



INVENTORY OF GREENHOUSE GAS
EMISSIONS FOR THE FERROALLOYS
AND SILICON METAL SECTOR

BASE YEAR 2022

22/09/2024



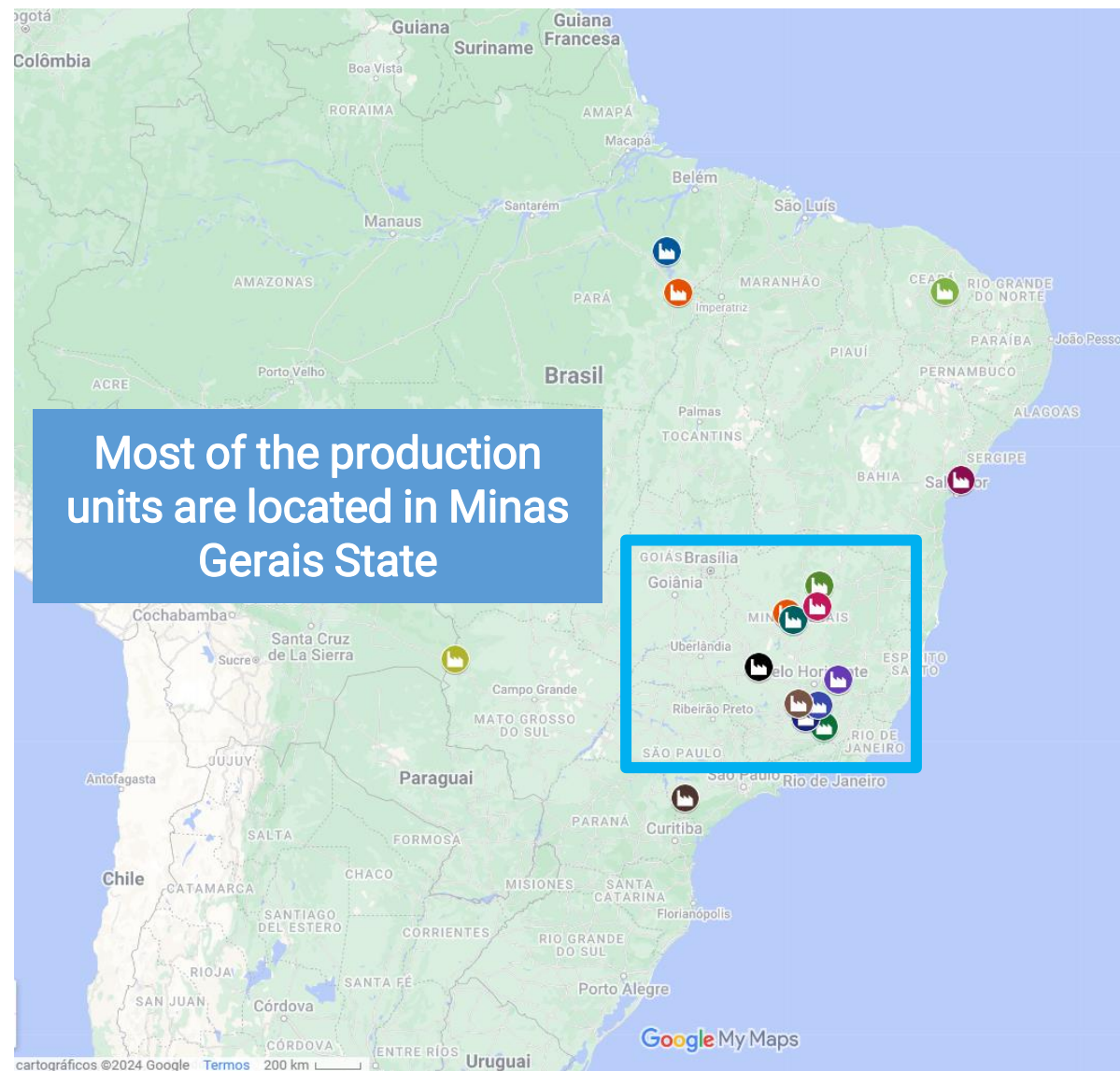
ABRAFE - BRAZILIAN INDUSTRY ASSOCIATION OF FERROALLOY AND SILICON METAL



ELETROLIGAS LTDA.



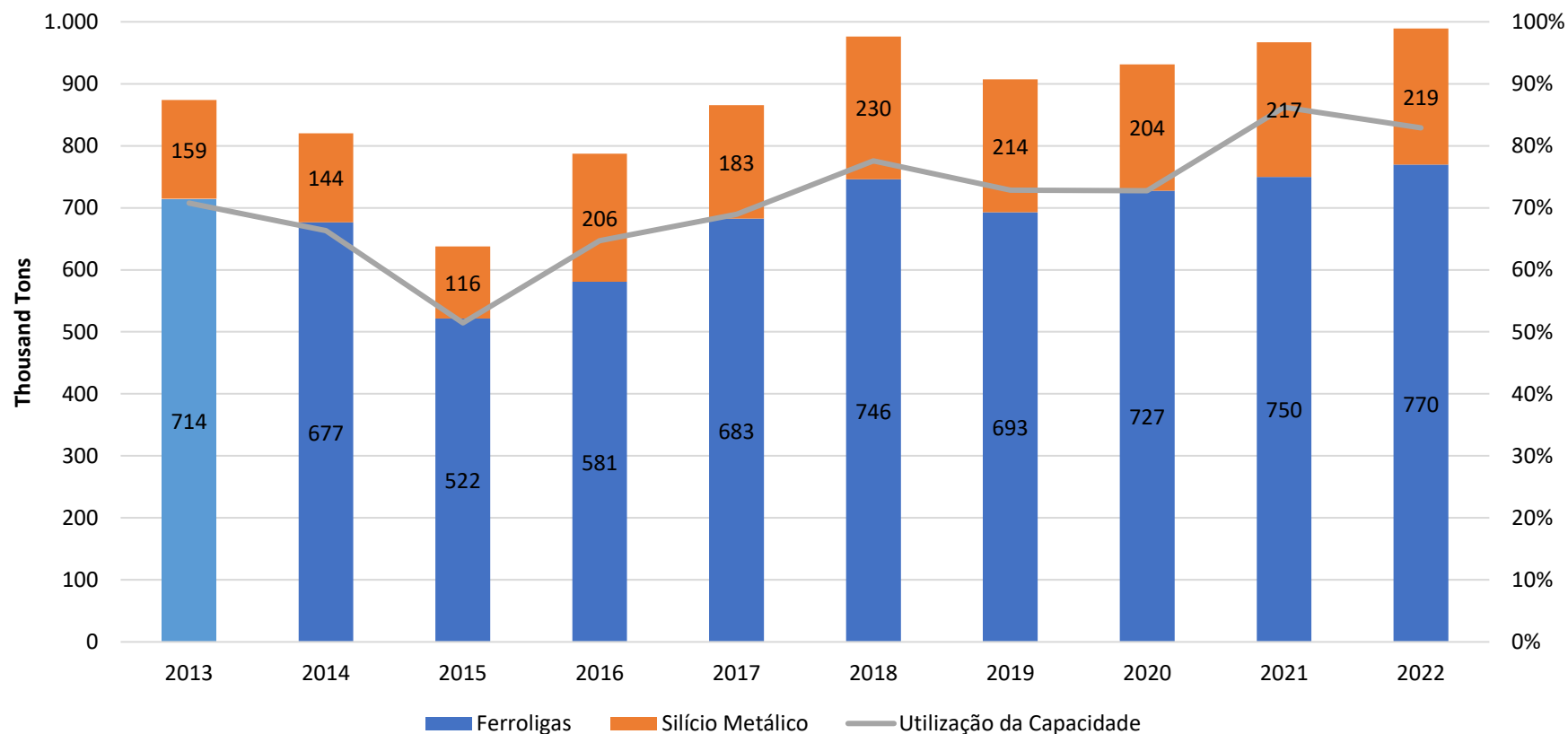
Ferbasa



Municípios

- Pojua
- Pirapora
- Capitão Enéas
- Santos Dumont
- Várzea da Palma
- Breu Branco
- São João del Rei
- Nova Era
- Itapeva
- Bocaiúva
- Corumbá
- Banabuiú
- Conselheiro Lafaiete
- Passa Tempo
- São Gotardo
- Marabá

