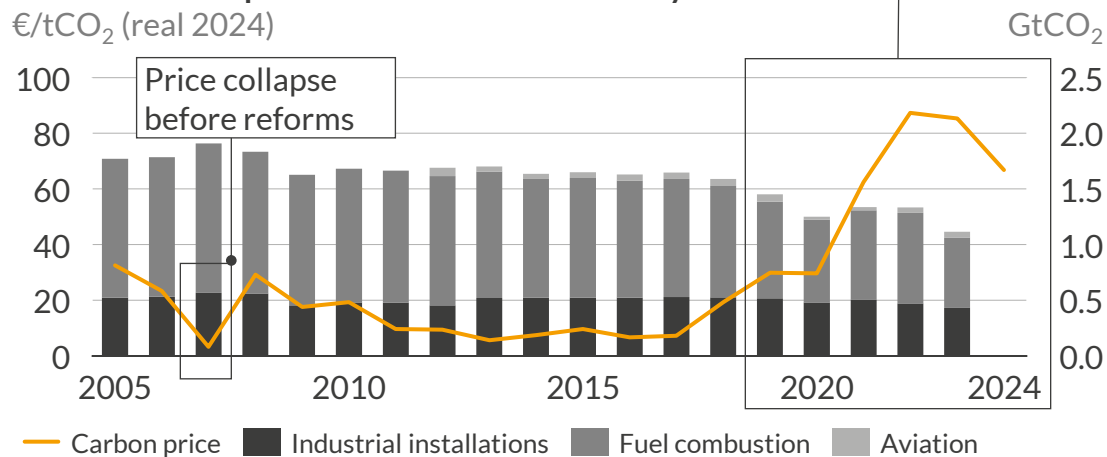
2021: More **ambitious climate policy** reflected in tighter cap and limited free allocations leads to higher prices

2026: **CBAM** gradually becomes main measure against carbon leakage, replacing free allocations

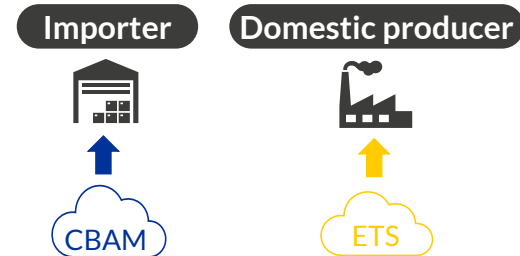
2027: EU-ETS 2 comes into force. The market will be separate from ETS 1 initially but potentially merged in the 2030s



Historical ETS 1 price and emissions covered by ETS 1
€/tCO₂ (real 2024)



- All importers to the EU will be **subject to the same carbon price** as domestic producers



- ETS 1 mainly targeted large industrials & energy producers
- From 2027, a separate carbon market covering transport & buildings will be introduced










Brazil became the third country in LATAM to implement an emissions trading system (ETS), after Mexico and Colombia

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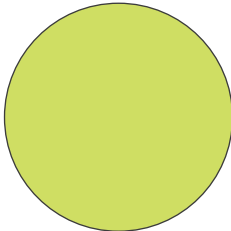
Five countries in LATAM have implemented carbon taxes, but Mexico is the only one to successfully implement an emissions trading system as well¹. Brazil now joins Colombia as the two countries currently developing an ETS.

Status of ETS and carbon tax implementation by country in LATAM

| Country | ETS status | Carbon tax status |
|-----------|--|---------------------|
| Mexico |  Implemented in 2023 ¹ | Implemented in 2014 |
| Colombia |  Under development since 2018 (expected by 2030) | Implemented in 2017 |
| Brazil |  Under development since 2024 (expected by 2029-2030) | - |
| Argentina |  Under consideration | Implemented in 2018 |
| Chile |  Under consideration | Implemented in 2017 |
| Uruguay |  - | Implemented in 2022 |

