

Key actions to 2030

The implementation of tangible actions by all stakeholders is fundamental to achieve the scenario for CO₂ reduction presented in this Roadmap. To reach the levels of improvement in the different key performance indicators (KPIs) and the subsequent reductions in carbon emissions, government, industry and civil society in general must create a joint agenda of structural actions, in order to accelerate the sustainable transition of the Brazilian cement industry. The major priority actions, in a short to medium term view (2030) are the following:

- Reinforce national and international cooperation for gathering and publishing reliable emission data, as well as performance indicators referring to energy efficiency, use of alternative fuels and clinker substitutes, such as those from the Cement Sustainability Initiative (CSI) database Getting the Numbers Right.
- Promote the development of new standards for cement, allowing the use of greater content of clinker substitutes, without compromising the durability of concrete and in accordance with standards already in use at a global level. Develop awareness campaigns in the whole cement value chain in order to inform consumers and facilitate the acceptance of cement with a higher content of clinker substitutes, showing their benefits in reducing the sector's emissions.

- Enhance energy recovery from waste, following the National Policy for Solid Waste (PNRS); update existing legislation in order to streamline licensing of alternative fuels and encourage their use; create specific legislation establishing directives on co-processing of fuels derived from municipal solid waste (MSW) in cement kilns; develop every type of waste management/treatment, promoting competitive conditions between the different alternatives.

- Share best practices at a national and international level to promote energy efficiency in the cement industry; encourage the adoption of public policies that result in less consumption of energy and generation of less waste; identify available public and private national and international financing mechanisms for equipment and technology that result in an increase of energy efficiency and a reduction in emissions.

- Promote R&D in emerging and innovative technology for mitigation of greenhouse gas emissions, including CCUS, through cooperation with research institutes; identify and/or create mechanisms for encouraging pre-commercial research, projects on a laboratory scale and pilot-projects for demonstration of technology.



CEMENT TECHNOLOGY ROADMAP

Main guidelines

Roadmap objectives, partners and collaborators

This study aims to map the current situation and future trends of the Brazilian cement industry, proposing ways to further reduce its already low CO₂ emissions. It's also points out barriers and constraints that limit the deployment of identified measures, and suggests a series of recommendations for public policies, support mechanisms, regulatory and legal issues, among others, that are emissions reduction enablers in the short, medium and long term.

This Roadmap represents the joint effort of a number of national and international partners plus the views and contributions of numerous local experts. The Brazilian cement sector was represented by the manufacturing groups Cimentos Liz, Ciplan, InterCement, Itambé, LafargeHolcim and Votorantim Cimentos, as well as through the industry associations SNIC and ABCP. The project also had the collaboration of IEA, CSI and IFC and a number of renowned specialists from Brazilian universities and technological centers.