Production of Ferroalloys and Silicon Metal ABRAFE Associates

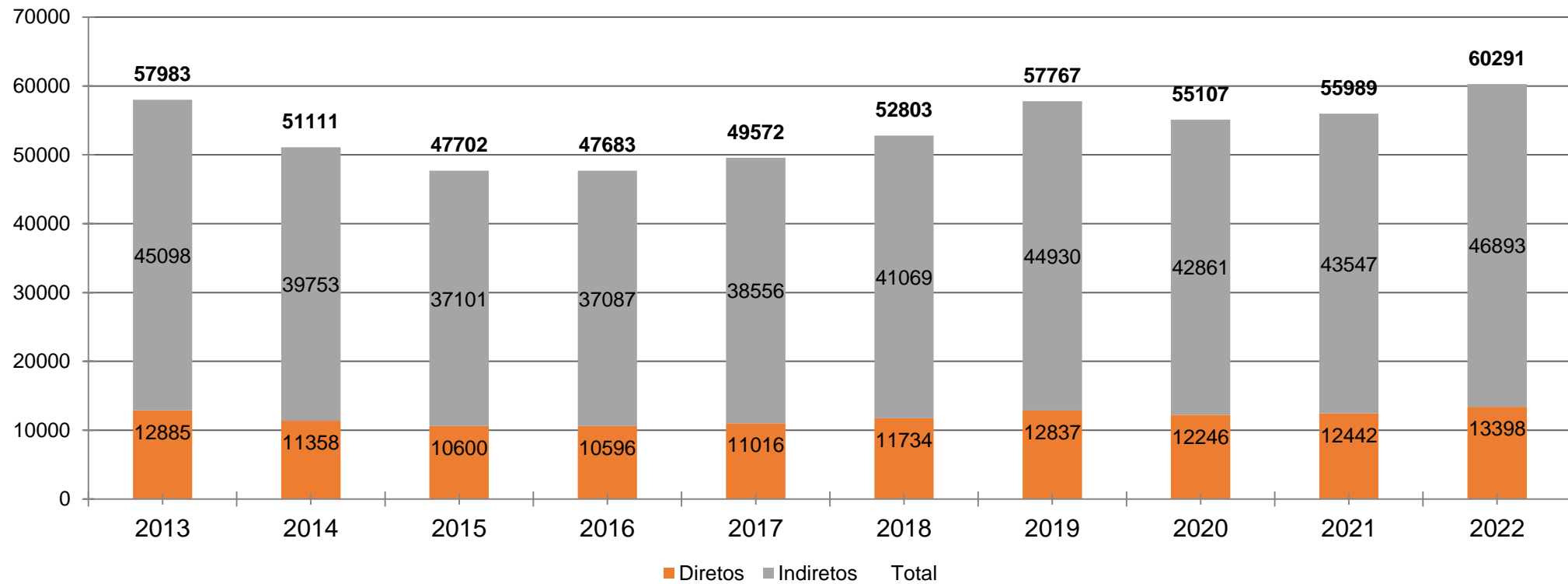


Ferroalloy production shows significant growth, reaching 770 thousand tons in 2022.

Silicon metal production was 219 thousand tons in 2022, representing an increase of 88% compared to 2015.

With capacity utilization at 86%, ABRAFE members together produced 989 thousand tons in 2022.

Job Generation – ABRAFE Associates



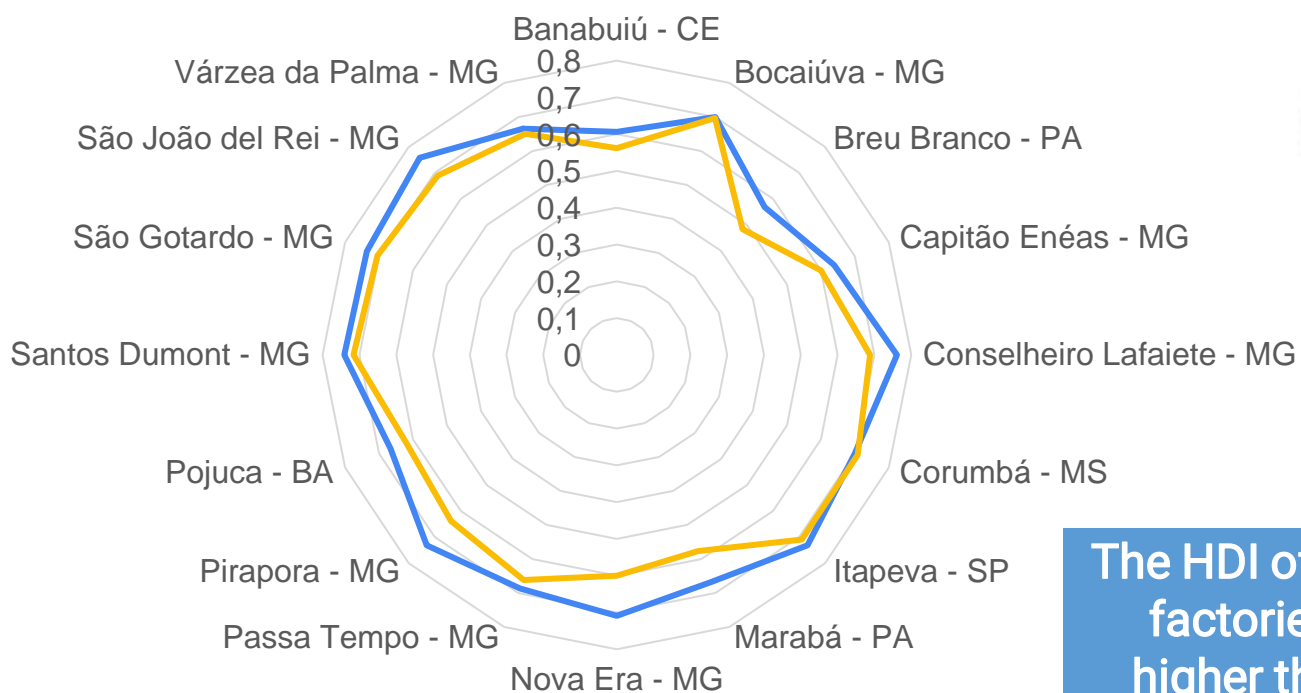
Companies directly and indirectly employ over 60,000 people, surpassing pre-pandemic employment levels.

