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Voluntary Sustainability Standards (VSS) and the "Greening" of High-Emitting Industry Sectors in Brazil

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Abstract

The work aimed to analyse the sustainability efforts – the *greening* – of five industry sectors in Brazil: aluminium, chemical, steel, cement, and oil and gas. These sectors were chosen because they are the industries with the highest carbon emissions. The research sought to verify the sustainability measures adopted by business and industry actors, with special emphasis on the use of Voluntary Sustainability Standards and ESG values. In order to verify the information provided by the companies, the documents that informed the measures taken by the companies and the numbers supporting their results were always sought out and explained in the text. The conclusions were that the sectors, guided by industry associations, have adopted a broad set of sustainability measures. The results of these measures, however, sometimes lack proof and sometimes lead to sporadic conduct, contrary to the precepts of environmental and social sustainability.

Resumo (Portuguese)

O trabalho teve como objetivo analisar os esforços de sustentabilidade de cinco setores da indústria brasileira: alumínio, químico, aço, cimento e petróleo e gás. Os setores foram escolhidos por serem altamente poluentes. A pesquisa buscou verificar as iniciativas de sustentabilidade dos setores, com especial ênfase no uso de normas voluntárias de sustentabilidade e de padrões ESG. A fim de comprovar a veracidade das informações prestadas pelas empresas, buscou-se sempre a identificação de documentos que formalizassem as ações das empresas e de números que comprovassem seus resultados. As conclusões foram que os setores, orientados por suas associações, adotam um conjunto amplo de medidas de sustentabilidade. Essas ações, entretanto, por vezes carecem de comprovação de resultados e não impedem a adoção esporádica de condutas contrárias aos preceitos de sustentabilidade ambiental e social.

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Abbreviations

ABAL	Brazilian Aluminium Association / Associação Brasileira do Alumínio
ABCIC	Brazilian Industrialized Construction of Concrete Association / Associação Brasileira da Construção Industrializada de Concreto
ABCP	Brazilian Portland Cement Association / Associação Brasileira de Cimento Portland
ABIQUIM	Brazilian Chemical Industry Association / Associação Brasileira da Indústria Química
ABNT	Associação Brasileira de Normas Técnicas
ANP	National Agency for Petroleum, Natural Gas and Biofuels / Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
ASI	Aluminium Stewardship Initiative
CBA	Brazilian Aluminium Company / Companhia Brasileira de Alumínio
CCCs	Consultative Community Councils
CDP	Carbon Disclosure Project
Cerflor	Certificação Florestal
CNI	National Confederation of Industry / Confederação Nacional da Indústria
CO_2	carbon dioxide
CSN	Companhia Siderúrgica Nacional
CSR	corporate social responsibility
EPD	Environmental Product Declaration
ESG	environmental, social and governance
EU	European Union
FSC	Forest Stewardship Council International
GCCA	Global Cement and Concrete Association
GDP	gross domestic product
GHG	greenhouse gas
GRI	Global Reporting Initiative
GVC	global value chain
IAB	Instituto Aço Brasil
ICCA	International Council of Chemical Associations
ICMM	International Council on Mining and Metals
INMETRO	National Institute of Metrology, Quality and Techonology / Instituto Nacional de Metrologia, Qualidade e Tecnologia
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organization for Standardization
ITC	International Trade Centre

kg	kilogrammes
KPI	key performance indicator
LCA	life cycle assessment
LEED	Leadership in Energy and Environmental Design
Mt	megatons
NBR	Norma Brasileira Regulamentadora
NGO	non-governmental organisations
OECD	Organisation for Economic Co-operation and Development
PNMC	National Policy on Climate Change / Plano Nacional sobre Mudança do Clima
R&D	research and development
RBMA	Atlantic Forest Biosphere Reserve / Reserva da Biosfera da Mata Atlântica
SASB	Sustainability Accounting Standards Board
SASSMAQ	Safety, Health, Environment and Quality Assessment System / Sistema de Avaliação de Segurança, Saúde, Meio Ambiente e Qualidade
SDG	Sustainable Development Goal
SDO	Sustainable Development Outcome
SNIC	National Union of Cement Industry / Sindicato Nacional da Indústria do Cimento
TBT	Technical Barriers to Trade
UN	United Nations
UNFSS	United Nations Forum on Sustainability Standards
UNGC	United Nations Global Compact
VSS	Voluntary Sustainability Standards
WTO	World Trade Organization

Executive summary

This paper aims to examine five industry sectors in Brazil that have high levels of carbon emissions, namely the steel, oil and gas, chemical, cement and aluminium industry sectors. The analysis focus on how such sectors develop and implement sustainable practices using Voluntary Sustainability Standards (VSS), environmental, social and governance (ESG) standards, and other instruments and initiatives. The Emissions Gap Report 2022 (United Nations Environment Programme [UNEP], 2022) calls for a rapid transformation of societies to get on track to limiting global warming to 1.5°C by cutting 45 per cent off current greenhouse gas (GHG) emissions by 2030. The report estimates that the industry sector can reduce its emissions by 7.3 gigatons yearly by embracing passive or renewable energy-based heating and cooling systems, improving energy efficiency and addressing other pressing issues such as methane leaks. At the same time, in 2022 Brazil has updated its Nationally Determined Contributions committing to reduce its GHG emissions by 37 per cent by 2025 and by 50 per cent by 2030 relative to 2005 levels. Connected to this is the May 2022 adoption of a federal decree establishing sectoral plans for climate change mitigation; the decree is expected to gradually lead to sectoral targets for emission reductions.

The empirical work was carried out in three stages. In the first stage, the discussion paper focusses on the information available on the official websites of companies and associations. The second step was to contact these companies and associations via email to verify data and information. In the third step, the main information collected was organised according to the following topics: overview of the sector (with general economic data); sustainability in the sector (general view of the sector on sustainability); use of voluntary or private sustainability standards (by associations and companies); and use of ESG values (adopted by associations and companies). The organisations in the oil and gas sector were handled differently because there is significant state involvement in this sector, and the industry associations are not relevant.

In the chemical industry, the Brazilian Chemical Industry Association (ABIQUIM) emphasises the importance of achieve sustainability goals to guide the conduct of companies. The two crucial certification programmes implemented in the sector reinforce the association's relevant role. The use of VSS and ESG standards is essential for reaching sustainable targets.

The Brazilian Aluminium Association (ABAL) also has a relevant role in the aluminium sector. It established the Strategic Route of the Brazilian Aluminium Chain 2030, which is connected to the Sustainable Development Goals (SDGs). Regarding VSS, the main one identified is the Aluminium Stewardship Initiative (ASI) standard, which is applicable to the chain of custody certification and performance certification. An ESG culture in the sector is found in the Manifest Brazilian Aluminium for a Sustainable Future, created by ABAL, in the sustainability management of the sector companies.

In the cement industry, it is worth noting the importance of the Cement Technology Roadmap, which was coordinated by the National Syndicate of the Brazilian Cement Industry and the Brazilian Portland Cement Association (ABCP), in association with Brazilian research institutes and international institutions. The Roadmap establishes guidelines to reduce carbon emissions in the Brazilian cement industry by approximately 35 per cent by 2050. The companies also use several VSS and adopt ESG programmes, as exemplified in Votorantim's case.

In the steel sector, the five most significant steel production companies (ArcelorMittal, Companhia Siderúrgica Nacional (CSN), Gerdau, Ternium and Usiminas) obtained five environmental certifications linked to sustainable practices in the production of crude steel, namely OHSAS 18001, FSC (Forest Stewardship Council International), Cerflor (Certificação Florestal) and the ones derived from compliance with standards of the International Organization for Standardization (ISO), namely ISO 9001 and ISO 14001. These companies have only

recently adopted ESG practices. They are mainly guided by the Global Reporting Initiative (GRI) system, which offers a set of standards for the companies to base their sustainability reports on.

The oil and gas sector has different characteristics in Brazil. The sectoral association has little importance, and the environmental standards are public and compulsory (technical regulation). The broadest business initiative is Petrobras' Social and Environmental Program. The main VSS used is the GRI. The International Petroleum Industry Environmental Conservation Association (IPIECA) also created the SDG Roadmap for the oil and gas sector.

The selected industrial sectors show concern for sustainability issues. Their position is connected to lock-ins and path dependencies in the face of the new wave of environmental awareness, with pressure coming not only from public policies but also the internal market and from abroad. They seek to present a clear transformation strategy connecting their industrial sustainability initiatives to national targets related to the 2030 Agenda for Sustainable Development and a variety of SDGs. Sectoral associations seem to be leading with regard to green strategies together with their corresponding international institutions, thereby showing a high degree of engagement. However, most of the companies and sectoral associations themselves define and apply sustainability standards, and the non-governmental organisations (NGOs) do not have a relevant role, as observed in the agriculture sector.

The strategies of ESG standards were developed more recently and are connected to social issues, entrepreneurial responsibilities and ethics. Interestingly, in Brazil, financial entities are not leading the process for the adoption of ESG practices, which opens the space for consultancy and auditing firms.

For both sets of standards – VSS and ESG – it is evident that the central government is relatively indifferent about facing the multiplication of standards, without clear rules concerning public control. Despite this reality, it is important to mention that there is the Brazilian National Platform on VSS, which is the responsibility of the National Institute of Metrology, Quality and Technology (INMETRO). The institute has been working to create awareness about these issues since 2017, discussing the impacts of these standards on trade and producing knowledge about the topic.

There is an essential difference between the use of VSS in the agriculture and industrial sectors: agricultural VSS are defined by NGOs. They are developed according to frameworks for international standards and have transparent compliance with assessment procedures. Industry VSS are segmented into (sub-)sectors and defined by companies and associations. There is limited or no public control through certification, accreditation or other compliance assessment procedures, creating a considerable risk of greenwashing.

Concerning the mapping done by the International Trade Centre (ITC), the broadness in the agriculture sector contrasts with the lack of VSS for the manufacturing companies. For the farming sector, standards identified by the ITC are found and applied by Brazilian companies. In the manufacturing sector, the ITC only determines generic standards that are foreseen in the recommendations of international treaties, but nothing more concrete is identified.

1 Introduction: Seizing the world stage for Brazil

The world is currently experiencing multiple transitions, each of which poses both risks and opportunities for the future. The plethora of political, economic and societal transitions brings unprecedented formats to transnational cooperation, as states and non-state actors become aware of common vulnerabilities and own capabilities for jointly addressing these transitions, which are partly defined by exogenous factors. On one hand, climate change has amplified existing global and local inequalities, which reinforce conflicts. On the other hand, it has accelerated deep transformations on various levels and scales and in various sectors (Hernandez, 2021c, 2022a; Hughes et al., 2021; McCauley & Heffron, 2018; Penetrante, 2011). In addition, transnational cooperation on industry sectors will still depend on governance frameworks. These frameworks could help, for instance, with coordinating target settings and standards as national and subnational governments introduce and strengthen infrastructures and supporting policies to allow for cooperation on zero-carbon basic materials or to share best practices.

Efforts to mitigate and adapt to climate change, resulting in solutions such as the Paris Agreement, have been embedded to varying degrees by most countries in their “modernisation” priorities and development policies. This has resulted in synergies and trade-offs between climate and other goals and priorities, such as good governance, energy security, poverty alleviation, job creation and public health (Halsnæs, Shukla, & Garg, 2008; Hernandez, 2021b, 2021c; Sjöstedt & Penetrante, 2013). In addition, the emergence of new rising powers from the Global South and powerful non-state actors is challenging the existing international order and norms as well as the concept of a global society that originates from the Global North (Kahler, 2013; Murshed, Goulart, & Serino, 2011; Penetrante, 2011). For example, the Belt and Road Initiative not only represents China’s response to calls for it to assume a greater leadership role in global affairs, but it also questions existing global regimes that are dominated by Western countries (Smith, 2021; World Bank, 2019). Moreover, the increasing convening power of non-state actors – including multinational corporations and civil society groups – is laying the groundwork not only for the polycentric architecture of global governance, but also for new forms of power structures within states. These structures can be used as new channels for political accountability as well as new drivers of social innovation (Bernauer & Betzold, 2012; Chan, Iacobuta, & Hägele, 2020; Guttman et al., 2018).

At the same time, the efforts to adapt to the planetary and societal boundaries, as envisioned by the Paris Agreement and the 2030 Agenda for Sustainable Development, need to confront the various “cascades” of global and local crises. As Dirk Messner (2022) observes, the world has for decades been continually moving from one crisis to another. Therefore, it is entrapped in various cascades that hamper the motivations and capabilities to effectively address climate change. These cascades of crises include, for example, Russia’s invasion of Ukraine, restrictions on political freedoms (often justified with Covid-19 pandemic measures), the vulnerability of societies to disinformation, uneven access to scientific knowledge about climate protection, the water conflict between Ethiopia and the adjacent states along the Nile River, and the emerging trade conflicts due to the new due diligence law in several European states (Felbermayr, Godart, Langhammer, & Sandkamp, 2021; Hernandez, 2021a; Mbaku, 2020; Synovitz, 2020). As countries in the Global South reject taking a backseat and demand more recognition and participation in global policymaking, the architecture of global governance as well as the meaning of multilateralism are currently changing. This is leading to various contestations between the Global North and the Global South, as well as between countries within the Global South (Hernandez, 2021c; Kumar & Messner, 2010; Messner & Leggewie, 2014).

At the forefront of these challenges is Brazil. As a rising global power, Brazil seeks to ensure the compatibility of its global leadership with its national identity. Although Brazil gained international recognition and symbolic power by hosting the 2016 Olympic and Paralympics

Games as well as the 2014 Football World Cup, this new soft power did not fully resonate within the Brazilian population. Instead, the shortcomings of the country's public services (especially public health in light of the Zika virus), its slowing economy, high crime rates and political corruption seized the national discourse (Aguirre, 2016; Schausteck de Almeida, Marchi Júnior, & Pike, 2013). It became evident that Brazil still needs to connect its global ambitions with its domestic priorities and national context. On one hand, Brazil is fulfilling its international commitments to combat climate change, as reflected in its National Climate Change Plan and the related ambitious emission reduction targets (Governo-Federal, 2007; Sánchez, 2021). On the other hand, it still needs to find effective ways of translating these international commitments to decarbonise into tangible opportunities for the Brazilian society at large, which includes companies, industrial sectors as well as private households.

At the same time, as Brazil seeks a global leadership role after years of political upheaval, it needs to confront other enduring challenges related to its efforts to achieve its sustainable development priorities. Brazil aims to revise its domestic goals to better align them with multilateral environmental agreements as well as with other multilateral non-environmental agreements that are still linked to environmental and climate issues because of trade-offs and co-benefits (e.g. trade, security, energy). Here, the major challenge is combining positive sum issues that are defined by common vulnerabilities with zero sum issues in which competition between states and the related power asymmetries limit the preparedness of states to cooperate (Hernandez, 2022a). At the same time, these linkages call for transitions in related industrial sectors that lead to changes, for example in production practices and economic policies.

1.1 Connecting the global to the local – Brazil's "greening" instruments

To address the challenges mentioned above, this paper identifies the following five main (global) governance frameworks for "greening" that provide Brazil instruments to connect global environmental and climate protection visions with local solutions and related actions:

- the World Trade Organization (WTO) with the Technical Barriers to Trade (TBT) agreement;
- NGOs and other private actors with their Voluntary Sustainability Standards (VSS);
- financial institutions employing environmental, social and governance (ESG) standards;
- the Organisation for Economic Co-operation and Development (OECD) with its guidelines and recommendations on due diligence for several production chains;
- the United Nations (UN), particularly the UN Forum on Sustainability Standards (UNFSS) and the VSS National Platform and Initiatives advancing awareness, knowledge production, transnational cooperation, capacity-building and the promotion of governance (e.g. code of actions and materials).

Aligning environmental and climate protection priorities with the mandates of these instruments remains a major stumbling block. One major reason is that existing policy frameworks and economic interests in many countries have yet to be geared towards fossil fuels and carbon-intensive activities (OECD, IEA, NEA, & ITF, 2015). At the same time, the sequencing of environmental and climate protection principles with these instruments offers new opportunities not only for decarbonisation, but also in overcoming other political constraints. For example, carbon pricing – either through carbon tax or cap-and-trade, as implemented by the European Union (EU) and other "low-carbon leaders" such as California – paved the way not only for low-carbon policy by building new economic interest groups and networks that support decarbonisation and climate justice, but also for new green finance instruments (Meckling, Sterner, & Wagner, 2017). Nevertheless, there are several researchers and activists who argue

that market-based solutions for decarbonisation are often overestimated because policies are the drivers of increasing emissions (Buira et al., 2021; Holscher, Frantzeskaki, & Loorbach, 2019; Meckling, Sterner, & Wagner, 2017). Another example is the positive impact of sustainability reporting on firm performance in terms of operational performance (return on assets), financial performance (return on equity) and market performance (Tobin's Quotient) (Al Hawaj & Mohamed Buallay, 2021).

These five frameworks and the related instruments for greening are still evolving as several sectoral transitions towards sustainability unfold. The WTO has no agreement on trade and the environment. There are only a few references to the environment in all WTO Law, such as in the preamble of the Marrakesh Agreement and the Agreement on TBT (article 4), the Agreement on Subsidies and Countervailing Measures (ASCM) (article 8.2.c), the Agreement on Agriculture (AoA) (preamble and annex 2) and TRIPS (Agreement on Trade-Related Aspects of Intellectual Property Rights) (article 27). However, the WTO Secretariat has already listed more than 13,000 environment measures related to trade (sustainability database), most of them classified as TBT measures established by governments. The International Trade Centre (ITC) in Geneva is also examining the issue from the perspective of the private sector. For example, in a 2020 report, the ITC constructed its mapping of around 350 VSS created by independent NGOs (Bissinger et al., 2020). Recently, financial institutions – including credit institutions and investment firms providing credits to responsible investors – began to play an important role in environmental governance. In a 2021 report, the European Banking Authority analysed the resilience of institutions to the potential financial impacts of ESG risks that require early and proactive measures (European Banking Authority, 2021). However, the proliferation of ESG standards with no or less coordination, fewer certification procedures and little supervision is perceived by financial institutions as a threat. Increasing the complexity of this scenario are the current initiatives of several European countries and the OECD to follow the guidelines and recommendations on (social and environmental) due diligence, which will substantially affect several production chains (Business & Human Rights Resource Centre, 2020; Zamfir, 2020). With all these instruments, private actors need to answer the question – which rules to follow.

VSS, also often referred to as private sustainability standards, are key sustainability instruments in two of the five frameworks. They are defined as

> standards specifying requirements that producers, traders, manufacturers, retailers or service providers may be asked to meet, relating to a wide range of sustainability metrics, including respect for basic human rights, worker health and safety, the environmental impacts of production, community relations, land use planning and others. (United Nations Forum on Sustainability Standards [UNFSS], 2022, p. 4)

Companies are increasingly placing VSS at the centre of their sustainability efforts not only to ensure the stability of global value chains (GVCs), but also to help them mitigate environmental crises and contribute towards the achievement of sustainability goals such as fostering food security and job creation (UNFSS, 2022). At the same time, because of the additional challenges and barriers presented to the Global South because of VSS – such as the increase in production costs due to high compliance costs and restrictions on the integration of smallholders and producers from developing countries into GVCs through exclusionary effects – VSS need to be a subject in discussions concerning transnational cooperation (Hernandez, Reiners, & Grimm, 2021). To address these barriers, five UN agencies have established the UNFSS to support decision-makers and other stakeholders in developing countries in expanding their knowledge about VSS.

This paper identifies a gap in the current academic literature on VSS, which tends to cover the connection of sustainability, climate protection and environmental integrity with the agriculture sector and the food industry (Corrêa, 2019). However, the changes related to the environmental restrictions derived from international commitments (such as the Paris Agreement) affect

policies and private-sector preferences outside of these two sectors. Behavioural changes among companies in other sectors, such as the manufacturing sector, are also game changers for sustainable development. Against the background of most companies in the manufacturing sector perceiving the greening framework as barriers, this paper offers a new area of study and explores how these five "greening" frameworks are affecting the preferences and behaviours of business and industry actors from five sectors in Brazil with high levels of carbon emissions*: steel, oil and gas, chemical, cement* and *aluminium*. These sectors were chosen for this paper because they are classified as "hard-to-decarbonise" or "hard-to-abate" industries. They have technological, logistical and economic challenges to reach zero carbon dioxide (CO_2) emissions and have currently limited mitigation options (Fischedick et al., 2014; Hebeda et al., 2023). These sectors are integrated in the Carbon Border Adjustment Mechanism (CBAM), proposed by the EU. In addition, improving the environmental performance of these industries will have significant effects on many social and environmental goals. The steel industry is responsible for 7 per cent of global CO_2 emissions (2020), and it also intensively consumes energy and water. The oil industry is attributed with the continuous emission of liquid effluents characterised by wastewater containing by-products that are harmful to the environment and communities in the vicinity. The chemical inputs released during the production process by the chemical industry have adverse effects on human health and the environment. The negative environmental impacts of the cement industry, which range from air contamination in the crushing of limestone, to the bagging of the final product, are made throughout the entire industrial process. Lastly, the aluminium industry requires intensive mining in bauxite mines.

In contrast to common perceptions, actors from these often called "dirty" industry sectors (Mani & Wheeler, 1999) have already started to redefine their "greening strategies", as they are increasingly being confronted by overlapping standards as well as shifts in consumer demand. Using the Brazilian experience, the analysis of this paper focusses on how these high-emitting sectors develop and implement sustainable practices using VSS and ESG standards. Table 1 provides a brief overview of the data and information that will be analysed in this paper more deeply, confirming the significance of these sectors with regard to climate protection, environmental integrity and sustainable development.

Table 1: Macro-data of the polluting sectors in Brazil

Sectors	Share of GDP	Exports share	World ranking	Exports (2019, in US$ billions)	GDP 2019 (in US$ billions)	Emissions (estimated) Mt CO_2
Chemical industry	10%	4.50%	6	13.1	150	104.2
Steel	3.19%	5.70%	9	7.3	48	33.3
Oil and gas (HS 27)	13%	10.95%	10 (oil)/ 31 (gas)	24.2	195	135.46
Aluminium	1.2%	0.35%	15	3.77	18	12.5
Cement	7.9% (civil construction)	0.01%	12	0.037	120	82.3

Notes: GDP (gross domestic product); Mt (megatons).

Sources: AÇOBRASIL (2020), National Agency for Petroleum, Natural Gas and Biofuels (ANP, 2020), Brazilian Aluminium Association (ABAL, 2020b), Brazilian Chemical Industry Association (ABIQUIM, 2022a), Ge, Friedrich, and Vigna (2020) and National Union of Cement Industry (SNIC, 2019)

1.2 Methodology and approaches – research questions and analytical framework

The overarching research question of this paper is:

> *How are the governance frameworks leading to concrete greening in the high-emitting industry sectors in Brazil?*

Answering this can provide insights that help to answer emerging questions in sustainability research:

- Relational infrastructures for climate protection and sustainable development
  - Which types and constellations of governance structures and institutions can help facilitate cooperation between (public- and private-sector) actors to advance climate protection and sustainability goals?
- Global to local scales and vice versa
  - How can the local context of politics, policies and polities be adequately reflected when applying global visions and the related instruments such as carbon pricing?
- Human behaviour at different levels
  - How can international agreements such as the Paris Agreement help challenge unsustainable patterns of human behaviour as well as modify local configurations of power and inequalities that maintain high-carbon path dependencies?

Before answering these questions, this paper introduces a theoretical framework that characterises the theoretical assumptions made here. This analytical framework allows for a focussed comparison between the “ought to be” and the empirical reality. This comparison allows for the formulation of explanations for the deviations, which will offer insights on possible answers to the abovementioned questions. In addition, the theoretical framework can guide the prescriptive analysis by providing potential benchmarks: Under which conditions can the desired benchmarks be achieved? However, this paper is not able to provide an evaluation of the measures taken (initiatives, VSS and ESG), because more time would be needed for these to evolve in terms of their impacts. At the same time, existing indicators used to measure impacts still need to be revisited.

To answer the overarching research question, this empirical case study commences with the comparative mapping of the landscape of sustainability goals in the five high-emitting industry sectors in Brazil, with special emphasis on the use of VSS and ESG values. This sustainability mapping includes an assessment of whether and which of the aspects of sustainability – environmental, social and economic – companies are implement equally. This assessment provides insights on how, for example, they conceptualise and define the social relevance and environmental impacts of their operations, products and services. Furthermore, the assessment offers insights on the milestones and approaches of decarbonisation being pursued by the companies of the five industry sectors in Brazil. This can eventually indicate how sustainability principles such as just transitions are increasingly defining business visions and strategies. In addition, the sustainability mapping can shed light on how companies and other sector actors are dealing with overlapping standards as well as shifts in consumer demand.

The mapping of the sustainability measures of each of the industry sectors consists of three stages: (1) *background research on the sectors’ sustainability*, (2) *verification of background information* and (3) *documentation of information*. In the first stage, the paper focussed on the information provided about the sustainability of each sector, as presented to the public through the websites of companies and associations. By exploring the companies’ websites, the research focussed on documents that formalise and define in detail their sustainability initiatives and programmes. As far as possible, the research also sought documents that proved and

evaluated the concrete results of these initiatives. For example, when identifying that the company declared its commitment to the circular economy, specific programme documents were sought to prove that this commitment was put into practice. For example, that was the case when researching the programme Recycling that Transforms, which was created by Dow and has clear impacts on a poor part of the population that works with selective waste collection on the streets of large urban centres.

The second step after mapping out sustainability measures was communicating with companies and associations to verify the data and information gathered. Information about the following topics were collected:

A. Sectors

1) identification of the analysed sectors
2) economic information provided by the sector
3) identification of sector-wide association(s)
4) identification of the sector's sustainability initiatives and the acknowledgement of any sustainability standards being promoted
5) identification of the associated companies with the largest market shares

B. Companies

1) verification of the adoption of ESG values and the 2030 Agenda for Sustainable Development
2) identification of sustainability, decarbonisation and conscious energy consumption projects
3) identification of sustainability standards

Relevant to the collection of data is the use of the ITC Standards Map. This database for sustainability standards provides information on more than 200 standards for environmental protection, worker and labour rights, economic development, quality and food safety, and business ethics (International Trade Centre, 2022). The keywords provided on the platform helped with the search for the relevant sectors and the related industry sector-wide standards. The second step also involved seeking public information and formulating questions, which were directly communicated with the relevant associations and companies. The respondents answered the following questions, and the collected and organised information was used to consolidate the empirical work of this paper:

1) Which initiatives did they develop to help implement the 2030 Agenda for Sustainable Development?
2) In case they developed initiatives, are these of commercial concern?
3) How are these commercial concerns monitored and addressed inside the company?
4) Is there any mechanism within the company that monitors consumer preferences?
5) Is sustainable production a trend for the company?
6) Is the company employing any VSS and/or ESG values?
7) Which strategies have been developed and implemented by the sector to conserve and protect the climate and the environment?

Following verification of the information, the third step involves the organisation of the collected information and classifying it into the following topics:

1) overview of the sector (with general economic data)
2) sustainability in the sector (general view of the sector on sustainability)
3) use of voluntary or private sustainability standards (by associations and companies)
4) use of ESG values (adopted by associations and companies)

However, the steps taken for the oil and gas sector deviate from the abovementioned procedures. The reason is the significant degree of state involvement in this sector in Brazil. Because of this, the industry associations are, for example, not relevant due to the different types of market concentration in this sector.

The fourth and last step is the formulation of lessons for both theory and practice. Presenting Brazil's experiences – both shortcomings and good practices – sheds light on the challenges that similar industry sectors in developing countries with emerging economies, such as China, India, Indonesia, Mexico and South Africa, need to overcome.

Finally, it is important to clarify that this work does not aim at evaluating the extent to which the identified policies and initiatives work. This is due to the fact that some sustainability measures still lack standardisation, which makes it very difficult to access results, as well as the need for more time for these measures to evolve. This effectiveness evaluation is a suggestion for future work.

2 A theoretical framework for "greening": The role of initiatives, VSS and ESG in the scaling game to achieve sustainability

The process of implementing the Paris Agreement and achieving the Sustainable Development Goals (SDGs) is complex for many reasons (Hernandez, 2022a, 2021c; Rogelj et al., 2017). The varying capabilities of countries to design and implement greening policies are one major source of complexity (McCauley & Heffron, 2018; Penetrante, 2013). The success of policy cycles – *problem definition, agenda-setting, adoption, implementation and evaluation* – depends on various resources and factors such as good governance, geopolitics as well as on what many social scientists and philosophers call "Zeitgeist", which can either generate support that achieves critical mass or public resistance to greening policies (May & Wildavsky, 1978; Hiery, 2001). Whereas some countries can easily implement greening policies through technological innovation, others face additional barriers such as unique carbon lock-ins, which limit the scope of implementation (Djelic & Quack, 2007; Hernandez, Pacheco Rojas, & Barrón Villaverde, 2021; Reyes Hernandez, 2020). However, as this paper argues, despite capabilities defining the feasibility of policies, actions from non-state actors such as companies and networks will not be sufficient to achieve the necessary structural changes to slowly shifting paradigms and eventually drive greening activities as state actors fail. Interestingly, this paper contends that such activities can be observed in industry sectors that are largely perceived as *anti-hero* in transformations towards sustainability.

Throughout this research work, the different types of "greening" from the five high-emitting industry sectors are explored to identify whether and how companies and sectoral organisations define the social, environmental and economic relevance of their operations, products and services from the vantage point of sustainability. Greening is often used to depict sustainability efforts by and for the financial, business and/or industry sectors (Altenburg & Assman, 2017; Bohnenberger, 2022). In other words, greening efforts of the private sector or policies implemented by the public sector are therefore instruments that aim at aligning market practices and technological or organisation innovation with sustainability principles. Some of these

greening efforts are directly related to the application of VSS and ESG values; others are unclassified and have hybrid characteristics that depend on a multiplicity of aspects, causes and consequences. Therefore, to understand this greening process, a theoretical framework is necessary to conceptualise and eventually evaluate these greening efforts.