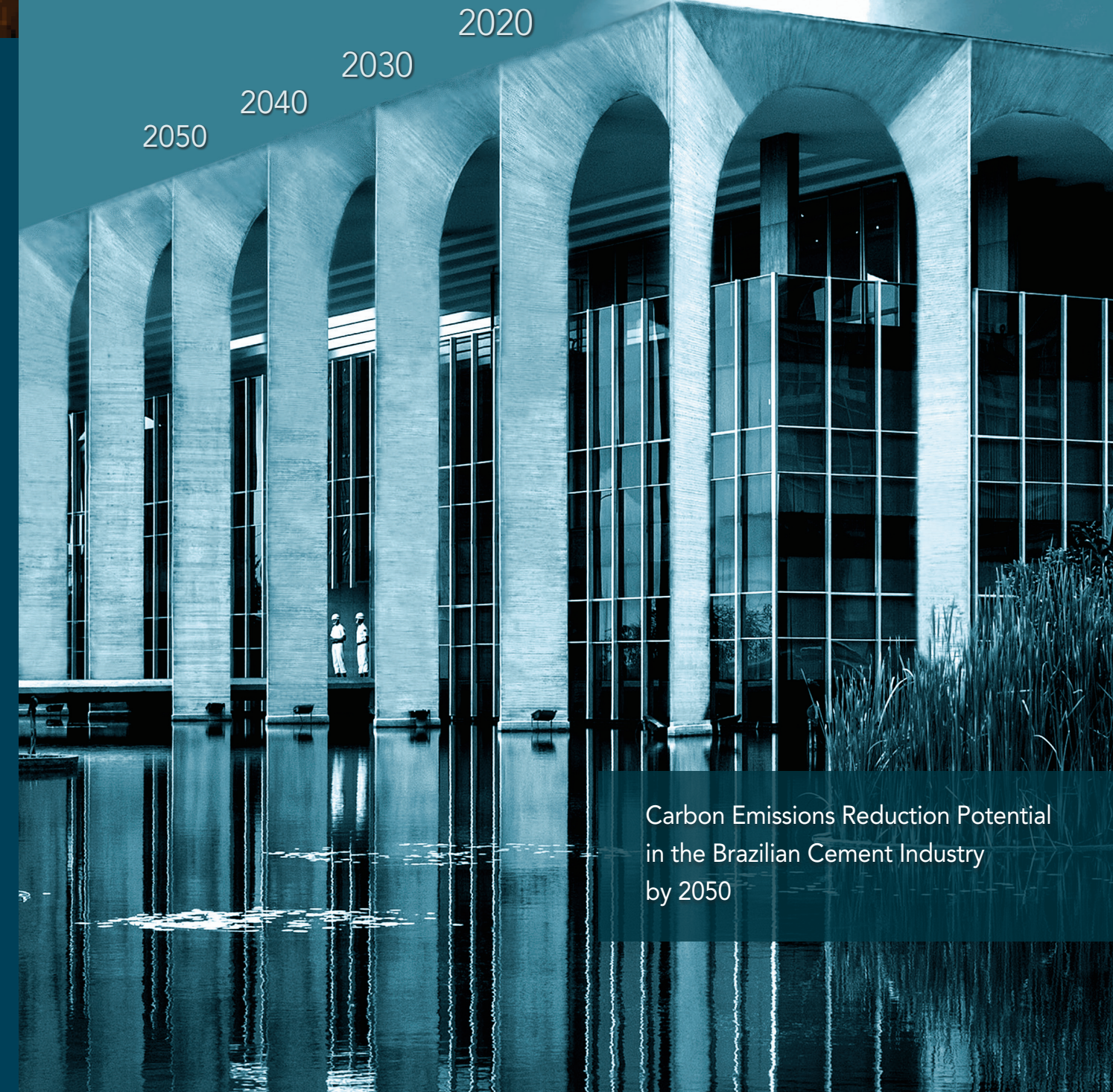
General Coordination



Collaborators



Participating Companies



Carbon Emissions Reduction Potential in the Brazilian Cement Industry by 2050

Key findings

- The Brazilian cement industry has one of the lowest levels of specific CO₂ emissions in the world, thanks to mitigating actions implemented by the sector over recent decades. While cement production increased by 273% between 1990 and 2014 (from 26 to 71 Mt), total emissions grew by 223% over the period, due to the 18% reduction in emissions intensity (from 700 to 564 kg CO₂ /t cement).

- In the same period, thermal intensity had a reduction of 17%, the use of alternative fuels increased from 5% to 19% and the use of clinker substitutes increased from 20% to 33%.

- The low per capita cement consumption in Brazil (260 kg/person/year) when compared to the worldwide average (553 kg), and coupled with the high housing deficit, the country's infrastructure and the expected population growth, indicates a resumption of production in the medium to long term, increasing between 60% and 120% by 2050 compared to 2014 (in the variants of low and high demand respectively).

- Regarding CO₂ mitigation, the main alternative and the biggest challenge to the sector is to further increase the use of clinker substitutes - Brazil is among the countries that use them the most. By reducing the clinker/cement ratio from 67% in 2014 to 52% in 2050, it would be possible to achieve a cumulative reduction of 290 Mt in CO₂ emissions. This would represent 69% of the CO₂ emissions reduction in the sector by 2050.