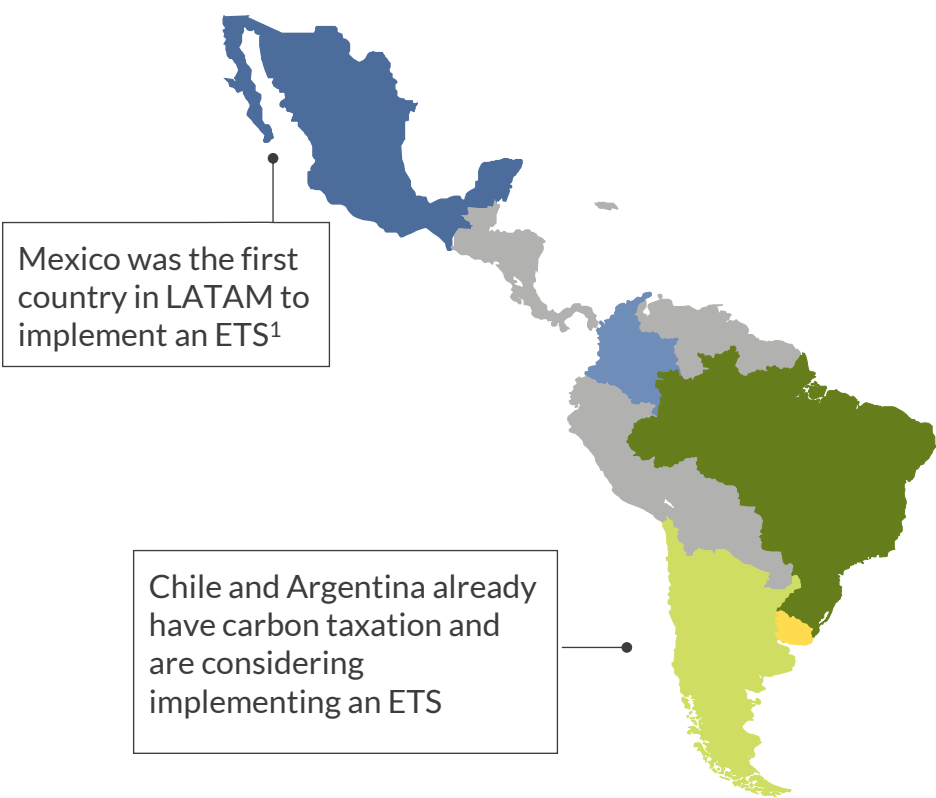


1Country has implemented an ETS



5Countries have implemented a carbon tax

Status of carbon compliance implementation by country in LATAM

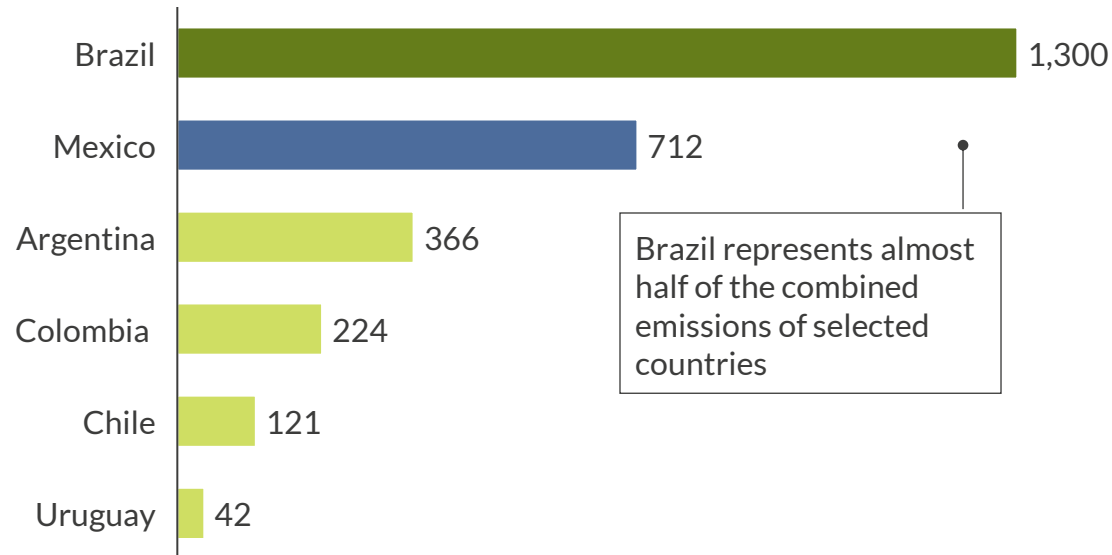


 Both implemented  Carbon tax implemented and ETS under development  ETS under development  Carbon tax implemented and ETS under consideration  Carbon tax implemented

1) The Mexican ETS is currently in a pilot phase and is expected to be fully operational by 2026.

With 47% of total emissions from the selected countries in the region, Brazil holds the greatest potential

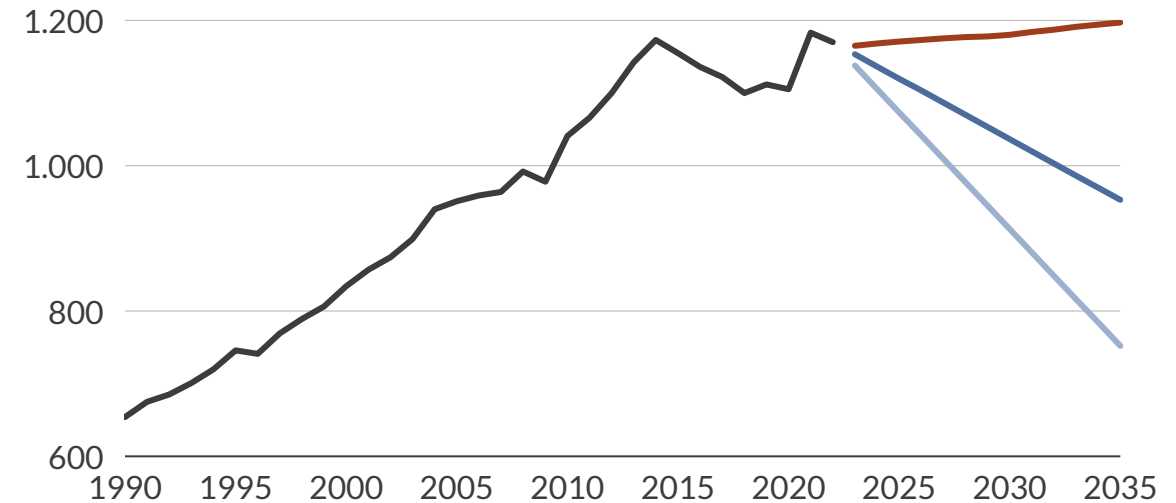
Total emissions by LATAM countries in 2023^{1,2}
MtCO₂e



- Brazil has the highest number of emissions in the region and could therefore become the biggest carbon market. With the right framework, the Brazilian carbon market has the potential to cover almost half of the region's emissions.
- Brazil will be the first country in Latin America to implement a carbon market without implementing a carbon tax first.

■ Brazil ■ Countries with ETS ■ Countries with carbon tax

Brazilian historical and forecasted emissions^{1,3}
MtCO₂e



- Historical data from Climate Action Tracker indicates that Brazil's GHG emissions have nearly doubled since 1990.
- According to the Climate Action Tracker, the country's emissions are projected to continue rising. However, to align with Brazil's NDC commitments, emissions should be on a downward trajectory, with a target of 750-950 MtCO₂e by 2035^{1,3}.

— Historical — NDC (upper bound)
— Forecast (by Climate Action Tracker) — NDC (lower bound)

1) Excluding Land Use, Land Use Change and Forestry (LULUCF). 2) Data provided by The Emissions Database for Global Atmospheric Research. 3) Forecast provided by Climate Action Track.