In this complex context, one of the difficulties in controlling the effectiveness of companies' sustainability efforts is often the absence of independent control in terms of monitoring and compliance. At the same time, initial efforts can already be observed in some sectors where companies have already established de facto control mechanisms. Aligning these de facto control mechanisms with credible monitoring and compliance measures is an important next step to avoid greenwashing. Generally, state agencies and civil society entities have this controlling role (Bernauer & Betzold, 2012; European Center for Constitutional and Human Rights e.V., 2019). In the case of the companies chosen for this research work, some have closer relationships with civil society entities (e.g. the aluminium sector). In other cases, the relationship is distant (e.g. oil and gas), primarily because those companies undergo stringent government control and they do not see the need for the involvement of addition actors. As a rule, companies operating in a more competitive market that need to maintain a good image in society and depend on a large amount of private investment are interested in closer relationship with civil society. This example illustrates the need to conceptualise the necessary governance and structural conditions to ensure the effectiveness of sustainability initiatives and shows how these can serve as multipliers for new initiatives.

The first and currently the most dominant discussion on greening policies has been consolidated by the 2012 "World Bank Annual Report", which coined the term "inclusive green growth" and identifies it as *the* pathway to sustainable development (World Bank, 2012). The report defines greening policies as those that aim at supporting inclusive green growth and allow the world's poor and developing countries to reconcile the rapid growth required to come to the desired level of prosperity while improving the management of the environment. Greening policies include a blend of smart solutions to eliminate obstacles to greening growth such as political and behavioural inertia and a lack of financial instruments (World Bank, 2012). The greening of economic systems has been recognised as a deep transformative force, as it allows the private sector – both the civil society and industry/business sectors – to substantially contribute towards sustainability without a "fat" or "big" government (Madrick, 2009). At the same time, as the Brazilian case shows, the greening of the economy is not possible without a minimum level of state intervention because the economic system is inherently not sustainable. There is a need for more action from the state, either to align policies with VSS or to support some industrial sectors with research policies, among other instruments. The discussions on "greening" policies are continuously gaining ground in areas outside technology-driven and economic discourses. For instance, debates on urbanisation and sustainable cities have coined "greening" policies as those that can conserve green spaces, despite competing societal demands such as affordable housing, economic development and infrastructure provision (Artmann, Kohler, Meinel, Gan, & Ioja, 2019; Bush, 2020).

The theoretical framework of this paper focusses on greening, or "green transitions". Green transition as a concept is distinct, as it refers primarily to systemic changes that are driven by sustainability efforts in finance – in other words, by new policy designs and policy mixes that aim at mobilising new financial resources to improve, for instance, the quantity and quality of production and consumption, and in the long-run improve the competitiveness of business and industry actors that opt for sustainable practices (Lamperti, Mazzucato, Roventini, & Semieniuk, 2019; Skjoldager et al., 2021). At the same time, greening policies often focus on the interlinkages between energy, resources utilisation and paradigm shifts in high-emitting industry sectors. This paper goes beyond the green transition definition and uses *greening* as the *systemic changes brought about by efforts of business and industry actors to align their organisations, technologies and processes with sustainability principles*. This greening can be driven by green finance as business and industry actors revisit their cost–benefit calculations.

Despite this approach still being in an early stage (Lamperti et al., 2019), this paper contends to provide insights from the Brazilian case study to demonstrate how greening instruments are introduced and implemented from the bottom. Which factors are changing the game in the high-emitting industry sectors in Brazil that motivate greening? Which interrelated techno-economic paradigm changes that enable greening from the bottom are created by which reconfigurations of existing economic structures, societal relations and institutions in Brazil?

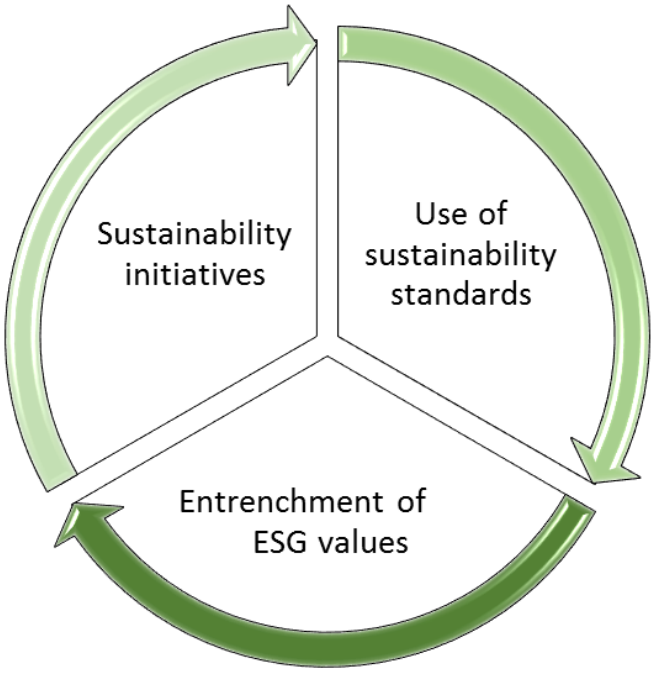
Table 2: A theoretical framework for "greening" or green transitions

Dimensions	Variables and indicators	Theoretical assumptions
Actors	Cooperation	(1) Several interacting actors and networks of actors from the public and private sectors (entrepreneurs, local communities, different levels of government, civil society groups) across state boundaries cooperate to carry out, channel and adopt different forms of innovation that create enabling conditions for greening (Ciarli, Savona, & Thorpe, 2021; Hale, 2020; Hernandez, 2022b).
Issues	Normativity of greening	(2) Greening is related to the concept of sustainability, climate protection, deep transformation and their normative instruments, and therefore cannot be separated from just transitions (Ahmad, Fielitz, Leinius, & Schlichte, 2018; Hughes et al., 2021; McCauley & Heffron, 2018; Rogelj, Geden, Cowie, & Reisinger, 2021; Schlaile et al., 2017).
	Mixing of issues, policy instruments and actions	(3) The interlinkages of issues and the resulting trade-offs, co-benefits and synergies necessitate the mixing of policy instruments and actions of non-state actors to explore synergies and trade-offs (von Lüpke & Well, 2019; Weitz, Strambo, Kemp-Benedict, & Nilsson, 2017).
Structures	Relational infrastructures	(4) Relational infrastructures that go beyond technologies and involve human interactions are needed to align, coordinate and sequence greening policies, activities of sectors and technological innovation (Hernandez, 2022a; Hernandez & Vogel, 2022).
Processes	Multiple phases	(5) Greening instruments (both policies and non-state actions) are embedded in a wider context of transformation towards sustainability, which implies the need for a meta-framework to manage the heterogeneity of actors, the relational infrastructures that promote cooperation between them, and governance and institutions that connect issues and structures (Grießhammer et al., 2015; Hernandez, 2022a).
	Innovation in human development	(6) Greening processes can unfold when the focus goes beyond technological innovations and expands to social and institutional innovations (Elzen, Geels, & Green, 2004; Grießhammer et al., 2015; Hebinck et al., 2021; Hernandez, 2022a; Moore et al., 2014).
Outcomes	Trade-offs and externalities	(7) Cooperation between interacting actors and networks can be created due to varying access to technologies and opportunities (Christensen, Bauman, Ruggles, & Sadtler, 2006; Hernandez, 2022a).
	Multiplying effects of policies and actions	(8) Greening can create new activities that can either render existing ones obsolete (incl. technologies) or reinforce existing asymmetries that promote them, requiring new skills while making old ones redundant, prompting upgrades in skills that can exclude those who are not willing or who are unable to do so (Rogelj et al., 2018; Velasco-Herrejon & Bauwens, 2020).

The theoretical framework of this paper consists of theoretical assumptions that can be empirically tested using the sectoral case studies for Brazil. These assumptions are represented in Table 2. The theoretical assumptions are classified according to the dimensions *actor, issues, structures* and *outcomes* to highlight the systems approach. Each dimension represents a perspective that entails a distinct set of priorities. The variables and indicators pertain to a selection of enabling factors that can drive greening. They can be considered as both a means and an end to greening. On one hand, they are the requirements for greening. On the other hand, they are themselves priority goals that can stand alone. The successful orchestration of these enabling factors can help steer and complete the transformation process towards sustainability (Hale & Roger, 2014; Hernandez, 2021d). Each variable and theoretical assumption can be attributed to a type of sustainability measure – initiatives, sustainability standards and ESG values. However, this attribution is not in absolute terms, as some measures cannot be clearly classified. This attribution characterises the cyclical nature of sustainability measures, as elaborated upon in the next sections.

The next step is to conceptualise the relevant sustainability measures, such as VSS and due diligence. This paper introduces a typology of these measures and argues that they can also be analysed as a cycle. Figure 1 illustrates the analytical framework in order to assess later whether and how the five sectors are adopting sustainability principles.

Figure 1: Analytical framework – the three phases of greening



Source: Authors

As illustrated, the three phases of greening considered in this mapping are: 1) *sustainability initiatives*, 2) *the use of sustainability standards* and 3) *the entrenchment of ESG values*.

First greening phase: Sustainability initiatives

Sustainability initiatives refer to (voluntary) measures implemented by companies as a response to changing conditions in the legislation, corporate social responsibility (CSR) measures and society at large (e.g. consumption patterns). Even before the first global agreements on sustainable development, the private sector had largely recognised that with their role as an

engine of growth comes commitments to both society and the environment. Corporations, investors, industry associations and networks have engaged in various activities to support and complement the sustainable development policies of the public sector (Hestad, 2021). In 2020, multinational companies such as Microsoft, Mastercard, Starbucks and BlackRock pledged to reduce their carbon emissions through improvements in their operations and new investments. Currently, many influential companies and private-sector actors see themselves as partners in achieving sustainable development (Ayling & Gunningham, 2017; Guix, 2021; Hestad, 2021). However, as is explained below, some of these sustainability initiatives can already be outcomes of previous cycles.

Acknowledging the diversity in private-sector engagement, this paper attempts to conceptualise sustainability initiatives as concrete efforts of business and industry sectors to align their goals, milestones and targets with those of sustainable development. These initiatives are often implemented to pave the way for more ambitious efforts in the future. In other cases, these initiatives might not have direct benefits for the company but work as confidence-building measures to facilitate relations with communities. However, because the implementation of these initiatives is often not fully formalised, or because these efforts were scheduled to be implemented anyway, they can be perceived by the public as "greenwashing" tactics for reputational purposes. Here are some examples of these initiatives:

1. Impact investment that reconciles social and environmental impacts alongside financial return.
2. Reductions in the consumption of water, energy and other natural resources in direct operations, including production and distribution.
3. Material support to civil society groups, such as women's movements, that are working towards sustainable development.
4. Planting trees or direct material support for reforestation projects.
5. Digitalisation of operations, including transport, to reduce waste and loss of resources.
6. Inclusion of sustainability principles in business models, highlighting long-term profits from environmental and social sustainability.
7. Improvement of CSR portfolios.
8. Information campaigns to educate consumers on the benefits of sustainability.
9. Participation in public–private partnerships to help the state render (welfare) services to society.
10. Adopting technologies and practices that can help prolong the life of products.

Referring to the theoretical framework can provide insights on the possible roles of sustainability initiatives in the greening of the five high-emitting sectors. The sustainability initiatives implemented by a company can be both the means and outcomes of their cooperation with other public- and private-sector actors (*theoretical assumption #1*). These initiatives can represent a company's strategy to further foster cooperation by signalling reciprocity (Messner, Guarín, & Haun, 2013). Reciprocity is a calculated positive response to an initiative of another actor, thereby consolidating trust, for example, in the value chain or society at large. For example, a company's initiative to reduce its consumption of water and other natural resources signals that it can be a viable and credible societal partner in related issues. This initiative can help build its reputation and boost the credibility of its products and services. As Messner et al. (2013) contend, reciprocity is – together with trust, communication, reputation, fairness, enforcement and we-identity – a basic mechanism that can ensure the success of cooperation. In addition, the intention of a company to cooperate can be driven by the acknowledgement that it is better off with cooperation towards sustainability than remaining isolated or being part of the "merchants of doubt", which is a group of companies, key individuals and interest groups

involved in disinformation about climate change and ozone-depleting substances (Oreske & Conway, 2011). Sustainability initiatives can be a way for a company to signal where exactly it stands between “sustainability agents” and “merchants of doubt”.

Sustainability initiatives are initial instruments that can connect companies’ intrinsic goals with normative societal goals and show that they identify with the normative goals of sustainable development such as just transitions, human rights and environmental protection (*theoretical assumption #2*). As the Brazilian case study shows, when companies identify with these goals, they develop intelligent and innovative products and services that, for example, can help save energy and conserve water, which can help them ensure their long-term competitiveness.

Second greening phase: (Voluntary) sustainability standards

To bring consistency and scalability to the sustainability measures, companies can opt to push for these sustainability initiatives to become widely accepted sustainability standards or link them with existing standards. Besides improving the quality and performance of their products, reduce risk and support reputations, companies can use standards to access additional benefits (e.g. increased premiums), gain access to additional markets (e.g. the *bio* or organic market), reduce monetary and non-monetary risks in the value chain, attract the best employees or be considered the first mover or leader and reliable suppliers (Hernandez, Reiners, & Grimm, 2021; Smith et al., 2019; UNFSS, 2013). First movers and leaders often have additional competitive advantages, as they can set the technical narratives on specific issues or introduce technical standards that best suit their operations (Egidi & Narduzzo, 1997). In general, standardisation across sectors is a response to the need to monitor and evaluate impacts using repeatable procedures to ensure comparability. Standards represent a consensus on uniform indicators of quality and safety to attribute change to a specific action. Although some sustainability standards are de facto mandatory, they are primarily voluntary, as they offer demand-led or market-based regulatory instruments to achieve sustainability (UNFSS, 2013, 2018). VSS are requirements that producers, traders, manufacturers, retailers and service providers voluntarily commit to and are monitored against (UNFSS, 2013). Examples of relevant VSS for the selected high-emitting industry sectors in Brazil are:

1. SEDEX Global Supplier Ethical Data Exchange
2. UN Guiding Principles on Business and Human Rights
3. Carbon Trust Product Footprint Certification
4. Eco Vadis
5. International Labour Organization Labour Standards
6. LIFE Certification
7. OECD Guidelines for Multinational Companies
8. Social Accountability International - SA8000
9. UN Global Compact (UNGC)
10. Aluminium Stewardship Council

Referring to the theoretical framework, VSS are bottom-up instruments that can be mixed with policy instruments implemented by the state and actions of other non-state actors to cover areas that cannot be legislated (*theoretical assumption #3*). Although some of the sustainability standards are sector-specific (e.g. Aluminium Stewardship Council), others cover multiple sectors or connect issues such as business with human rights (e.g. UN Guiding Principles on Business and Human Rights). These sustainability standards can eventually become de facto mandatory or parts of legislation. They can offer needed (relational) infrastructures and

knowledge for legislated corporate social and environmental due diligence (*theoretical assumption #4*). VSS can help monitor, evaluate, report and implement social and environmental due diligence obligations, because both instruments are based on similar requirements and use overlapping infrastructures and related disclosure elements.

Third greening phase: The entrenchment of ESG values

As companies are increasingly "greening", they entrench sustainability principles in their organisations. The entrenchment of ESG values as the third greening phase refers to the point by which the implementation of several sustainability initiatives and the adoption of sustainability standards have helped aligned the "culture" and "values" of companies to sustainability principles. This alignment means that ESG values have become intrinsic or "entrenched". This indicates that ESG values as lock-ins are instrumental in present and future decisions. They have become the self-evident guidelines of business operations and of incentives or penalties, as companies can be held accountable for failing to follow the guidelines, either to their investors or society at large. Therefore, entrenchment generates more concrete measures. In addition, entrenchment refers to that "scaling game" (Hernandez, 2022a), which pertains to the long-term efforts of actors such as companies to replace non-sustainable (carbon) lock-ins. The actors internalise sustainability principles due to the way they become self-enforcing and deeply embedded in the company's governance structure, organisation, business culture, personal interactions and relationships with suppliers and consumers. At the same time, entrenchment means that deviations from the newly established sustainability norms can be directly or indirectly sanctioned, because failing to adhere to these norms means unacceptable material disadvantages (*theoretical assumption #5*). For example, due to the EU taxonomy (European Union, 2020), which is a classification system that allows comparability of companies by establishing a list of environmentally sustainable economic activities, companies that are lagging behind are more likely to become unattractive to investors in the long term.

The greening of the companies can be operationalised through the three-fold scaling of sustainability principles in companies (Hernandez, 2022a; Moore, Riddell, & Vicisano, 2015): (1) *scaling up* (institutionalisation of guidelines in the organisation), (2) *scaling out* (focus on impact through replication and dissemination) and (3) *scaling deep* (changing relationships within and outside of the value chain, cultural values and mandates). Scaling up refers to the institutionalisation of sustainability principles as guidelines or a "tolerable window" within the company. The degree of scaling up can be used as an indicator to compare companies. For example, it is manifested through the close proximity of their CSR departments to their executive boards; the re-orientation of the risks and chances for management to effectively manage emerging risks and identify the emerging opportunities behind greening; and the strengthening of change management to limit the shocks and disruptions following fundamental shifts in priorities. Scaling up makes sustainability principles mandatory in future decisions, which are regularly monitored and evaluated, most likely by independent parties to ensure compliance.

Scaling out is indicated by the replication of a company's ideas on innovation in other companies, with the intention of achieving similar results (Hernandez, 2022a; Moore et al., 2015). As companies become confident leaders in the relevant sector or in the communities in which they operate, they become confident about sharing their good practices with their counterparts. However, their preparedness to share their methods with the public demonstrates that this intention is not specifically driven by altruism, but rather by their sense of responsibility to the global society as well as local societies (*theoretical assumption #8*). At the same time, scaling out implies sectoral leadership, which allows the company to further define and set the scope of lock-ins that can be beneficial in the long run. In addition, as companies face common vulnerabilities, sharing good practices can help reduce the risks they face by distributing the risks among themselves. Finally, as sectors continuously scale up and out sustainability principles, the products and services of companies are measured not only for their quality, but

also their impact on the achievement of other societal sustainability goals, such as the reduction of inequality or gender injustice or access to quality education (*theoretical assumption #7*). This is particularly relevant in a post-growth future, where the non-monetary value of products and services is as important as financial gains in terms of the companies' attractiveness to investors.

Scaling up and out are both prerequisites of scaling deep. Scaling deep pertains to the attainment of "big cultural ideas" from the perspective of actors such as companies and sector representatives. The concepts of these ideas have been influenced by previous measures and the organisation cultures of companies (Hernandez, 2022a; Moore et al., 2015). For example, new ideas about the future of work have emerged from the responses of companies to the Covid-19 pandemic. Scaling deep involves structural changes driven by the transformative learning of actors. Newly learnt ideas about – and points for debate on – a decarbonised world or post-growth are then shared and replicated, not only among companies and sectors, but also in society. These ideas are concretised through stories or sociotechnical narratives, which are then later used as benchmarks and provisions in key performance indicators (KPIs) to evaluate advances in business operations. In simple words, scaling deep is driven by learning processes. Through the KPIs, sustainability principles and their benefits are mainstreamed, which eventually helps in appraising the learning rate and capacity of the company (and therefore its resilience). The inclusion of sustainability principles in the KPIs will lead to sustainability becoming an identifying marker for the company. This inclusion will link sustainability to the company's cooperative and competitive relationships with other companies and society (*theoretical assumption #6*). It will most likely lead to technological innovations that respond to societal needs such as the advancement of digital technologies, thereby enabling the company's products and services to fulfil sustainability goals such as saving energy or reducing food waste and loss (Food and Agriculture Organization of the United Nations, 2019; Hernandez & Prakoso, 2021).

The "greening" of high-emitting industry sectors in Brazil

Research scholars and policymakers advancing sustainable development often have a "love-hate" relationship with the high-emitting industry sectors (Binder, 2001). On one hand, these sectors – such as those extracting natural resources or transforming crude oil or coal into final fuels such as petroleum products – are the main polluters among producing sectors. Yet, changes in the composition of the economy and policy instruments such as subsidies that favour these sectors are difficult to implement due to their material and geopolitical importance to the state and society. On the other hand, these sectors can play key roles in implementing sustainability policies, as minor changes in these sectors could already be beneficial for the environment. At the same time, sectors such as the chemical industry can offer "bridging technologies" and products that can help other sectors and society at large to reduce their material consumption levels (Turnheim et al., 2015). In addition, as many oil-exporting countries have proven, revenues from these sectors can be used to invest in technological innovations that can speed up the green transition. Moreover, although some of these high-emitting industry sectors are declining, other sectors are experiencing a renaissance following Russia's invasion of Ukraine. Therefore, any transformation pathway towards sustainability will need the engagement of these sectors.

In the case of Brazil, these high-emitting sectors will continue to play a key role in the country's sustainable development pathway (Governo Federal, 2007). Not only are these sectors major sources of employment and income, they are – as compared with sectors in many other countries with emerging economies – not declining. Their current engagement in sustainable development will make it more difficult for policymakers to justify further restrictions, as many of them have more ambitious environmental protection goals. Nevertheless, as the following mapping shows, there is still room for improvement, particularly in the social dimension of sustainability. In addition, these industry sectors are key to Brazil's global leadership ambitions.

The theoretical framework introduced in this paper serves as the common thread for the mapping of the sustainability efforts of each of the five industry sectors in Brazil. The framework also allows for a comparison of the different sectors in terms of their current greening status as well as in terms of the challenges each sector is facing.

3 Becoming part of the solution by being a role model – the "greening" of the chemical industry sector of Brazil

The chemical sector has a dual and often opposing role with regard to environmental sustainability. Although the sector produces and handles substances that are highly harmful to the environment as well as human, animal and plant health, chemical companies are also primarily responsible for creating and improving products and solutions that can contribute to the preservation of fauna and flora, the reduction of climate change and the recovery of environments degraded by human actions, such as rivers, lakes and forests. In relation to other dimensions of sustainability, the role of the chemical industry is less ambiguous, as it is represented by companies endowed with social responsibility and the capacity for positive local transformation. The sector enables the development of new technologies and materials so that production in other industries becomes increasingly sustainable. Examples of the sustainable uses of chemical industry technologies: harnessing renewable sources; the transformation of biomass as an alternative source for the preparation of liquid fuels; the use of agricultural sources to produce compounds with high added value – such as fragrances, perfumes, additives – and the use of hydrates of carbon (such as sugar, cellulose, etc.) as precursors of synthetic intermediates and biodegradable polymers (Sbartati Nudelman, 2010).

In 2017, the chemical industry contributed US$5.7 trillion to global GDP – 7 per cent of the world's GDP – and supported 120 million jobs. Over the course of 2017, the global chemical industry invested an estimated US$51 billion in research and development (R&D), supporting 1.7 million jobs and US$92 billion in economic activity (International Council of Chemical Associations [ICCA], 2020; International Institute for Sustainable Development, 2019). The Brazilian chemical industry is the eighth-largest in the world. In Brazil, it is responsible for 10 per cent of industrial GDP, which places it as the third-largest entity in the country's manufacturing sector, which accounts for 2 million direct and indirect jobs. However, the Brazilian chemical industry has little participation in international trade: The country ranks 31 among exporters and importers of the world (ABIQUIM, 2021). Most of its production is directed to the domestic market, which, in turn, is supplied mainly by national industries. Part of the explanation for the lack of international trade lies in the origins of the companies that operate in the Brazilian market and in their sales strategies: They are multinational companies that seek to sell mainly to the domestic market and, secondarily, to the Mercosur (Southern Common Market) and ALADI (Latin American Integration Association) countries. A similar scenario can be observed, for example, in the automobile sector. In both cases, foreign trade is not a priority for companies. Thus, it is understood that non-tariff barriers are not the largest obstacle to the internationalisation of trade in the chemical sector.

3.1 Challenges for the chemical sector in Brazil

The sustainability measures promoted by companies in the sector cannot guarantee the absence of environmental, social and ethical shortcomings on the part of companies. Many of the companies that invest in sustainability also adopt, even if residually, problematic and even illegal conduct. In historical terms, the chemical industry in Brazil was associated with some of

the most serious instances of environmental damage. In the 1980s, the city of Cubatão became world famous and came to be considered the most polluted city in the world. Its inhabitants, especially children, began to suffer from serious respiratory problems. The large concentration of chemical factories and the topography of the city (located in a valley of the Serra do Mar) created a pocket that did not let emissions (of gases) rise to a higher level in the atmosphere (da Silva, de Azambuja Maraschin, Geisler Bispar, Cordeiro da Silva, & Nardon Noal, 2020). Although the situation in Cubatão has improved and the country's environmental legislation has become more stringent, there are still occasional cases of abuse and environmental damage by chemical companies. For example, the Capuava Petrochemical Complex, located in the municipality of Santo André, in the state of São Paulo, has been criticised by environmentalists and the target of fines and lawsuits. Companies such as Braskem operate at the Pole, which was fined by the health authorities due to the release of odoriferous substances into the atmosphere (Mesquita, 2021).

Another example involving Braskem concerns a serious environmental disaster in the city of Maceio, in the state of Alagoas, where its mining activities resulted in the subsidence of the soil of the region. Studies by the Geological Survey of Brazil pointed out that five neighbourhoods in the city were sinking, and that the rock salt mining in the region by Braskem was to blame (Madeiro, 2022). Furthermore, the storage and transport of chemical products can often put the population and the environment at risk. Leaked products can cause accidents that pose risks to the health of the population, due to inhalation of vapours, for example. Another serious example of environmental damage is the contamination of the subsoil and groundwater.

3.2 "Greening" of the Brazilian chemical industry sector

In Brazil, the chemical sector's sustainability efforts are coordinated and monitored by the Brazilian Chemical Industry Association (ABIQUIM). The Association, through a series of voluntary programmes, promotes several dimensions of sustainability, always seeking to observe the SDGs. As with companies in other sectors, the country's large chemical companies present several sustainability initiatives, regularly publishing documents that formalise and disclose their programmes and the results achieved. In this sector, companies with national capital, which are listed on the country's stock exchange, present more detailed data on their initiatives. On the contrary, transnational companies sometimes do not present specific information about their programmes and results in Brazil. Despite these efforts, large companies in the sector are frequently involved in cases where there are violations of environmental laws. However, such involvement is rare and therefore should not disqualify the general sustainability efforts of the analysed companies.

ABIQUIM covers around 3,000 products that are used in the chemical industry itself (ABIQUIM, 2022a). It is the main entity in the chemical sector in Brazil, and it coordinates the sustainability efforts of the companies, setting the agenda and goals as well as suggesting priorities. ABIQUIM draws its convening power in the sector from the mandate given by its members. The chemical industry in Brazil seems to take the path of sustainability through sector-wide VSS and the recent adoption of ESG values. This path is embodied by the two certification programmes implemented, which are the Programme of Responsible Action (Programa Atuação Responsável) as well as the Safety, Health, Environment and Quality Assessment System (SASSMAQ). Whereas the Programme of Responsible Action has become de facto mandatory because membership in or affiliation with ABIQUIM requires the adoption of this programme, SASSMAQ is a certification scheme that members adopt.

ABIQUIM is a signatory of the UN Global Compact, whose operations in Brazil take place through the Global Compact Rede Brasil (Tavares, 2021). The UN Global Compact provides a universal language for corporate responsibility and provides a framework to guide all businesses, regardless of size, complexity or location. It helps businesses to commit to, assess,

define, implement, measure and communicate their sustainability strategies. Corporate and organisational success requires stable economies and healthy, skilled and educated workers, among other factors. Sustainable companies experience increased trust in their brands and investor support. More than 10,000 business participants, and 5,000 non-business participants in the UN Global Compact are already changing the world by alleviating poverty, addressing labour issues and reducing environmental risks around the globe.

ABIQUIM also participates in international and national discussions on the subject at the Energy and Climate Change Leadership Group of the International Council of Chemical Associations (ICCA), and at the Advisory Committee of PMR Brazil Project, an initiative of the World Bank in partnership with the Ministry of Economy (ABIQUIM, 2020; National Confederation of Industry [CNI], 2020). The association emphasises the contribution of the chemical industry to the achievement of sustainability goals. For example, the chemical industry is relevant for generating jobs, ensuring food safety, developing health care products, improving water technology, producing clean energy, etc. (ABIQUIM, 2021). Some examples of the importance of the chemical industry are: the development of new drugs, the improvement of pesticide correctives and the invention of new materials favourable to the circular economy.

The measures set by ABIQUIM reinforce the provisions established by legal instruments and usually have goals that are more ambitious. For example, the Olho Vivo Road Programme (Programa Olho Vivo na Estrada), an initiative that aims to prevent accidents on the roads, establishes a set of activities and instruments not provided by law, such as the communication of risky behaviours (ABIQUIM, 2022c; UN Global Compact [UNGC], 2022). The initiative is part of a risk management system in which the goal is to reduce the number of road accidents involving the transport of chemical products to zero. In other words, the programme aims at continuous improvement for the logistical stage of the production chain by creating a risk management system to reduce accidents, with a focus on human behaviour. With the support of ABIQUIM, the Brazilian Association of the Alkali, Chlorine and Derivatives Industry (ABICLOR) and the Transport Social Service and the National Transport Learning Service (SEST SENAT), the programme is shared with the entire chemical industry in Brazil and its logistics service providers. ABIQUIM has a set of measures related to sustainable development in accordance with the SDGs (UNGC, 2022). The following table summarises the sector's greening efforts.

Table 3: ABIQUIM and SDGs

Programme or project	SDGs	Content
Responsible Care Programme (ABIQUIM, 2022b)	SDGs 3, 4, 6 and 8	Voluntary certification programme on Responsible Care. The objective is to improve the safety, health and environmental performance of the chemical industry.
Safety, Health, Environment and Quality Assessment System (ABIQUIM, 2022b)	SDGs 3, 8, 11, 13 and 14	Voluntary certification programme to be used by logistic companies. The objective is to ensure that the transport of chemical products is responsible and sustainable.
Olho Vivo Road Programme (ABIQUIM, 2022c)	SDGs 3 and 16	This programme aims to prevent accidents on the roads.
Consultative Community Councils (CCCs) (ABIQUIM, 2022c)	SDGs 3 and 4	This programme is targeted to ensure more security to communities who live around chemical industry facilities. Through this programme, projects and courses are promoted in the communities.