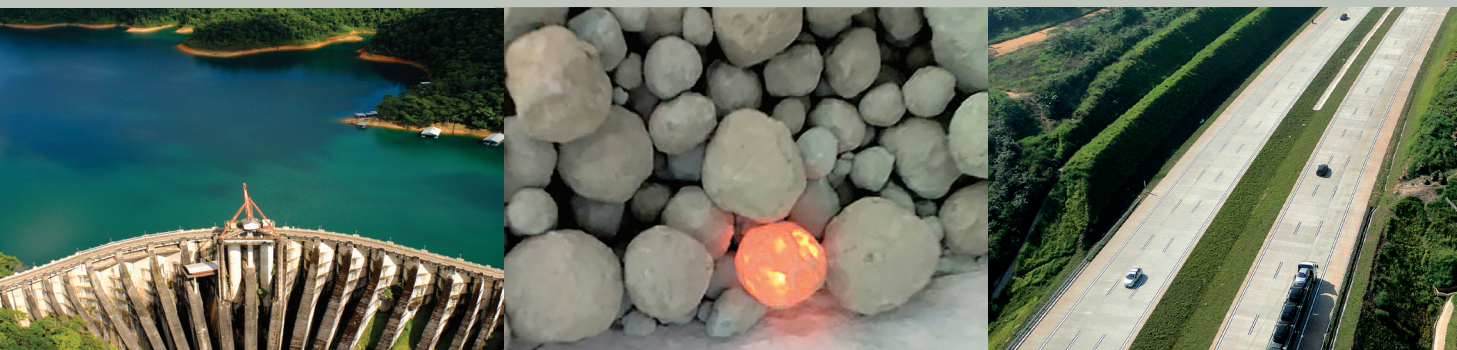
- The use of alternative fuels, substituting fossil fuels, such as petroleum coke, represents the second largest carbon emissions mitigation strategy for the sector. The increase in

thermal substitution rate from 15% in 2014 to 55% in 2050 would result in a cumulative reduction of 55Mt in CO₂ emissions. This would signify around 13% of the CO₂ emissions reduction.

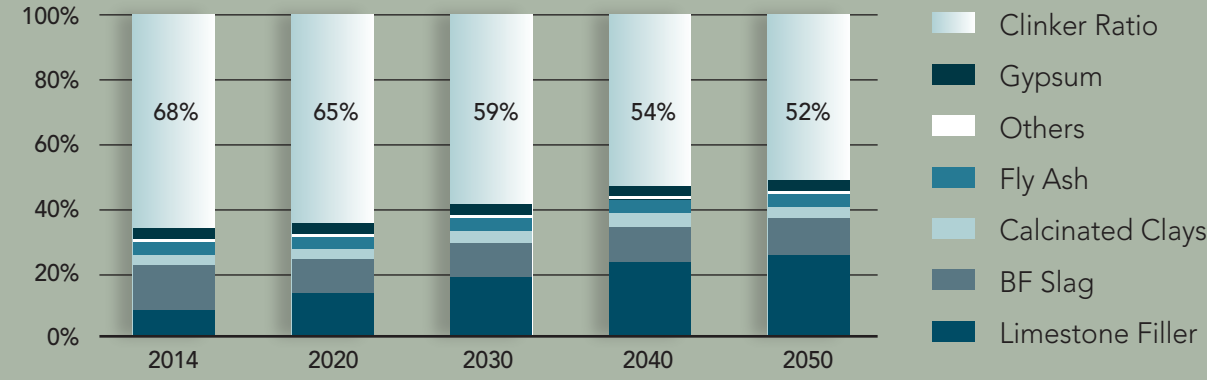
- Brazil has a modern and efficient industrial complex, with an average thermal consumption of 3.5 GJ/t of clinker and electricity consumption of 113 kWh/t of cement. Therefore, major changes in energy intensity of cement production are not expected before 2030, when the gradual replacement of the more obsolete units and equipment with new lines using the best available technologies (BAT) will start taking place. It will then be possible to achieve values of 3.2 GJ/t of clinker and 91 kWh/t cement by 2050 and a cumulative reduction of 38 Mt of CO₂ by 2050, representing around 9% of the sector's mitigation effort.

- In order to achieve emissions reduction compatible with the global commitments of minimum climate impact, it is necessary to search for innovative and disruptive solutions, such as Carbon Capture and Utilization or Storage (CCUS). By doing so, it would be possible, from 2040, to achieve a cumulative reduction of 38 Mt CO₂, representing about 9% of the sector's mitigation by 2050.