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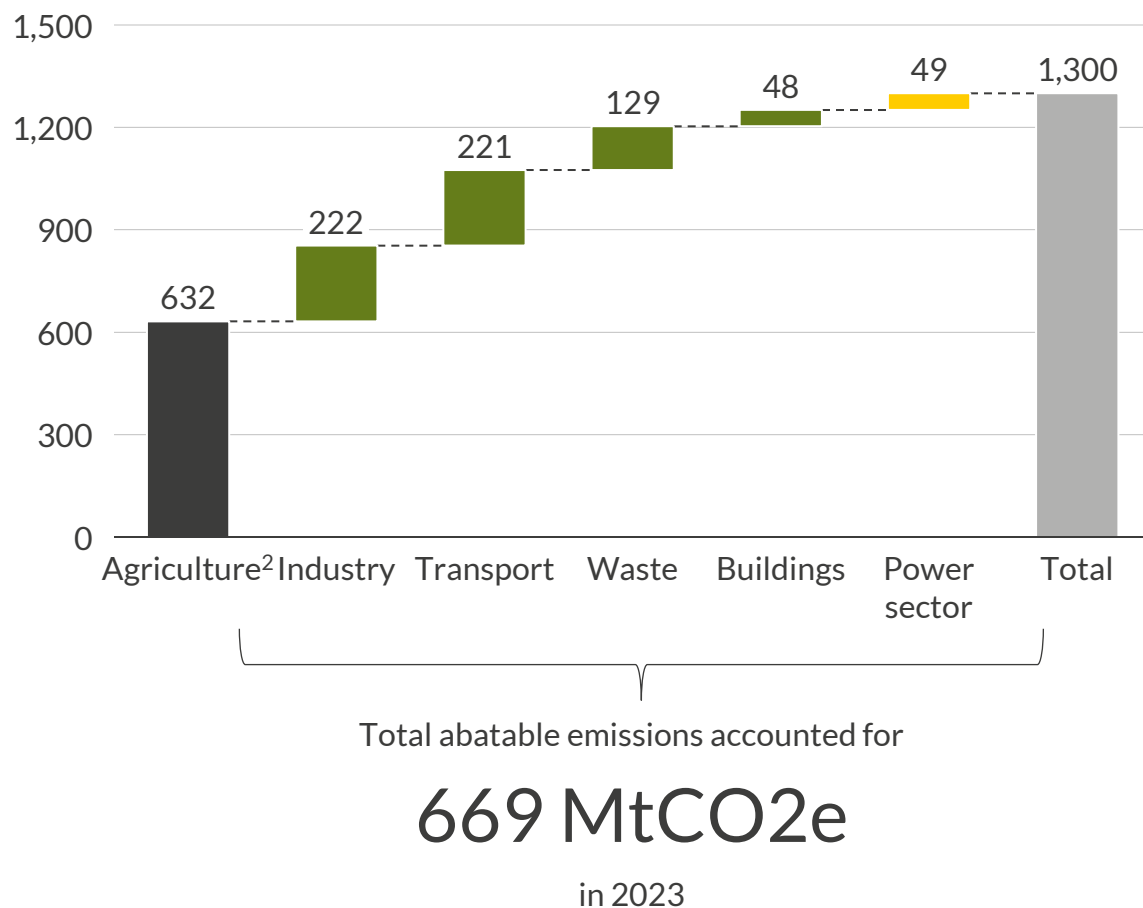
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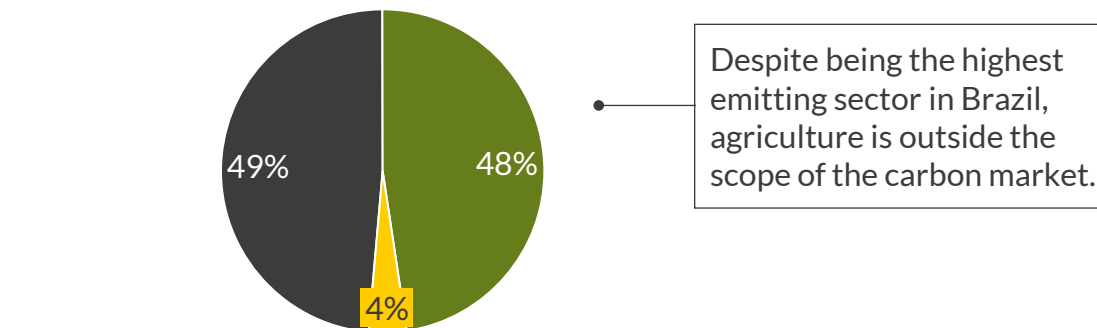


In 2023 ,the Brazilian carbon market would have had the potential to abate 669 MtCO₂e, equivalent to 51% of the country's CO₂e emissions

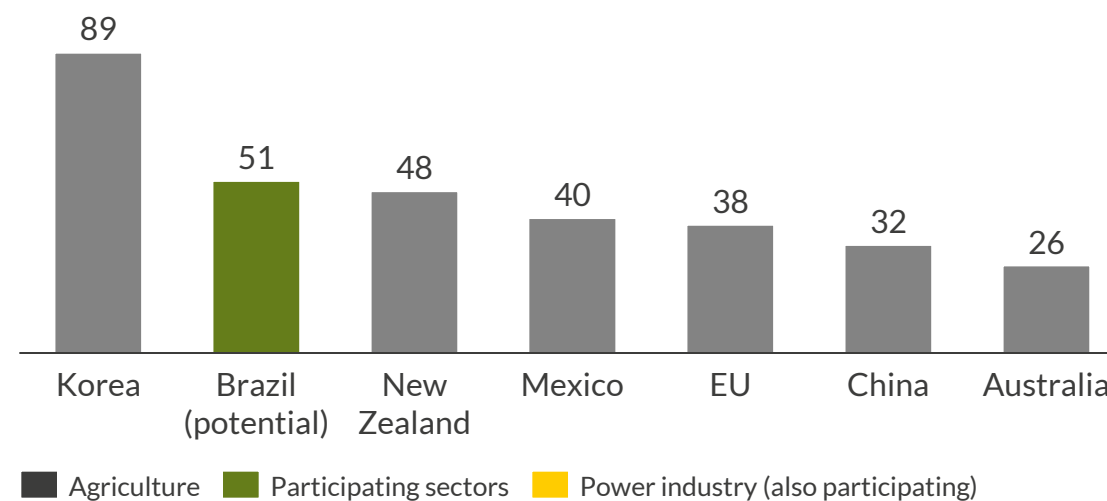
Emissions by sector in Brazil (2023)^{1,2}
MtCO₂e