Source: Authors, based on ABIQUIM (2022c, 2022b)

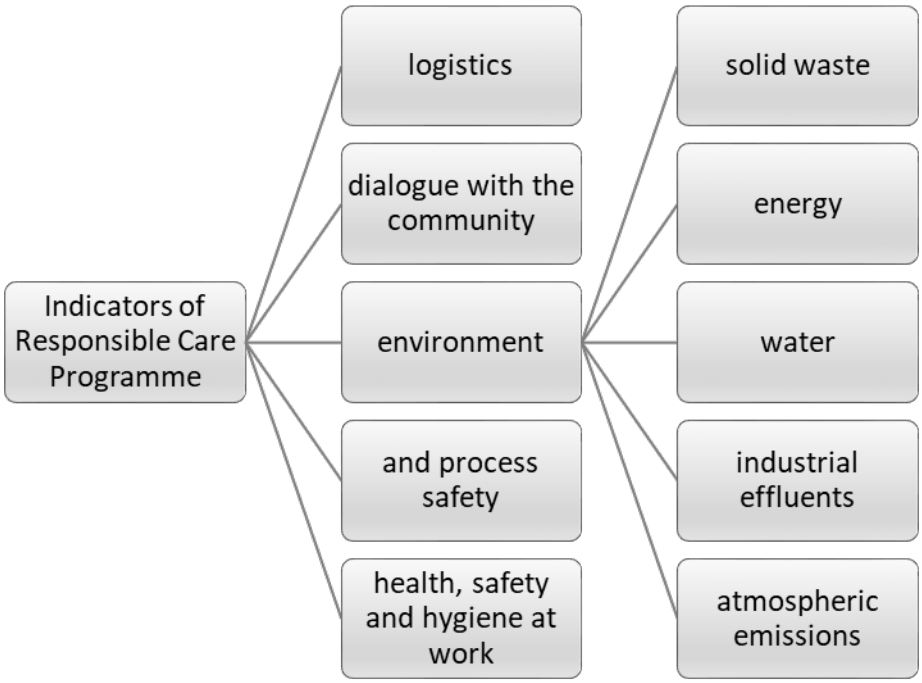
The efforts listed in Table 3 can be classified both as sustainability initiatives and VSS, because they pave the way for more concrete activities – coordinated and monitored by ABIQUIM – and because they encompass a degree of monitoring and compliance. Most are voluntary and seek more ambitious goals than those contained in the legal provisions, although they also attempt to explicitly converge with legal norms. Many companies in the industry develop different and often more ambitious initiatives than those listed above. ABIQUIM has two certification programmes: the Responsible Care Programme and SASSMAQ.

Responsible Care Programme

The Responsible Care Programme is part of the chemical industry's transparent and open strategy for continuously improving health, safety and the environment. The programme promotes a sustainable chemical industry (ABIQUIM, 2022c). Joining is voluntary, but to be an ABIQUIM affiliate, it is necessary to adopt this programme, which encourages a Global Products Strategy application, for example. The strategy is an initiative developed by the ICCA that is based on the product stewardship elements of Responsible Care and the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) legislation of the EU. It is also a contribution to the application of the Strategic Approach to International Chemicals Management and for compliance with the UN Environment Programme (ISOPA, 2022).

The Responsible Care Programme is based on the analysis of different groups of indicators: health, safety and hygiene at work; logistics; dialogue with the community; environment; and process safety. The environment axis is subdivided into solid waste, energy, water, industrial effluents and atmospheric emissions (ABIQUIM, 2018). Companies can be certified through a compliance assessment procedure. They can also carry out self-assessments and issue self-declarations to prove compliance with the requirements. ABIQUIM had audited all of its associates as of 2022 (ABIQUIM, 2022c).

Figure 2: Indicators of Responsible Care Programme



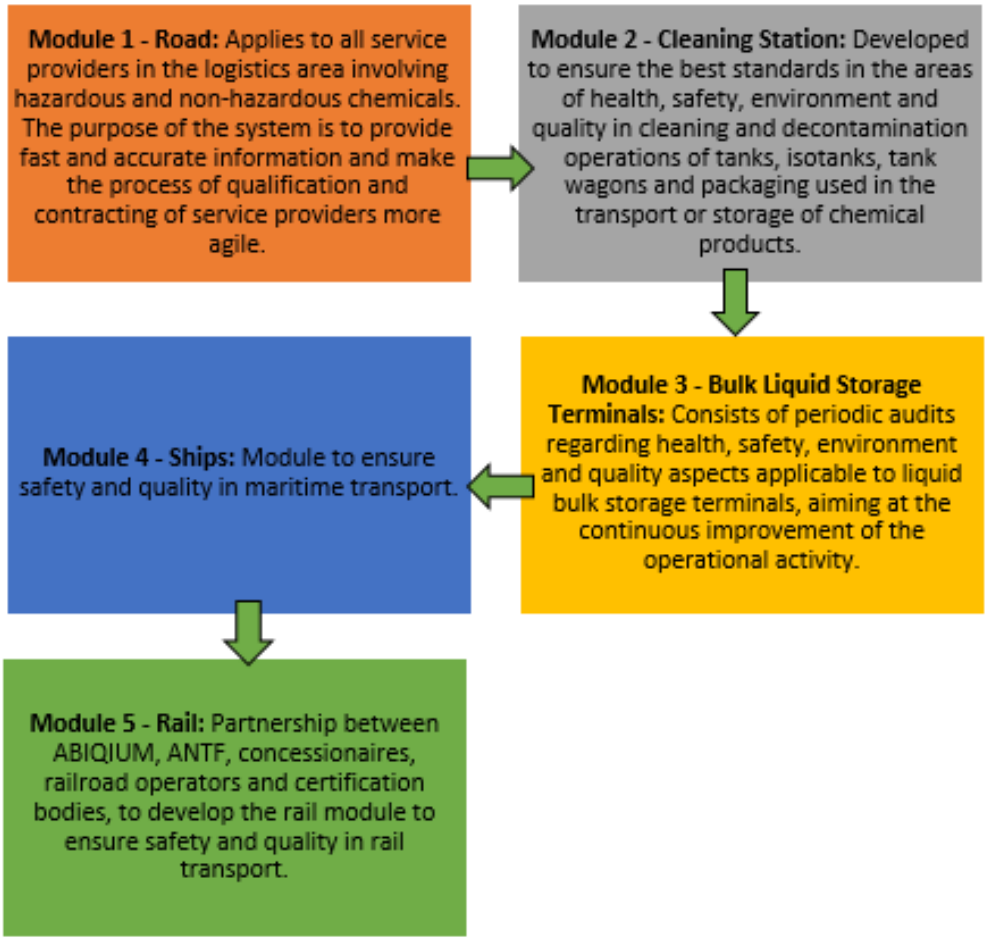
Source: Authors, based on ABIQUIM (2018, 2022a, 2022c)

In terms of purposes, the programme is clearly more ambitious than the legal provisions. For example, concerning safety and well-being at work, it seeks not only to comply with legal provisions on working hours and accidents at work, but also to reward companies that avoid accidents and require shorter working hours (ABIQUIM, 2018).

Safety, Health, Environment and Quality Assessment System

SASSMAQ is the certification of responsible and sustainable performance managed by ABIQUIM. It is applied to companies, usually in logistics, that provide services to the chemical industry. This is a company evaluation system that is carried out by independent certifying bodies accredited by ABIQUIM. Based on the assessment, a report is generated on the service provided by the company that encompasses its administrative, financial and social aspects. SASSMAQ is not mandatory, but according to the Association, there has been significant adoption of this certification. In 2018, around 850 units were evaluated by the system, covering a significant percentage of the almost 1,000 chemical factories in the country (PwC, 2013). Improvements have been observed in the performances of these companies. SASSMAQ is divided into five modules: road, cleaning station, bulk liquid storage terminals, ships and rail (see Figure 3).

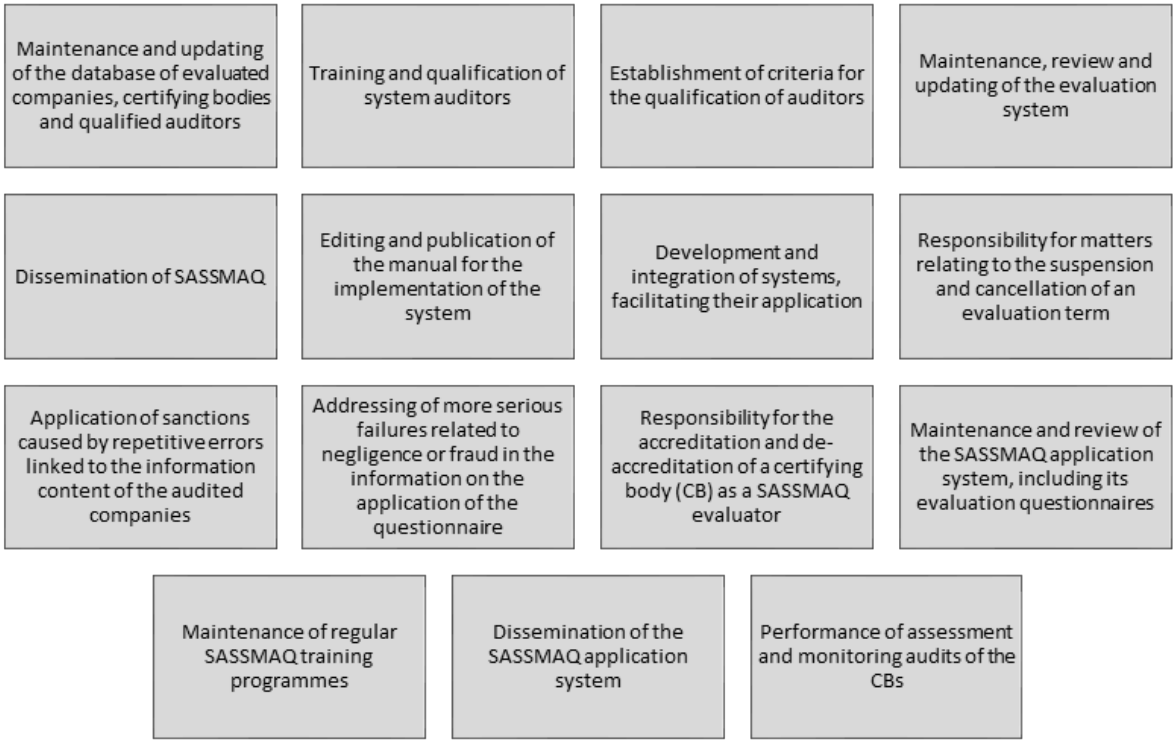
Figure 3: Five modules of SASSMAQ



Source: Authors

ABIQUIM's management of SASSMAQ involves the activities described in Figure 4.

Figure 4: ABIQUIM's management of SASSMAQ



Source: Authors

ABIQUIM's management of the system implies that it cannot prevent any certifying body from accessing its services if the general requirements are met and establish undue conditions of any nature, including financial ones that prevent certifying bodies from accessing the assessment process (SASSMAQ, 2021). This increases the number of certified bodies and broadens the available Quality Infrastructure and may decrease the costs for the companies because there will be more availability of certifying bodies near companies. It basically opens the system to multiple certifying bodies and facilitates access to certification. Such facilitation makes the existence of non-certified companies in the sector unreasonable and increases the pressure for certification, which is non-madatory.

To become a certifying body accredited by ABIQUIM, it must also be accredited by a national or international accrediting body for the application of two systems, namely the Quality Assurance System (ISO 9000), the Environmental Management System (ISO 14000) and/or the Health and Safety Management System (OHSAS 18001 or similar). In addition, it must meet the following requirements: 100 ISO 9000 certifications and 30 ISO 14000 certifications; or 100 ISO 9000 certifications and 10 OSHAS 18000 certifications; or 30 ISO 14000 certifications and 10 OSHAS 18000 certifications. These requirements manifest the important role of standards in this sector in Brazil.

Olho Vivo Road Programme

The programme trains drivers who transport chemical loads by road to be agents of observation of unsafe behaviour on roads and highways, identifying risk situations and contributing to the development of measures to prevent accidents (ABIQUIM, 2022c). The concept of the programme is that, before a major accident, there were minor failures in operations that were not properly addressed. In this sense, the programme encourages the driver to report these failures, enabling the adoption of corrective actions, as well as the prevention and elimination of unsafe attitudes.

Consultative Community Councils

The CCCs stand out as the main channel for dialogue between the industry and the nearby population, promoting dialogue with the community and serving as one of the priorities of the chemical industry (ABIQUIM, 2017). Through the CCCs, companies help, for example, prepare the community for emergencies that may arise from industrial operations, with a focus on activities related to safety, health and the environment. For instance, the CCC for Cubatão reached 20 years of action in 2019. Formed by representatives from industries, the public sector, civil society and community leaders, the forum is a channel for open dialogue conducted by the Center for Integration and Development (Cide) and gathers its members monthly to debate topics related to the Industrial Complex and the surrounding communities. Each member plays a role of spokesperson to disseminate relevant information to the other neighbourhoods they represent.

3.3 Good practices from Brazilian companies from the chemical industry sector – "greening" through VSS and entrenching ESG values

In addition to the sector-wide efforts to achieve sustainability, the biggest players in the chemical industry sector have adopted multiple VSS. At the same time, some of the players are already entrenching ESG values. The survey selected the five largest companies in the chemical products market, based on revenue and market share in Brazil.

Table 4: Sustainability standards used by companies

Braskem	Sustainability Accounting Standards Board (SASB); Responsible Care Management System (RCMS); Bonsucro (etanol); International Sustainability and Carbon Certification (ISCC) – Tracking emissions' chain to the inventory of GHGs; stock index portfolio with Corporate Governance Trade; index portfolio Carbono Eficiente of B3 (Brazilian stock exchange); Programa Global de Sustentabilidade (Carbon Disclosure Project, CDP); listed in the Índice de Sustentabilidade Empresarial – ISE; EcoVadis; Life Cycle Initiative; ISO 9001, ISO-14001, ISO-37001, ISO/TS 16949, ISO 50001
BASF	Together for Sustainability AISBL (TfS); Responsible Care Developed; Value Balancing Alliance (Value to Society (BASF, 2022k)); AgBalance® (elaborated from the European Commission Recommendation in 2017 and ISO 14040 and 14044); SEEbalance®; Product Carbon Footprint (based on ISO 14044, ISO 14067 and on Greenhouse Gas Product Protocol Product Standard). BASF starts sharing its proprietary digital solution and methodology to third parties via licensing agreements (BASF, 2021); BASF's eco-efficiency analysis (based on DIN EN ISO 14040 e 14044); Targeting of Sustainable Solution (helps third parties to measure the contribution of their products to sustainability); Bioplastic (based on European DIN EN 13432, North American ASTM 6400, Japanese Green PLA, Australian AS 4736) (BASF, 2022d)
Oxiteno	Roundtable on Sustainable Palm Oil (required of palm oil suppliers); EcoVadis Sustainability Rating; Programme of Responsible Action; OHSAS 18001 (in transition to ISO 45001); UN Global Compact; ISO 14064-1, ISO 9001, IS0 14001, ISO 26000; the GRI; International Labour Organization Labour Standards
Dow	Green Building LEED (Leadership in Energy and Environmental Design); Responsible Care® Initiative; the GRI; Dow Jones Sustainability World Index; Great Place to Work® Certified; HRC's Corporate Equality Index; International Sustainability and Carbon Certification (ISCC) system (Dow, 2020); EDGE certification; ISO-14001, ISO-9001; UN Global Compact
Elekeiroz	ISO 9001:2015; Responsible Care Programme

Source: Authors

3.3.1 Braskem

In 2019, Braskem's net revenue was US$9.8 billion and gross profit was US$1.0 billion for the company's operations in Brazil, which involve around 6,000 employees (4,674 men and 1,358 women) (Braskem, 2019). Braskem has the Global Strategy for Sustainable Development initiative based on an analysis of the challenges and global trends for achieving the SDGs of the 2030 Agenda and the Paris Agreement. The strategy has three main areas of work or areas of action: (1) Increase the number and quality of sustainable processes and resources, (2) making the product portfolio increasingly sustainable and (3) providing solutions to enable society to live an increasingly sustainable life. The strategy applies to all investments, operations, products, services, acquisitions, joint ventures and divestments involving Braskem (Braskem, 2018).

The company recognises the new challenges of having the carbon-neutral circular economy meet the targets of the SDGs and Paris Agreement (Braskem, 2020b). Braskem has some projects based on the Global Strategy: "I'm Green" provides a portfolio of products for the circular economy; there is also a partnership with the University of Illinois, USA, to develop research on the capture and use of CO_2 in industrial processes; and finally there is the Global Volunteer Programme. It has also begun to structure a Community Engagement Framework.

The company assesses energy efficiency and the use of renewable energy. According to company data, at least 74 per cent of all electricity purchased globally comes from renewable sources. In 2019, the company started the Energy Efficiency Programme, which is focussed on the use of energy from renewable sources such as wind and solar. Braskem is among the best chemical companies in the world in terms of the intensity of energy consumption (Braskem, 2022a). For example, initiatives such as the cracker, adopted in Bahia, resulted in a reduction of 833 GWh of energy consumed and a reduction of 247,000 tons of CO_2.

Due to the signing of contracts with a solar and wind energy company, Braskem estimates avoiding the emitting of around 1.5 million tons of CO_2. Braskem's corporate inventory accounts for 100 per cent of the company's global operations and, in 2020, received the Gold classification from the Brazilian GHG Protocol Programme for coverage of emissions in Scopes 1, 2 and 3 (Braskem, 2020b). According to the company, GHG emissions were reduced more than 17 per cent (almost 30 million tons of CO_2) between 2018 and 2020 (Braskem, 2019). In 2016, the Internal Carbon Pricing methodology was adopted in Brazil. Braskem has a goal of reducing direct GHG emissions by 15 per cent (from 10.8 million tons of CO_2 to 9.2 million tons of CO_2).

In addition to its efforts in environment sustainability and energy efficiency, Braskem has taken important steps to address social issues. In its community investments, Braskem – in addition to its Global Volunteer Programme – is leading further initiatives to promote social inclusion and the socio-economic development of workers in waste-sorting units by advancing the development of the national recycling chain. The company is also active in the creation of an online learning network on conscious consumption and sustainability whose content encompasses: conscious consumption and post-consumption; the promotion of workshops dedicated to environmental education and training to support the restoration and conservation of the environment; the generation of income for the population; the promotion of local culture in Maceió; and the creation of green areas around Braskem units in Alagoas, Bahia and Rio Grande do Sul, where there are learning environments about sustainability, conscious consumption, product life cycles and biodiversity. In addition, Braskem collaborates with universities such as Petrobras University, investing in improvement programmes in the areas of process engineering and mechanical maintenance, in particular.

The company uses the Customer Satisfaction Score to assess weekly satisfaction and customer satisfaction. In the scope of reputation management, it uses the RepTrak® methodology to analyse the perceptions of stakeholders on emotional aspects (which include the degree of study,

admiration, empathy and trust) and seven rational dimensions: products and services, innovation, work environment, governance, citizenship, leadership and performance. Braskem's reputation on the circular economy, ESG and innovation is considered to be positive (Braskem, 2019).

Under the ESG concept, Braskem has adopted its Code of Conduct: Commitment to Ethical, Honest and Transparent Performance (Braskem, 2020a). This code aims at establishing guidelines on Braskem's professional responsibilities as well as on interactions with the company's customers, shareholders, suppliers and business partners. It has guidelines in the social, environmental and economic scope of the company. These include the reinforcement of the Global Strategy for Sustainable Development as well as measures to combat harassment and discrimination, determine transparency and provide accurate communication with investors, among other things.

Braskem's ESG values showed improvement from 2020 to 2021, as evaluated by the following agencies: Vigeo Eiris (rating/score 51/100, in February 2020), ISS ESG (rating/score C, in July 2020), CDP (rating/score A-Clima and A-Água), in December 2020), MSCI (rating/score B, in February 2021), and DJSI (rating/score 70/100, in November 2021) (Braskem, 2022b). Although there is still room for further improvement, Braskem's efforts represent an important benchmark for the sector.

3.3.2 BASF

In 2019, BASF's net revenue was R$5.7 billion and gross profit was US$139.7 million for the company's operations in Brazil, which involve around 4,000 employees (Química e Derivados, 2012). BASF supports the achievement of the SDGs through its more than 60 projects worldwide, many of which are in Brazil (BASF, 2022c). BASF is concerned with being more efficient in its production and use of energy, as well as increasing the use of renewable energy. BASF also has initiatives to development new technologies, replace fossil raw materials and reduce CO_2 (BASF, 2022e).

Due to its ESG concept, BASF shares are attractive to investors looking for businesses that are related to environmental, social and governance standards. The company is considered a leader in ESG, as the leading ESG rating agencies classify BASF as representing a benchmark within the chemical industry, particularly in its integrated sustainability reporting, business ethics and the development of sustainable products. BASF has published information and opportunities related to climate change and the use of water and forests under the CDP, which is an international organisation that represents more than 560 investors with US$106 trillion in assets and more than 150 major buyers with more than US$4 trillion in spending on acquisitions. BASF was ranked among participating chemical companies as being in the top 25 per cent (BASF, 2022g). BASF is also listed in the FTSE4Good Index Series, which features companies that meet strict criteria for social, environmental and corporate governance. In turn, the ISS ESG classified BASF in the "Prime" category, indicating that the company meets specific criteria in terms of social and environmental compatibility. BASF was also recognised for addressing material sustainability issues, for example business ethics, the Environmental Management System and energy efficiency. In the MSCI ESG 2021 classification, BASF has an A grade, an indication that it has clean technology and a robust carbon mitigation strategy. According to Sustainalytics, BASF is among the top 10 per cent of diversified chemical products companies, standing out for meeting its sustainability goals. As for the Vigeo Eiris classification, BASF is classified in the "Advanced Performance" category, with a total score of 60 out of an average of 48 (BASF, 2022g).

According to the company, the concept of sustainable development is difficult to apply in practice. Therefore, it has developed methodologies to help verify whether the process or product is sustainable (BASF, 2022c). The methodologies identified are:

- Value for society: A method adopted by BASF to communicate the company's value for a sustainable future that led to the development of the Value Balancing Alliance.

- BASF's eco-efficiency analysis: The analysis considers end-user behaviour as well as disposal and recycling options. This analysis contains questions about: the needed amount of energy to serve the customer's benefit, the triggers and waste results, and the quality of parameters and costs of packaging (Saling, 2022).

- SEEbalance®: A socio-eco-efficient analysis developed by BASF to compare different product and process alternatives as well as to directly compare the alternatives while considering the following dimensions of sustainability: the economy, the environment and society. This methodology assesses the environmental impacts and costs of products and processes as well as their social impacts. The production of this method has been the result of cooperation between the company and several academic institutions (BASF, 2022h).

- AgBalance®: This is a life cycle assessment (LCA) tool that allows farmers to review their current agricultural operation to achieve sustainable agricultural production (BASF, 2022a).

- Product Carbon Footprint (PCF): a methodology that sums up total GHG emissions generated by a product at different stages of its life cycle. A digital application was developed by BASF to calculate the cradle-to-gate PCFs of its 45,000 products on sale. These objectives reinforce the company's determination to comply with the Paris Climate Agreement (BASF, 2022f).

- Sustainable Solution Steering: a tool that helps its customers to create more sustainable solutions; establish new regulations and standards in the value chain and establish changes in the social and business environment. The objective is to increase BASF's portfolio with innovative and sustainable solutions, reduce the environmental impacts along the value chain and mitigate the risks associated with sustainability (BASF, 2022j).

In addition to the methodologies of analysis that were developed by BASF, sustainability projects were implemented by the company. Examples of these projects are:

- ChemCyclingTM targets plastic waste that is not mechanically recycled for technological, economic or ecological reasons. Through the project, chemical recycling is used to process plastic waste streams that have not been recycled. This form of recycling is considered important in the recycling scenario (BASF, 2022b).

- The Supplier CO2 Management Programme has the objective of achieving transparency in the CO_2 obtained in raw materials (BASF, 2022f).

- The Circular Economy Programme aims to use more recycled and renewable raw materials. By 2030, the goal is to double sales by generating circular economy solutions. It focusses on circular raw materials, new material cycles and new business models as well as the replacement of fossil raw materials (BASF, 2021).

- Starting Ventures helps low-income people achieve a better quality of life by offering solutions for their businesses as part of the company's mission to achieve a sustainable future (BASF, 2022i).

In Brazil, the following projects are worth mentioning:

- Espaço ECO Foundation: It was founded in 2005 and is based on a pioneering and innovative vision, recognition by and investment of BASF. The Foundation is qualified as an OSCIP (Civil Society Organisation of Public Interest), thus it reinvests the resources it obtains through commercial projects via studies, research and activities aimed at developing sustainable attitudes that benefit society. It prepared around 250 studies and projects around

the concept of LCA: measuring the environmental, social and economic impacts of products and services along the entire value chain. It planted more than 1.2 million native Atlantic Forest seedlings, reforesting around 73 hectares of land through the Mata Viva® programme (BASF, 2022g).

- Water Producer Incentive Programme: The programme was implemented in the city of Graratinguetá (SP) together with the municipal government, the Espaço ECO Foundation and other partners to increase the availability of water in the Ribeirão de Guaratinguetá Hydrographic Basin. Through the practices and management of soil conservation, the recovery of riparian forests and protection of remnants of native vegetation and springs (encouraging rural producers to take care of permanent protection areas on their properties) has been achieved. Eight years after this initiative, there has been an observed annual 3.4 per cent reduction in surface water runoff and 18.9 per cent reduction in soil erosion (BASF, 2022g).

3.3.3 Oxiteno

In 2019, the net revenue of Oxiteno was R$4.2 billion and gross profit was US$1.0 billion for the company's operations in Brazil, which involve around 1,800 employees (4,674 men and 1,358 women) (Ultra, 2019). Oxiteno has a Strategic Sustainability Plan focussed on the following areas: supply chain; economy; environment; safety; valorisation of the workforce; ethics, transparency and integrity; product portfolio and product safety (Oxiteno, 2022c). The following elaborates the aforementioned areas (Oxiteno, 2022c):

- Supply chain: The aim here is to promote sustainability in the supply chain through the consumption of raw materials within "good supply practices". An example is the purchase of palm kernel oil (óleo de palmiste) certified by the Roundtable on Sustainable Palm Oil. This area is related to SDGs 3, 11, 16 and 17.

- Economy: The economy aspect aims to generate value for shareholders through financial returns that are greater than the costs of integrated capital. It seeks to increase competitiveness through, for example, advances in the use of technologies. This area is related to SDGs 8 and 9.

- Environment: This is where the specific targets for water, waste, energy and GHGs are advanced. For water, the goal is to reduce the amount of water consumed per ton produced by 10 per cent (2019 base) as well as to double the amount of water from reuse (2019 base). For waste, the aim is to have zero landfills for industrial waste and to reduce waste generation by 10 per cent. For energy, the goal is to reduce energy consumption per ton produced by 10 per cent (base 2019). Moreover, in GHG, it aims to reduce the intensity of emissions per ton produced by 25 per cent (base 2008). Advanced Process Control is used to reduce GHG emissions. This area is related to SDGs 6, 7, 11, 13 and 14.

- Safety: The aim is to rank among the benchmarks of the chemical industry in terms of safety. The area is related to SDGs 3, 8, 9 and 12.

- Valorisation of the workforce: The aim is to develop a management model that generates superior results as well as to value people and promote evolution in the work environment. It relates to SDGs 3, 4, 5, 8 and 10. For example, Oxiteno has a Quality of Life Programme to promote health and well-being for its employees. It is part of the "Valuing the Workforce" pillar of the company's sustainability plan and is structured on five fronts: physical health, emotional health, well-being, self-development and relationships.

- Ethics, transparency and integrity: The aim is to support the culture of ethics and compliance with integrity initiatives and transparency. It relates to SDGs 5, 8, 10 and 16.

- Product portfolio: The aim is to develop solutions that are aligned with society's needs as well as environmental and social impacts. It relates to SDGs 2, 3, 6, 7, 13, 14 and 15. For example, at the Tremembé (SP) unit, a project was carried out to replace the consumption of fuel oil with natural gas. This was for the production of steam used in the production process of the entire unit. In 2020 (the first year in which the plant operated entirely with natural gas), there was a reduction of 2,300 tons of CO_2. There was a sharp drop in the amount of pollutants emitted into the atmosphere, such as nitrogen and sulphur oxides, carbon monoxide and particulate matter (Oxiteno, 2022b).
- Product safety: The aim here is to develop products that are safer for both people and the environment. It relates to SDGs 3 and 12.

Furthermore, Oxiteno is concerned with developing processes to reuse waste under the concept of circular economy (Oxiteno, 2020). In relation to this, the company is committed to the following projects and actions:

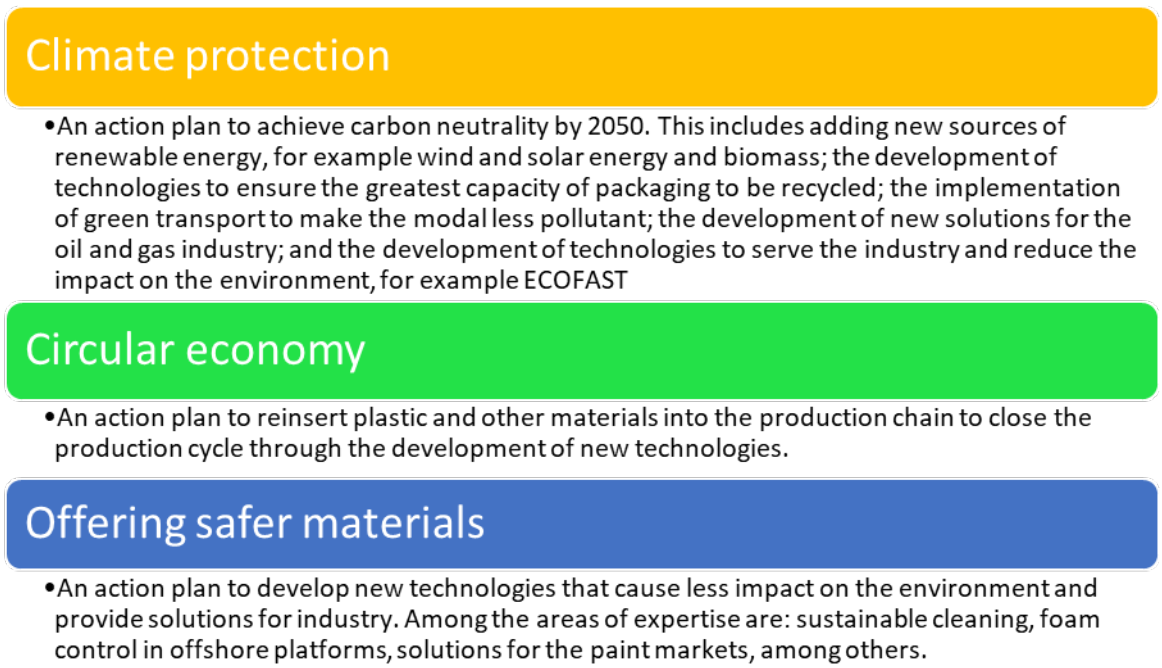
- Structuring Together: Oxiteno's diversity and inclusion programme.
- Life Cycle Assessment Programme: The aim here is to quantify the environmental impacts of products and provide information for the development of solutions (Oxiteno, 2022a).