Contribution to Regional Development

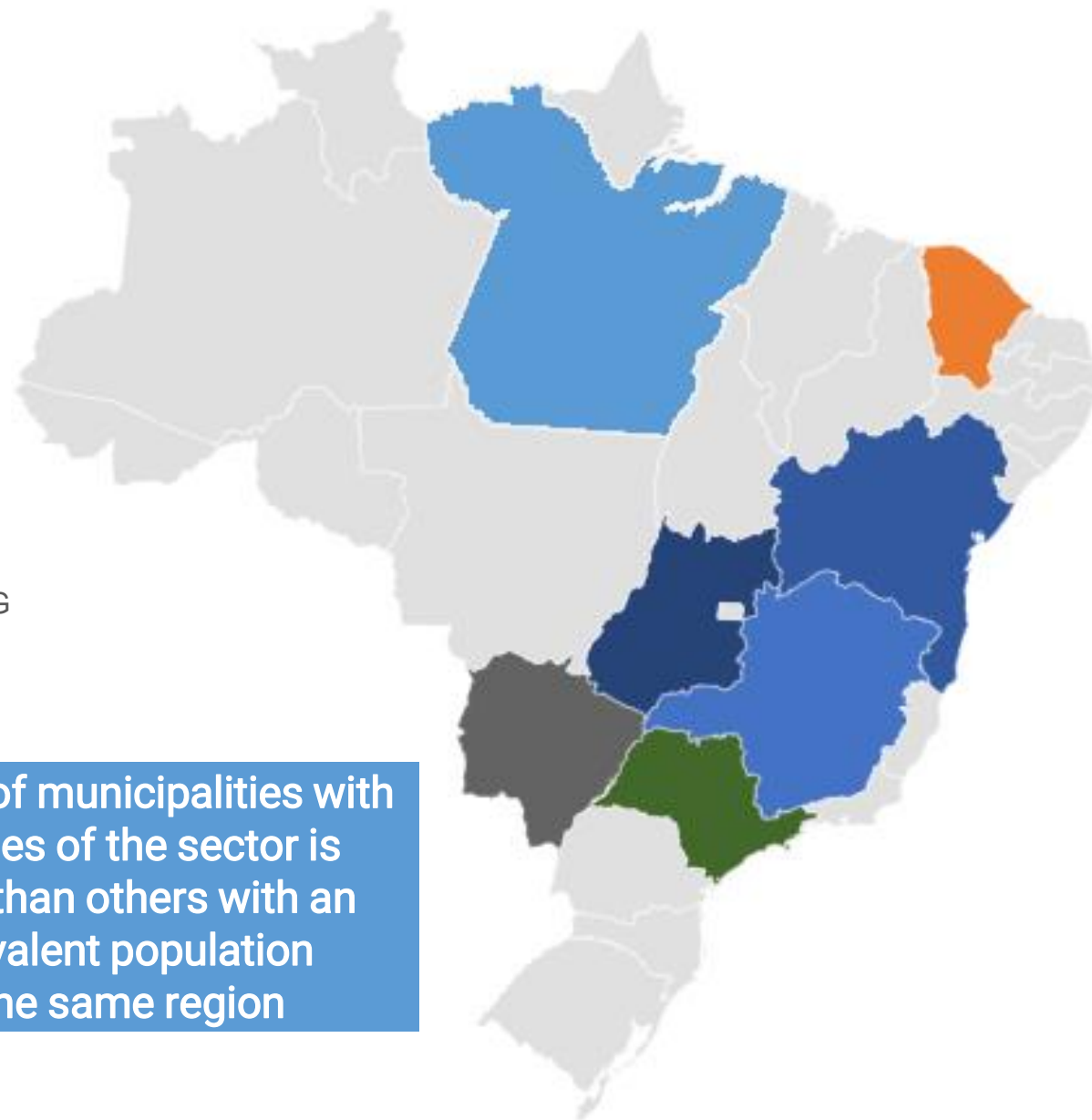
Human Development Index

— Município com Fábrica do Setor

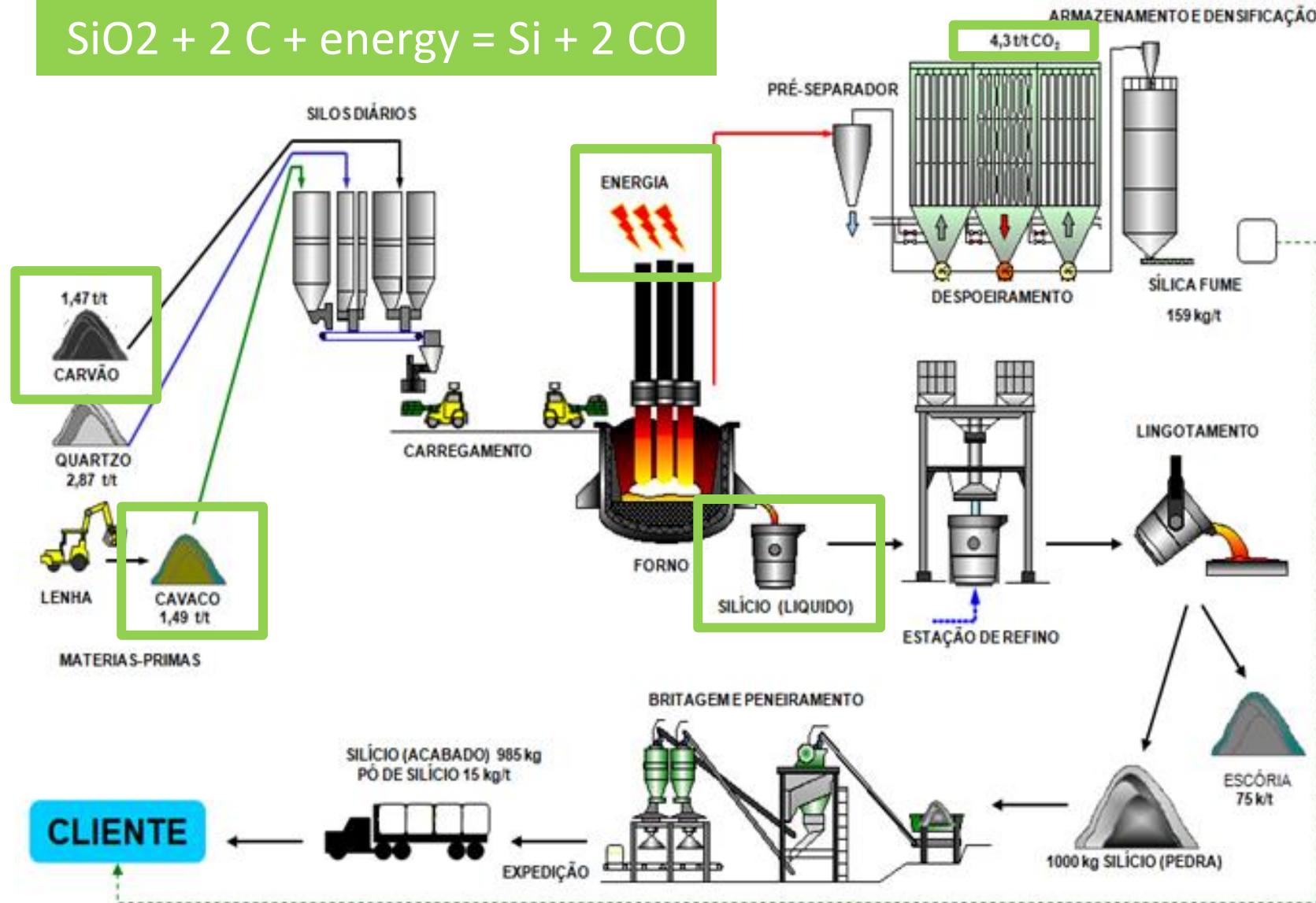
— Equivalente sem Fábrica



The HDI of municipalities with factories of the sector is higher than others with an equivalent population in the same region



Silicon Metal Production



Consumption of Charcoal and Electric Energy in the Manufacturing of Ferroalloys and Silicon Metal

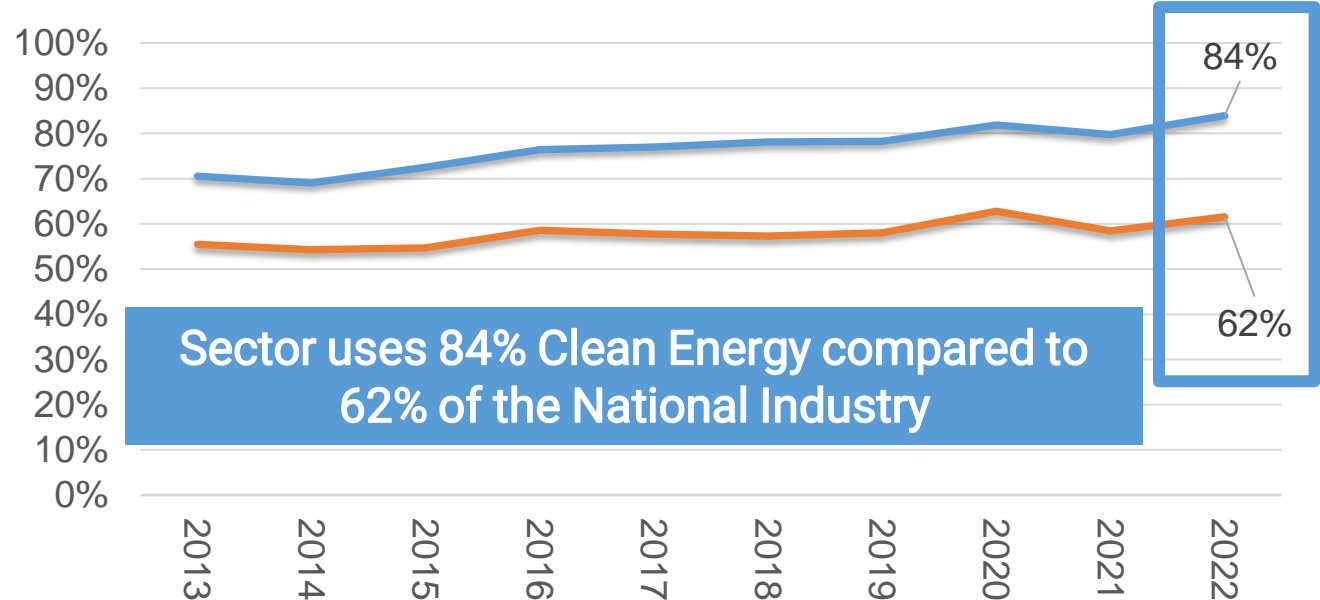
Production and Consumption

YEAR	PRODUCTION	ELECTRICITY	CHARCOAL
	(t x 10 ³)	(GWh)	(t x 10 ³) (m3 x 10 ³)
2017	1,159	9,381	1.005 4.022
2018	1,270	10.135	1,247 4,987
2019	1.214	9,887	1.210 4,840
2020	1.222	10.284	1.309 5.236
2021	1,273	10.122	1,400 5,600
2022	1,396	11.016	1,534 6.138