Emissions by participating sectors in Brazil (2023)¹
%



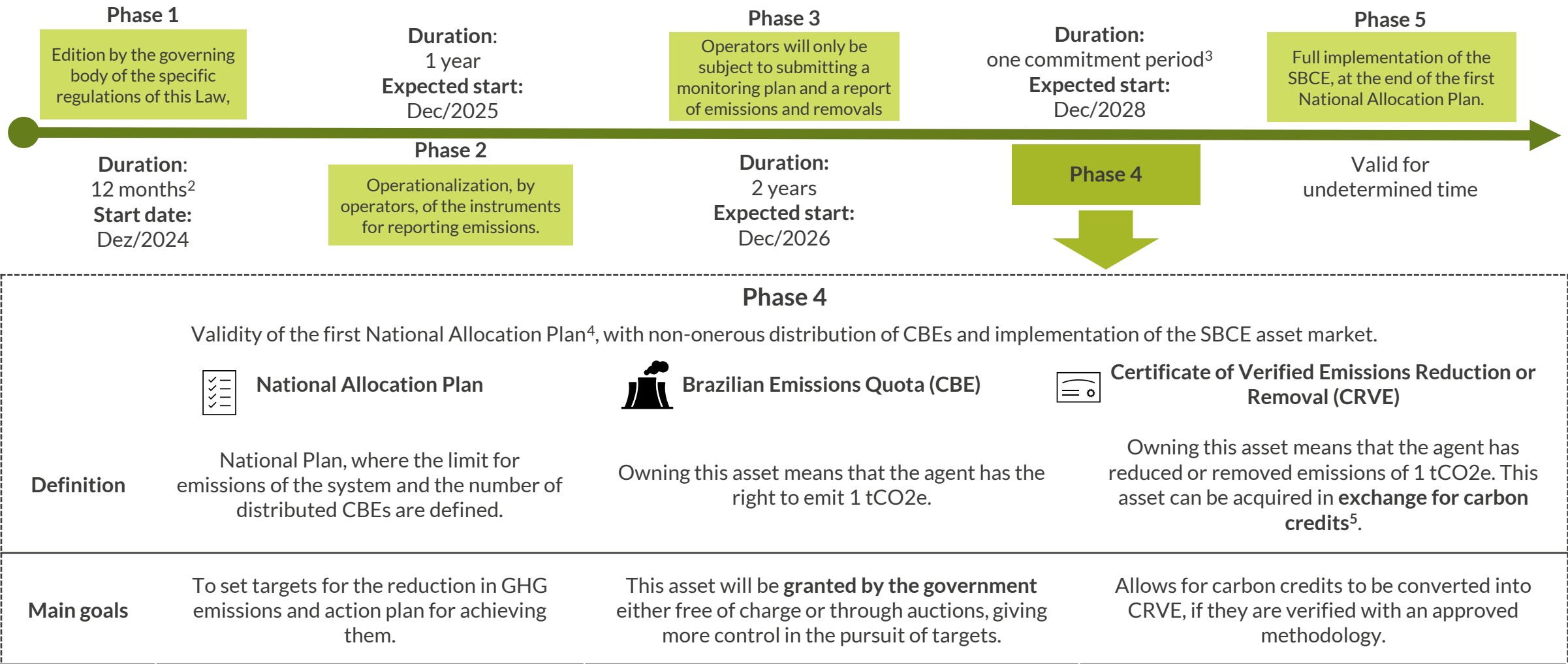
Emissions covered in the ETS by country
%



1) Excluding Land Use, Land Use Change and Forestry (LULUCF). 2) Despite being the highest emitting sector in Brazil, agriculture is outside the scope of the carbon market.

The implementation of the SBCE¹ is divided into 5 phases and is expected to be fully completed by the end of 2029

The system will be progressively implemented in five phases, each one starting after the previous one has completed and with Phase 1 beginning in December 2024. The implementation of the assets (CBE and CRVE) will be completed during Phase 4.

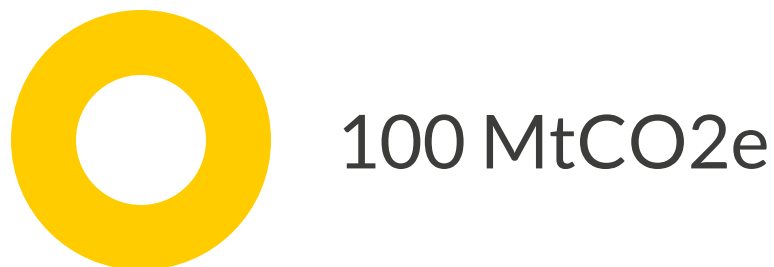


1) Sistema Brasileiro de Comércio de Emissões. 2) Can be extended for more 12 months. For the purposes of this timeline, we considered the fastest deadline possible. 3) Commitment period: established in the National Allocation Plan for meeting targets defined in accordance with the maximum emissions ceiling. 4) The first National Allocation Plan gains validity by the start of Phase 4 but needs to be approved at least one year prior to that date. 5) In the context of the SBCE, carbon credits are traded in the voluntary market and are not in the same category of assets as the CBE and CRVE.