However, despite the sustainability report and the Strategic Sustainability Plan, which present several values that can be classified as ESG, Oxiteno does not address ESG directly.

3.3.4 Dow

Another major chemical company in Brazil, Dow, has more than 2,000 employees and 10 production units distributed throughout the different states of the federation. Dow's performance is aligned with the achievement of the SDGs of the 2030 Agenda and the UN Global Compact (Dow, 2020). Dow's collaboration towards a sustainable chemical industry has three focus areas in Brazil: climate protection (Dow, 2022d), promotion of the circular economy (Dow, 2022c) and offering safer materials (Dow, 2022b). Figure 5 illustrates Dow's sustainability measures.

Figure 5: Dow's sustainability policy



Source: Authors

The company encourages its carriers to participate in the Programa Logística Verde Brasil and Transporte Limpio (Mexico). It has started the Recycling that Transforms programme (Reciclando que Transforma) with the objective of increasing the quality of life of people who work with recycling and the productivity of their projects. The company participates in the Regional Initiative for Inclusive Recycling, a programme that aims to increase workers' access to recycling information for recycling markets in Latin America and the Caribbean. In Brazil, the company is part of the Plastic Cooperation Network and supports the circular economy education programme, the Circular Movement (Dow, 2022a).

Dow highlights its ESG values in the development of its business, environmental performance, inclusion and diversity, relationship with communities, promotion of health and safety, and in the promotion of corporate governance. It prepared the "environmental, social and governance" report to demonstrate its growth as an ESG company (Dow, 2020). In 2020, Dow Brasil issued the first ESG report for Latin America (Dow, 2020). The report covers the following topics: environmental performance; health and safety; inclusion and diversity; community; corporate governance. Environmental performance focusses on three main areas: climate protection, circular economy and safer materials. The report mentions that the industrial complex of Aratu, in the state of Bahia, is Dow's largest unit in Brazil. Around 75 per cent of the energy it consumes is provided by renewable energy sources, largely from hydropower and eucalyptus biomass steam from a cogeneration project started in 2014.

In addition, the report states that Dow now has four units in Brazil – out of a total of 10 – for which 100 per cent of their electricity is generated from renewable sources: Jacareí, Hortolândia and two in Jundiaí (one being the Latin America Inspiration Center, Dow's innovation centre for Latin America). In terms of the circular economy, the document mentions the Recycling that Transforms programme, an inclusive recycling programme that guaranteed a reliable and consistent source of waste for the production of the new PCR (post consumer recycled) resin. Held in São Paulo, the pilot for this project brought together five collectors' cooperatives for the implementation of management and production improvement programmes, enabling the development and professionalisation of this market. More than 200 waste pickers and around 450 families benefited in the first year of implementation. In addition, the project increased the amount of waste sent for recycling by 37 per cent and the income per capita by 35 per cent compared to the previous year.

In health and safety, the report stresses the partnership with the Brazilian company Ortobom, which resulted in the donation of thousand of hospital mattresses to health units dedicated to patients with Covid-19 in the state of Bahia. For production, Dow donated about 10 tons of technologies to Ortobom, which manufactured products within all specifications. The document also highlights the readjustment of operations in Hortolândia, in the state of São Paulo, which produces silicone to manufacture gel alcohol on an emergency basis. This was done at the beginning of the pandemic when sanitizer was scarce worldwide. Several other concrete actions of the company are mentioned under the topics of inclusion and diversity, community, and corporate governance.

3.3.5 Elekeiroz

Elekeiroz has three strategically located sites: two in the largest petrochemical complex in Brazil in the municipality of Camaçari (BA), and the other in Várzea Paulista (SP), close to the largest consumer market for industrial inputs in the country in the south-east region. Elekeiroz operates in a B2B (business to business) format. Its products and solutions serve the following segments: civil construction, paints and varnishes, footwear and clothing, industrial chemicals, films and packaging, transport, pesticides, pulp and paper, and fertilisers. The company's revenues in 2019 and 2020 were around R$1 billion. Net income was R$60 million in 2019 and R$90 million in 2020 (Elekeiroz, 2021). In its safety, health and environment policy, Elekeiroz does not

emphasise the SDGs of the 2030 Agenda. The policy has three premises: the permanent search for adequate health and safety conditions, the preservation of the environment, and harmonious coexistence with neighbouring communities, customers and suppliers (Elekeiroz, 2019).

Elekeiroz has a safety, health and environment policy. However, it does not highlight them as the company's ESG values. The main document regarding the company's social and environmental responsibility is a generic declaration called the Safety, Health and Environment Policy. Through this document, the company commits to respecting the country's legislation by seeking to avoid accidents, use natural resources in a responsible manner and promote the continuous training and qualification of its employees (Elekeiroz, 2019).

3.4 Partial conclusion – Brazil's chemical industry sector as an emerging role model in greening?

To maintain or even improve its position as the world's sixth-biggest producer of chemical products, the Brazilian chemical industry sector is keen on optimising the operative processes, which are increasingly being aligned to the 2030 Agenda for Sustainable Development. ABIQUIM, the main entity in the chemical sector in Brazil, has emphasised the importance of greening, as this unlocks new opportunities. To achieve greening, the chemical industry in Brazil has adopted several VSS and initiated the scaling of ESG values. This path is illustrated particularly by the two certification programmes implemented: the Programme of Responsible Action and SASSMAQ. Individual companies in the sector also adopted a series of initiatives and created new sustainability programmes. Many of these programmes are directly related to the SDGs.

However, it is noteworthy that the data on the implementation of programmes and their results is often not available. Because of these shortcomings, it is legitimate to ask whether the greening of the sector is thus far nothing more than declarations of intent. At the same time, despite the companies' sustainability initiatives, they still adopt specific practices that violate environmental and labour standards. Therefore, there is the question how these contradictions will create doubts and justify the impression of greenwashing.

4 A holistic approach – the "greening" of the aluminium industry sector of Brazil

Aluminium is a strategic and fundamental metal for the future. Aluminium consists of the most abundant metallic elements of the Earth's crust and constitutes a structural material for means of transport such as airplanes, ships and vehicles. It is used in the manufacture of cans, in inks in the form of aluminium powder and in hanging cables regarding electricity conduction. Modern society depends on the application of aluminium for innovative and sustainable projects. Moreover, aluminium is a strategic element that provides greater competitiveness in various economic segments such as automotive, civil construction, packaging and energy. Initiatives that continuously raise questions about innovation, safety, the environment and health are essential to ensure the competitiveness of the sector and the resumption of growth and investment in a sustainable manner. These questions are necessary as CO_2 emissions in Brazil are mainly concentrated in the production processes for primary aluminium and alumina. That correspond to around 90 per cent of total emissions, which includes direct emissions from the process and indirect emissions, for example from transport and energy use. Moreover, the aluminium industry aims to reduce the impacts of its activities and believes in protecting the environment, health, safety and human rights, which are all mentioned in the 17 SDGs.

The total amount of primary aluminium produced in 2020 was 685 million tons. The sector's impact on Brazilian GDP in 2020 was 0.23 per cent. In terms of international trade, Brazil is not a relevant player in aluminium sector: It exported US$800 million (38th in world raking) and imported US$1.68 billion (24th in world ranking) in 2019. In 2020, the sector generated 423,762 jobs. The main legislations that impact the Brazilian aluminium industry are the *ex-tarifario* regime – a mechanism for the temporary reduction in the import tax on capital, information technology and telecommunication goods, when there is no national production – and other decrees, ordinances, resolutions, normative instructions and laws that influence the Brazilian aluminium industry. The current *ex-tarifario* regime mechanism for the aluminium industry is applied to, for instance, gas incinerators, aluminium profile electrostatic machine combinations, and machine combinations for die casting aluminium and machining centres with computer numerical control. Additional legislation regulates, for example, personal protection equipment, accessories, anchoring systems, and safety at work in machinery and equipment.

4.1 Challenges for the aluminium sector in Brazil

Additional measures to provide continuity to the aluminium sustainability agenda are the strengthening of the ESG cultures in the sector's companies. At the same time, the sector should employ oversight regarding the implementation of this culture. It should also oversee the continuous application of the comparative advantages of the national industry behind responsible mining and the low-carbon footprint of aluminium products. However, these initiatives and their sustainability profiles in Brazilian companies cannot fully prevent the breach of environmental and social standards by companies. Despite sustainability initiatives, companies in the aluminium sector often adopt behaviours that, with some frequency, are in violation of environmental and labour laws in the country.

The extraction and processing of bauxite (aluminium ore) naturally has high impacts on the environment. Nevertheless, mining companies that explore bauxite deposits are encouraged to carry out an independent impact report and inform the authorities and the local community about the social and environmental impacts of their activities. The Brazilian Aluminium Company (CBA), for example, carried out a detailed impact study for the exploration of bauxite in Serra do Brigadeiro, located in Zona da Mata Mineira (Minas Gerais, MG). The report clearly described negative impacts on soil, vegetation and fauna. It also considered the possibility of controlling negative impacts on water resources. Nevertheless, it highlighted the positive impacts on the local economy – with the generation of direct and indirect income – in addition to the important increase in municipal government revenues (de Carvalho Maffia, 2011). However, carrying out an impact study and providing community-conscious information does not prevent opposition from certain social actors or even discontent on the part of the community.

There are other situations in which the impacts are clearly illegal and reveal the negative impacts made by companies. For example, residents of Barcarena, in the state of Pará, contend that contamination caused by toxic leakage (lead, bauxite and aluminium) in 2018 continues to cause sickness among the people and may even be behind the malformation of babies in the communities (Passarinho, 2021). In the survey "Mining Conflict Map 2020", it was found, however, that most environmental and social violations in mining areas are perpetrated by transnational companies (e.g. ArcelorMittal, Anglo American, Hydro). The same document mentioned that almost 14 per cent of the conflicts with the quilombola people were in relation to bauxite mining. It is important to highlight that these companies have strong formal commitments to sustainability in their global policies. However, their performance in Brazil follows these commitments less rigorously, apparently.

4.2 Sector-wide “greening” of the aluminium industry

In Brazil, companies in the aluminium sector work on several sustainability fronts, especially in reducing energy consumption in their production processes. They also highlight the relevance of aluminium in the low-carbon economy, since the characteristics of aluminium are favourable to the circular economy. ABAL, as the main association in the sector (comprised 100 per cent of the companies producing primary aluminium), encourages companies to adopt sustainable practices and projects, in addition to leading the sector in the Aluminium Stewardship Initiative (ASI). The analysis identified a variety of sustainability initiatives, with ASI certification being the most striking one, as it is based on a performance standard and a chain of custody standard.

The motivations for these industry initiatives are diffuse and difficult to identify. The economic dimension, even if present, may not be decisive in certain situations. Building a positive image for companies and the sector is certainly a fundamental aspect and has positive economic impacts in the long term, especially in terms of attracting investments. These positive impacts are also related to the conquest of highly regulated and demanding foreign markets in environmental and social matters.

In contrast to other industry sectors, human rights issues and especially the protection of indigenous communities are relevant for companies involved in aluminium production in Pará. In 2021, Human Rights Watch – an NGO representing more than 11,000 people, including Indigenous People and Afro-Brazilians – has reported that it filed several ongoing legal complaints against Norsk Hydro, which operates a bauxite mine, refinery and aluminium smelter, over the alleged contamination of waterways in the Amazon basin. Norsk Hydro told Human Rights Watch that it respects the claimants’ right to file the lawsuits and will respond based on the facts and evidence presented in court.

An important initiative proposed by ABAL is the Strategic Route of the Brazilian Aluminium Chain 2030. Its primary purpose is to promote a culture of prospective thinking and strategic planning for the chain because of the transformations and challenges posed by national and global scenarios. To concretise this endeavour, ABAL established strategic partnerships. Examples of partners are the National Confederation of Industry (CNI), the National Department of the National Service for Industrial Learning (SENAI/DN), the Euvaldo Lodi Institute (IEL/SP) and the Federation of Industries of the State of Paraná System. As a whole, there are 75 public and private institutions that compose the Strategic Route of the Brazilian Aluminium Chain 2030 and contribute towards the discovery of prosperity paths.

During the construction of the Strategic Route, each link of the Brazilian aluminium chain provided a broader view. The mining and primary transformation link highlighted the creation of a competitive, innovative and sustainable industry oriented towards value aggregation, market expansion and self-sufficiency in primary aluminium. For the recycling link, the features attributed to the recycling chain were its integrity, innovation, sustainability and the recycled content’s maximisation. With the semi-manufactured link, the industry clarified that it sought to provide sustainable, innovative, high-technology solutions. For the application of aluminium products link, the aluminium appeared as an integrated solution and key to the generation of value, innovation and sustainability. In broad terms, the keywords of the Brazilian aluminium chain are competitiveness, innovation, sustainability and integrity.

A synthesis map was created to consolidate the proposals of the Strategic Route. This map is comprised of 60 actions. Regarding the links of a value chain, the ones highlighted in all map topics are (first place) mining and primary transformation; (second place) recycling; (third place) semi-manufactured products; (fourth place) the application of aluminium products. In first place, there is the search for competitive, innovative and sustainable bauxite mining and the primary transformation of industry oriented towards adding value and expanding markets, with self-sufficiency in primary aluminium. In second place there is a search for a formalised, integrated,

innovative and sustainable recycling chain to maximise recycled content. In the third place there is a search for a competitive aluminium transformation industry, a provider of sustainable, innovative and high-tech solutions. For the fourth place, aluminium is sought as an integrated solution, a protagonist in the generation of value, innovation and sustainability. The information provided above is summarised in Table 5.

Table 5: Synthesis map of the Strategic Route of the Brazilian Aluminium Chain 2030

Mining and primary transformation	Recycling	Semi-manufactured products	Application of aluminium products
Competitive, innovative and sustainable bauxite mining and primary transformation industry oriented towards adding value and expanding markets, with self-sufficiency in primary aluminium	Formalised, integrated, innovative and sustainable recycling chain to maximise recycled content	Competitive aluminium transformation industry, provider of sustainable, innovative and high-tech solutions	Aluminium as an integrated solution, protagonist in the generation of value, innovation and sustainability

Source: ABAL (2022f)

Together with the aluminium industry in its pursuit of sustainable development, ABAL initiatives are also directly connected to the SDGs of the 2030 Agenda. Table 6 shows that the sector has already acknowledged the importance of the SDGs and it provides in a programmatic manner the contributions of ABAL towards the fulfilment of the SDGs (ABAL, 2022f). A comprehensive explanation of the ABAL initiatives is not provided, because ABAL's function is to represent its member companies and not to promote sustainable development.

Table 6: ABAL and the SDGs

SDG 1 (No poverty)	The sector offers investments in the qualification of professionals, income-generation programmes, social initiatives and volunteering. Additionally, there is an incentive for adopting initiatives aimed at income generation and inequality reduction in the supported localities, and developing transparent relationships with all stakeholders – for example, the CBA programme for entrepreneurship in the city of Alumínio in the State of São Paulo (ABAL, 2022d).
SDG 2 (Zero hunger and sustainable agriculture)	The Brazilian aluminium industry offers solutions in the packaging market that allow for extending the shelf life of food and maintaining its quality while also using fewer preservatives. In addition, the industry contributes by investing in social and volunteer initiatives, implementing projects to absorb the local labour force as well as supporting the local development and growth of the economy through potential production chains that include the sustainable packaging of aluminium and allow for a substantial reduction in food loss (ABAL, 2014), all while respecting conservation areas, traditional cultures and initiatives on environmental preservation and land management. Additionally, during the Covid-19 pandemic, aluminium companies donated food to poor communities.
SDG 3 (Good health and well-being)	The aluminium industry has a fundamental role in the development of vaccines, acting on adjuvants and contributing to the protection and eradication of diseases that can be lethal in all age groups. CoronaVac – a vaccine to combat Covid-19 – contains aluminium hydroxide. It is one of the most used adjuvants and is considered safe. Each 0.5 ml dose of CoronaVac contains 225 micrograms of aluminium hydroxide, only 34.6 per cent of which is aluminium ion, that is, 77.8 micrograms of aluminium ion per dose (Instituto Butantan,

	2022). Aluminium-based components are used as adjuvants to help inactivated vaccine antigens elicit a more robust protective immune system response. Examples of additional measures are: offering wellness, sport and health programmes to professionals and the surrounding communities; investments in hospitals and health care posts; development of awareness campaigns for professionals from companies and localities of operation, and the creation of an ombudsman to receive and resolve demands from the surrounding communities.
SDG 4 (Quality education)	Companies that comprise the Brazilian aluminium chain continually invest in the professional and personal training of employees and support the local workforce and suppliers of the municipalities where they operate (ABAL, 2022h). Further efforts taken are investments in education programmes aimed at the surrounding communities in their areas of operation and investments in actions aimed at diversity in the workplace.
SDG 5 (Gender equality, diversity and inclusion)	Several programmes focus on gender equality in the workplace. An example is Mineração Rio do Norte's diversity and inclusion programme (MRN para Todos). This includes the generation of thousands of direct and indirect jobs and investments in occupational safety and human rights due diligence (ABAL, 2022g).
SDG 6 (Clean water and sanitation)	The aluminium industry plays a fundamental role in providing drinking water to everyone. Efforts to comply with this SDG include investments in the management, reuse and reduction of water consumption in operations and continuous analysis of the aluminium life cycle (e.g. Filtro Prensa in Poços de Caldas in the State of Minas Gerais) (ABAL, 2021b). Sulphate is used in flocculation and filtration to make the water clearer, eliminating particulate elements that may harm human health.
SDG 7 (Affordable and clean energy)	According to ABAL, companies in the Brazilian aluminium chain are investing in projects to reduce CO_2 emissions in the short and long terms. One long-term investment is the application of aluminium in systems that generate renewable energy (e.g. the use of aluminium cables in large solar power plants), such as photovoltaic panels and collectors for heating water; this investment contributes towards optimising energy efficiency and air quality (ABAL, 2019a). Further examples are investments in self-generated electricity from renewable sources, such as the aforementioned photovoltaic panels, and the use of equipment with low nitric oxide and nitrogen dioxide emissions in operations.
SDG 8 (Decent work and economic growth)	The Brazilian aluminium chain generates thousands of direct and indirect jobs in the country and continuously invests in the training and development of human capital. Moreover, a work environment is fostered that focusses on diversity and inclusion as well as the health and safety of employees while considering the mitigation of risks in operations. Efforts include, for instance, developing transparent relationships with all stakeholders, including the communities surrounding the operations; providing support to local suppliers; the generation of thousands of direct and indirect jobs; and investments in conduct and compliance behaviour.
SDG 9 (Industry, innovation and infrastructure)	The aluminium sector invests in R&D and technology for the development of new goods and services (e.g. R$38 million in 2019) (Brazilian Aluminium Company [CBA], 2020a). The industry invests in R&D, technology and innovation in line with the concepts of Industry 4.0 (e.g. Conexão Alumínio 4.0).
SDG 10 (Reduced inequalities)	Several initiatives are aimed at communities living near the operations and at socially vulnerable families. Essential elements are provided for a dignified life, such as jobs and income generation as well as access to health and education. Efforts made in this sense are investments in social and volunteer initiatives; developing transparent relationships with all stakeholders, including the communities surrounding the operations; investments in occupational safety and human rights due diligence; and investments in actions aimed at diversity in the workplace (ABAL, 2020c).

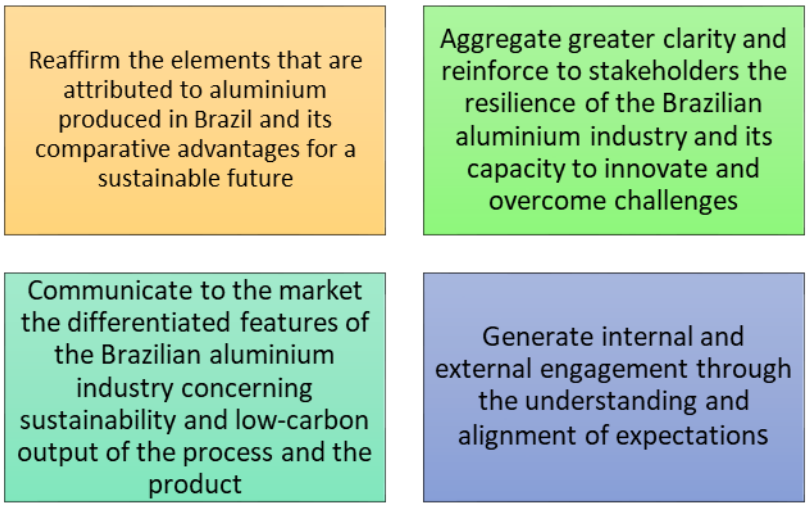
SDG 11 (Sustainable cities and communities)	Examples of elements that confirm the importance of aluminium for building a more sustainable future are the recovery of mined areas, the management of water resources, emission reductions and greater efficiency in the recycling process. In this sense, the measures taken are: investments in waste management; selective collection and recycling; developing transparent relationships with all stakeholders, including the communities surrounding the operations; and investments in R&D, technology and innovation that are in line with Industry 4.0 concepts. In cities, the application of aluminium in facades, roofs, windows and ducts creates acoustic comfort in the building while creating a balance between cooling, ventilation, lighting and noise levels (ABAL, 2022f).
SDG 12 (Responsible consumption and production)	The performance of the Brazilian aluminium chain serves as a benchmark. This is due to ASI certification for companies that extract bauxite and recover mined areas. It is also due to the recycling of beverage cans, with an average recycling index above 95 per cent. In 2018, according to ABAL and the Brazilian Association of Aluminium Can Manufacturers (Abralatas), around 97 per cent of cans produced in Brazil were recycled. According to ABAL, the sector also continually invests in new technologies to manage resources and waste, as aluminium is 100 per cent recyclable and has a low carbon footprint – a key element in the circular economy concept (ABAL, 2019b). ABAL also emphasises that further efforts linked to this SDG are: investments to increase recycling levels; investments in R&D, technology and innovative solutions for sustainable buildings (civil construction) and food conservation (packaging); the effective management of waste and its reuse in the production chain; and education measures with the surrounding communities about conscious consumption.
SDG 13 (Climate action)	According to ABAL, the Brazilian aluminium chain continuously invests in improvements in the production process to reduce GHG emissions, improve competitiveness and generate value for society; the chain is increasingly eager to offer “green products” (ABAL, 2022f). Electric and hybrid vehicles are examples of such products, as they are said to be silent and emissions-free. Aluminium plays a key role in these vehicles, as it creates lighter structures that are more resistant and reduce the high costs of the batteries. Moreover, the lighter weight of the vehicles reduces fuel consumption and emissions, which improves air quality and the health of the population. A study conducted by ABAL claims that each kilo of aluminium that replaces another heavier material can prevent the emission of up to 20 kilos of CO_2 (ABAL, 2017). Efforts by the Brazilian aluminium chain include, for instance, the use of a renewable and clean energy matrix; a reduction in carbon emissions across the whole chain; active participation in discussions about carbon pricing; and ASI certification for the chain of custody.
SDG 14 (Life below water)	ABAL and its associates participate in activities with regulatory bodies, the Brazilian Navy and the International Maritime Organization to meet regulatory requirements for the safety and prevention of marine pollution in maritime transport. Further activities include workshops and working groups with various stakeholders to develop measures that minimise the impacts of emissions on marine transport (ABAL, 2022f).
SDG 15 (Life on land)	Technology and research are important to help the Brazilian aluminium chain to recover and preserve mined areas, including the reforestation of 1 to 1 of the areas explored during bauxite extraction. Efforts include investments to promote biodiversity research, with continuous analysis of environmental risks; investments in new projects for sustainable mining based on the impacts of bauxite extraction; and more significant relationships with the surrounding communities and landowners. Other efforts include developing transparent relationships with the communities in the territory and not depriving them of carrying out activities in the region. An example is the project Communitarian Participation, promoted by CBA, which strengthens the formation of local networks, generates efforts towards social mobilisation in the municipalities and motivates communities to search for solutions that contribute towards social empowerment.

SDG 16 (Peace, justice, and strong institutions)	Efforts here include investments in social and volunteer initiatives; developing transparent relationships with all stakeholders, including the communities surrounding the operations; investments in initiatives to strengthen communities neighbouring operations; and investments in initiatives aimed at diversity in the workplace. One example is the project Engage – Engagement with Stakeholders, which strengthens risk management and enhances the opportunities generated through dialogue with local actors on different fronts (ABAL, 2022f).
SDG 17 (Partnerships for the goals, and means of implementation)	ABAL and its associates work in partnership with signatory entities of the UN Global Compact. Additional processes include promoting sustainable development with partners such as the ETHOS Institute, Fundação Getulio Vargas Sustainability Studies Center (GVces/FGV); holding meetings and training for the engagement of industry professionals on the SDGs; acquiring membership in international bodies such as ASI and the International Council on Mining and Metals (ICMM); and developing policies in the management and contracting of suppliers that take on legal, ethical, social and environmental responsibilities.

Source: Authors

An important initiative of ABAL is the Manifest Brazilian Aluminium for a Sustainable Future. The manifest starts by recalling the current world moment in which the pandemic and the climate crisis have created an uncertain and complex future where there is less time to make changes. Some consequences of this reality are manifested in the intensification of protectionist measures, the redesign of supply chains, the valuing of solutions committed to sustainability, carbon neutrality and the leading role of new actors in the search for a fair transition to a new economy. Figure 6 illustrates the objectives of the manifest (ABAL, 2022f).

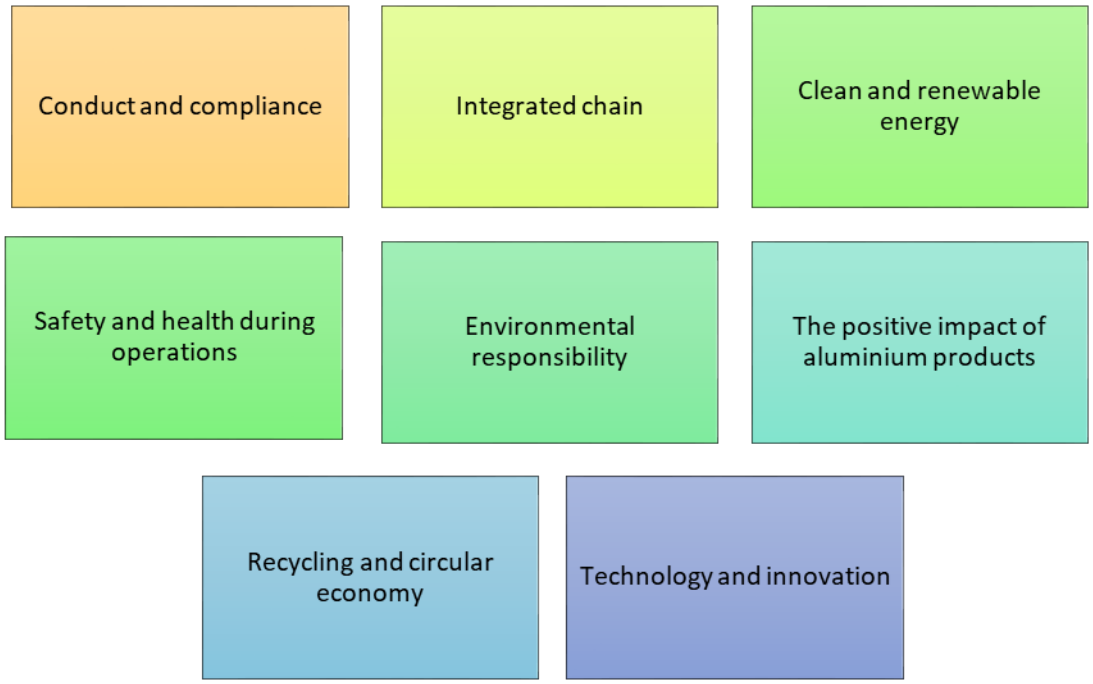
Figure 6: Manifest Brazilian Aluminium for a Sustainable Future: Objectives



Source: ABAL (2022f)

The aluminium sector develops instruments to evaluate, certify and value the sustainability dimension of the metal, its products and processes. The sector has launched various “green” products and the initiatives of multiple associations to maximise aluminium’s contributions to a sustainable society through standards and certification. Besides the manifest’s objectives and the identification of favourable future scenarios, the industry delineates eight resilience principles to support sustainable measures, as illustrated in Figure 7.

Figure 7: Eight resilience principles to support sustainable measures in the aluminium sector



Source: ABAL (2022f)

The content of some principles deserves further elucidation. The integrated chain principle reveals that the sustainability of Brazilian aluminium results from an integrated and responsible value chain. It reduces the need for the transport of alumina and aluminium – and, consequently, the emission of associated GHGs – and it contributes to the promotion of Brazilian biodiversity via bauxite mining. This activity preserves an area more significant than the one impacted by its operations.