**Charcoal 6.1 million m3
increased 52% in 5 years**

Source: ABRAFE





Participation of Renewable Energy Sources



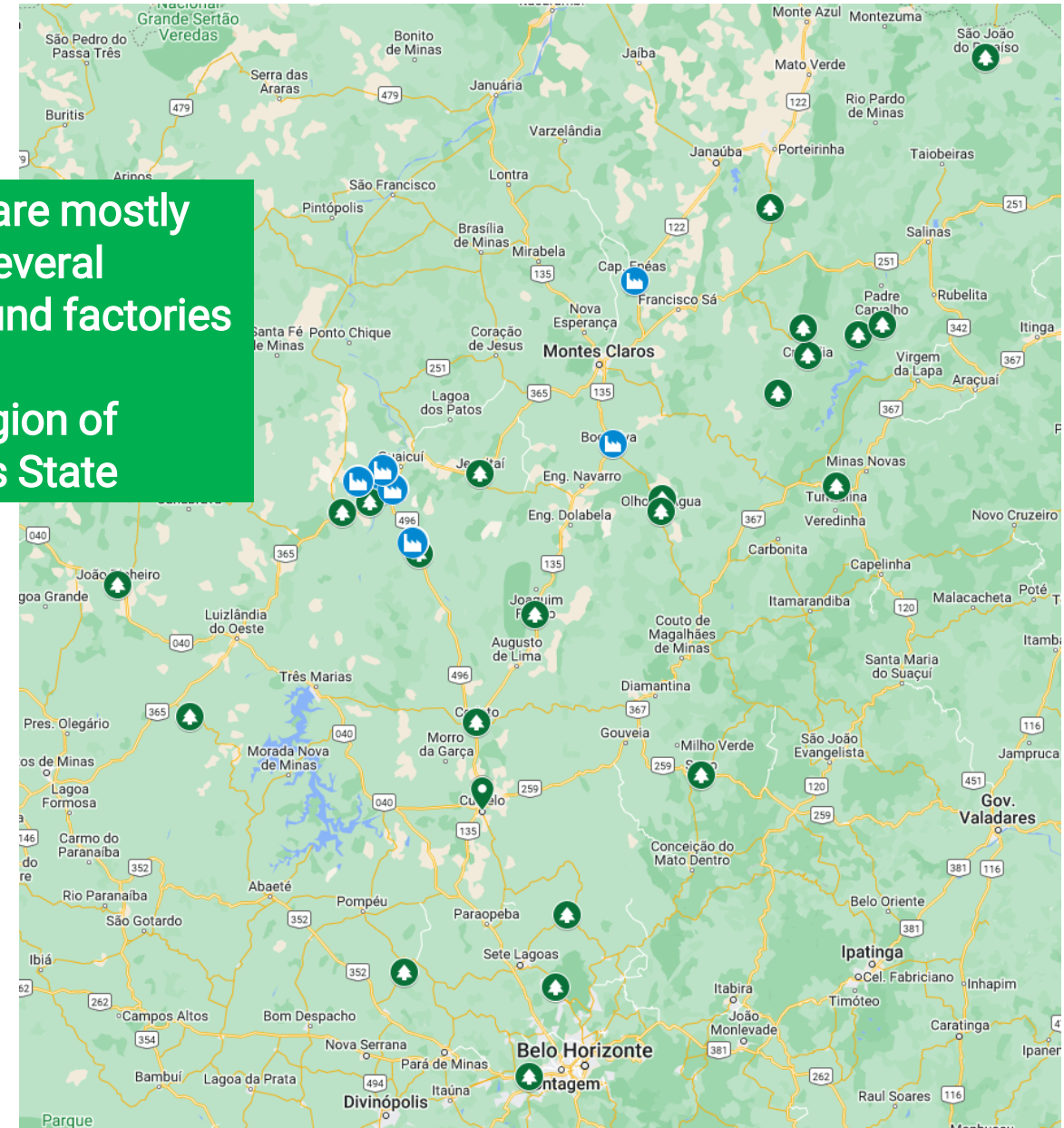
Source: EPE

Scope of Activities in the Northern Region of Minas Gerais

. Factories in the Northern Region of Minas:

-  LIASA – Pirapora
-  MINASLIGAS – Pirapora
-  INONIBRAS – Pirapora
-  RIMA INDUSTRIAL – Capitão Enéas, Varzea da Palma and Bocaiuva

Planted forests are mostly located in several municipalities around factories in the Northern Region of Minas Gerais State

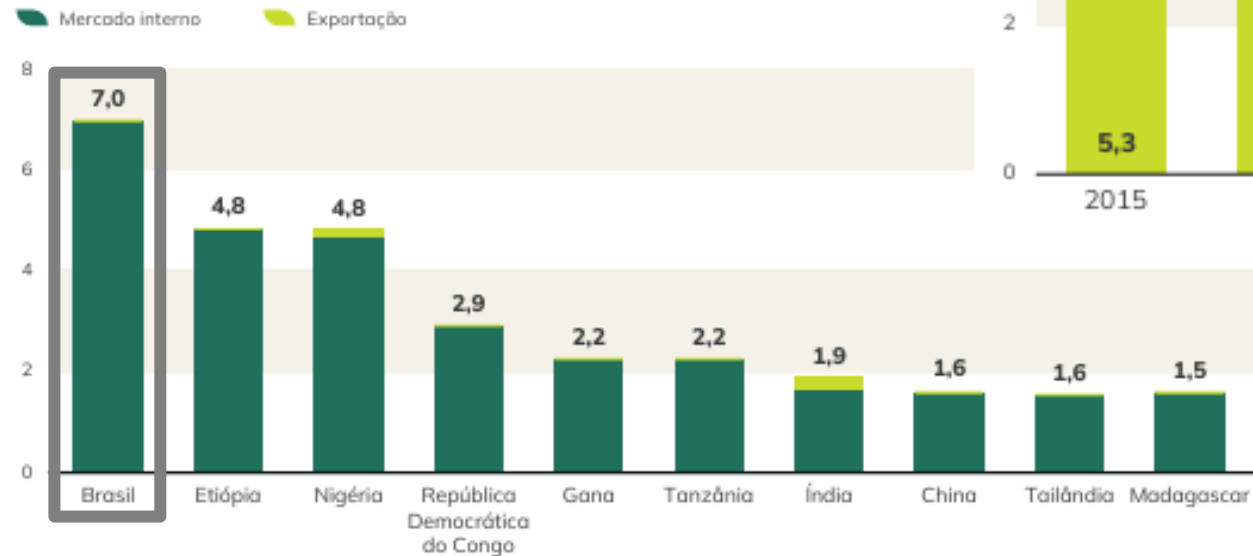


Production and Consumption of Charcoal in the Steel Industry

Brazil leads the global ranking of charcoal producers, reaching 7.0 million tons in 2022