Sources: Aurora Energy Research, Brazilian Congress PUBLIC VERSION 13

The carbon market will work as a cap-and-trade system, with allowances and carbon credits being issued to players in applicable sectors

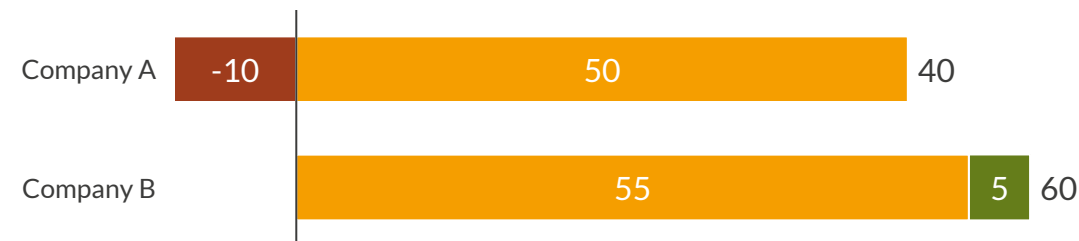
- 1 The governing body will define a target for total emissions and issue the same number of allowances.



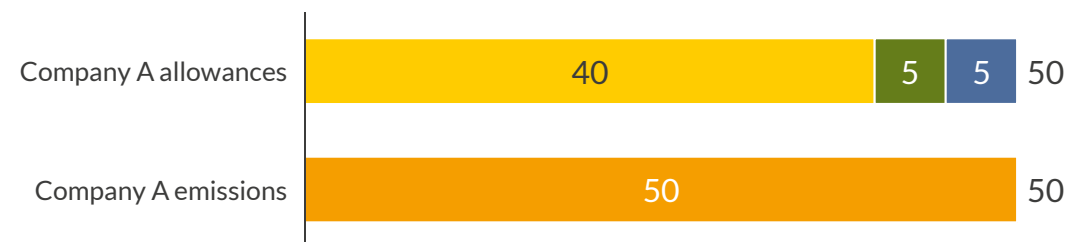
- 2 Market players buy allowances, based on their expectations for the year.



- 3 At the end of the period, players reconcile emissions: those emitting less than purchased can sell the surplus, while those emitting more must buy the shortfall.



- 4 Carbon credits serve as a certificate of emissions reductions and are equivalent of one allowance and can be freely negotiated as well.



■ Initial allowances
 ■ Total emissions
 ■ Allowances traded by the agents
 ■ Emissions covered with carbon credits
 ■ Emissions that company A must abate

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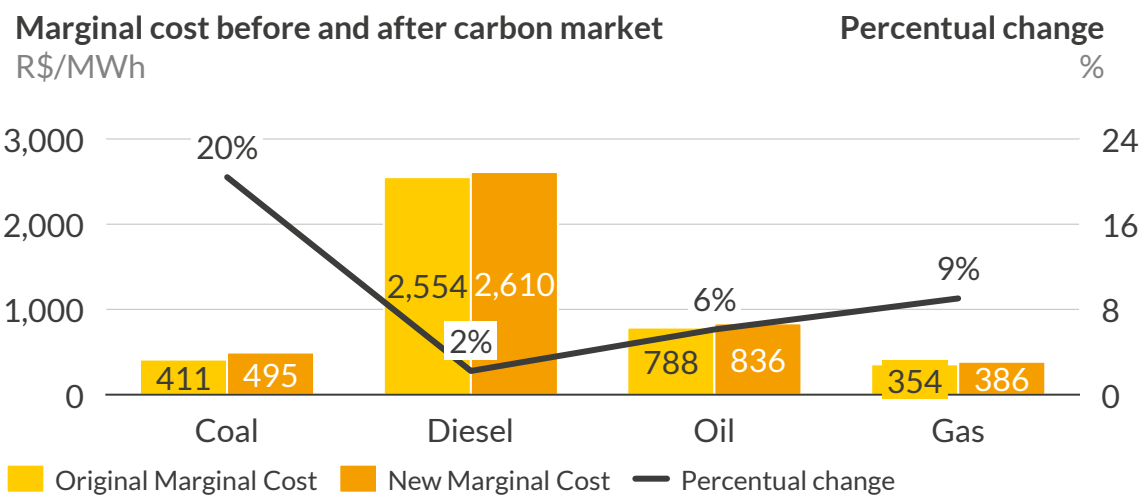
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In the power sector, fossil-fuel based power plants will have an extra cost due to the price of carbon

- 1 The carbon market can generate an extra cost for thermal plants that depends on specific emissions and efficiency of each plants