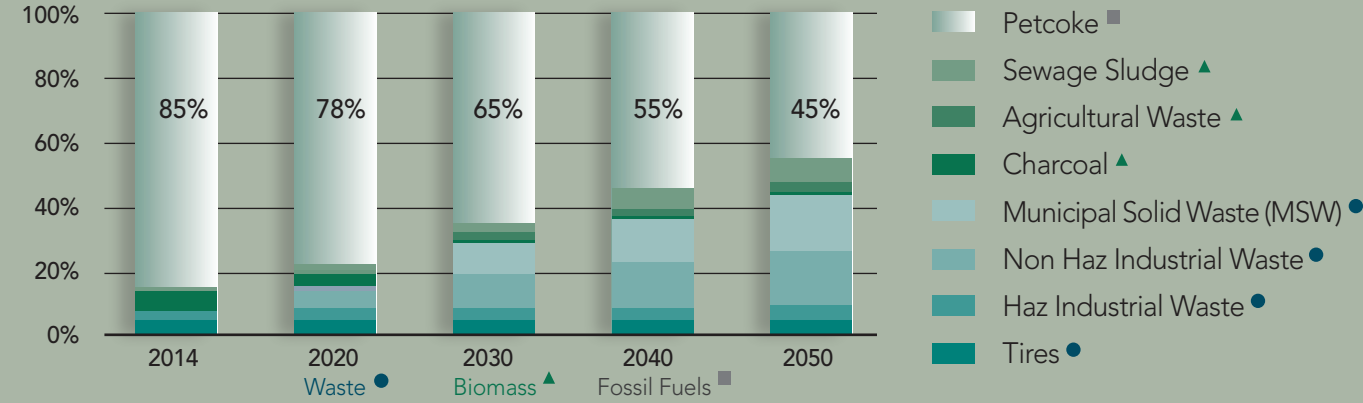
- The different measures for carbon emissions reduction are not distributed evenly around the country. Considering Brazil's continental dimensions, and its many different regions, it is fundamental to understand that the various actions recommended in this Roadmap, as well as their potential for penetration and reduction of CO₂, cannot be replicated with the same intensity in all regions of the country.