The principle of renewable and clean energy allows for the identification of environmental advantages. This type of energy confers a lower carbon footprint to Brazilian aluminium products, in contrast to the production of primary aluminium with mineral coal, which generates indirect GHG emissions. In the study “Evaluation of GHG Emissions in the Aluminium Value Chain”, conducted by ABAL and the Espaço ECO Foundation, it was identified that, in Brazil, total emissions from mining to recycling were 4.2 CO_2 tons per aluminium ton, whereas the global average of emissions is 9.7 CO_2 tons per aluminium ton. ABAL has acted to increase the geographical reach of natural gas use in the industry, which will allow an even more significant reduction in emissions from refining, manufacturing and recycling (ABAL, 2021c). Natural gas constitutes a less-intensive CO_2 alternative than fuels used in the production of alumina and can enable emission reductions in the category of thermal energy emissions.

The principle of environmental responsibility contributes to sustainable practices. Brazil has an unrivalled performance in recycling, which is essential to the circular economy (ABAL, 2022e). Recycled aluminium accounts for about 56 per cent of the total volume of consumption of aluminium products in Brazil, whereas the global average is 26 per cent. The use of recycled aluminium reduces the carbon footprint compared to the use of aluminium obtained from the mineral. Aluminium recycling rates in Brazil are among the best in the world. In the case of aluminium cans for beverages, it reaches 97 per cent, a rate that is possible with the support of the Cada Lata Conta programme and partnerships focussed on reverse logistics (cadalataconta, 2022).

The principle on the positive impact of aluminium products has already generated substantial results. A shared value is developed with the communities in the regions where the operations are located. In addition to the thousands of direct and indirect jobs that aluminium provides, companies in the aluminium sector in Brazil actively participate in local development through foundation projects, direct investments and/or volunteer programmes. The participation in the UN Global Compact supports, diffuses and generates engagement with universal principles on human rights, labour, the environment and anti-corruption as well as with the 17 SDGs. The partnership with local communities and organisations results in practical measures that are taken concerning education, income generation, the environment and health (including recent efforts to support the fight against the pandemic) (ABAL, 2020a).

The principle on recycling and circular economy generates the development of aluminium applications in products that meet social and environmental needs. The use of aluminium in civil construction, transport and packaging provides numerous advantages – such as food safety, energy conservation and natural resources, weight reduction, the encouragement of circularity and durability – and it has an impact on reducing GHG emissions (ABAL, 2021a). The principle on technology and innovation produces social and technological innovation first and foremost. The industry is approximated to disruptive ecosystems and centres on technology and innovation as well as initiatives such as the national development plan for Industry 4.0. Quality standards and the certification of aluminium products are overseen using performance parameters and traceability. All of these actions favour the exchange of information and the disclosure of good practices.

After presenting the principles, the manifest concludes with a future vision of the aluminium industry. This industry must be active in international trade, resume its installed capacity and supply certified aluminium products with a low-carbon footprint. The partnership of the industry with the government and with entities interested in the improvement of the regulatory environment, structural reforms and increased participation in international trade guarantees its competitiveness and sustainability. The amplification of natural gas and electricity at competitive prices in the Brazilian aluminium industry can reduce the carbon footprint of products even more and increase its global competitiveness. ABAL commits itself to continue helping Brazilian companies adopt ASI certification. Lastly, ABAL aims to continue supporting and participating in initiatives led by the government and interested agents for creating a carbon market in Brazil.

ABAL considers VSS to be valuable tools to concretise the SDGs, as they enable the demonstration of the commitment to social, environmental and ethical values. The main VSS adopted in the sector is ASI. ASI certification does not aim to go beyond the regulation of the aluminium sector but allows it to demonstrate compliance with rigorous performance standards and management standards inside the aluminium value chain. ASI also allows the sharing of best management practices, evidence of positive impact, and the mitigation and management of risks with stakeholders. ASI certification also allows for the development of partnerships between public, private and voluntary sectors through socio-environmental projects and collective approaches.

ASI performance and chain of custody standards apply throughout the aluminium value chain to (i) enable the aluminium industry to demonstrate responsibility and provide independent and credible assurance of performance; reinforce and promote consumer and stakeholder confidence in aluminium products; (ii) reduce reputational risks concerning aluminium and aluminium industry players; (iii) and address the expressed needs of downstream industrial users and consumers about the responsible sourcing of aluminium. ASI's standards apply to all stages of aluminium production and transformation, specifically: bauxite mining, alumina refining, primary aluminium production, semi-fabrication (rolling, extrusion, forging and foundry), material conversion, and refining and re-melting of recycled scrap, as well as material stewardship criteria relevant to downstream users of aluminium. Table 7 clarifies the different roles performed by the ASI performance standard and the ASI chain of custody standard.

Table 7: Understanding the ASI performance and chain of custody standards

ASI performance standard	ASI chain of custody standard
Provides a common standard for the aluminium value chain regarding ESG performance	Provides a common standard for ASI members in the Production and Transformation and Industrial Users membership classes who wish to implement Mass Balance and/or Market Credits chain of custody systems in the aluminium value chain
Establishes requirements that can be independently audited to provide objective evidence for the granting of ASI certification	Establishes requirements that can be independently audited to provide objective evidence for the granting of ASI certification
Reinforces and promotes consumer and stakeholder confidence in aluminium	Serves as a broader reference for the establishment and improvement of responsible production, sourcing and stewardship initiatives in metals supply chains
Serves as a broader reference for the establishment and improvement of responsible production, sourcing and material stewardship initiatives in metals supply chains	

Source: Aluminium Stewardship Initiative (ASI, 2022a), elaborated by the authors

Beyond the scope and roles of ASI standards, critical issues that are covered are GHG emissions, waste management, material stewardship, biodiversity and human rights. These issues are in line with the following SDGs: SDG 12 (Responsible consumption and production), SDG 13 (Climate action) and SDG 15 (Life on land). ASI standards thus contribute towards increasing transparency in supply chains, meeting the expectations of consumers who value sustainability and helping to distinguish a certified product from those of competitors.

ABAL is affiliated with ASI, which is a global NGO that sets standards for sustainability performance for the aluminium value chain. As a member, ABAL integrates international discussions about responsible practices; shares the comparative advantages of Brazilian aluminium, such as clean energy and low-carbon footprint; influences the definition of protocols and governance; and participates in a committee promoted by the organisation that discusses sustainable mining.

4.3 Good practices of Brazilian companies from the aluminium industry sector – standards and VSS

In addition to the sector-wide greening efforts, the biggest players in the aluminium industry sector have initiated their own more ambitious efforts. Such efforts can be classified into three groups: *emission reductions and increased energy efficiency*, *recycling and circular economy*, and *social initiatives*. Alcoa and CBA were chosen for analysis because of their significant contributions in the mining of bauxite (ABAL, 2022c) and production of alumina (ABAL, 2022b). Albras was chosen due to its position as the largest producer of primary aluminium in Brazil (Hydro, 2020). Lastly, Alcast was chosen due to its production of a wide range of aluminium laminate products (AMANHÃ, 2022).

Brazil is the only country in the world among the greatest producers of aluminium in the market with 100 per cent of its aluminium production certified by ASI. The modalities of certification performed in Brazil are the certifications for the chain of custody standard and the performance standard (ASI, 2022a). Certified Brazilian companies are: Crown Holdings, Alcoa World

Alumina, Albras, Hydro Bauxite & Alumina, the Instalações Alcoa Alumar, CBA, Novelis and SIG Combibloc. The ASI label is a guarantee that alumina operations are sustainable, positioning the country more competitively in the global aluminium market.

It is important to highlight that these companies have strong formal commitments to sustainability in their global policies. However, their performance in Brazil indicates they have been less rigorous in maintaining these commitments. Reasons for this include less-demanding legislation, less pressure from social actors, corruption and difficulty in fully implementing initiatives related to environmental and social sustainability. For example, the literature finds that, in terms of social commitments, garbage collectors and scrap dealers act as outsourced workers in the recycling industry – deprived of any labour benefits – because this condition reduces the production costs for aluminium companies. Moreover, the recycling industry does not support the creation of cooperatives for scrap dealers and their fair remuneration.

4.3.1 Alcoa

In general terms, data from September 2021 reveals that Alcoa was able to produce 268,000 metric tons of aluminium following the restart of its production facility in Alumar, located in Maranhão (Alcoa, 2021). Moreover, according to data from April 2021, Alcoa employs more than 6,000 direct and indirect workers (Revista Alumínio, 2022a). Alcoa takes socio-environmental responsibility for the production units in Poços de Caldas (Minas Gerais), São Luís (Maranhão) and Juruti (Pará), seeking sustainability in its relationships with partners and the environment (Revista Alumínio, 2022b). In all operations, Alcoa minimises negative impacts and maximises value. The sustainability guidelines support the company's strategic priorities through three pillars: create shared value with the communities in which the company operates; reduce environmental impacts to improve the efficiency of operations; and differentiate products to better meet sustainability demands.

The company's operations in Juruti (Pará) and São Luís (Maranhão) are certified by ASI. In Juruti, this certification is for bauxite mines, port, ore beneficiation and administrative facilities, and it verifies compliance with the ASI performance standard (ASI, 2022c). Bauxite mining constitutes the supply chain activity included in the scope of the audit. In São Luís, the certification is for refining facilities, which includes refining processes, port and administrative facilities, residue storage areas and landfill, and also for verification of compliance with the ASI performance standard (ASI, 2022b). The supply chain activity within the scope of the audit is alumina refining.

Alcoa is also a member of ICMM, an organisation focussed on enhancing the industry's contributions to society with safe, fair and sustainable practices. The mission of the Council is to strengthen the social and environmental performance of the mining and metals industry and build recognition of its contributions to local communities and society at large (International Council on Mining and Metals [ICMM], 2022a). As a membership commitment, every ICMM company member adheres to its Mining Principles, which constitute a best practice framework on sustainable development for the mining and metals industry, incorporate comprehensive ESG requirements, robust site-level validation of performance expectations and credible assurance of corporate sustainability reports with annual disclosures (ICMM, 2022b). Each member is also committed to stringent performance expectations and third-party annual reporting. As a CEO-led organisation, company members are able to respond to evolving societal expectations in a meaningful way; most recently on tailings management and water stewardship (ICMM, 2022b). Recognised as a Gold class supplier by EcoVadis (universal supplier of sustainability classifications) for supplier responsibility, Alcoa is among the leading companies in sustainability in the sector, confirming its excellence in environmental, labour, commercial, ethical and human rights practices.

Moreover, the company has a Human Rights Policy (Alcoa, 2022b) and complies with the Declaration on Indigenous Peoples (Alcoa, 2022a). Figure 8 offers details on both documents.

Figure 8: Human Rights Policy and Declaration on Indigenous Peoples

Source: Alcoa (2022a, b, c), elaborated by the authors

Alcoa is also a company that comes closer to having an ESG culture, participating in a recent event promoted by ABAL about innovation and ESG in the aluminium industry. The company's director stated that industries in the aluminium sector are references on the ESG tripod whose practices are present in many measures consolidated in the Manifest Brazilian Aluminium for a Sustainable Future. Alcoa's sustainability directives support strategic priorities in three pillars (Alcoa, 2022c). The first pillar seeks to create shared value with the communities in which the company operates. The second and third pillars aim to reduce environmental impacts to improve the efficiency of its operations and differentiate from the products of competitors to meet sustainability demands. Additional sustainable initiatives of Alcoa are the certification of its operations in Juruti (Pará) and São Luís (Maranhão) by ASI and participation in the ICMM, which is an institution focussed on improving the industry's contributions to society with – and recognition as – a Gold class supplier in the EcoVadis index on supplier responsibilities. The methodology of EcoVadis is to evaluate the quality of the management system regarding the business social responsibility of a company through its policies, implementation measures and results.

The mandate of the ESG strategy focusses on ensuring the supply of low-carbon aluminium and sustainable solutions for the world's problems. The most relevant issues are emissions, energy, water, circular economy, dams and biodiversity. From a social point of view, the main elements are talent attraction and retention; health, safety and quality of life; diversity and inclusion; and social legacy. Finally, the governance item involves ethics and transparency, the sustainable value chain and ESG ownership (which is directly related to how to move forward with incorporating sustainability into CBA's culture).

4.3.2 Albras

In 2020, the company produced 378,918 tons of liquid aluminium, from which 293,562 tons were used for the production of primary aluminium ingots and 84,700 tons for primary metal in liquid form. In 2020, there were 383,843 tons of aluminium sold, which represented an increase of 64,890 tons compared to 2019. Gross revenue was R$3.784 billion, 41.4 per cent higher than in 2019. In December 2020, the total number of employees was 1,229. Developing a more

holistic approach to sustainability, Albras launched a series of initiatives to reduce environmental impacts and emissions in production, develop greener products and have a positive influence by strengthening local communities and business partners. Environmental impacts can be reduced firstly through the assessment of the risk and materiality of impacts on biodiversity from land use and activities in Albras's area of influence, and secondly through the joint study Barcarena Baseline & Effect Study, which is produced by major companies in the region and investigates impacts on ecosystems, flora and fauna (ASI, 2021). Regarding emission reductions, Albras was granted the Golden Seal of the Brazilian GHG Protocol Programme in 2021 for the fourth consecutive year (ABAL, 2022a). The programme attests to the quality in the management of GHGs in companies and governments (ABAL, 2022a). With a globally recognised methodology, the Gold Seal is the most used in carrying out GHG inventories, and it attests to the robustness and transparency of Albras's GHG emissions inventory, which fulfils all prerequisite international standards and is part of the plant's Environmental Management System (ABAL, 2022a).

The following list organises and details Albras's main efforts on sustainability:

- The company's new climate strategy calls for a 30 per cent reduction in CO_2 emissions across the aluminium value chain by 2030. Albras will do this through greener sources, greener production, and greener products. In its production, for example, ALBRAS provides an initial processing of the residue worn tub lining that is then supplied to Brazilian cement industries. After physical treatment, the residue becomes an appropriate input to be used in cement production. The initiative to supply the waste as a raw material for cement production meets the national environmental demand to reduce the volume of waste (ABAL, 2022i).

- A new environmental strategy for 2030 seeks to address the industry's key environmental challenges. It will primarily focus on continuous restoration at the Pará bauxite mine, reducing the impact of tailings and bauxite waste, recycling our spent lining of electrolytic vats, and halving non-GHG emissions (sulphur dioxide, nitric oxide, nitrogen dioxide and particulate matter).

- Through its social responsibility policy, Albras emphasises community dialogue as well as education and training of people, recognising that it can only be successful if communities and partners are also successful. Albras integrates the Programme Sustentar Barcarena, a partnership between Alunorte, Albras and the city hall of Barcarena. The policy fosters the social inclusion of recyclable material collectors and the use of environmental education as a structuring public policy (Hydro, 2020). The environmental education axis of the programme builds an education environment aimed at the engagement, awareness, training and instrumentalisation of the various segments of Barcarena (Hydro, 2020). Albras also sought to educate the community of Barcarena – the municipality where it operates – through the Forum of Urban Solid Residues and Environmental Education, held in 2020. In this forum, population engagement plays a fundamental role in raising the consciousness of the local population about the responsible destination of residues, effective management of urban solid waste, public cleaning and healthy living in Barcarena (Hydro, 2020).

4.3.3 Alcast

In broad terms, Alcast currently produces 24,000 tons of aluminium per year. It has more than 600 direct employees (Alcast, 2022a). The company provides little information on its sustainability projects and initiatives in Brazil. Compared to other companies in the sector, its performance is also less impactful, as it has a small number of employees and has operations centralised in only one municipality in the country (Francisco Beltrão, Paraná). Its sustainability initiatives, therefore, are specifically aimed at mitigating environmental and social impacts in the municipality in which it operates. In addition to generating jobs in the cities where the factories are located, the company also supports important social projects in the region. It collaborates

with the Beltronense cancer prevention project “Mão Amiga” and encourages local sports, culture and leisure activities (Alcast, 2022b).

Concerned with the future of nature, Alcast claims to have a modern Environmental Management System that is fully compliant with current legislation. All aluminium leftovers generated through the casting process are recycled internally, while plastic and paper waste, as well as other materials, are disposed of in an ecologically correct manner, with continual inspection by environmental agencies. The company also seeks to maximise its use of recyclable products and raw materials, such as renewable electricity, generated through its own plant, throughout the production process. Part of the 760,300 sq. metre area of the Francisco Beltrão unit is located in a section of preserved Atlantic Forest, and other parts of the structure compensate for the use of land by reforesting and planting trees native to the region.

4.3.4 Brazilian Aluminium Company

CBA is part of the industrial conglomerate Votorantim. The sales volume of the company registered 370,000 tons in the first three quarters of 2021. Total net revenues from products sold and services rendered in the three first quarters of 2021 totalled R$5.234 billion, a value higher than the R$4.797 billion obtained for all of 2020. Gross profit in the first three quarters of 2021 was of R$917 million, a value higher than the R$354 million obtained for all of 2020. CBA has more than 5,000 employees in its operations (CBA, 2020c).

ESG elements can be found in the sustainability management of CBA. Initial differential aspects of CBA are aluminium production with a low carbon footprint (Caetano, 2022), acting in a socially responsible manner that is recognised by society and engagement in the fight for environmental issues. An ESG culture has developed in the company. With the support of the Votorantim Institute, an ESG strategy was created, according to which sustainability is a fundamental pillar of the business. The ESG strategy was approved in late 2020 and the goals were presented thereafter (CBA, 2020b). The Sustainability Committee approved the ESG strategy, with 15 programmes grouped within 10 categories and 4 pillars: 4 in the environmental pillar, 2 in the social pillar, 3 in the governance pillar and 1 in a general-purpose pillar. In total, the initiatives approved by the CBA in December 2020 will have more than R$1 billion in direct investments planned by 2030.

The mandate of the ESG strategy is centred on ensuring the supply of low-carbon aluminium and sustainable solutions for the world’s problems. In the environmental aspect, the most relevant issues are emissions, energy, water, circular economy, dams and biodiversity. From a social point of view, the main elements are talent attraction and retention; health, safety and quality of life; diversity and inclusion; and social legacy. Finally, the governance item involves ethics and transparency, the sustainable value chain and ESG ownership (which is directly related to moving forward with the incorporation of sustainability into CBA’s culture) (CBA, 2020b).

4.4 Lessons from the aluminium sector in Brazil

The analysis above shows a variety of sector-wide greening efforts. The most important effort is ASI certification based on a performance standard and a chain of custody standard. The institutionalisation of sustainability initiatives and projects has already been advanced, as depicted in the quality of documentation and communications of the companies, as well as by the standards that have been implemented with clear benchmarks. Whereas the performance standard covers the key issues explained above for the whole aluminium value chain, the chain of custody standard complements the first standard by setting requirements for the establishment of a chain of custody for ASI-certified aluminium. ASI is leading the initiative to

establish standards for the certification of aluminium products, and its standards are applied to the whole value chain – from mining to the sectors that use aluminium in its products.

Additional recent initiatives are the ones being promoted by ABAL, namely the Strategic Route of the Brazilian Aluminium Chain 2030, which is directly connected to the SDGs and the Manifest Brazilian Aluminium for a Sustainable Future. This exemplifies the scaling processes, as various goals are converging. These initiatives allow for those elements that attribute comparative advantages to aluminium produced in Brazil for a sustainable future to be identified and reaffirmed. They communicate to the market the differentiated features of the Brazilian aluminium industry regarding sustainability and the low-carbon nature of the process and the products. A further measure that provides continuity to the aluminium sustainability agenda is the strengthening of the ESG cultures in the sector's companies. At the same time, the sector should employ oversight regarding the implementation of this culture. It should also oversee the continuous application of the comparative advantages of the national industry behind responsible mining and the low-carbon footprint of aluminium products. However, these initiatives and their sustainability profiles in Brazilian companies cannot prevent the breach of environmental and social standards by companies. Additional measures are still needed to increase the costs of non-compliance.

5 Efficiency and research as drivers of the "greening" of the cement industry sector of Brazil

The cement industry is one of the most critical industries for economic development. Cement is the main building material worldwide. It is an essential ingredient used for building infrastructure, constructing roads, bridges, water supply and sewerage systems, schools, hospitals and housing. Cement is the product of an integrated industrial activity resulting from the mining and processing of limestone and clay. The industrialisation process involves the milling, homogenisation, and production of flour (raw mixture), which is transformed into clinker (non-pulverised cement) before the respective grinding.

The companies in the cement sector in Brazil have already started to adopt sustainable practices through reductions in energy consumption and interactions with sustainable civil construction sectors. Generally, alignment with the SDGs is reported by companies in the sector. The association usually replicates these reports and comments on aspects related to the SDGs. For example, the company Cimento Apodi published an extensive sustainability report that describes its alignment with the SDGs (Brazilian Portland Cement Association [ABCP], 2022). Additionally, the big players in the sector (e.g. Votorantim Cimentos) have already adopted VSS and assumed ESG commitments focussing on improving efficiency in the value chain. In Brazil, the cement sector has many players. There are 93 cement production plants controlled by 23 industrial groups in 80 municipalities with a total output of 56.6 million tons of cement and apparent utilisation of 54.8 million tons in 2019 while generating 19,000 direct jobs. The main demand for cement in Brazil is in construction, which comprises 90 per cent of cement consumption, distributed as follows: 60 per cent for residential buildings, 30 per cent for commercial and industrial buildings, and 10 per cent for infrastructure.

Brazil's cement sector is an emerging global player. In comparative terms, Brazil is an important producer of cement (ranking 12th in the world), but a marginal player in international trade (ranking 79th exporter and 75th producer in the world) (SNIC, 2019). In 2018, Brazil produced 53.6 million of tons of cement. The global leader was China, with 2.17 billion tons, followed by India with 327.7 million tons, Vietnam with 90.2 million tons and the United States with 87.8 million tons. After four years of significant losses in sales (28 per cent) and idle capacity in the industry – reaching 46.5 per cent – the sector recovered in 2019, growing 3.5 per cent in relation

to the previous year. The Brazilian construction sector ended 2019 with slight growth of 1.6 per cent after five years of steady decline. In 2019, Brazil exported 142,000 tons of cement and imported 101,000 tons, an increase of 40.6 per cent. In terms of imports, Brazil imported 977,000 tons in 2018 and 136,000 tons in 2019 (SNIC, 2019). Regarding cement from the Brazilian Portland Cement Association (ABCP), another variety of cement, Brazil exported 142,000 tons in 2019. It is mostly produced in the south region (94 per cent of total production) and largely exported to Paraguay. Brazil imported ABCP cement mainly from Turkey in 2019 (64,669 tons), followed by Mexico (30,544 tons).

5.1 Challenges for the cement industry sector in Brazil

Cement production is believed to have significant negative impacts on the environment because of the huge amount of energy needed and the natural resources that have to be extracted. The magnitude of cement production's impact leads to more than 7 per cent of annual anthropogenic GHG emissions, resulting from both energy use and chemical reactions. This imposes a notable barrier to reaching net zero emissions by 2050 (Miller, Habert, Myers, & Harvey, 2021). However, although Brazilian cement production is relatively less impactful compared to that of other countries, it is still significantly high. At the same time, despite sustainability initiatives, companies in the cement sector often adopt behaviours that, with some frequency, are in violation of environmental and labour laws in Brazil.

In addition, the cement industry sector in Brazil is often in conflict with local actors. Socio-environmental conflicts in the mid-west region – more specifically in the community called Queima Lençol (near the Federal District), due to the presence of cement factories – have been denounced by academics and journalists for years. The company Ciplan is accused of being responsible for the high density of pollutants in the atmosphere of the locality, causing respiratory problems and illnesses, especially in children (de Carvalho, 2008). For the cities where the cement plants are located, the worst problems are related to the deterioration of air quality. Factories generally release smoke and particulate matter into the atmosphere, which has important impacts on daily life, especially in small towns. The case of the Intercement factory in João Pessoa resulted in an agreement between the company and the municipal government (Nunes & Cerqueira, 2021).

5.2 Sector-wide greening of the cement industry

The companies in the cement industry sector in Brazil are represented by two main associations, namely ABCP and SNIC. Founded in 1936, ABCP has the goal of promoting studies on cement and its applications. It is a non-profit maintained voluntarily by its 11 members.[1] Along with ABCP, there is SNIC, which was founded in 1953 in Rio de Janeiro. It was created with the goal of studying, disseminating and representing the cement industry. There is no competition between the associations, and they have complementary roles. ABCP is on one hand dedicated to a specific type of cement, called ABCP, and it promotes studies in this area such as the promotion of courses and seminars, the publication of books and technical events, and it also contributes to the generation of Brazilian technical standards. SNIC, on the other hand, is responsible for following up with the legislative, executive and judiciary powers on matters of interest to the sector. Serving as a policy entrepreneur or interest group, it maintains working relationships with federal and state public agencies and private institutions as well as the media, as spokesperson for the sector. In general, the associates of ABCP are members of the industry

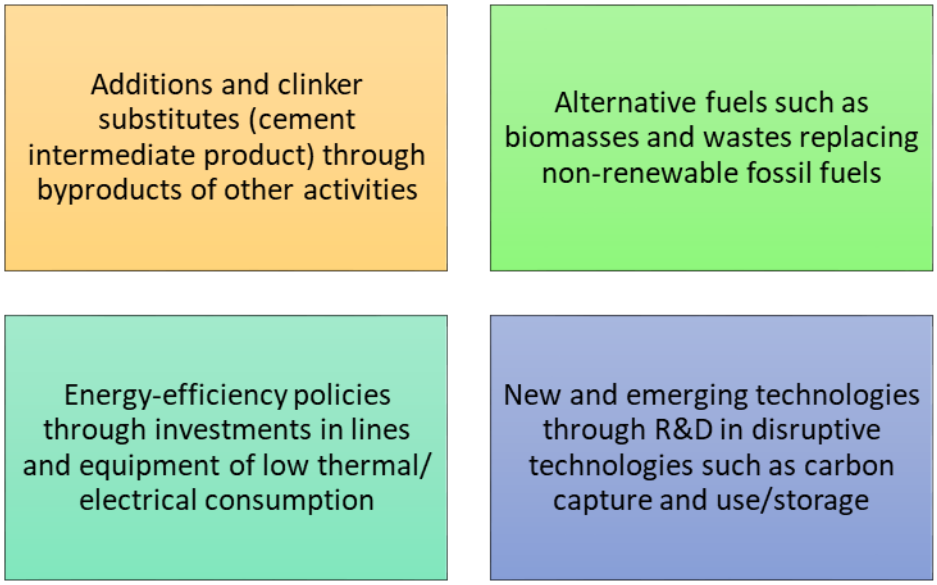
1 Cimento Apodi, Brennand Cimentos, Ciplan, Cia de Cimento Campeão Alvorada, Intercement Brasil, Cia de Cimento Itambé, Lafargeholcim, Cimentos Liz, Mizu Cimentos Especiais, Supremo Secil Cimentos and Votorantim Cimentos.

interested in promoting the sector, whereas SNIC represents administrative and judicial authorities and the general interests of the industry.

The Cement Technology Roadmap to 2050, launched by SNIC and ABCP with little participation from the Brazilian government, is intended to help the Brazilian cement industry cut its carbon footprint in the medium and long term. The Roadmap was designed with the IEA, the Cement Sustainability Initiative of the World Business Council for Sustainable Development, the International Finance Corporation of the World Bank, and a group of academics led by Brazilian professor José Goldemberg (Global-Cement, 2019). The Roadmap establishes the central vision and guidelines to reduce carbon emissions in the Brazilian cement industry by about 35 per cent by 2050.

Certainly, the goals of the Roadmap are ambitious, but they are realistic and have a supportive regulatory structure. However, the report requires supportive public policies such as credits and investments in order to be successful. The Roadmap does not include penalties, and incentives are mainly related to the positive international image of the Brazilian industry, which can be beneficial for its competitiveness. The Roadmap does not evaluate the probability of compliance with these incentives, but obviously large reductions in CO_2 emissions can only be achieved if all parts of society (industry, government, community) contribute collectively. The scenario of an economic crisis creates pressures to reduce some costs and rapidly resume economic output, which obviously has grave consequences for environmental degradation, as economic recovery becomes the priority, and the reduction of carbon emissions becomes secondary. Therefore, the outlook has worsened for all sectors that are trying to reduce emissions. The Roadmap has four major principles, as described in Figure 9.

Figure 9: Four major principles of the Cement Technology Roadmap to 2050



Source: ABCP (2019), elaborated by the authors

Energy efficiency is one of the central aspects of all sector-wide sustainability efforts. Concentrating efforts on energy has two important consequences: coordinated work with governments (since energy is a highly regulated sector with direct economic participation by the state) and learning from cyclical energy crises. Energy is a crucial part of cement production and a substantial cost. Therefore, the industry has had an interest in reducing costs in this segment, as this is not the central activity of the industry. In this regard, the energy crisis probably pushed the sector towards more efficient alternatives and the continual search for energy autonomy. Votorantim, for example, is engaged in producing its own energy sources. Votorantim Energia is a Brazilian energy company, part of the Votorantim Group conglomerate

created in 1996. They are responsible for the generation of energy through 21 eolic parks with 564 MW of installed capacity and 98 wind turbines in Piaui State and 156 wind turbines in Ceará State (Votorantim-Cimentos, 2022b).

The reduction in the amount of clinker/cement from 68 per cent in 2014 (Roadmap base year) to 52 per cent in 2050 – or, conversely, increasing additions from 32 to 48 per cent – can help avoid the accumulated emission of 290 Mt CO_2 throughout the period. This reduction would represent 69 per cent of the sector's reduction potential by 2050. Cement production increased 273 per cent between 1990 and 2014 (from 26 Mt to 71 Mt), and total emissions grew comparatively less, by 223 per cent in this interval, due to the 18 per cent reduction in specific emissions (from 700 kilogrammes (kg) CO_2/tons (t) cement to 564 kg CO_2/t cement). The Roadmap outlines the current situation and future trends in the Brazilian cement industry. If the trajectories of growth and degree of technological development continues without intervention, in a reference scenario, absolute emissions from cement production would reach about 66 Mt CO_2 in 2050, an increase of 64 per cent compared to 2014 levels (40 Mt CO_2) (SNIC, 2019).