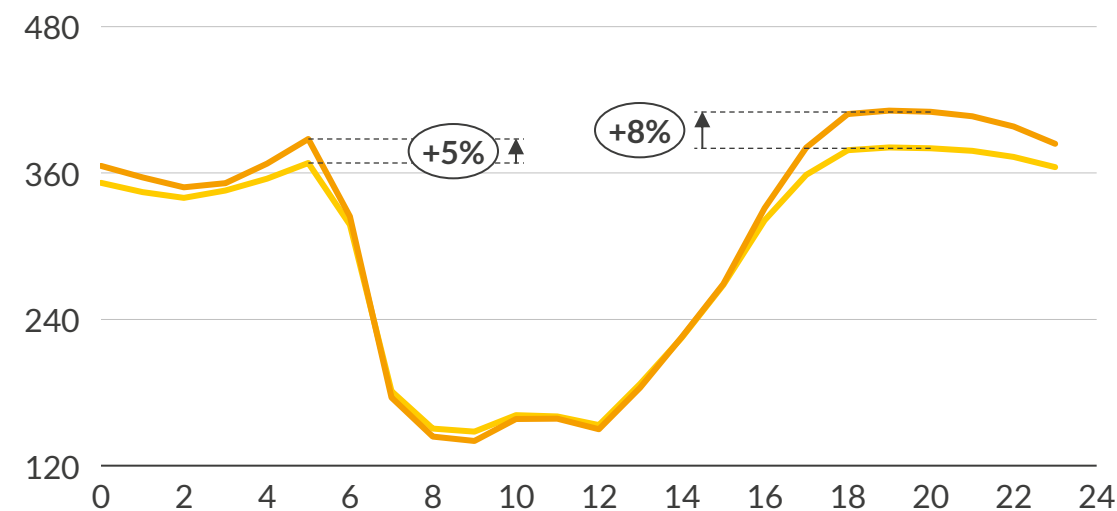
| | Carbon Price R\$/tCO ₂ e | Emissions tCO ₂ e/MWh _{fuel} | Efficiency MWh _{elet} /MWh _{fuel} | Carbon Cost R\$/MWh _{elet} |
|--------|--|---|--|--|
| Coal | 80 | 0.34 | 0.33 | 83.94 |
| Diesel | 80 | 0.27 | 0.37 | 56.83 |
| Oil | 80 | 0.25 | 0.42 | 48.24 |
| Gas | 80 | 0.18 | 0.46 | 31.95 |

- 2 This cost would raise marginal costs; for coal, an R\$80 carbon price could mean up to 20% increase in marginal cost¹



- 3 With the increase in marginal cost for thermal plants, prices are expected to rise during peak load hours²

Average hourly wholesale price (PLD) in 2060 before and after carbon market R\$/MWh



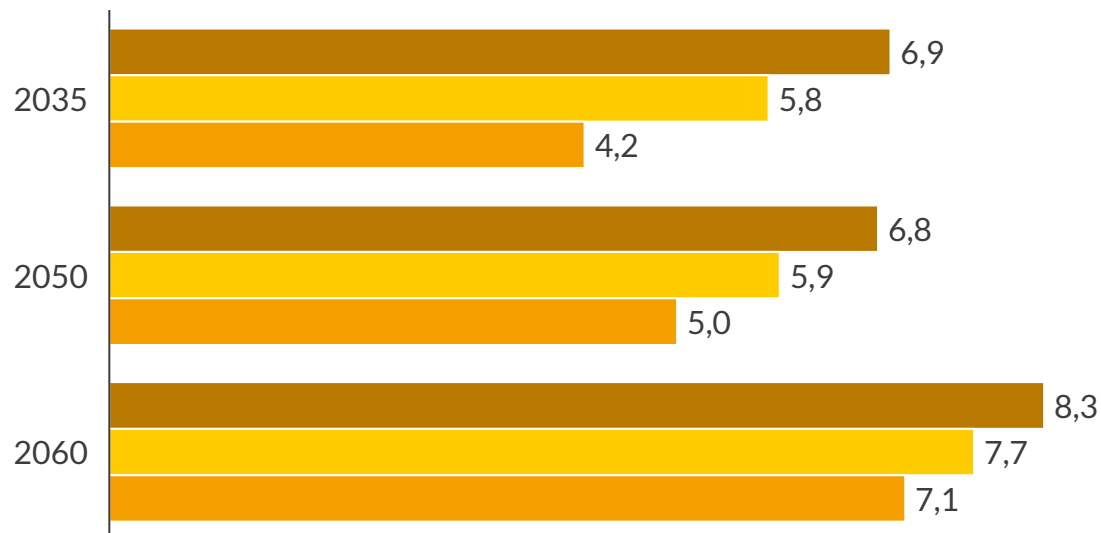
- Due to higher marginal cost from thermal plants, prices increase during peak demand hours.
- During hours of high renewable penetration, when solar generation is at its peak, no significant difference is expected.

1) These costs refer to the 2030 costs. 2) Prices refer to the average of 2060.

The change in thermal marginal costs can reshape Brazil's capacity matrix and generation mix through 2060

Fossil-fuel based generation in multiple carbon price scenarios

% of total generation

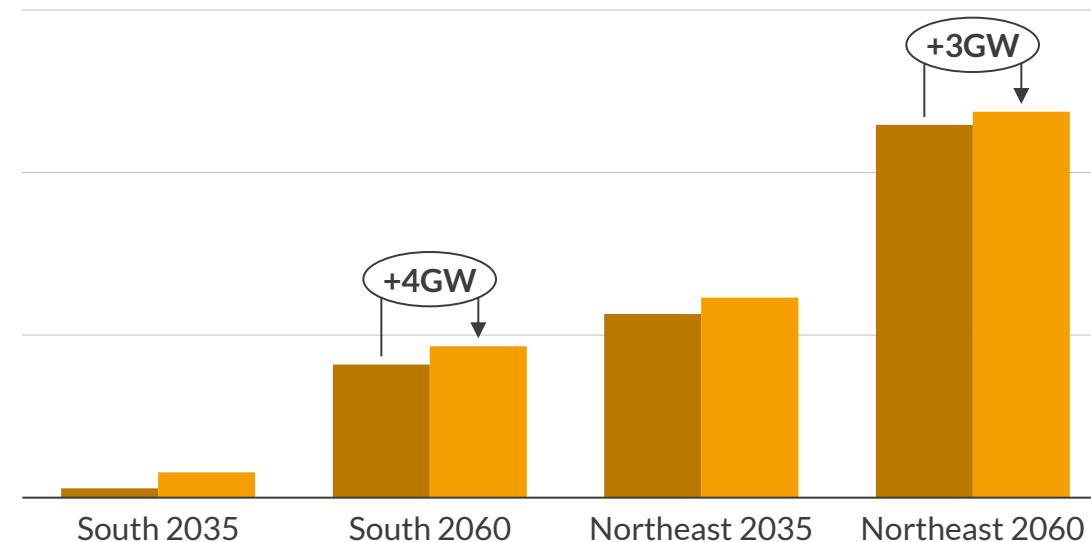


- In general, the higher the carbon price, the lower the thermal generation, as marginal cost increases and these plants are placed further in the merit order.
- This effect is more evident in the short term, as other resources, such as hydro and wind, are sufficient to meet demand, significantly reducing thermal generation. In the long term, as demand grows, thermal generation becomes more necessary, regardless of carbon prices—unless prices rise significantly enough to limit their dispatch.