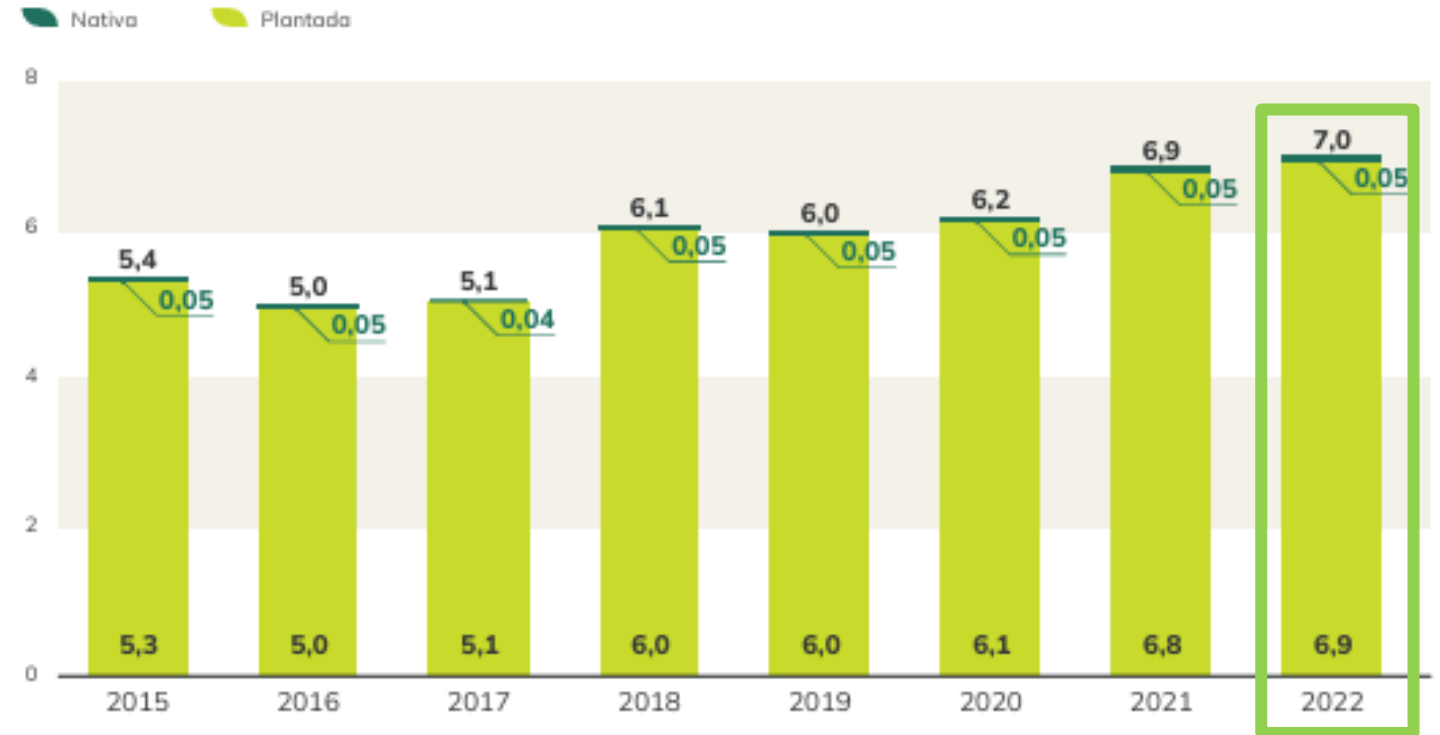
Principais países produtores de carvão vegetal em 2021 (milhões de toneladas)

Fonte: Brasil: SINDFER e ESG Tech (2022) | Demais países: FAO (2021) | Elaboração: ESG Tech



Consumo de carvão vegetal na siderurgia (milhões de toneladas)

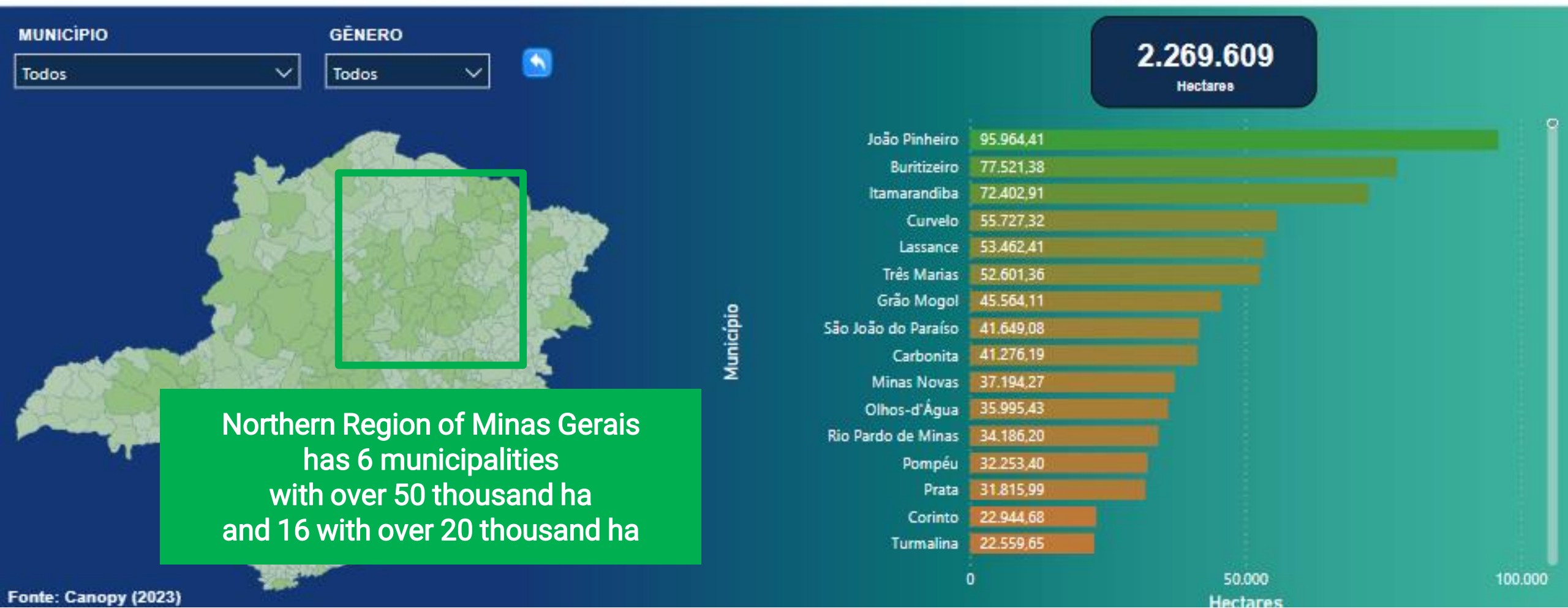
Fonte: Ibrá (2022) e SINDFER (2022) | Elaboração: ESG Tech



Over 99% of charcoal is obtained from planted forests

Planted Forests in Minas Gerais

ÁREA PLANTADA POR MUNICÍPIO MINEIRO



Forestry activity is present in 803 of the 853 municipalities in Minas Gerais

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

FIEMG CIT-SENAI SINFERSI Partnership

(2022 base year)



Accounting for greenhouse gas emissions is the first step towards contributing to the fight against climate change when used as a management tool. The information generated from the preparation of the inventory can fulfill the following objectives:

- Historical data recording;
 - Setting goals;
 - Assessment of risks and opportunities;
 - Competitive advantage;
- with stakeholders ;
- Participation in GHG emissions disclosure programs;
 - Conditions for participating in carbon markets.
 - Assessment of the contribution of different production sectors to national and global GHG emissions

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

Participating Company	Unit
BOZEL BRASIL S/A	Sao Joao Del Rei/MG
ELETROLIGAS LTDA	São Gotardo/MG
FERLIG FERRO LIGA LTDA	Passa Tempo/MG
GRANHA LIGAS LTDA	Corumbá/MS
LIBRA LIGAS DO BRASIL S/A	Banabuiú/CE
LIGAS DE ALUMÍNIO LIASA S/A	Pirapora/MG
MARINGA FERRO LIGA S/A	Itapeva/SP
MINASLIGAS S/A	Pirapora/MG
NEXUS LIGAS	Ouro Preto/MG Barbacena/MG
NOVA ERA SILICON S/A	Nova Era/MG
PALMYRA DO BRASIL INDÚSTRIA E COMÉRCIO DE SILÍCIO METÁLICO E RECURSOS NATURAIS LTDA	Breu Branco/PA Santos Dumont/MG

In this first inventory we had the participation of 11 units of associated companies, which represent more than 60% of ABRAFE.