By adopting the different technical alternatives proposed, the sector would reduce these emissions to levels consistent with the one with the lowest climate impact, limiting the increase in global temperature to 2°C in the long term. It would imply reducing the carbon intensity from 564 kg CO_2/t cement in 2014 to 375 kg CO_2/t cement by 2050, a decrease of 33 per cent. Therefore, the sector would reduce its absolute emissions from 66 Mt CO_2 in 2050 to 44 Mt CO_2, making them practically constant compared to 2014, despite the projected increase in cement production of almost 70 per cent for the period. In terms of accumulated emissions over the entire period, comparing the two scenarios, it would be possible to avoid the emission of 420 Mt of CO_2 (SNIC, 2019).

The Brazilian Industrialized Construction of Concrete Association (ABCIC) has a Seal of Excellence, which is a programme aligned with the concept of sustainability, as it introduces not only quality but also social responsibility, safety and the environment (ABCIC, 2022). As it is a specific programme designed for the sector, it evaluates not only quality management but also the effective compliance with ABNT NBR 9062 (Design and Execution of Precast Concrete Structures). It is an evolutionary programme that seeks to improve companies according to their advancement in the level of the seals, encompassing environmental issues at level III. Created in 2003, the ABCIC Seal of Excellence is conducted and operated by the Falcão Bauer Quality Institute, an entity contracted by the ABCIC to ensure the effectiveness of, interdependence with and exemption from the certification process (ABCIC, 2022).

Table 8: ABCIC Seal of Excellence

Level I	Level II	Level III
Compliance with basic technical standards and testing of the main materials	Expansion of aspects of quality management and process control records	Environmental aspects
Initial control of company processes, product quality and assembly	Compliance with complementary technical standards and testing of other materials	Monitoring and measuring results
Regulation of operations and employees	Compliance with regulatory standards	
Security management aspects	Customer satisfaction assessment	

Source: ABCIC (2022)

5.3 Good practices of Brazilian companies from the cement industry sector – standards and VSS

Large Brazilian companies in the cement and building sector have adopted several sustainable practices. Many of these practices make use of VSS. However, it was not possible to find documents from the cement association that link their activities with the SDGs. Few companies in the sector make direct reference to them. Nevertheless, for example, the company Votorantim has existing commitments on ethics and integrity; safety, health and well-being; diversity and inclusion; innovation; environmental footprint; circular economy; and shared value that are in line with the SDGs. The company also has ambitions to achieve carbon neutrality by 2050 to fulfil its commitment as a signatory to the 2050 Carbon Neutral Concrete Climate Ambition of the Global Cement and Concrete Association (GCCA). The two main SDGs affected by cement production are SDG 7 (Affordable and clean energy) and 13 (Climate action). These two SDGs are related to the sector's intensive energy use. However, companies in the sector have sought to actively achieve other SDGs, such as, for example, SDG 5 (Gender equality) and SDG 8 (Decent work and economic growth) (ABCP, 2020, 2021). Table 9 summarises the main standards and VSS adopted by the cement industry sector in Brazil.

Table 9: Sustainability standards used in the cement industry sector

VSS	DESCRIPTION
EPD System (EPD, 2022)	An Environmental Product Declaration (EPD) is defined by ISO 14025 as a Type III declaration that "quantifies environmental information about the life cycle of a product to allow comparisons between products that fulfil the same function". The EPD methodology is based on the LCA tool, which follows the ISO 14040 series. EPDs are intended to facilitate business-to-business transactions, although they can also benefit consumers who consider the environment when choosing goods and services. Companies implement EPDs to improve their sustainability goals and demonstrate to their customers a commitment to the environment.
Leadership in Energy and Environmental Design (GBC-Brasil, 2022)	LEED is an international certification and environmental guidance system for buildings used in more than 160 countries. It aims to encourage the transformation of projects, construction and operation of buildings, always focussing on the sustainability of performance.
Seal of the Company Friend of the Atlantic Forest (CN-RBMA, 2022)	The Atlantic Forest Biosphere Reserve (RBMA) is an integral part of the Man and the Biosphere (MaB)/UNESCO Programme, whose work was recognised in six successive phases between 1991 and 2008. It was the first unit of the World Network of Biosphere Reserves declared in Brazil and is the largest reserve of the planet's biosphere. The total area is about 78,000,000 hectares – 62,000,000 of which is in terrestrial areas and 16,000,000 in marine areas – in the 17 Brazilian states where the Atlantic Forest exists. This allows it to operate across the entire biome. A Seal is given by the National Council of RBMA – after analysis by a Management Committee – and it can be used by the company holding the title of "Company Friend of the Atlantic Forest" in institutional and advertising materials, in print and in digital media. The main commitments of Friend of the Atlantic Forest are: to demonstrate that it works effectively for the conservation of the Atlantic Forest; to invest in the operations of the Mata Atlântica Biosphere Reserve through an annual financial contribution; to keep the participation identifiers exposed (Plate and/or Certificate); to allow the RBMA to offer recognition as a Friend Company of the Atlantic Forest using all forms of communication of the entity.
Sustainability Charter – GCCA (Votorantim-Cimentos, 2022a)	The GCCA's Sustainability Charter identifies five key pillars that span the sustainability spectrum of the cement and concrete industry and set out the requirements for full membership for each of them. The five pillars are: climate protection; the responsible use of fuels and raw materials; employee health and safety; emission reduction; and local impacts on land and communities. Full members must implement sustainability initiatives across all five pillars and set performance improvement targets for each pillar to achieve compliance.

Source: Authors

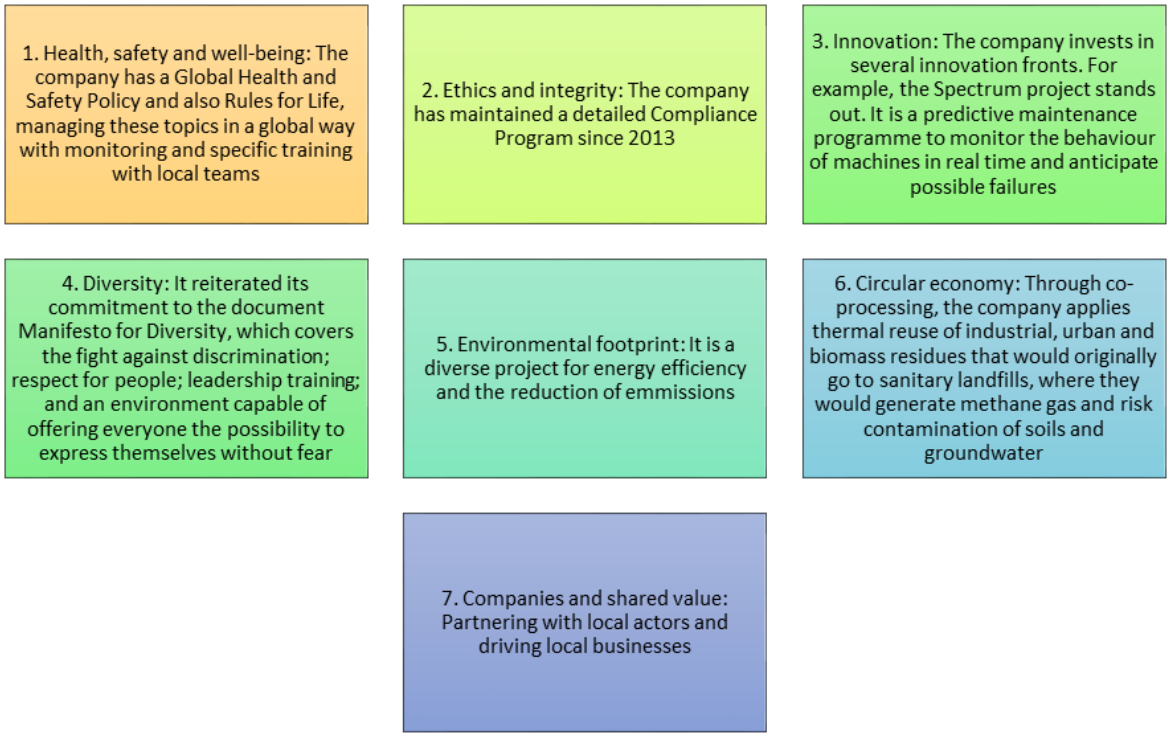
5.3.1 Votorantim Group

Votorantim Group is a prominent company in the cement sector in Brazil (37 per cent market share) with total revenue of R$16.7 billion in 2020. It is present in 11 countries, constituting the seventh-largest company in the sector, excluding Chinese companies. Votorantim is involved in many projects related to sustainable development, such as the World Business Council for Sustainable Development, the Entrepreneurial Brazilian Council on Sustainable Development (CEBDS), the GCCA, the Global Cement and Concrete Research Network, and the Open Letter on Climate Change to Brazil. Votorantim is also part of the CDP, which is a project that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. The world's economy looks to the CDP as the gold standard of environmental reporting, as it is considered to be the most comprehensive corporate dataset. The CDP evaluates how companies prepare themselves for climate change (Votorantim-Cimentos, 2020).

Votorantim has also established initiatives to decarbonise the sector. For example, Votorantim commits to reducing emissions related to thermal energy, maximising the co-processing of energy waste from other industries or processes and replacing the use of fossil fuels. The company also commits to eliminating indirect energy emissions through the use of renewable sources of electricity and to reducing the emissions process via new technologies and the development of carbon capture. Two critical steps for accomplishing these goals are reducing the amount of clinker content in cement and concrete, and using concrete more efficiently in the construction of buildings and infrastructure. Reprocessing and recycling demolition concrete will make the chain more circular and maximise the absorption of CO_2 by the concrete through recarbonation.

The company has goals for 2030 that are composed of seven pillars, as described in Figure 10.

Figure 10: Seven pillars for 2030



Source: Votorantim-Cimentos (2022b), elaborated by the authors

Regarding environmental goals, the company intends to increase to 30 per cent the percentage of revenues from products and services that mitigate the environmental footprint or offer environmental benefits in application compared to traditional options (Votorantim-Cimentos, 2022a). Regarding the net CO_2 emission/ton of cementitious products, the goal of Votorantim is to reach 520 kg of net carbon emission per ton of cement product. Votorantim also wants to reduce particulate matter emissions for a ton of cement to 30 grams/ton of clinker and reduce sulphur oxide emission per ton of product to 490 grams/ton of clinker (Votorantim-Cimentos, 2022a).

Additionally, Votorantim intends to achieve a share of 45 per cent renewable electricity for its energy consumption level and to implement plans for water and biodiversity management in sensitive areas (Votorantim-Cimentos, 2022c). Votorantim wants to reach a share of 53 per cent for thermal replacement, which is the amount of thermal energy consumed in the process of production using alternative fuels (waste and biomass) (Votorantim-Cimentos, 2022c). Regarding the percentage of clinker in cement, the goal of Votorantim is to reduce the proportion of clinker to 68 per cent. In relation to the amount of concrete returned in operations that is recovered as new concrete or aggregate, Votorantim wants to have 70 per cent of the concrete returned to be recycled (Votorantim-Cimentos, 2022c).

5.3.2 Intercement, Nassau and LafargeHolcim

The cement sector in Brazil is very concentrated. The largest companies (Intercement, Nassau and LafargeHolcim) in the sector have some type of programme or initiative focussed on sustainability. However, information about their sustainability efforts is limited. In the case of Intercement, there are initiatives on energy efficiency, the development of sustainable materials and circular economy. Of these companies, Intercement is the one that provides the greatest amount of information about its sustainability initiatives. Energy-efficiency projects stand out.

5.4 Partial conclusion – lessons from the cement industry sector

Brazil is an emerging global player in the global cement sector. In 2019, Brazil was the world's 12th-largest cement producer. Therefore, the greening of the Brazilian cement sector will have significant positive effects on emission reductions. The cement sector in Brazil has introduced and widely adopted the 2019 Cement Technology Roadmap to 2050. The Roadmap is the outcome of collaboration between the National Syndicate of the Brazilian Cement Industry and ABCP, in association with Brazilian research institutes and international institutions. Therefore, it can be argued that national and international networks mainly drive the greening of the Brazilian cement sector. They ensure that members are aware that greening entails efficiency. The Roadmap establishes guidelines to reduce carbon emissions in the Brazilian cement industry by approximately 35 per cent by 2050. The vision of the Roadmap is based on an energy system pathway and a CO_2 emissions trajectory that provide at least a 50 per cent chance of limiting the average global temperature increase to 2°C by 2100, which is the upper limit for the Paris Agreement.

The greening of the sector is pursued through standardisation. The main VSS used in the industry are the ABCIC Seal of Excellence, the EPD System, LEED, the Seal Company Friend of the Atlantic Forest and the Sustainability Charter of the GCCA. In the sector, the Votorantim Group is a prominent company that participates in many projects related to sustainable development and very engaged in its ESG programme. In general, the industry is aware of the problem of climate change and has plans to reduce emissions, as elaborated in an ambitious Roadmap. However, progress in the industry has to be monitored, and the Brazilian government needs to become more involved.

The main challenges for the industry in reaching its sustainability goals include increasing the use of additions and reducing the amount of clinker in cement as well as increasing the use of alternative fuels and replacing non-renewable fossil fuels such as petroleum coke. Alternative binding materials to replace clinker offer opportunities for carbon emission reductions. However, there is currently no robust life-cycle analysis for any of the alternative binders or an associated comparative analysis of production costs. The deployment of commercially available alternative binding materials is highly driven by production costs. More research into the process optimisation of alternative binders could create possibilities for commercial deployment, yielding environmental improvements to the performance of the industry. Therefore, investment in research is fundamental to tackle the current emission levels in the industry. Also, more participation by the Brazilian government is needed to help the industry meet the established goals, whether in research efforts or on the issue of replacing fossil fuels with renewables.

6 Nexus thinking – the "greening" of the steel industry sector of Brazil

World crude steel production yielded more than 1.87 billion metric tons in 2020, a stable volume compared to 2019 and 2018 (1.87 and 1.82 billion, respectively). The Covid-19 pandemic did not contribute to a noticeable drop in production, but a reduction in steel prices negatively impacted revenues from global leaders in the steel market such as ArcelorMittal. Monthly crude steel production in 2020 fluctuated due to the Covid-19 crisis, with dips recorded between February and June of that year by the top producing countries (Statista, 2022). China, the world's largest producer of steel, recorded an 11 per cent drop in the span of two months (December 2019 to February 2020). However, after a recovery that lasted from the fourth quarter of 2020 to the first quarter of 2021, world crude steel production decreased again at the end 2021 compared to the same period in 2020 (World Steel Association [WSA], 2021c). The European steel sector is not expecting the demand for steel to recover from the Covid-19 crisis and return to pre-crisis levels until 2030, which presents further challenges for Brazil (Espel, Müller, Van Hoey, & Zeumer, 2021).

In 2020, on average, every metric ton of produced steel led to 1.85 metric tons of CO_2 emissions. In 2020, 1.87 billion tons of steel were produced, and total direct emissions from the sector were on the order of 2.6 billion tons, representing between 7 and 9 per cent of global anthropogenic CO_2 emissions (WSA, 2021b). Worldwide, the iron and steel industry accounts for around a quarter of GHG emissions from the global industrial sector. Global steel production has more than doubled between 2000 and 2018. China accounted for 51 per cent of global steel production in 2018 (Hasanbeigi, 2020).

Brazil is a key country for the global steel industry sector. It is the second-largest producer of iron ore in the world, in addition to having one of the largest reserves of high-quality ore (Hebeda et al., 2023). In addition, Brazil is the ninth-largest steel producer in the world, with an output of 35.4 million tons of steel, equivalent to 2 per cent of world production (Ministério de Minas e Energia [MME], 2021; WSA 2021a). In 2019 and 2020, the country maintained this position (WSA, 2021a). In Latin America, Brazil stands out, representing 53.8 per cent of the region's steel production. The steel industry is characterised by the presence of large business groups operating within different stages of the production process. The steel industry is a raw material supplier for other transformation industries, as well as for civil construction and the automobile industry. Due to the characteristics of the industry, investments require large capital contributions, thus generating strong entry barriers (Soares & Coimbra de Souza, 2020).

In Brazil, the steel industry is seen as a strategic industrial sector, especially because of its capacity to generate links, jobs and its contribution to GDP. For this reason, it has been the

target of industrial policies in which the state played a decisive role in its development until the end of the 1980s. After this period, due to the privatisations that took place during the 1990s, the sector grew significantly in terms of technology and market position (Soares & Coimbra de Souza, 2020). The exact GDP contribution of the steel sector in Brazil was not available. However, regarding the production of metal products and metallurgy, the manufacturing industry represents 11 per cent of the national GDP. The metal products sector and the metallurgy sector comprise 5.1 per cent of the manufacturing sector.

Brazilian steel imports and exports suffered due to the Covid-19 crisis in 2020. In 2018 and 2019, the numbers remained fairly stable, with small increases and decreases for imports and exports of different steel products. But 2020 registered a steep decline for both, except for imports of semi-finished products, which increased compared to 2018 and 2019. The sector saw a reduction in the number of employees during the three years analysed (2018-2020). In 2020, the total number of workers in the sector was 103,308 (Instituto Aço Brasil [IAB], 2021).

There has been a recent decline in the steel industry's contribution to GDP. The industry is responsible for converting raw materials into products and goods. In 2019, the sector that encompasses the plastic, food, beverage, metallurgy and textile industry, among others, represented only 11 per cent of economic activity (Perfil da Indústria Brasileira, 2022). Two decades ago, the industry's activity accounted for more than 15 per cent of GDP; in 1970, it was 21.4 per cent. Brazilian industry has shown one of the biggest declines in the world for the last 50 years. According to a survey by the Institute of Studies for Industrial Development (IEDI), since 1970, Brazil had the third-largest retraction in the sector among 30 countries surveyed, only coming in behind Australia and the United Kingdom (IEDI, 2019).

6.1 Persisting challenges for the steel industry sector in Brazil

The existence of sustainability initiatives in the steel industry sector in Brazil and in most countries does not mean strict observance of rules and principles related to environmental preservation and the protection of workers. Particularly in Brazil, many of the steel companies have at times violated environmental and social rights. It is worth noting, for example, the frequent reports of pollution produced by the Usiminas factory, in the municipality of Ipatinga (Minas Gerais). These complaints resulted in the Public Ministry proposing to sign a conduct adjustment term, through which the company agrees to adopt certain measures to mitigate environmental damage to the surrounding community (Mesmer, 2019). These challenges are exacerbated by the deteriorating outlook for global steel markets and steel consumption due to the global economic slowdown; declining demand from China; high energy prices; accelerating inflation; and political instability following Russia's invasion of Ukraine (OECD, 2022). Because of plunging steel prices, companies' margins are being squeezed, which has direct and indirect impacts on investments in technologies and organisational innovations that would improve their environmental performance.

Steel production remains a carbon- and energy-intensive activity, and the steel industry has made efforts to lower costs and limit environmental pollution in the last decades. Producing 1 ton of steel today requires just 40 per cent of the energy it did in 1960 (WSA, 2022). However, there is no single solution to drastically reducing CO_2 emissions from this industry, and the World Steel Association believes that individual countries are best placed to assess and implement policy and technical strategies to suit their own circumstances. The steel industry is highly reliant on coal, which is primarily used in steel production. In contrast to the steel industries of other countries, Brazil's is known for using biomass (e.g. charcoal) in production. However, the amount of biomass has decreased from 28 per cent of the steel energy mix in 2005 to 16 per cent in 2020 (Hebeda et al., 2023). One reason for this decline is that charcoal production is not as efficient and competitive as coal production (EPE, 2018). Also, there are additional

environmental and social issues linked to steel production in Brazil, such as deforestation and slave labour on charcoal farms. Brazilian steel companies are increasingly using coal for energy. The decarbonisation of the Brazilian steel sector primarily means switching to hydrogen-based steel production, which requires long investment cycles of 10 to 15 years as well as many billions of euros for financing, as well as improvements in the capacities of suppliers (Hoffmann, Van Hoey, & Zeumer, 2020). In light of the middle- and long-term (rather) negative outlook, investment in energy-efficiency technologies is limited.

6.2 Sector-wide greening efforts – standards and VSS

Advancing the sustainable development agenda clearly presents challenges for Brazil, but also opportunities. In terms of the environment, efforts towards energy efficiency, emission reductions and reductions in water consumption stand out. One of the most important challenges for the steel industry is its use of water. All the companies analysed have already implemented strategies and programmes for the sustainable use of natural resources, including water, and they indicate that they are using sources of renewable energy (hydroelectric, wind and solar). ArcelorMittal, for example, based its programme on the Environmental Management System requirements outlined in ABNT NBR ISO 14001, on the Brazilian Business Commitment to Water Security and on the guidelines of the Water Master Plan.

Although all the companies have implemented decarbonisation plans and processes following Brazil's concept of "green steel", the activities cannot be fully carbon neutral. The use of hydrogen gas in the steelmaking process, which produces a minimal amount of CO_2, is still incipient and being applied in only a few pilot plants that are not yet operating on a commercial scale. The main hurdle is the hydrogen supply, typically extracted from methane, which requires energy and also creates carbon monoxide. Hydrogen can also be obtained by splitting water in a process called electrolysis, but it is expensive on global scale, and existing plants would have to be replaced and massive electrolysis facilities would need to be built. Even then, because mining and transport will likely emit CO_2, production would not be completely "carbon neutral" (Zaparolli, 2022).

The Brazilian steel industry has high levels of water recirculation – more than 96 per cent, according to the Instituto Aço Brasil (IAB), the main association of industries in the sector. This increased efficiency has resulted in significant reductions in cavitation in water bodies and sewage discharge. The companies have effluent and water treatment stations permitting its reuse in the original production unit or its allocation to other units (CNI, 2012).

Ventures in the mining sector use abundant surface and underground water resources in production processes, and they are often located in areas of springs and water recharge. The ratios between the quantity of new water used in the process and recycling/recirculation varies according to the type of extraction and productive processes; the ideal situation being the one in which the discharge is zero, that is, the recycling optimisation process allows for the reuse of all the water that has already been used in a closed circuit (CNI, 2012). According to the Instituto Brasileiro de Mineração, water recycling or recirculation in mining plants is never less than 50 per cent, with some cases reaching 90 per cent – iron mining, gold and coal, for example. In the case of industrial quartz sand, dolomite and limestone, it is up to 95 per cent. The data is comparatively dated: It comes from In the Mine from 2011 and refers to the activities of the mining sector in Brazil (CNI, 2012).

It is important to stress that the production of steel offers the conditions necessary for implementing a circular economy. It is 100 per cent recyclable without a loss in quality, making it the most reused material on the planet, with 630 million tons being recycled each year, according to data from the World Steel Association (2022). Each year, the steel industry promotes progress with a circular economy through innovations in technology and production

processes. Some of these measures for developing a circular economy are: use of steel co-products in paving of roads, civil construction and in agriculture; adoption of technologies allowing for the re-appropriation of gases produced in steel production processes; and maximising the use of steel scrap in production processes.

For the steel sector companies, VSS and ESG criteria are important for reputational and competition reasons. Even with high entry barriers, large companies compete against each other for exports and market share. In order to remain competitive, it is essential for companies to show that they are having a positive impact on the world. The growth in the application of ESG criteria in the market has been due to greater awareness about sustainability and its importance for the planet. The concept gained traction in companies due to its impacts, such as changes in consumption habits. In addition, the concept began to be widely used in financial markets, leading to more sustainable investments. As a result, the application of ESG criteria has become a tool for maintaining relevance and competitiveness.

From the institutional perspective, the UN Framework Convention on Climate Change impacts Brazilian national policies and the performance of the industry. The National Policy on Climate Change (PNMC), determined by law n° 12.187, from 29 December 2009, established the voluntary national commitment on reducing GHG emissions between 36.1 and 38.9 per cent of projected emissions up to 2020. This is in line with the reductions reported by Brazil for the Copenhagen Agreement. These reductions are to be met through the development of Nationally Appropriate Mitigation Actions (CNI, 2012).

As a result of this voluntary international commitment, by means of Decree 7390/2010, Brazil established Plans of Sectoral Actions to avoid deforestation in the Amazon and the Cerrado and the need for the steel industry to plant trees in deforested areas. Other sectors (transport, processing industries, durable consumer goods, fine chemicals, pulp and paper, mining, civil construction and health services) had to be regulated in 2012, as mentioned in the above regulation, amended by Decree 7643/2011. In addition, the Federal Decree 9,578/2018, which regulated the aforementioned Federal Law 12.187/2009, consolidated normative acts issued by the federal Executive Branch that provide for the National Fund on Climate Change and the PNMC and instituted, in its Article 17, the Sectoral Plan for the Reduction of Emissions from the Steel Industry.

A plausible explanation for the smaller proportion of emissions generated in the production of Brazilian steel is the greater use of renewable sources in energy generation and the accelerated technological modernisation of Brazil’s industrial parks, which have increasingly efficient machines and equipment that consume less energy (Brasil Steel Institute [BSI], 2020; Rodrigues & Palma, 2021). Whereas the share of renewables in electricity generation in OECD countries is around 18 to 27 per cent, in Brazil renewable sources represent 83 per cent of the electricity matrix (Rodrigues & Palma, 2021).

The Brazilian steel industry pioneered the use of charcoal as a reducing agent for iron ore in blast furnaces to produce steel with a low-carbon footprint (BSI, 2020). Replacing a portion of the coal and coke used in metal production with charcoal can significantly reduce carbon dioxide emissions without substantially modifying the process (CSIRO, 2022). The production of steel via the integrated charcoal route distinguishes Brazil’s steel industry from those in other countries. About 11 per cent of Brazilian steel production uses charcoal instead of fossil coal. Worldwide, the production of iron and steel with current technologies requires large amounts of fossil coal (European Parliament Research Service [EPRS], 2020). As it is produced using wood taken from forests planted by the companies themselves (biomass), charcoal is considered by the industry to be an input of a renewable origin.

Over the years, steelmaking companies have been optimising techniques used in the planting and sustainable management of forests. Fast-growing tree species that are ready for cutting

within 5 to 10 years are converted into charcoal, which feeds blast furnaces used to reduce iron ore to metallic iron. The uptake in CO_2 occurring during the growth of trees compensates for the volume of CO_2 released during the steel production process (BSI, 2020). The substitution of fossil coal with charcoal reduces emissions, although the method raises other issues, such as illegal deforestation and slave labour. These labour and environmental violations need to be addressed and avoided. According to IAB, the charcoal that members use comes from forests cultivated by the companies for commercial purposes, and they are certified by the FSC or Cerflor.

Other countries – such as member states of the EU facing issues related to climate change and the reduction of GHG emissions – started to present initiatives for the use of hydrogen gas for the production of green steel and other approaches for decarbonising the steel production process (e.g. combining traditional steel mills emitting CO_2 with carbon capture technologies and subsequently utilising or restoring the captured carbon; direct electrolysis of molten iron ore was also tried, but only in laboratory conditions) (EPRS, 2020).

Due to the industry's crisis, the industrial processes and product use sector, known by the acronym IPPU, showed a 2 per cent drop in its emissions in 2019 – it was the only sector that showed a reduction (Viana, 2021). Emissions fell from 101 million tons of CO_2 in 2018 to 99 million tons of CO_2 in 2019, representing 5 per cent of Brazil's emissions. The slowdown in steelmaking activity was the main factor for this sector, which – since the adoption of the PNMC in 2010 – had the lowest growth in emissions in the Brazilian economy: 3.7 per cent, which reflects the situation of the national industry in the "lost decade" of 2010 to 2020.

In 2020 during Covid-19, all the major steel companies operating in Brazil mentioned in this paper – together with IAB – published sustainability reports that addressed the pandemic, its consequences and measures adopted by the companies. The reports detailed how they provided the communities in which they operate with financial and infrastructural aid, and maintained production levels when the government announced the relaxation of social distancing measures (BSI, 2020).

6.3 Good practices of Brazilian companies from the steel industry sector – VSS and ESG values

The ESG and sustainability measures and initiatives of the five biggest steel producing companies in Brazil were analysed by looking at their sustainability reports and other documents. These companies are ArcelorMittal, Companhia Siderúrgica Nacional (CSN), Gerdau, Ternium and Usiminas. The companies analysed in this paper and associated with IAB have also adopted the Global Reporting Initiative system as a reference for their ESG practices and to compile their sustainability reports. The GRI is an independent, international organisation that helps businesses to take responsibility for their impacts, providing the most widely used standards for sustainability reporting, called the GRI Standards. Companies associated with IAB are signatories of various voluntary initiatives by society and the business community that aim to promote sustainable development. The main certifications obtained can be found in Table 10.

Table 10: Certifications obtained by companies associated with IAB

CERTIFICATION	STEEL SECTOR
ISO 9001 – Attests to good management and relationship practices between customers and suppliers	Companies responsible for producing 100% of crude steel certified by ISO 9001 in 2018, 2019 and 2020
ISO 14001 – Demands commitment to the prevention of pollution and continuous improvements as part of the normal cycle of business management	Adopted by companies responsible for producing 98% of crude steel in 2018, 2019 and 2020
OHSAS 18001 – Defines the requirements for better practices in health management and occupational safety	The certification was adopted by companies responsible for producing 46% of crude steel in 2018 and 44% in 2019 and 2020
FSC – Attests that the raw materials of a product do not harm the environment	The total amount of crude steel produced with certification of its planted forests by the FSC was 47% in 2018, 42% in 2019 and 46% in 2020
Cerflor – Aims for the certification of sustainable forest management and chain of custody of forest-based products	The shrinking total amount of crude steel produced with certification of its planted forests by Cerflor: 21% in 2018, 19% in 2019 and 17% in 2020

Source: IAB (2021) and BSI (2020)

ESG is becoming an important initiative of the Brazilian steel industry sector. The use of the term “ESG” is quite recent in IAB’s documents and reports, appearing only in the ones published since 2021. The institute does not present its own concept or definition of ESG, but indicates that – for the purposes of the ESG concept, which has increasingly guided the conduct of the sector – the companies associated with IAB have also invested in social practices that have benefited society as a whole and the communities neighbouring the companies. Together, they injected more than R$70 million into social measures in the first months of the pandemic (BSI, 2020).

The circular economy is also the subject of documents published by the IAB, mainly the annual sustainability reports. It is a new production and consumption model that goes beyond recycling and dissociates economic development from the recurrent use of natural resources. In this sense, steel not only offers the necessary qualities, but also significant advantages for the transition from the linear economy to the circular economy model. It is 100 per cent recyclable, infinitely, without any loss of quality. It ranks as the most reused material on the planet, with 630 million tons recycled per year, according to data from the World Steel Association.