■ No Carbon Market ■ Carbon Price at R\$80/MtCO₂e ■ Carbon Price at R\$160/MtCO₂e

Onshore wind capacity by subsystem and year in two carbon price scenarios

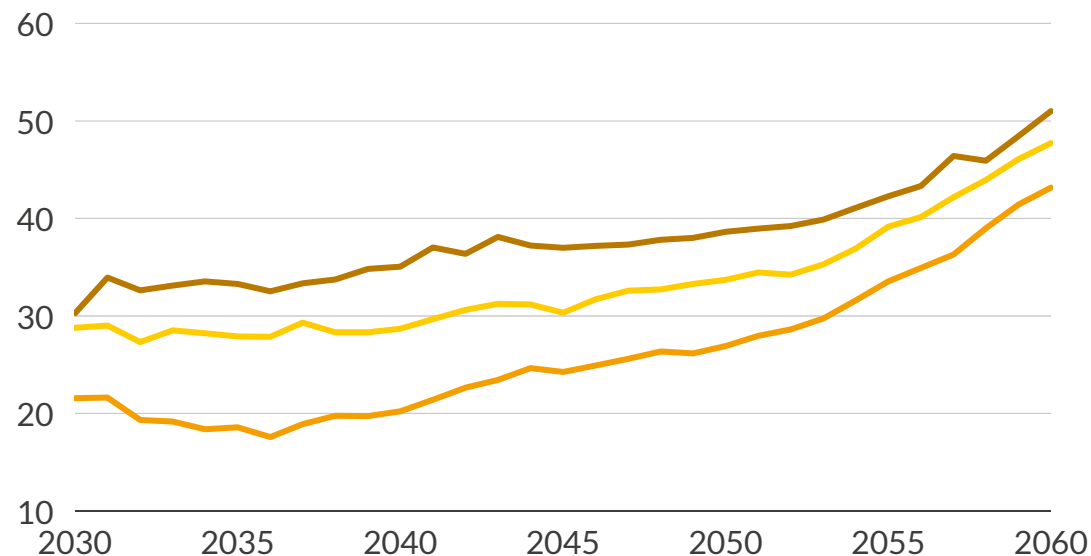
GW



- The introduction of the carbon market raises wholesale prices during peak hours, improving the business case for technologies generating when demand is higher and thermal plants need to be dispatched, such as onshore wind.
- However, since load factors vary significantly across subsystems, this effect is more pronounced in the South, where the generation profile aligns more closely with the demand pattern, and where 52% of the coal capacity is located (most impacted by the carbon price).

Growing thermal reliance will increase emissions in the long term, making carbon cost quantification crucial for pricing signals and reinvestment

Total emissions in the power sector for different carbon pricing scenarios
MtCO₂e



- The lower thermal generation driven by higher costs decreases the power sector emissions. Therefore, the higher the carbon pricing – and the lower the thermal generation – the lower the emissions as well.
- While carbon pricing reduces emissions by limiting thermal generation, total emissions still rise as demand grows. In Brazil, gas plants remain the main firm capacity source in reserve auctions, driving higher thermal generation and emissions.

— Carbon Price at R\$80/tCO₂e — Carbon Price at R\$160/tCO₂e — No Carbon Market

Key outcomes from the Carbon Market for the power sector
(at a R\$160/tCO₂e carbon price)

Emissions averted

370
MtCO₂e

averted until 2060

Revenue generated

R\$60
billion

total generated
revenue until 2060

- In the R\$160/MWh carbon price scenario, power sector **emissions fell by 31% over the period**. In this scenario, the carbon market generated almost R\$60 billion reais from quota emissions and trade.

Next steps



- This analysis reflects a case where firm capacity is met primarily by thermal plants, with a limited role of batteries. **However, greater battery penetration could further reduce emissions, bringing Brazil closer to its NDC targets, as we are exploring in Aurora analyses for subscribers.**

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Brazil's new carbon market will impact all applicable sectors; in the power sector, it will raise thermal costs while reducing emissions

1

With Law 15.042, Brazil introduced the regulated carbon market in 2024, becoming the third country in Latin America to establish an Emissions Trading System. This legislation creates a cap-and-trade system, aligning with previous international experiences, especially with the European carbon markets.

2

Brazil's carbon market is set to launch by 2029 under a cap-and-trade system, covering all sectors except agriculture. The scheme will apply to entities emitting over 10,000 megatons of CO₂ annually, targeting sectors responsible for 51% of the country's emissions.