The report was prepared in compliance with the five principles guided by the accounting methodology of the Brazilian *GHG Protocol Program* : relevance, completeness, consistency, transparency and accuracy.

Emissions were recorded and converted to tons of carbon dioxide equivalent (tCO₂e) using the Brazilian GHG Protocol Program tool .

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

Table 1- Global Warming Potential (GWP) of the main greenhouse gases

Greenhouse Gas	GWP	Reference
Carbon dioxide (CO ₂)	1	IPCC (2014)
Methane (CH ₄)	28	
Nitrous Oxide (N ₂ O)	265	
Sulfur hexafluoride (SF ₆)	23,500	
Nitrogen trifluoride (NF ₃)	16.100	
Hydrofluorocarbons (HFCs) ¹	2.213	
Perfluorocarbons (PFCs) ¹	9,562	

Figure 5 - Emission factors for reducers used in furnaces

Fuel type	Unit	Sector Emission Factors:		
Fossil fuels		CO2 (kg/ unit)	CH4 (kg/unit)	N2O(kg/unit)
Coal Coke	Tons	3.093	0.28889	0.04333
Petroleum Coke	m ³	3,563	0.10960	0.02192
Charcoal	Tons	2,886	5.40935	0.10819
Commercial Firewood	Tons	1,451	0.38937	0.05192

Source: Table 1 of calculation tool v2023.0.3 (Emission factors) – FGV/GHG (2023).

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

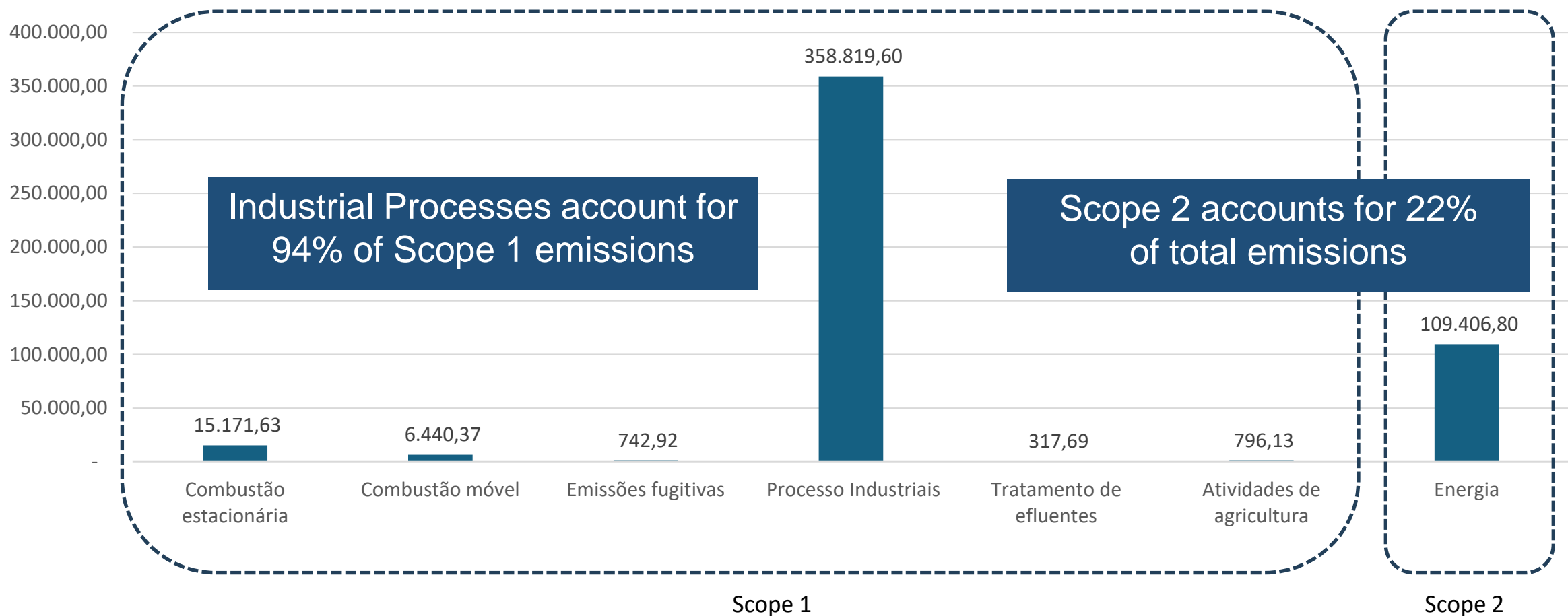
- The total emissions of the inventoried companies associated with ABRAFE, for the year 2022, were 529,212.67 tCO₂e;
- The Industrial Processes category is responsible for the highest emissions rate, 358,819.60 tCO₂e in E1;

GHG (t)	Emissions in metric tons of CO ₂ equivalent (tCO ₂ e)	
	Scope 1	Scope 2
CO ₂	315,674.72	109,406.80
CH ₄	53,893.92	---
N ₂ O	11,978.27	---
HFCs	741.46	---
PFCs	---	---
SF ₆	---	---
NF ₃	---	---
Total	419,805.87	109,406.80

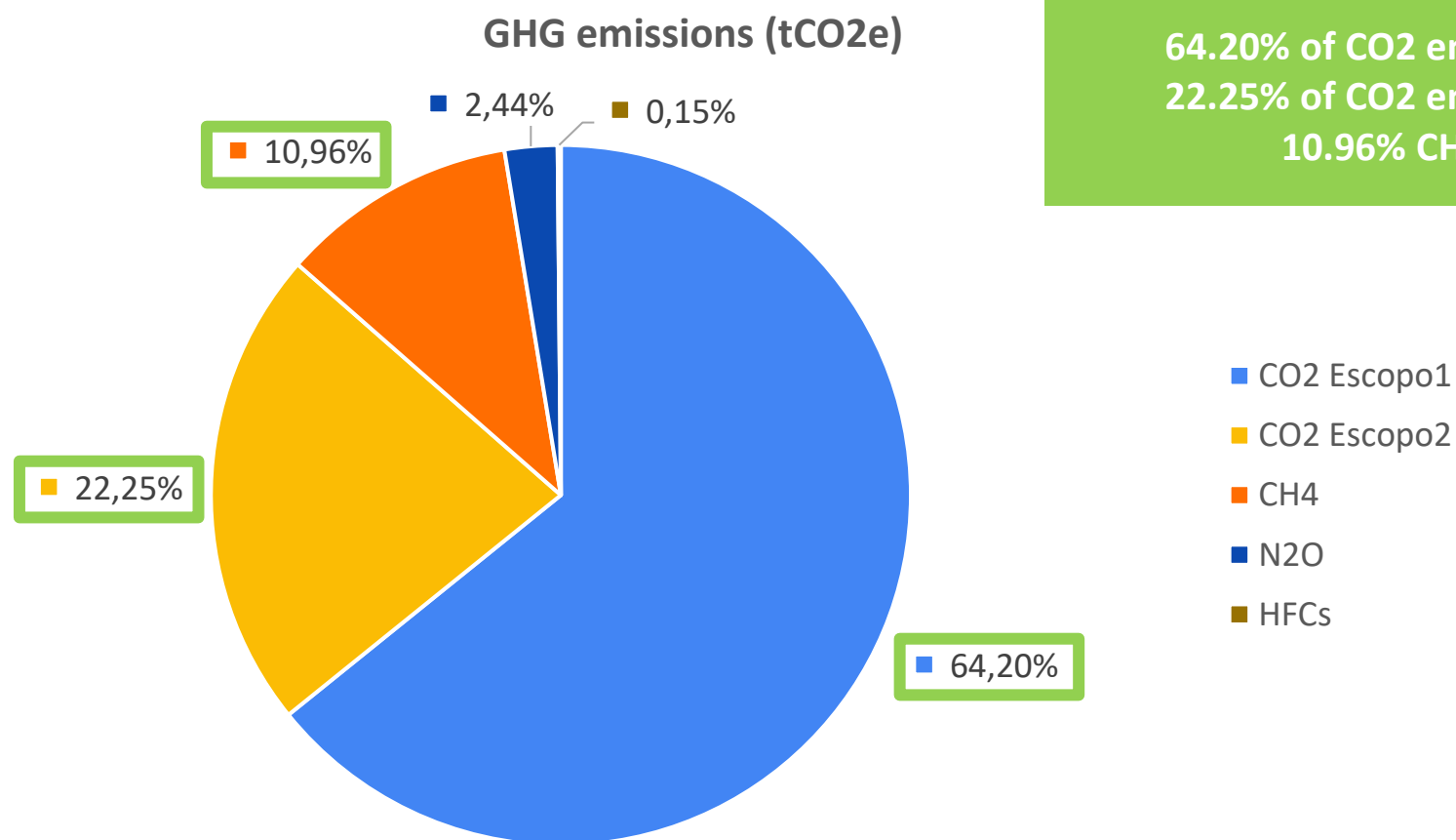
Category	Emissions (tCO ₂ e)	Biogenic CO ₂ emissions (t)	Biogenic CO ₂ removals (t)
Stationary combustion	15,171.63	175.77	---
Mobile combustion	6,440.37	716.18	---
Fugitive emissions	742.92	---	---
Industrial Processes	358,819.60	1,042,245.75	---
Effluent treatment	317.69	---	---
Land use change	---	---	3,004.63
Agricultural activities	796.13	---	---
Total	419,805.87	1,043,137.69	3,004.63