The sector’s decarbonisation initiatives, identified by the IAB, come from the companies themselves. The steel industry has sought to develop innovative solutions that allow it to reduce the carbon footprint of its operations and the emissions created during the use of its products. In line with targets of the 2030 Agenda, the goals and measures were established by the companies in the sector. In its documents, the IAB reinforces the importance of encouraging sustainability in the sector and the commitment of member companies to implement initiatives from ESG criteria, the circular economy and the 2030 Agenda, but it does not determine specific commitments for companies. The companies were analysed based on the following topics: ESG concept adopted by the company; initiatives being in line with the 2030 Agenda; sustainability

projects; decarbonisation efforts; energy consumption; and application of sustainability standards. The information in the following section was derived from the sustainability reports published by the companies.

6.3.1 ArcelorMittal

ArcelorMittal Brazil recorded a net profit of R$1.235 billion in 2020, an increase of 16 per cent compared to 2019, when it recorded R$1.068 billion. Net revenue reached R$33.070 billion, an increase of 1.9 per cent compared to the previous period (Dinheiro, 2021). With industrial plants in six states, it employs around 16,000 people (ArcelorMittal, 2022b). ArcelorMittal does not propose its own concept of ESG. The company prepares its sustainability reports in accordance with the core option of the GRI Standards and draws guidance from the integrated reporting framework (International Integrated Reporting Council), which guides the ArcelorMittal Group's reporting practice.

To fulfil the objectives of the 2030 Agenda, as driven by the sector-wide debate on sustainability, the Integrated Reputation and Sustainability Management Platform guides the company's efforts to build and maintain its reputation – an intangible asset translated into trust, admiration, esteem and empathy. The sustainability management is based on the 10 Sustainable Development Outcomes (SDOs), which were based on the UN's 17 SDGs. The 10 SDOs support the effective management of stakeholders' expectations and needs, underpinned by ethical and transparent governance. Each outcome articulates a commitment in building a more sustainable future in areas such as the quality of life of employees and communities, the responsible use of natural resources, value-added supply chains, scientific support and investment in new solutions. ArcelorMittal also has a robust Integrity Programme, through which the company orchestrates initiatives to foster an ethical corporate culture, built on the pillars of honesty, transparency, dignity and exemplarity.

On the topic of sustainability projects, ArcelorMittal Brazil applies the Groupwide Environmental Policy, which calls for compliance with environmental laws and regulations. The policy also aims for the efficient use of natural resources and reducing emissions in general. Consistent with these principles, the company invests in developing operational solutions and products that generate minimal environmental impacts. In addressing these challenges, the company relies on innovative business models, research and technologies to mitigate the impacts inherent to its core business. To accommodate differences across operations and geographies, each business unit has its own risk- and impact-monitoring and control models, going beyond compliance with applicable federal, state, and municipal laws and regulations. ArcelorMittal Brazil works to obtain certification for internationally recognised standards such as ResponsibleSteel™ and Initiative for Responsible Mining Assurance (IRMA), as well as EPDs. All initiatives prioritise developing positive relations with communities and employees and safeguarding their health, safety and quality of life. Environmental management at ArcelorMittal Brazil is focussed on initiatives to mitigate and manage the impacts from its production activities; these initiatives are based on the Environmental Management System requirements outlined in ABNT NBR ISO 14001 (ArcelorMittal, 2022a).

As a decarbonisation initiative, in 2020 ArcelorMittal announced the ArcelorMittal group-wide commitment to being carbon neutral by 2050, putting the company at the forefront of the efforts to reduce GHG emissions from steelmaking. In Brazil, ArcelorMittal set a target to cut emissions by 10 per cent by 2030 and to achieve carbon neutrality by 2050. To reduce energy consumption, and as part of its commitment to the Group's SDOs, ArcelorMittal Brazil has a policy in place on energy efficiency and conservation, and it encourages employee engagement around energy savings through awareness programmes. The ArcelorMittal Energy Policy applies to all business units in Brazil, but each business unit has its own teams and targets. In each operation, the consumption and distribution of utilities in production processes are

managed and tracked against indicators measuring how efficiently energy inputs and other materials are consumed, as part of its quality management system (ISO 9001) and Environmental Management System (ISO 14001). These processes are periodically assessed by plant managers and through internal and external audits to identify and adopt best practices and more efficient technologies. These initiatives are aligned with its corporate climate change strategy of mitigating – and minimising – the causes of the global warming trend created by GHG emissions. The initiatives are structured around the role that industry has been called on to play in improving energy efficiency and adopting cleaner production processes, as defined in Brazil's commitment under the Paris Agreement (ArcelorMittal, 2022a).

The Long Carbon production plants are certified with the ABNT Environmental Label. This certification, called EcoLabel, is based on the ABNT NBR ISO 14024 standard and includes the assessment of the products' life cycle. The EcoLabel for Steel Products certifies that ArcelorMittal Brazil's processes actively seek to reduce energy and material consumption levels, and to minimise the impacts caused during production. Keeping the EcoLabel also represents a competitive differential directly associated with sustainability (ArcelorMittal, 2022a).

6.3.2 Companhia Siderúrgica Nacional

CSN reports follow the GRI, a global model of ESG indicators to standardise sustainability reports for actions related to the proper management and reporting of environmental, social and economic indicators in companies. Other data and information follow the guidelines of the World Steel Association. In addition, the company presents indicators from the materiality map of the SASB. The reports also meet the requirements of commitments made as a signatory company to the UN Global Compact, in compliance with the guidelines of ISO 26000:2010 and the SDGs (Companhia Siderúrgica Nacional [CSN], 2021).

In order to integrate the objectives of the 2030 Agenda into its activities, in 2020, the company presented a new Corporate Policy on Sustainability, Environment and Occupational Health and Safety. The policy was recently approved by its Board of Directors and commits to the SDGs and the 10 Principles of the Global Compact – initiatives by the UN for which CSN is a "signatory" company – to promote sustainable development and expand the company's relationship with the various stakeholders, constituting even more solid and transparent governance (CSN, 2022). CSN contributes towards achieving the SDGs through the development of initiatives, corporate policies and good practices that create value for society through direct and indirect impacts. The integration of the SDGs into its operations and relationships with stakeholders is strategic and essential for the company's success. Although CSN operations have direct and indirect impacts on all 17 SDGs, it has chosen to focus on 10 of them. These are the SDGs that are considered to be the most relevant to the company: SDGs 3, 5, 6, 7, 8, 9, 12, 13, 15 and 16.

In the area of decarbonisation, to ensure that air quality remains within the standards and does not pose risks to the population, CSN continually monitors its air emissions in the communities where it operates. At Presidente Vargas Steelworks, in Volta Redonda (Rio de Janeiro), there are three automatic and five semiautomatic air-quality monitoring stations, in addition to weather stations that contribute to efficient environmental controls and air quality indicators. At the Presidente Vargas Plant and at the cement plants in Volta Redonda (Rio de Janeiro) and Arcos (Minas Gerais), this monitoring is carried out through isokinetic and continuous measurements via automatic particulate and gas metres. At the Presidente Vargas Plant, data is reported in real time to the state environmental agency, which consolidates the information and discloses the Air Quality Index (IQAr) to the community. To lessen and mitigate the air pollutant emissions from fixed sources, the company uses the best environmental control technologies and Bag House and Electrostatic Precipitators Dust Collector Systems.

CSN, one of the largest industrial electric power consumers in Brazil, states that it prioritises the use of renewable energy in its production process. Aiming to guarantee a competitive cost for

this essential input, it has been investing in self-production energy projects since 1999. To expand the installed capacity of self-produced energy, the company frequently prospects and analyses the feasibility of new generation assets, always aiming to maintain the competitiveness of production costs and consider the contracting of energy from renewable sources. As a self-producer of energy, the aim is to make investments in new power-generation plants for renewable sources (hydroelectric, wind and solar) in the search for self-sufficiency in electricity.

6.3.3 Gerdau

Gerdau does not propose its own concept of ESG. The company's sustainability reports are prepared following the core option of the GRI Standards and also use the principles of the International Integrated Reporting Council as a reference.

To integrate the 2030 Agenda into its activities, in 2019 Gerdau carried out a materiality process, which is a procedure structured and supported by a specialised consulting firm. Through this procedure, the company defined the relevant material topics to guide its strategy and management, as well as to guide communications with stakeholders and society. The main steps of this process are distributed throughout the report and relate to SDGs 5, 7, 8, 9, 10, 11, 12, 13, 16 and 17 (Gerdau, 2019) .

Concerning sustainability projects, Gerdau has a Sustainability Policy and an Environmental Management System in place, which reinforce the company's commitment to creating value for its stakeholders, showing that it is in line with global regulatory guidelines and best practices. These guidelines are cascaded throughout the company's operations, detailing responsibilities and procedures to be followed. Increasingly, the ESG plan – with the environmental component playing a major role in industrial activities – is being regarded as a key factor to be considered in the debate, planning and decision-making on the company's day-to-day operations (Gerdau, 2019).

To reduce emissions generated by the company's activities, Gerdau tries to make its processes energy-efficient and to use carbon sources with less potential for GHG emissions through economically viable and innovative solutions to meet the goals defined by the organisation. The company also identifies, evaluates and manages topics related to climate change while observing risks and opportunities and embedding this topic in its strategy and financial planning. The topic is also included in the company's Sustainability Policy. In 2020, Gerdau participated in the Simulation Emissions Trading System of the Fundação Getulio Vargas (FGV). Through this initiative, FGV and a group of Brazilian companies look to understand how carbon-pricing instruments, which are being discussed internationally, would work as alternatives to pursuing the goal of reducing GHG emissions. Gerdau is also part of the Carbon Efficient Index (ICO2), an indicator created by B3, Brazil's stock exchange, in partnership with the National Economic and Social Development Bank (BNDES). The index is comprised of shares of companies participating in the IBrX 50 that agreed to adopt transparent practices with respect to its GHG emissions, stating its concern with global warming. Gerdau is the only steel producer to be included in this portfolio.

On the topic of energy consumption, steel production is energy-intensive, therefore Gerdau continually seeks to use energy efficiently to raise the awareness of the entire chain on the subject. Managing energy is based on the reliability of data on consumption, the mapping of consumer areas, and opportunities for projects and initiatives on the subject. The purchase and selection of more efficient energy sources are two of the fundamental pillars for the business's continuous economic and sustainable growth in these times of energy transition. Energy management is based on the reliability of consumption data, which makes it possible to ascertain the consumption profile of each material in consumer areas and allows for mapping opportunities for improvement. The company invested in the digitalisation of energy management and mathematical modelling software, ensuring for the control and online

monitoring of all consumption, the expected energy consumption according to production planning and other process parameters. All the efforts towards energy management, the continuous improvement of projects, the redefining of functions and changes in the fuel mix resulted in GHG emission reductions of 89,000 tons of CO_2 at the Ouro Branco mill (Minas Gerais) in 2020 (Gerdau, 2019).

6.3.4 Ternium

Ternium does not propose its own concept of ESG. Ternium's reports are prepared taking into account the guidelines established by the World Steel Association, the UN Global Compact, the GRI and the New York Stock Exchange. There is no mention of the term "ESG" in Ternium's sustainability reports.

To align the activities with the objectives of the 2030 Agenda, the company participates in the UN Global Compact Initiative, committing to integrate its 10 Principles into the company's strategy, culture and day-to-day operations. Ternium engages in collaborative projects to advance the broader development goals of the UN, particularly the SDGs. The company recently set a target to reduce the CO_2 emission intensity of its steelmaking facilities by 20 per cent by 2030. The main initiatives Ternium plans to carry out to achieve this objective are to increase the proportion of renewable sources in the energy mix and of scrap in the metallic mix; to expand the CO_2 capture capacity at its direct-reduced iron facilities; to partially replace metallurgical coal with biomass; to further develop its Energy Efficiency Programme; and to prioritise lower specific-emission steelmaking technologies when planning organic expansions. The company has goals related to SDGs 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17 (Ternium, 2019).

Concerning sustainability projects, Ternium has recently adopted a decarbonisation roadmap to reduce the company's carbon footprint in the medium term as part of its climate change strategy. In addition, the company has announced a R$460 million environmental investment plan that will be deployed over the next seven years. Investment projects will focus mainly on improvements in emissions control, raw material management and water quality control, the primary areas of the company's operations in Mexico, Brazil and Argentina. Ternium assesses the life cycle of its steel production and participates in the World Steel Association's LCA initiatives to help document and improve the environmental footprint of steel products.

As a decarbonisation initiative, in February 2021, Ternium announced the adoption of a new decarbonisation strategy with the medium-term target of reducing the company's CO_2 emission intensity rate for steel production by 20 per cent by 2030, compared to its 2018 base rate. Ternium's corporate environmental and energy policy requires that each of its business units comply with applicable environmental laws and regulations, and it aims to achieve the highest standards of environmental performance to ensure sustainable development. The supervision of the company's environmental performance leans on an environmental and energy management system encompassing every production unit. Ternium's environmental and energy management system is one of the key elements used for pursuing excellence in environmental performance. Ternium periodically audits and certifies its systems and procedures. This process helps in identifying improvement opportunities, updating the company's environmental management processes and ensuring Ternium's compliance with applicable laws and regulations (Ternium, 2019).

6.3.5 Usiminas

Usiminas does not propose its own concept of ESG. The company's Sustainability Report is based on the GRI Standards. To include a wider range of stakeholders, Usiminas began – preliminarily – to consider some requirements from the SASB and the Task Force on Climate-

related Financial Disclosures in its 2020 report. Usiminas is aware of the UN's 2030 Agenda and the 17 SDGs – a global plan developed in partnership with public authorities, academia, civil society and the private sector. The SDGs highlighted by the company are SDGs 3, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16 and 17 (Usinas Siderúrgicas de Minas Gerais S.A. [Usiminas], 2019).

On the matter of sustainability projects, Usiminas has programmes for the preservation and conservation of green areas and takes special care of protected areas. Usiminas is part of the Planting for Export and Rural Development (PERD) Advisory Board, acting together with the State Forest Institute and other representatives of society's organised sectors. The objective is to contribute towards implementing and fulfilling PERD goals; come up with management-related proposals; discuss priority planning activities; propose measures to balance, integrate and optimise the relationship with the local population; and give opinions on the use of funds allocated to the conservation unit, among other things. Ever since its founding, Usiminas has developed the implementation, restoration and preservation of the company's green areas in Ipatinga, state of Minas Gerais, with the planting and supply of seedlings, in addition to preventive maintenance against fire by means of the firebreak technique. In 2020, 13,402 seedlings were produced at Usiminas' Nursery, of which 6,132 were planted in the company's preservation areas, as the company reports.

GHG emissions are a critical topic for the steelmaking agenda, and Usiminas has been preparing to face this challenge. According to calculations using methodology established by the Intergovernmental Panel on Climate Change (IPCC, 2006), Usiminas Steelmaking recorded 6,479,630 tons of CO_2 in 2020, and GHG emission intensity came to 2.28 tons of CO_2 per ton of crude steel in 2020. Usiminas seeks to invest in initiatives that contribute towards mitigating GHG emissions, such as the in-house use of steelmaking gases, in-house power generation to be used in industrial processes, the implementing of energy-efficient projects, and managing and monitoring the energy consumption of critical departments, all while focussing on process performance. Seeking to improve GHG emissions management, the company currently has a robust action plan to put into effect the "measurement, report and verification" process, as related to the company's GHG emissions, through the preparation and update of corporate GHG inventories. This will be done according to the ABNT NBR ISO 14064 standard, the Brazilian GHG Protocol Programme and the IPCC, and it will be verified by an independent assurance body that is accredited by INMETRO. Usiminas' collaboration and participation in the CDP Report and the Public Emissions Record of the Brazilian GHG Protocol Programme are also in progress. These are initiatives for the full and transparent reporting on and disclosure of GHG emissions information to stakeholders (Usiminas, 2019).

The company sets energy consumption goals for its processes, which are monitored by the Corporate Department of Reduction and the Corporate Department of Energy and Utilities. There is a specific tool (called the Roadmap to Oceans and Climate Action, ROCA) to report on the impacts of processes that will analyse the root cause and prepare action plans.

6.4 Partial conclusion – lessons from the steel sector in Brazil

None of the companies analysed developed their own ESG concept – all of them based their sustainability reports on the GRI Standards. The objectives of sustainable development of the 2030 Agenda are being pursued by all the companies in their initiatives, and the compatibilities between them are pointed out in the reports. However, more focussed research on these initiatives is still needed. To some extent, all the companies have developed sustainability projects and initiatives focussed on reductions in energy consumption and CO_2 emissions. There were few standards and certifications not adopted by the companies.

The Brazilian steel sector ranks ninth in the world for production. The industrial processes involved in the production of steel are responsible for 5 per cent of national GHG emissions,

and the companies have invested considerably in renewable sources for energy generation and technologies to modernise Brazil's industrial parks. The five biggest steel production companies – ArcelorMittal, CSN, Gerdau, Ternium and Usiminas – obtained five environmental certifications linked to sustainable practices in the production of crude steel, namely OHSAS 18001, FSC, Cerflor and the ones derived from compliance with standards ISO 9001 and ISO 14001. The ESG practices adopted by these companies are quite new and are mainly guided by the GRI system, which offers a set of standards for the companies to base their own sustainability reports on.

In terms of environmental performance, there have been significant changes in the sector in the last 10 years. In response to environmental regulations and greater environmental awareness in the industry and among stakeholders, steel firms have implemented technological and management responses to reduce emissions and control waste. The steelmaking process affects the environment through the consumption of natural resources and the generation of waste; this waste needs to be properly treated to mitigate its effects on the environment. The steel industry is receptive to changes that mitigate the impacts of its activities on the environment and in society. In Brazil, social innovations seek to meet the needs of neighbouring communities, while environmental innovations are aimed at improving processes and products, as well as reducing the consumption of the resources involved. The concern about reducing the environmental impacts of the iron and steel sector, through innovations, is also present in other countries that are developing alternatives to reduce or even eliminate emissions from the steelmaking process. One example is the use of hydrogen gas as a substitute for coal or charcoal in furnaces. But there is a cost involved in these processes, and in Brazil it might be considered too high for the time being.

Even though there are issues linked to the steelmaking chain in Brazil such as deforestation and slave labour on charcoal farms, efforts towards greening the sector can be observed. The development of innovations that mitigate the environmental impacts of the iron and steel sector is a worldwide concern, and Brazilian initiatives that address this issue are necessary.

7 Investment in solutions – "greening" of the oil and gas industry sector in Brazil?

The oil and gas sector has a crucial role in the global supply of energy and will continue to be important in the long term. This paper considers the oil and gas industry sector to be separate from the energy sector because of the competing priorities of non-fossil energy suppliers both in Brazil and the world. However, despite high levels of hydropower in electricity production, the oil and gas sector remains the largest energy source even in Brazil. Although the introduction of renewable technologies in the world energy matrix will reduce this percentage over time, projections indicate that the sector will keep supplying a significant share (30 per cent in 2050) of the world's energy needs (International Energy Agency, 2022). The International Energy Agency contends that, although current technology costs and government policy favour renewable energy, it cannot replace fossil fuels. At the same time, many developing countries – especially rising powers such as Brazil – will require more complementary investments, for example in infrastructures (e.g. grid systems) to appropriately absorb the expansion of renewable energy. The pandemic and the war in Ukraine have also shown how sustainability policies in the energy sector can be as easily rolled back as advanced. In addition, financing these projects to advance renewable energy remains a huge challenge due to the financial impacts of these two crises, including the effects on the results of operations, future earnings, and liquidity and capital resources (PwC, 2020).

Brazil is a big player in the global oil sector being the eighth-largest crude oil and condensate producer, the seventh-largest crude oil exporter and the seventh-largest consumer of oil products in the world (BP, 2022; MME, 2021). Brazil is home to most of the offshore projects under development, with 14 offshore production units scheduled to start operation in 2025 (Abelha, 2022). The Brazilian natural gas sector is closely linked to the oil sector because the country's natural gas production is mainly associated with oil produced in offshore fields. The natural gas sector in Brazil has the potential to double by 2030, but it requires the expansion of gas pipeline infrastructures to bring the gas to shore (Abelha, 2022).

In addition, the Brazilian oil and gas sector is particularly important for urban regions, as it supports the mobility requirements of cities. However, although Brazil recognises the enabling role of the oil and gas sector in its legislation, there are already several laws that indicate there is a political will to diminish this degree of importance in the near future. For example, the National Policy on Urban Mobility Law 12,587 of 2012 establishes the guidelines to provide Brazilian cities and municipalities with instruments to improve mobility conditions (Secretaria Nacional de Transportes e da Mobilidade Urbana Ministério das Cidades, 2012). The law prioritises non-motorised vehicles over motorised vehicles and collectively used and shared vehicles over individual motorised vehicles.

The Brazilian experience suggests that companies in the oil and gas sector should still be engaged and taken as partners in designing and implementing sustainability initiatives. The sector should not be fully dismissed as insignificant in the debate around innovation, safety, the environment and health. Innovation in the oil and gas sector can help Brazil fulfil its commitment to reducing GHG emissions in the short and medium terms. Innovation in Brazil's oil and gas sector is led by Petrobras, which is considered to be a pioneer in the production of low sulphur ship fuel and the first company to meet the criteria determined by the International Convention for the Prevention of Pollution from Ships (MARPOL). Innovation in the oil and gas sector allows for anticipating scenarios, diversifying energy generation, generating results with direct application in sectoral activities, anticipating trends and taking advantage of opportunities. For example, research and innovation led Petrobras to the development of its biological oil refining project known as BioRefino. Petrobras developed a diesel with renewable content based on a raw material abundant in nature, vegetable oils. This new fuel is capable of reducing GHG emissions by up to 70 per cent compared to regular diesel, and by 15 per cent when compared to conventional biodiesel. More than a new business programme, BioRefino materialises in Petrobras' strategy for emission reductions provided by a new generation of sustainable fuels. Additionally, sustainability efforts in the sector are present, for example, in the GRI reporting and the ESG agenda of Petrobras. Against this backdrop, the competitiveness of the oil and gas sector of Brazil still matters, but this competitiveness should be defined by growth and investment that is aligned with sustainability principles.

7.1 Remaining challenges for the oil and gas sector in Brazil

The Brazilian oil industry is expected to grow in its production output and operations. At the same time, its pace of growth is faster than the government's ability to police it, which is regarded as paving the way for environmental disasters. In 2019, more than 600 tons of oil had been collected from the coastline in north-eastern Brazil (Slattery & Nogueira, 2019). Monitoring and responding to incidents as well as holding oil companies accountable are huge challenges for the Brazilian government, despite collecting revenue of more than US$25 billion from global oil companies through the offshore oil auction.

Although companies in the sector, especially Petrobras, adopt various sustainability initiatives and programmes, the size of and risks involved in their operations make it nearly impossible to completely avoid environmental damage and violating labour regulations. Thus, the judiciary, with some frequency, condemns Petrobras for activities that lead to environmental damage and

socially harmful conduct. In 2014, a group of biologists produced a document that questions the content of the Environmental Impact Study produced by Petrobras for the production and disposal of oil and natural gas in stage 2 of the Santos Basin Pre-Salt Pole. This document deserves to be highlighted, as the production of oil from pre-salt represents 73 per cent of Petrobras' total production. According to the document, "the [environmental impact assessment] presented for the activity of production and disposal of oil and natural gas from the Pre-Salt Pole of the Santos Basin - Stage 2 is unsatisfactory and deficient in the environmental diagnosis and in the evaluation of the effective and potential environmental impacts of the enterprise", and can cause damage to the marine diversity of Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul. The technicians involved in the study classify the company's attitude as "negligence with the environmental damage resulting from pre-salt exploration" (Slattery & Nogueira, 2019).

The Federal Court sentenced Petrobras to pay compensation of more than R$700,000 for environmental damages. The decision is the result of a lawsuit filed by the MPF-SE (Federal Public Ministry in Sergipe) after an oil spill contaminated the beaches of Abaís, Caueira and Saco in October 2016 (UOL, 2020). The MPF put forward the justification that the establishment of indemnity had – in addition to the compensatory nature – a punitive, educational and preventive nature. Being forced to pay indemnities – the MPF claimed – Petrobras understands that it is not unpunished and "prevents this behavior from being repeated in the future" (UOL, 2020).

In a similar episode also in Sergipe, Petrobras was sentenced by the Federal Court to pay R$200,000 due to an oil spill on the coast of Aracaju (Sergipe) in May 2016. The environmental report pointed out that this resulted in the mortality of benthic organisms, which include urchins, sponges, shrimp and starfish, as well as planktonic organisms, such as algae. Additionally, the death of species that live in the strip of sand affected by the oil slicks, such as crabs, molluscs, echinoderms and sea crabs, was observed. Based on the polluter-payer principle, the court stated that every agent that causes pollution is obliged to pay compensation or repair the damage to the environment, regardless of the existence of *dolus*, or fault.

The Federal Regional Court of the 4th Region (TRF4) upheld the conviction of Petrobras Transporte S.A. (Transpetro) – a subsidiary of Petrobras that operates with fuel transport and logistics – for the spillage of around 1,000 litres of fuel oil in the Port of Rio Grande (Rio Grande do Sul), in an accident that occurred in April 2001. The defendant will have to pay compensation in the amount of R$6,000 for environmental damage, plus monetary compensation and default interest from the date of the fact. Already in 2017, the judge of first instance recognised the occurrence of environmental damage and the responsibility of the defendant, noting that, of the roughly 1,000 litres leaked, 600 litres reached the ground and contaminated the place. Petrobras was also sentenced in 2021 to pay R$1.4 billion for environmental damages caused in Paraná in 2000. At that time, 4 million litres of oil leaked from a company pipeline into the Iguaçu River, killing plants and animals. Most of the money will be invested in the recovery of the degraded areas, the protection of slopes and riverbanks, the implementation and preservation of conservation units in Paraná and the reduction of solid waste. Concrete action will benefit not only the area impacted by the serious environmental accident, but also state and federal conservation units and their ecological corridors.

7.2 Sector-wide greening efforts

At the international level, the International Petroleum Industry Environmental Conservation Association (IPIECA) created the SDG Roadmap for the oil and gas sector. The Roadmap aims to identify how IPIECA, together with oil and gas companies, can move towards a future with low emissions and contribute to a healthier and more prosperous world, in alignment with the 2030 Agenda for Sustainable Development. The Roadmap presents a range of impact

opportunities focussed on the potential of each sector to maximise its contributions to SDGs. These opportunities represent the amplification of good practices in environmental and social performance and the construction of innovative partnerships while recognising at the same time the need for an energy transition in order to achieve net-zero emissions under the Paris Agreement. Examples of opportunities are investments in technology and innovation that will yield low-carbon products and solutions, the responsible management of resources to support a circular economy and governments' support in achieving the SDGs by aligning priorities and accelerating the required activities.

In terms of initiatives, IPIECA – together with international organisations, governments, industry associations and NGOs – established the Partnership for Clean Fuels and Vehicles in compliance with SDGs 3, 7, 9, 11, 13 and 17. Its key objectives are phasing out leaded gasoline worldwide, reducing fuel sulphur levels to less than 50 parts per million and introducing vehicles emissions standards, such as the Euro 4/IV standard. The commitment of the partners mentioned above is the driving force behind the Partnership's success. An essential part of the sector's sustainability initiatives are the mandatory regulations, determined by the National Petroleum Agency as well as legal and *infra* legal norms. Thus, corporate sustainability initiatives based on voluntary standards and programmes are residual and should be understood as a complement to compliance with mandatory standards (technical regulation).

The most relevant norms from environmental authorities are summarised in Table 11.

Table 11: Environmental norms in the oil and gas industry sector

Regulation	Content
MMA Ordinance No. 422/2011	Procedures for the federal environmental licensing of activities and ventures for the exploration and production of oil and natural gas in the marine environment and in land–sea transition zone.
MME-MMA Inter Ministerial Ordinance No. 198/2012	The Environmental Assessment of Sedimentary Area - AAAS, disciplining its relationship with the process of granting exploratory blocks for oil and natural gas, located in maritime and onshore sedimentary basins, and with the process of environmental licensing of the respective undertakings and activities.
Conama Resolution No. 23/1994	Specific procedures for the licensing of activities related to the exploration and mining of liquid fuel and natural gas deposits.
The New Gas Law No. 14,134 of 2021	The objective of the new law is to increase competition in the natural gas and biofuels market, attracting new investors, consequently reducing production costs and the final price of gas for the consumer.

Source: ANP (2022)

It is incumbent upon the National Agency for Petroleum, Natural Gas and Biofuels (ANP) to establish and supervise the rules for regulated companies to ensure the best engineering practices to protect human health and the environment while conducting their activities. The operational safety regime used in Brazil is in line with the most modern in the world. It uses standards adopted in Norway and the United Kingdom and the lessons learnt from previous incidents. With a predominantly preventive and non-prescriptive focus, it aims to achieve the ideal environment for accident prevention. ANP's activities aim to improve risk management to highlight that risk management is the responsibility of regulated companies. In this sense, the Agency's activities aim to prove that companies are maintaining all operations with controlled risks through proper efforts to adequately monitor operational safety management systems.

Another sector-wide effort – the Brazilian certification RenovaBio – recognises that an energy transition is key for the achievement of the net-zero emissions foreseen in the SDG Roadmap

for the oil and gas sector. RenovaBio's main instrument is the establishment of annual national decarbonisation targets for the fuel sector to foster the increase of the production and participation of biofuels in the transport energy matrix in the country; the production of biofuels will be certified. The national targets for emission reductions of the fuel matrix were defined for the period between 2019 and 2029 by Resolution of the National Council of Energetic Policy (CNPE) number 15/2019.