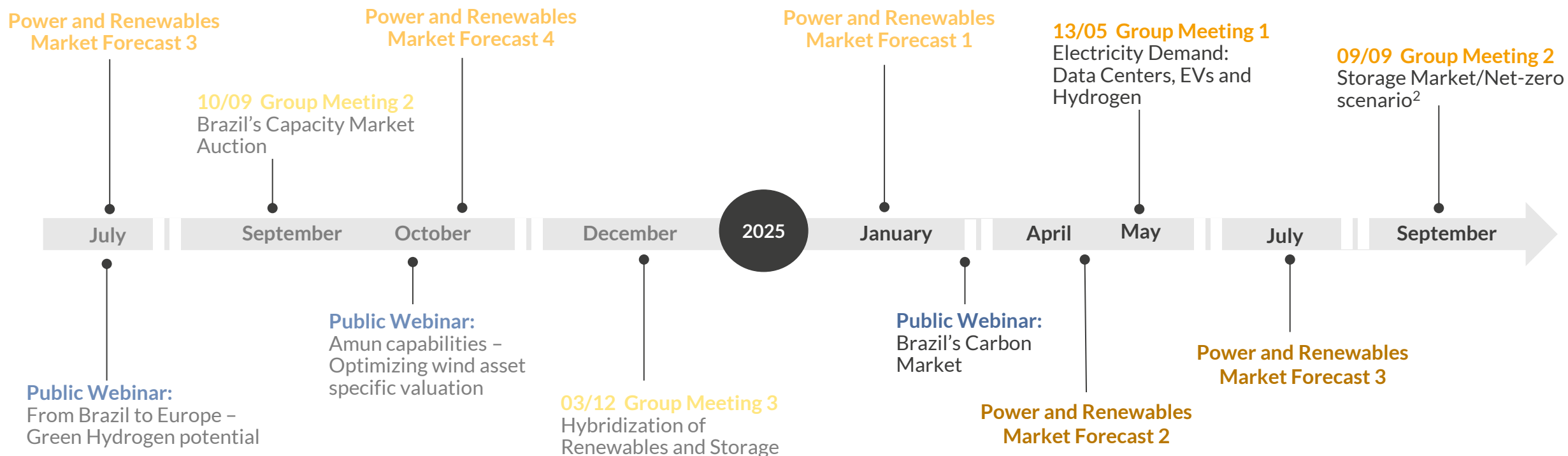
3

In the power sector, the introduction of a carbon market will increase thermal generation costs, making the wholesale market more volatile. During peak hours, when thermal plants are dispatched, prices are expected to rise by 8%, strengthening the business case for technologies that generate in these hours, such as onshore wind.

4

A carbon price of R\$160/MtCO₂ led to a 31% reduction in emissions. In this scenario, the carbon market generated nearly R\$60 billion from quota allocations and trading which can be directed toward government initiatives.

Upcoming developments for subscribers of Aurora's Brazilian services



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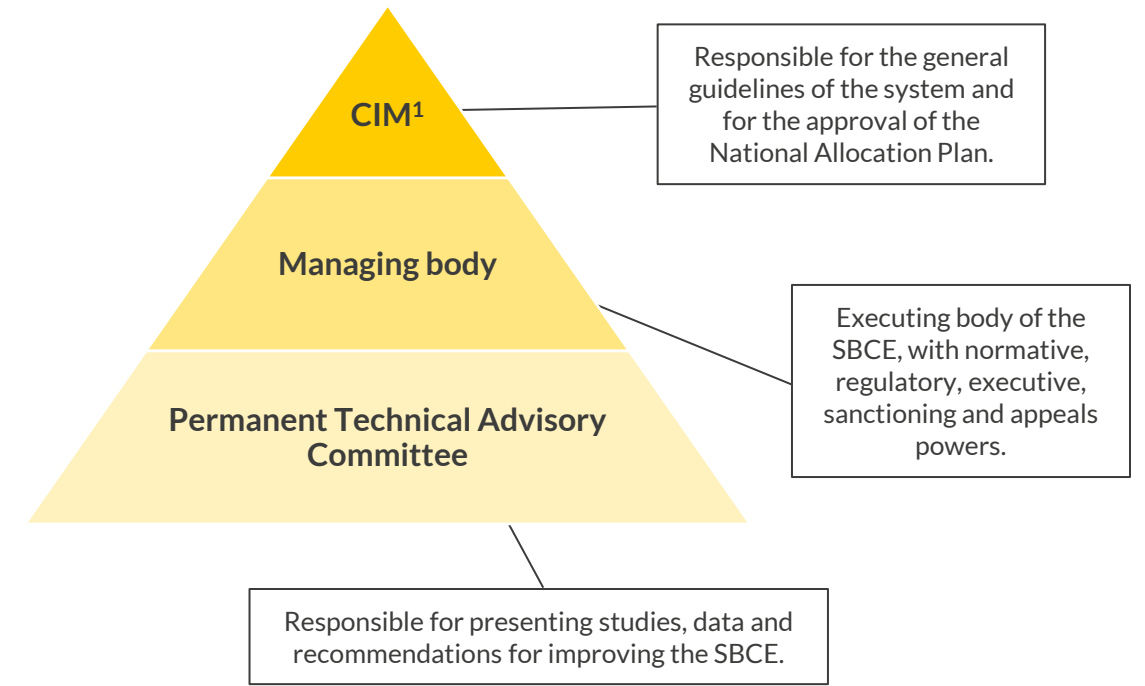
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The regulated carbon market will have a governing body and a set of rules that participants will follow

The governing body will have participation of both the government and the civil society and will be responsible for establishing the missing regulation.

1 The governing body will be responsible for the functioning of the system and for setting specific regulation



2 Every activity that emits or has potential to emit greenhouse gasses will take part in the regulated market, except for the agriculture sector

3 Regulated agents will have to follow a set of rules, according to their yearly emissions

| | Rule | To whom it is applied |
|-----|---|--|
| I | Monitoring plan | Submit monitoring plan for consideration by the SBCE management body. |
| II | Emissions and removals report | Submit a report on GHG emissions and removals, according to the approved monitoring plan. |
| III | Periodic report of obligations reconciliation | Send a periodic reconciliation report of obligations, proving that emissions and removals are equal to owned assets. |
| IV | Other | Meet other obligations provided in decrees or other specific acts of the managing body. |

1) Comitê Internacional sobre Mudança do Clima – Interministerial Committee on Climate Change. This authority was created by the government via Decree 11.550 in 2023.

Details and disclaimer

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