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

Emissions by Category (tCO₂e)



GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector



64.20% of CO₂ emissions in Scope 1;
22.25% of CO₂ emissions in Scope 2;
10.96% CH₄ emissions.

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector

Fossil Scenario (if all companies used thermal energy and coal)

Current Scenario presents 79.5% less emissions than the Fossil Scenario

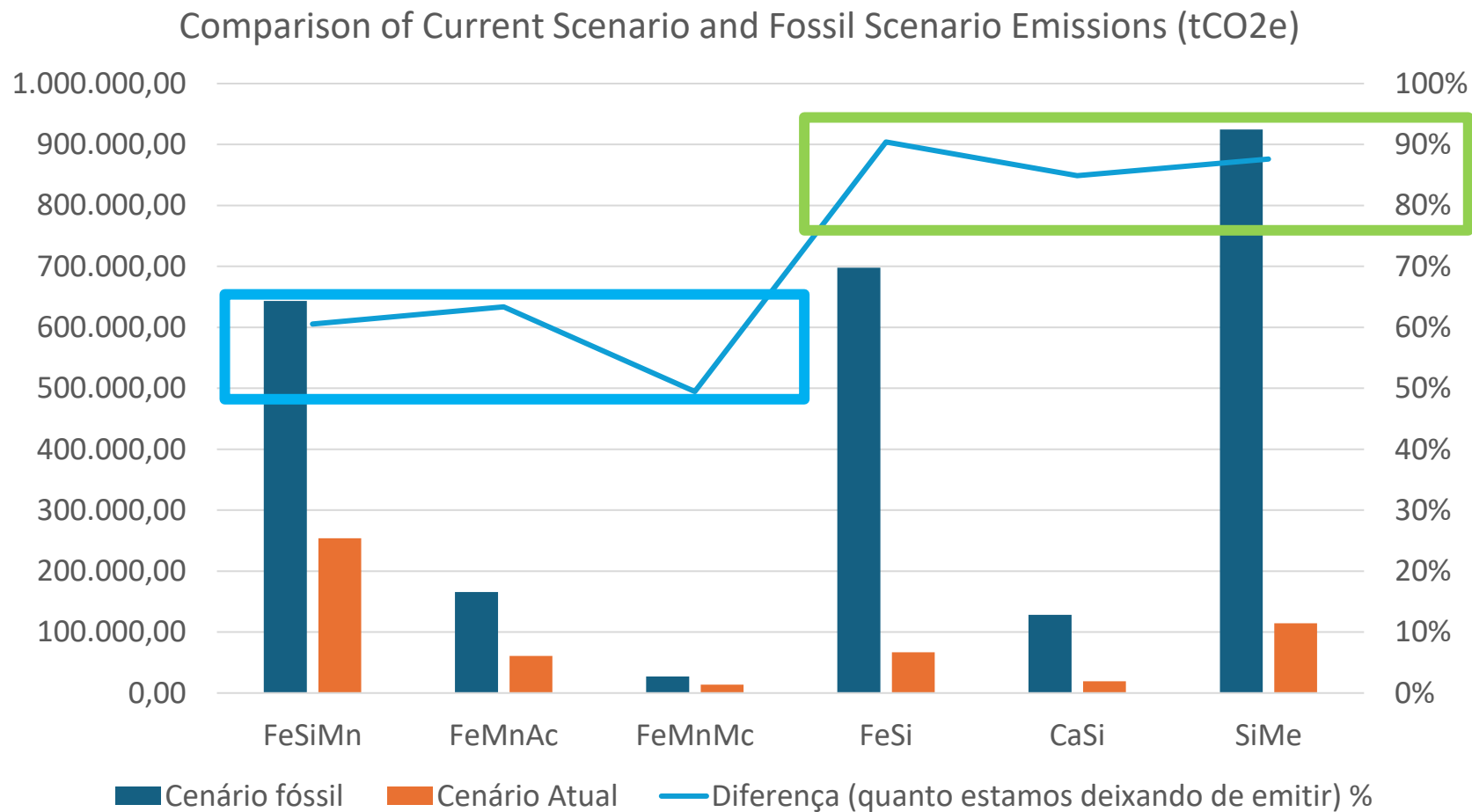
Decarbonization Scenario (using 100% charcoal and renewable energy)

SCENARIO	Ecopo 1 (t CO ₂ e)	Ecopo 2 (t CO ₂ e)	Total (t CO ₂ e)
Fossil scenario	1,450,430.67	1,136,690.13	2,587,120.80
Current scenario	419,805.87	109,406.80	529,212.67
Decarbonized scenario	224,212.59	0.00	224,212.59
Quicklime scenario	199,428.23	0.00	199,428.23

Product	Emissions of t CO ₂ e (E1 + E2) per t of alloy		
	Fossil scenario	Current scenario	Decarbonized scenario
FeMn (FeSiMn + FeMnAC + FeMnMc)	3.01	1.18	0.37
FeSiMn	2.98	1.17	0.37
FeMnAC	3.16	1.16	0.38
FeMnMc	2.99	1.51	0.30
FeSi	7.11	0.68	0.47
CaSi	7.61	1.15	0.72
YesMe	5.78	0.72	0.39
Total production	4.68	0.96	0.41

Source: CIT SENAI – Inventory base year 2022 (t CO₂e / t alloy)