7.3 Good practices of Brazilian companies from the oil and gas sector – standards and VSS

Petrobras is the biggest producer of oil and natural gas in Brazil, with net revenues of US$ 53,683 million and 41,485 employees (Petrobras, 2021). Founded in 1953, Petrobras has had a monopoly on several activities related to oil for 44 years, including explorations and fuel refining. This exclusivity, however, ended in 1997 with the Petroleum Law, which allowed the participation of other companies in the activities carried out by Petrobras. However, Petrobras still holds a significant market share of crude oil production (approximately 76 per cent), although this share is declining and gradually yielding to private companies, national and foreign (Nunes, 2021). In the refinery sector, from January to September 2021, state-owned refineries accounted for 98.9 per cent of all oil production in the country, with 479.9 million of the 485.2 million barrels being refined on national territory, according to data from ANP (Yano, 2021). In the area of distribution, Petrobras has progressively decreased its level of participation. In 2021, the company announced the sale of its remaining shares in BR Distribuidora, Brazil's largest distributor. Petrobras owned 37.5 per cent of the company and zeroed out its shares. In general, the sector became less monopolistic under the Jair Bolsonaro administration.

The broadest sustainability initiative in the Brazilian oil and gas sector is Petrobras' Social and Environmental Program. The drivers of the programme are the recurring demands of communities located in the places where the company operates, the strategy for the transition to a low-carbon economy and offshore performance. The lines of action of the programme are education, sustainable development, ocean protection and climate issues. Concerning decarbonisation, the company aims to reduce total operational absolute emissions by 25 per cent by 2030 and reinsert 40 million tons of CO_2 in projects for the capture, use and storage of carbon by 2025. It aims to reduce the carbon intensity of the sector by 32 per cent by 2025. Data gathered by the company reveals that in 2020 there were 56 million tons of CO_2 and GHG emissions – 5 per cent lower than in 2019.

Through the company's strategy for socio-environmental investment, the estimated potential contribution in carbon fixation and avoided emissions is 870,000 tons of CO_2. In addition, on energy matters, Petrobras invested R$21.5 million in renewable energy, focussing on wind and solar power and the use of bio kerosene. Furthermore, Petrobras has adopted the guidelines for sustainability from the GRI Standards in a comprehensive manner. Given the mounting pressure from different groups such as governments, consumers and investors to be more transparent about environmental impacts, Petrobras and many other companies publish their sustainability reports (Temper et al., 2020).

The GRI Industry Standard for Oil and Gas focusses on the industry's most pressing challenges for sustainable development. At the centre is how companies' decisions and actions address widespread stakeholder concerns about climate change-related impacts while ensuring a just transition for workers, communities and the environment. The first GRI Industry Standard applies to any organisation involved in the exploration, development, extraction, storage, transport or refinement of oil and gas. Key features include:

- Guidelines that report on the 22 most likely material topics, including climate adaptation, resilience and transition, site closure and rehabilitation, biodiversity, Indigenous Peoples' rights, anti-corruption, water and waste
- Comprehensive disclosure of GHG emissions – both direct (Scope 1 and 2) and indirect emissions caused by the end use of its products (Scope 3)
- Authoritative expectations for responsible business, including the Extractive Industries Transparency Initiative and the Task Force on Climate-related Financial Disclosures
- Multiple stakeholders and global legitimacy, with development led by experts representing businesses, investors, civil society, mediation and labour institutions

In Brazil, Petrobras adopts the sustainability guidelines of the GRI Standards following the comprehensive option (Petrobras, 2021). The company also uses IPIECA's Sustainability reporting guidance for the oil and gas industry as a complementary reporting methodology. It is a global association of the oil and gas industry for environmental and social performance that promotes reducing total absolute operating emissions by 25 per cent by 2030. The resilience concept of the oil and gas portfolio also involves low-carbon-intensity operations in the facilities. It reinforces including the topic of carbon in decision-making processes, intensifies the monitoring of emissions in the value chain and emphasises technological preparations for future business in renewable energies. In this sense, in the period 2021-2025, the company is stipulating 10 commitments for the low-carbon and sustainability agenda:

Table 12: Petrobras' commitments for the low-carbon and sustainability agenda

1	25% reduction in absolute operating emissions by 2030
2	Zero routine flare burning by 2030
3	Reinjection of 40 mm per ton of CO_2 by 2025 in carbon capture, use and storage projects
4	32% reduction in carbon intensity of the exploration and production sector by 2025
5	40% reduction in methane emissions intensity in the exploration and production sector by 2025
6	16% reduction in carbon intensity in refining processes by 2025, raising this to 30% by 2030 (30 kg CO_2 e/ complexity-weighted throughput)
7	50% reduction in fresh water abstraction in our operations with a focus on increasing reuse by 2025
8	Zero growth in process waste generation by 2025
9	100% of facilities with a biodiversity action plan by 2025
10	Investments in social and environmental projects, human rights programmes and community relations

Source: Authors

Item 10 of the sustainability commitments of Petrobras consists of five social responsibility commitments:

1. Human Rights training programme for 100 per cent of employees
2. Actions to promote diversity, providing an inclusive environment
3. Due diligence on human rights in 100 per cent of operations
4. Socio-economic diagnosis of communities
5. Measuring and disclosing the social returns of at least 50 per cent of social and environmental projects

The hiring of Petrobras employees in Brazil is done through a public selection process. This is carried out by offering equal base salaries for men and women. In accordance with Brazilian legislation, 20 per cent of vacancies are reserved for black candidates and 5 per cent for people with disabilities. Petrobras also has Human Rights Guidelines on combating discrimination and promoting diversity internally as well as the mitigation and prevention of human rights violations internally and in the supply chain (Petrobras, 2022). The commitments provide vulnerable families access to essential inputs, mainly food and cooking gas. Additionally, socio-environmental projects aim to contribute towards improving the quality of life in the communities in which Petrobras operates. Regarding the adoption of renewable energy, Petrobras' agenda aims to generate a high share of renewables in the Brazilian electricity matrix.

7.4 Partial conclusions – lessons from the oil and gas sector in Brazil

A major difference between the oil and gas sector and the other industry sectors in Brazil is the degree of state intervention. As Brazil is the world's ninth-largest producer of oil and gas, this sector is often subject to political calculations. In addition, due to a political will to reduce carbon emissions, the sector is expected to decline in the long term. At the same time, any low-carbon transition cannot advance without the oil and gas sector. Not only can the sector provide sources of financial capital needed to invest in technological innovation for renewables, the pace of the energy transition in Brazil is slow due to the lack of needed infrastructures. Therefore, sustainability initiatives from the oil and gas sector still deserve attention.

Brazil needs to expand the relevance of oil and gas as a temporary "bridging technology" while maintaining a clear vision of switching away over the long term in order to achieve its emission-reduction goals. Petrobras has created a centre of research, development and innovation that combines the most innovative knowledge about energy with accelerated digital transformation. The activities of the centre can pave the way for technological partnerships with the main scientific institutions and technology-based companies. These agreements are fundamental for anticipating solutions, overcoming challenges and innovating. Digital databases, three-dimensional models and machine learning are scientists' allies to streamline processes, estimate production curves, reduce risks and anticipate solutions to problems. These technologies, among others, are applied to the production of diesel with renewable content and the low sulphur ship fuel discussed above.

The broadest business initiative of the sector is Petrobras' Social and Environmental Program, which serves as a benchmark in the sector. In addition, the most important companies in the sector are making substantial efforts to reduce carbon emissions as much as possible. The main VSS used in the Brazilian oil and gas industry is the GRI. Furthermore, the Brazilian oil and gas sector is cooperating closely with their counterparts from other countries through its membership in IPIECA. The association's SDG Roadmap for the oil and gas sector is being implemented in Brazil. For example, Petrobras – the biggest producer of oil and natural gas in Brazil – has adopted the sustainability guidelines of the GRI Standards following the comprehensive option and is using IPIECA's Sustainability reporting guidance for the oil and gas industry as a complementary reporting methodology. In the period 2021-2025, the company stipulated 10 commitments relating to the low-carbon and sustainability agenda. In general, the sector, which is largely represented by Petrobras, is very engaged with sustainability goals and the mitigation of emissions, at least as a public commitment.

8 Lessons for theory and practice – "greening" of the high-emitting sectors in Brazil

The five high-emitting industry sectors – chemical, cement, aluminium, steel, and oil and gas – engage in "greening" their activities in Brazil, although to varying degrees. Except for the oil and gas sector, the move towards sustainability is advancing due to perceived opportunities through decarbonisation of the sectors and related companies to develop a self-governance framework that allows them to align their intrinsic motives with sustainability principles. As instruments of self-governance, VSS are shown by these case studies to often be underestimated in their effectiveness in attracting the private sector to improve their current business operations in terms of costs and risk management using sustainability concepts. The case studies also show that standards which initially barely meet environmental protection requirements can serve as departure points for more ambitious and stringent standards, particularly when the biggest players recognise the competitive advantages they bring.

Answering the overarching question – "*How are the governance frameworks leading to concrete greening in the high-emitting industry sectors in Brazil?"* – is difficult due to the complexity of the issues involved. The sustainability initiatives, VSS and the entrenchment of ESG values are difficult to measure and assess. In addition, it is difficult to attribute the improvement of environmental performance to certain measures. At the same time, the case studies on the sectors have delivered substantial insights into how governance frameworks can help facilitate the greening of the high-emitting sectors. From the five greening governance frameworks suggested in the introduction, the self-governance framework driven by voluntary schemes has proven to be effective in advancing the awareness of sustainability principles in the sectors. The greening governance frameworks – which involve the five dimensions (actors, issues, structures, processes and outcomes) and their variables and indicators (cooperation, normativity, mixing of issues, policy instruments and actions, relational infrastructures, multiplicity of phases, innovation in human development, trade-offs and externalities, multiplying effects of policies and actions) – are applied to test various theoretical assumptions in the context of high-emitting industry sectors in Brazil.

When adopting standards, companies and sector associations have often referred to the SDGs, particularly in reference to climate and environmental protection targets. As the Brazilian case study confirms, VSS are the preferred instruments of sectoral associations and companies for various reasons. Needless to say, the other four frameworks are still relevant, and even more relevant in the later stages of the greening process in these sectors. The WTO's TBT agreement is less relevant as a framework at this point because of Brazil's current production in the sectors that is directed to domestic markets. In addition, non-tariff barriers are not impactful obstacles to the internationalisation of trade in these sectors, particularly not in the chemical sector. At this point, the OECD guidelines on due diligence are not yet that relevant in Brazil. However, this framework might play a different role in the near future, as many OECD countries are expanding their national legislation on corporate environmental and social due diligence. At the same time, the importance of this framework will most likely depend on the degree of international trade and market-led globalisation.

The role of ESG values as a framework for the five industry sectors is – at least in the case of Brazil – still being developed. Further improvements are necessary to advance the application of ESG criteria as a tool for maintaining relevance and competition in each of these sectors. Most experts suggest that these sectors (except the steel sector) are not reliant on green finance because they are financially independent. For example, the Brazilian oil and gas sector is not subsidised in Brazil. However, the case studies on these sectors show that the major challenge is the limited access of these sectors to green finance instruments. Because these sectors are responsible for climate change and environmental damages, social injustice and human rights violations, their efforts on technological innovation as well as shifts in the weight or value of

sustainability in these sectors are often dismissed and easily labelled as “greenwashing”. Although this perception of them as being “merchants of doubt” can be well-grounded, they can also be – as the Brazilian case study suggests – part of the solution under certain conditions.

The adoption of VSS in the high-emitting industry sectors in Brazil is explained using the theoretical framework introduced in this paper. On one hand, VSS offer entry points for the private sector to gradually align business operations with more ambitious sustainability targets on their own terms. On the other hand, VSS deliver opportunities for policymakers to improve their greening policies, as the adoption of VSS directly and indirectly complements these greening policies. At the same time, from the meta-level perspective, VSS provide the necessary conditions to advance the transformation process towards sustainability, as is explained using the theoretical framework. Referring back to Table 2, the following theoretical assumptions are the initial outcomes of this paper with regard to the identified qualifiers and variables, which can be further investigated in future works.

Theoretical assumption on cooperation (#1): Several interacting actors and networks of actors from the public and private sectors (entrepreneurs, local communities, different levels of government, civil society groups) cooperate to carry out, channel and adopt different forms of innovation that create enabling conditions for greening.

VSS can play an important role in connecting actors and networks from the public and private sectors. Without VSS, the barriers to adopting sustainability principles can be unsurmountable for several private-sector actors, particularly those from high-emitting sectors. As “greening” covers economic, environmental and social issues, many companies adopting them will need to also address the environmental and social impacts of their business operations. As the Brazilian case study shows, this can be overwhelming for many companies because they open themselves up to more scrutiny, and thus might worry that their autonomy is being curtailed. As companies, they are accountable to their shareholders and investors, and adopting sustainability principles might be perceived as an undue shift of accountability towards policymakers and civil society actors. VSS ensure that autonomy is not undermined while engaging with actors and networks from the public sector and civil society. In addition, Brazil’s cement sector has shown the need for a more active contribution from the Brazilian government. As global competition becomes more intense and geopolitics lead to higher energy prices, the government’s lack of research funding, for example on how the cement industry can replace its use of fossil fuels, is contributing to the sector’s decline. The relative success of recycling in the aluminium sector, which is an example of a circular economy, depends on a wide range of actors, including recycling companies, collectors’ cooperatives and the government, which facilitates the formalisation of the collection activity and grants credit. A similar logic occurs in certain segments of the chemical sector, such as plastic, as expressed in the Recycling Transforms Program and in the activities of the Plastic Cooperation Network.

Theoretical assumption on the normativity of greening (#2): The interrelated concepts of greening, sustainability, climate protection, deep transformation and their instruments are normative and therefore cannot be separated from just transitions.

VSS connect the debate on technological and organisational innovation with just transitions. VSS have allowed the sector associations and companies to contextualise the social, environmental and economic issues as well as the solutions they each need to address sector-specific challenges, such as the intensity of market competition, the level and scope of technological innovation, the weight of sustainability and changing consumer preferences. By doing so, they can create a feedback loop on the conceptualisation of sustainability, climate protection, deep transformations and their instruments. Policies on “greening” need to reflect that actors from these high-emitting industry sectors are not to be excluded from just transitions. The sector associations and companies in Brazil can be part of this feedback loop through VSS and ESG. As they adopt multiple VSS, they push for the harmonisation of these standards and

pressure policymakers to act, leading to the convergence of the definitions, indicators and qualifiers used by each standard. This convergence challenges how some sectors define and measure sustainability. For example, with sustainability measures successfully implemented by high-emitting sectors such as oil and gas, some dominating ideas in the academic debate on sustainability can be challenged and lead to "green investment" being poured into these sectors to support energy efficiency and carbon capture and storage technologies. The proliferation of standards also pressures the government to act, as it creates confusion for consumers and companies and leads to a lack of transparency regarding sustainability initiatives.

Theoretical assumption on the mixing of issues and policy instruments and actions (#3): The interlinkages of issues imply the necessity of mixing policy instruments and actions of non-state actors to explore synergies and trade-offs.

Mixing or nexus-thinking approaches are key to transformations to sustainability. What is crucial for improving the sustainability of the five industry sectors is how they address issues related to water, energy and food security. Not only does this nexus approach create new values for the companies, it also allows for the emergence of a more holistic overview and effective management of the transformation to sustainability. VSS represent effective instruments of nexus approaches. VSS allow companies from the five sectors to address some of their shortcomings, such as the steel sector's negative impact on water security due to the application of solutions that target one aspect of their value chain, such as water recycling and recirculation, which benefit not only themselves but also other sectors. For example, the Brazilian chemical sector is reducing accidents through its adherence to standards on transport (*program olho vivo*). Additionally, companies such as Braskem usually involve multiple social actors affected by industrial activities, with the aim of improving the quality of life in the locations where they operate, involving for example the re-education of local populations. By looking at the whole value chain, ASI certification adopted by most aluminium companies in Brazil addresses the linkages between sectors such as energy and transport. In the initiatives of large transnational companies in the chemical sector, there is also a concern about the sustainability of the entire chain, as evidenced by BASF's sustainability verification mechanisms. Generally, large companies in the sectors with intensive emissions that are exploring natural or mineral resources are developing measures that are aimed at multiple environmental dimensions. This is the case, for example, with concerns about water resources, currently present in the steel, aluminium and some chemical product sectors. The Brazilian Business Commitment to Water Security and the Water Master Plan are other examples of VSS that employ nexus thinking. From the meta-level perspective, the mixing of issues through VSS can lead to push-and-pull effects, whereby one sector pushes the other to commit to sustainability principles, and the same sector is pulled by another one.

Theoretical assumption on relational infrastructures (#4): Relational infrastructures are needed to align, coordinate and sequence greening policies, actions of sectors and technological innovation.

Relational infrastructures are institutions, mechanisms, norms or practices that facilitate present and future cooperation. The case studies of the five industry sectors in Brazil confirm the importance of advancing sustainable development through international agreements and regimes. At the same time, the case studies highlight the role of international agreements forged by non-state actors and networks from the private sector. For example, the World Economic Forum, an independent international organisation comprised of more than 1,600 multinational companies, was instrumental in paving the way for sustainability initiatives of companies from the five sectors in Brazil. The World Economic Forum's Partnering Against Corruption Initiative motivated Enuata, an oil exploration company, to develop its Code of Ethical Conduct and the Guide of Ethical Conduct for Suppliers and improve its ESG commitments. In addition, the sector associations in Brazil have proven themselves to be important relational infrastructures where companies can exchange experiences and solutions. At the same time, these sectoral

associations are self-driving infrastructures and are even pushing their members to go beyond their comfort zones. For example, the steel sector association encouraged social activities to help communities in the first months of the pandemic. The chemical association – also managed by large companies in the sector – offers a network of sustainability programmes that were later adopted by companies, including small and medium-sized companies. In the aluminium sector, ABAL has coordinated and guided broad sustainability efforts through the Strategic Route of the Brazilian Aluminium Chain 2030. The association, in addition, serves as an intermediary between various business and civil society actors.

Theoretical assumption on multiple phases of transformation towards sustainability (#5): Instruments of "greening" (both policies and non-state actions) are embedded in a wider context of transformation towards sustainability that implies the need for a meta-framework to manage the heterogeneity of actors, the relational infrastructures that promote cooperation between them, and governance and institutions that connect issues and structures.

Some Brazilian companies in the five sectors are adopting sustainability standards that are either de facto or de jure roadmaps, such as the Cement Technology Roadmap to 2050 (developed by the IEA with the Cement Sustainability Initiative, among others), or the SDG Roadmap, created by IPIECA and based on possible industry and company contributions towards achieving the SDGs. When VSS are conceptualised as conditions needed to achieve a certain sustainable future, they become embedded in a bigger framework of policies and instruments for achieving sustainable development. As such, the evaluation of the relevance and impacts of VSS is no longer limited to their impact for the company, but now also includes their impact on the advancement of the transformation to sustainability. With this, it becomes difficult for companies to freeload or "greenwash" because VSS are continuously converging towards the goals of the International Sustainability Standards Board that resulted from the Glasgow summit.

Theoretical assumption on innovation in human development (#6): Greening processes can unfold when the focus goes beyond technological innovations and expands to social and institutional innovations.

The value of technological innovations is measured through their impacts on the advancement of human development. This covers the relationships of humans within social systems as well the relationships between humans and the environment. The selected sectors and companies have recognised that technological innovations are drivers and enablers of transformative change towards sustainability. Industry sectors such as the aluminium sector are potential hubs of technological innovation. The Strategic Route of the Brazilian Aluminium Chain 2030 and the Manifest Brazilian Aluminium for a Sustainable Future have identified innovation as one of the resilience principles. The steel industry in Brazil sees innovation as the driver of the circular economy. However, as this paper argues, innovation is only of value if it is connected with other societal goals. The chemical industry is one step ahead in this regard. The Global Strategy for Sustainable Development adopted by the chemical industry clearly connects innovation with other sustainability goals, such as health and safety. Companies such as the chemical company Braskem apply the Customer Satisfaction Score to measure the perceptions of stakeholders on how they are innovating. The use of Consultative Community Councils, which in themselves are a type of institutional innovation, help to connect innovations with local demands. In the cement sector, innovations focus on reducing energy consumption (by increasing production efficiency) and on the use of renewable energies. Votorantim, the largest company in the sector, invests in reducing losses in the production process as well as in sustainable sources of energy by building small hydroelectric plants and improving the use of biomass.

Theoretical assumption on trade-offs and externalities (#7): Cooperation between interacting actors and networks can create new inequalities due to varying access to technologies and opportunities.

The case study suggests that companies from the five sectors are keen on maintaining a good public image. One way of doing this is by responding to the demands of civil society groups to address resulting disruptions such as inequality and the deteriorating environment. Petrobras' Social and Environmental Program is a response to the demands of the local communities in places where the company operates. As a result, the programme provides additional resources to improve education and ocean protection in their communities. The Circular Movement programme and various education initiatives related to the circular economy in the aluminium sector are also responses to widespread social demands. Another way of maintaining a good public image is to show that companies listen and are willing to collaborate with civil society groups. Through the adoption of VSS, the aluminium sector in Brazil is signalling its close relationship with civil society groups and human rights advocates, which are active in co-developing these standards. Therefore, VSS serve as outcomes of cooperation between actors and networks that focus on inequalities.

Theoretical assumption on co-benefits, synergies and multiplying effects (#8): Greening can create new activities that can either render existing ones obsolete (incl. technologies) or reinforce existing asymmetries that promote them, demanding new skills while making old ones redundant, and prompting upgrades in skills that can exclude those who are not willing or able to do so.

Advancement in one sector can spill over to other sectors as new technologies and practices resolve some carbon lock-ins that go beyond sectors. The selected industry sectors are – as the case study on Brazil confirmed – enablers of sustainability initiatives in other sectors. The aluminium sector develops needed materials that are more energy-efficient and facilitate the transition to a circular economy. Through its "Climate Initiative" of 2018, the oil and gas sector in Brazil has increased its investments in technologies and innovation, particularly for CO_2 reduction and carbon capture and storage. The search for more efficient production processes and the use of sustainable forms of energy generation also imply the creation of new economic activities. The increasingly intensive exploitation of biomass – including the use of organic waste and composting processes – demands less from workers and highly trained technicians who are specialised in chemical engineering, geology and biology. Through these actions, the high-emitting industrial sectors are themselves becoming agents of change. VSS and ESG are helping to institutionalise these actions and allow these sectors and the companies within them to upgrade their skills. Although some proponents of sustainable development can argue that these efforts are merely delaying the inevitable decline of these sectors, it can be argued that the current greening activities of the sectors are allowing states to meet their international commitments for emission reductions. Although the decline is inevitable, through VSS and ESG this decline occurs on the terms of the affected sectors.

9 Conclusion – ways forward

This paper examined how industry sectors have implemented sustainability measures while focussing on the use of VSS and ESG standards as the governance framework for "greening". The good practices of sector associations and companies from five high-polluting sectors in Brazil were selected: steel, oil and gas, chemistry, cement and aluminium. The paper identified and assessed the strategies of these sectors to address the social and environmental challenges, the solutions for which are being demanded by state and non-state actors.

This paper introduced a theoretical framework to assess how the greening of high-emitting industry sectors in Brazil fit into the bigger picture of the transformation to sustainability. The greening phases – sustainability initiatives, the adoption of VSS and the entrenchment of ESG values – are useful in determining the current stage of greening in the five high-emitting sectors. The case studies show that most of these sectors have moved beyond the sustainability

initiatives phase and are mostly in the second greening phase, whereby the adoption of VSS is helping the companies to address further sustainability issues. At the same time, the use of this greening framework is helpful in determining the needed next steps for these sectors. The analysis confirms that the companies and sectoral associations also have an active role to play in advancing sustainability and that their contributions can be connected to existing policies. Some of the lessons learnt from them can be applied in other countries with emerging economies, such as China and India, particularly when it comes to the measures taken in the absence of ambitious policies on sustainability from the state. In Brazil, the process is driven from the bottom. The experience of Brazil suggests the importance of sector associations and other networks as well as connections with international partners.

The mapped information allows for broad conclusions to be made. The industrial sectors selected show concerns about sustainability issues; they understand that they themselves are part of the solution. Their positions reflect uncertainty and their perceived vulnerable condition in the face of changing social and environmental attitudes, with pressure coming from the domestic market as well as abroad. At the same time, they realise that taking initiative is more effective than being a “merchant of doubt”. Through engagement, they are able to co-formulate socio-technical narratives. Even inherently high-emitting sectors such as oil and gas have adopted initiatives that support an environmentally friendly narrative.

The analysed sectors present a clear strategy related to industrial sustainability initiatives seeking to achieve the 2030 Agenda and a variety of SDGs. These strategies align their own business interests with the sustainability principles provisioned in several agreements as well as roadmaps and initiatives involving other players in the sector. Sectoral associations have proven themselves to be major drivers of greening strategies. Together with corresponding international institutions, they have shown a high degree of engagement. However, the companies and sectoral associations themselves are defining and applying sustainability standards. NGOs do not yet have a relevant role – as observed in the agriculture sector – except for in Brazil’s aluminium sector. This fact – and the lack of involvement of the government (with the exception of the oil and gas sector) – seriously affects the power balance of these greening initiatives as well as the companies’ accountability.

Regarding ESG standards, the strategies are more recent and connected to social issues, entrepreneurial responsibilities and ethics. In the case of ESG standards, equity appears to be more directly related to investor relations and fundraising. Interestingly, in Brazil, financial entities are not leading the process, opening space for consultancy and auditing firms. For both VSS and ESG – despite the initiative of the Brazilian National Platform on VSS, which is the responsibility of INMETRO – the relative indifference of the central government has become evident. The Brazilian government has almost no involvement in helping these sectors handle the multiplication of standards. Without clear rules concerning public control, the seriousness of any of these actions cannot be guaranteed, and suspicions about greenwashing cannot be avoided. Another critical point from the case study concerns the lack of trained experts on compliance with sustainability standards. Some associations and companies train technicians for the task, but none can guarantee the effectiveness of many initiatives.

The case study has also confirmed the essential difference between the use of VSS in the agriculture and industrial sectors. Agricultural VSS are defined by NGOs, developed according to frameworks for international standards and have transparent compliance assessment procedures. Whereas industry VSS are segmented according to sector and defined by companies and associations, with no public control over certification, accreditation or other compliance assessment procedures, creating a considerable risk of greenwashing. A significant difference is also reflected in the mapping of standards by the ITC: The broadness of standards in the agriculture sector contrasts with the lack of VSS for manufacturing companies. For the farming sector, standards identified by the ITC are found and applied by Brazilian companies.

In the manufacturing sector, the ITC only determines generic standards that are foreseen in the recommendations of international treaties, but nothing more concrete has been identified.

The adoption of VSS and ESG principles makes it easier for these companies to be questioned about sustainability once they have committed themselves to these principles. However, especially regarding inequality, which is a prominent problem in Brazil, a study has shown a relatively low number of VSS that target issues concerning inequality (Schleifer et al., 2022). In addition to this, power imbalances in governance and the lack of participation of the state make it difficult to expect great changes regarding social aspects.

The case study also pointed to some political questions that should be analysed in the international arena. These questions highlight the problems of multiplication and conflicts in current standardisation systems:

- Are sustainability measures – which are the basis for VSS and ESG – such as carbon footprints and product life cycles, among others, standardised?
- Which organisations should be involved in discussing and elaborating upon these measures and coordinating VSS and ESG industrial production and use?
- What is the role of ISO standards for the issues explored? Should the UNFSS expand its role beyond awareness, technical cooperation and capacity-building?
- Will coordination remain decentralised and in the hands of the private sector? Who is going to be responsible for certification, and under which accreditation rules?
- Can NGOs related to agriculture have a coordinating role in manufacturing VSS?
- What is the role of financial entities in ESG disclosures?
- VSS and ESG are overlapping. Should they be separated, or should they be joined in a common standardisation system?
- What should be the role of governments in this discussion of governance?

Another critical point is that VSS and ESG can be considered barriers to trade. The impacts of sustainability measures on developing countries should be further investigated as new forms of production, service provision and products emerge. Although the case study of the industry sectors did not raise questions about barriers to trade, some questions have indirectly emerged:

- What should the WTO’s role be on the issue?
- What will the impact of this “green revolution” be on the economic growth of developing countries?
- What will be the impact of this revolution on the survival of small and medium-sized enterprises?
- Can human rights issues concerning women and minorities such as Indigenous Peoples and black people be included in VSS and ESG?
- The OECD has performed extensive research on due diligence that overlaps with ESG and VSS. Who will promote the dialogue between so many actors?

Further research questions emerged that this paper was not able to address. One question relates to the impact of mixing policy and action, which is driven by nexus thinking. Although this approach ensures the effectiveness of combining policy and action, it is an open question as to whether nexus thinking unrealistically assumes that all countries have functioning

governance institutions. In countries where ministries are offered as “rewards” to competing political groups (and multiply according to the size of coalitions), how can policy and action be mixed? Questions related to accountability and transparency are linked. As policy and action are mixed, who will be held accountable should risks materialise?

Questions also came up regarding the emerging importance of the concept of circular economy as an instrument for sustainable transitions. As evidenced in the cases of aluminium, chemicals and, to a lesser extent, steel, the circular economy has driven a series of initiatives with important social and economic impacts and resulted in new economic activities. Circular economy projects are fully embedded in companies’ environmental policies. However, some questions emerge: Is the circular economy itself an emerging governance framework that requires further academic debate? If it is a framework that mainly focusses on innovation in technologies and practices, how can social issues be embedded in this concept? What does collaboration look like in a circular economy?

Ultimately, questions arise about the viability of achieving transformative structural changes. Profound changes are necessary to reach the goals of Agenda 2030. Can this be done within the current economic model adopted in the country? The paper showed the country’s deficiency in tackling the social aspects of development, which can be ascribed to the economic model, which is based on a market logic and focussed on profit, and thus on exploitation and accumulation. All instruments that the paper looked at also follow the market logic, and this might be why it is so difficult to tackle the social aspects of sustainability. This would threaten the system and perhaps make the standards unfeasible for adoption.

This paper has shown how the five high-emitting industrial sectors have chosen to be part of the way forward. Although some doubt their intentions – and there is still room for improvement – they demonstrate that they have the resources and the will to advance towards sustainability. On some issues, they can even present good practices that can be replicated in other sectors, such as in agriculture, particularly the role of networks, for example sector associations and international agreements between non-state actors. Finally, this paper has shown how VSS and ESG can turn “unlikely partners” of sustainability into probable “merchants” of sustainable change.

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