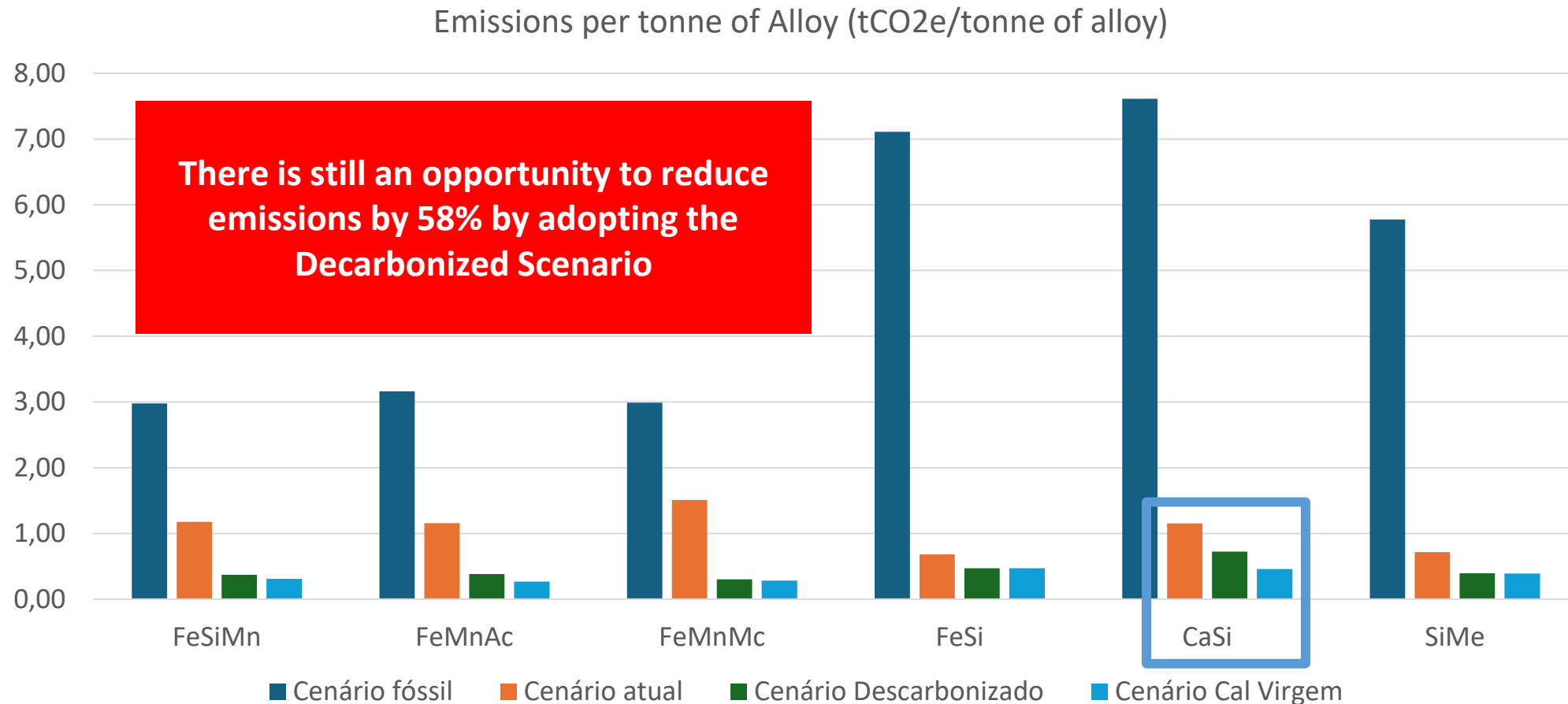
GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector



**Silicon-based alloys
emit 80 to 90% less
than the Fossil Scenario**

**Manganese alloys
emit 50 to 65% less
than the Fossil Scenario**

GHG Emissions Inventory for the Ferroalloys and Silicon Metal Sector



CaSi can have a reduction of more than 36% with the use of Quicklime

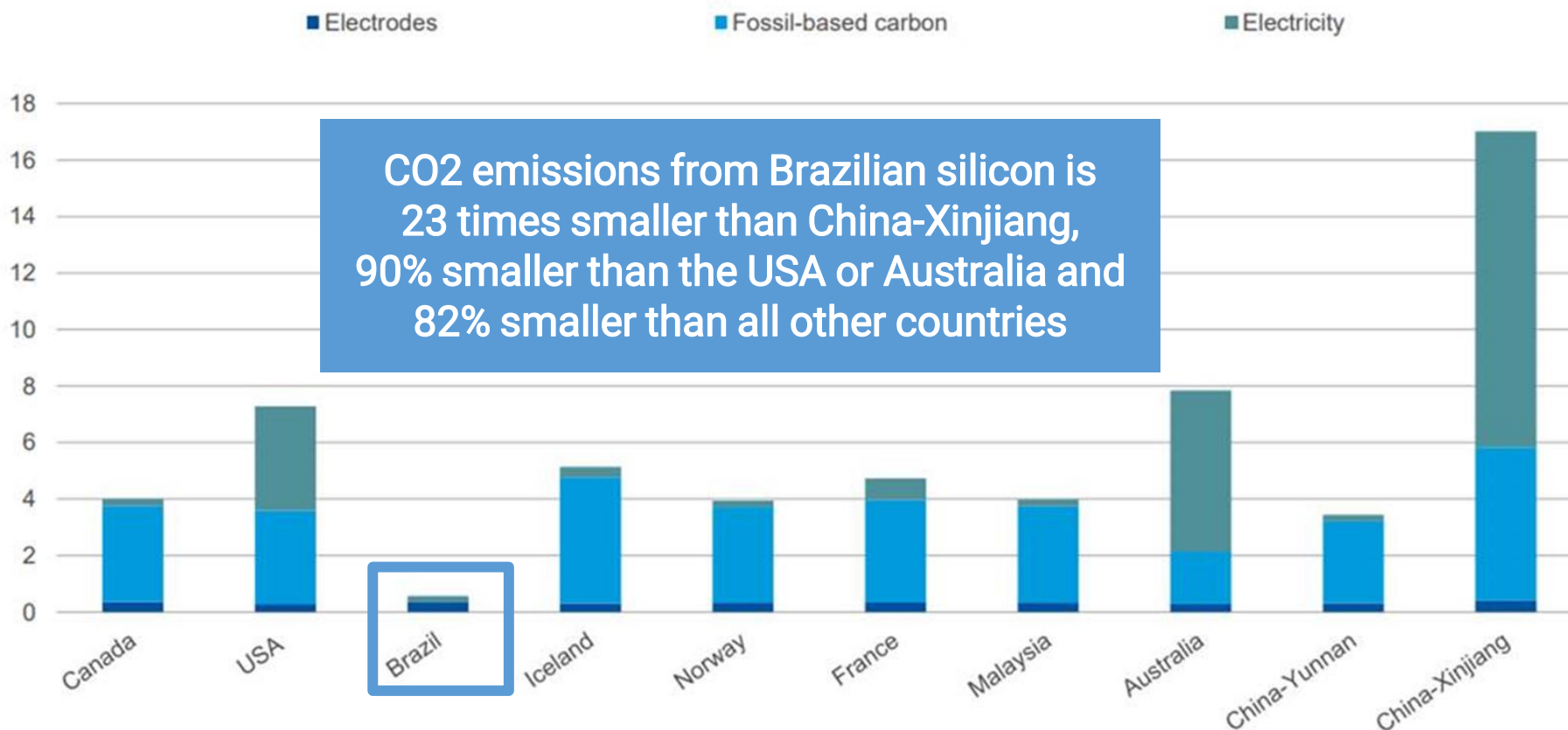
Carbon Footprint in Silicon Metal Production



CRU Silicon Market Virtual Forum 2020

Carbon footprint depends on the power source and the reductant mix

Indicative emissions from electricity, fossil-based carbon and electrodes per t of silicon, t CO₂



Report Observations

- The Brazilian scenario, in which charcoal is used as a reducer in furnaces and electrical energy comes from hydroelectric sources, brings benefits to Brazilian production when compared to the reducers and fossil energy matrices used in other countries.
- In emissions associated with electricity consumption, the Brazilian scenario is more sustainable than other parts of the world, since it has a predominantly hydroelectric matrix, in contrast to other countries, where thermoelectric power based on fossil fuels predominates.
- It is estimated that an area equivalent to 52,839.81 ha of Eucalyptus is capable of meeting the additional consumption needs of charcoal and firewood in the Decarbonized Scenario in relation to the year 2022.
- This area will be able to remove 81,373.30 tons of CO₂ from the atmosphere over the 7 years of the cutting cycle, which would be equivalent to 40.80% of the total emissions in the decarbonization scenario with the use of quicklime replacing limestone.

Final considerations

- The Ferroalloys sector uses 84% renewable energy sources compared to the national industry average of 62%.
- The consumption of Charcoal in the Ferroalloys and Silicon industry increased 52% in 5 years, reaching 6.1 million m3.
- Charcoal, which in Brazil comes from 99% of planted forests, is a renewable energy source unlike sources based on Fossil Carbon.
- Brazil leads the global ranking of charcoal producers, reaching the mark of 7.0 million tons in 2022.
- The Inventory of emissions from the Ferroalloys and Silicon sector has demonstrated that the Current Scenario presents 79.54% fewer emissions than the Fossil Scenario.
- Brazilian Silicon CO2 emissions are 23 times lower than China-Xinjiang, 90% lower than the USA or Australia and 82% lower than all other countries.



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