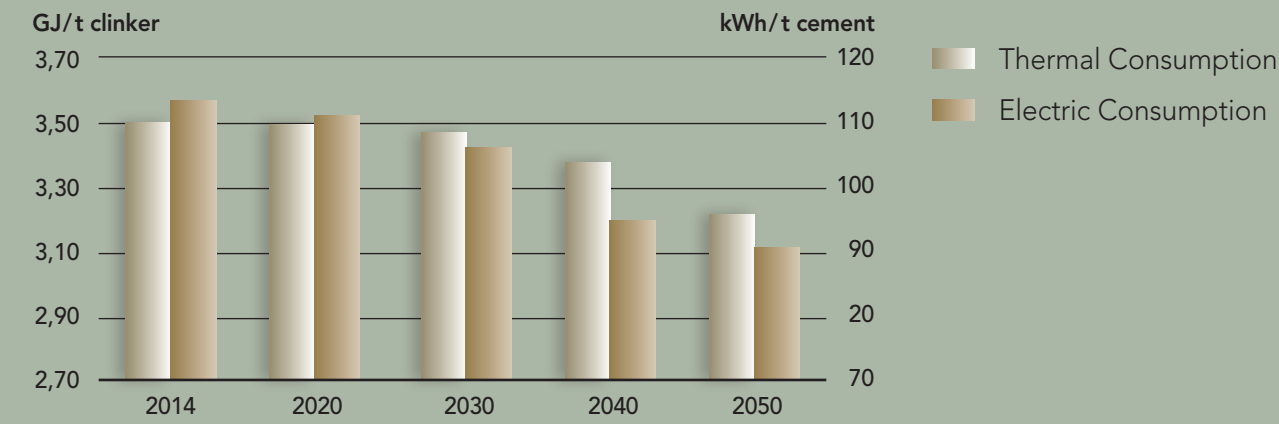
Clinker substitutes 2014 - 2050



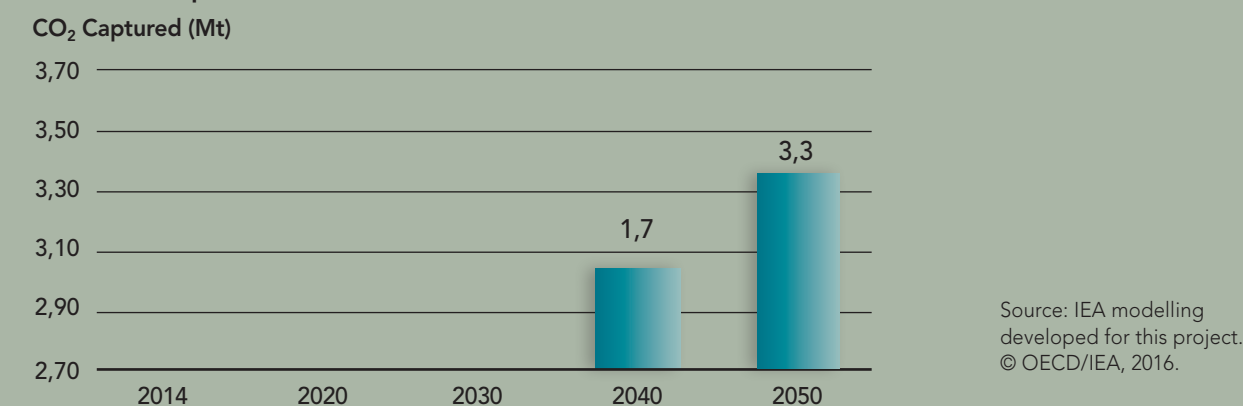
Alternative fuels 2014 - 2050



Energy efficiency 2014 - 2050

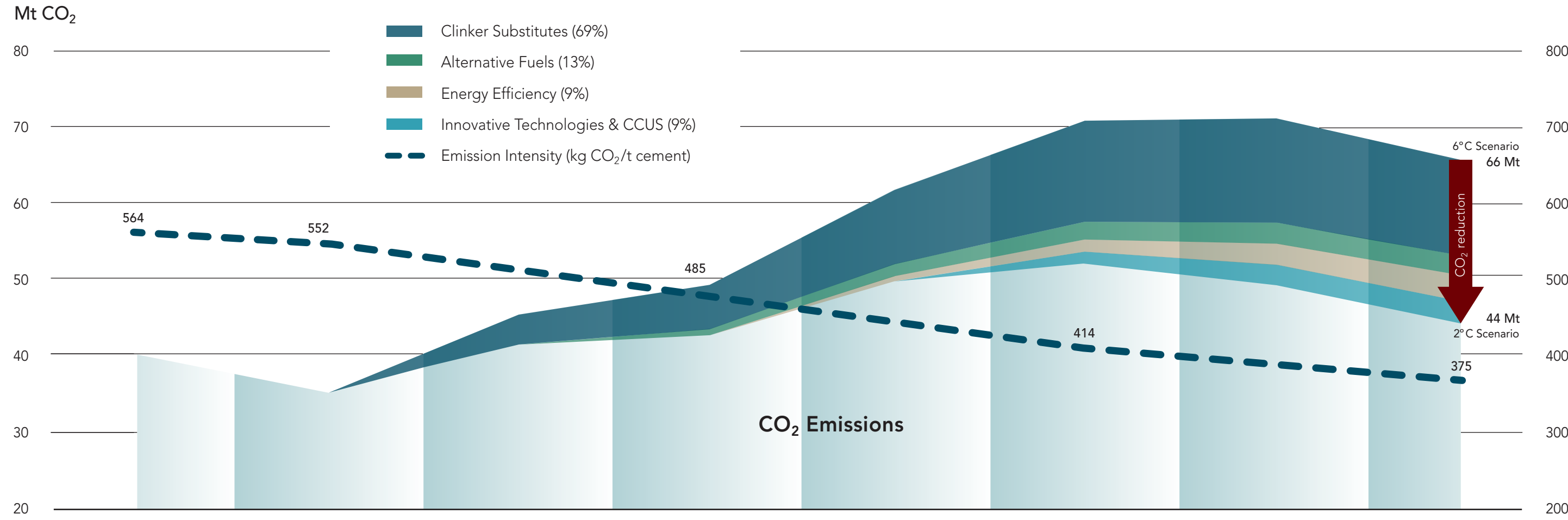


Carbon captured 2014 - 2050



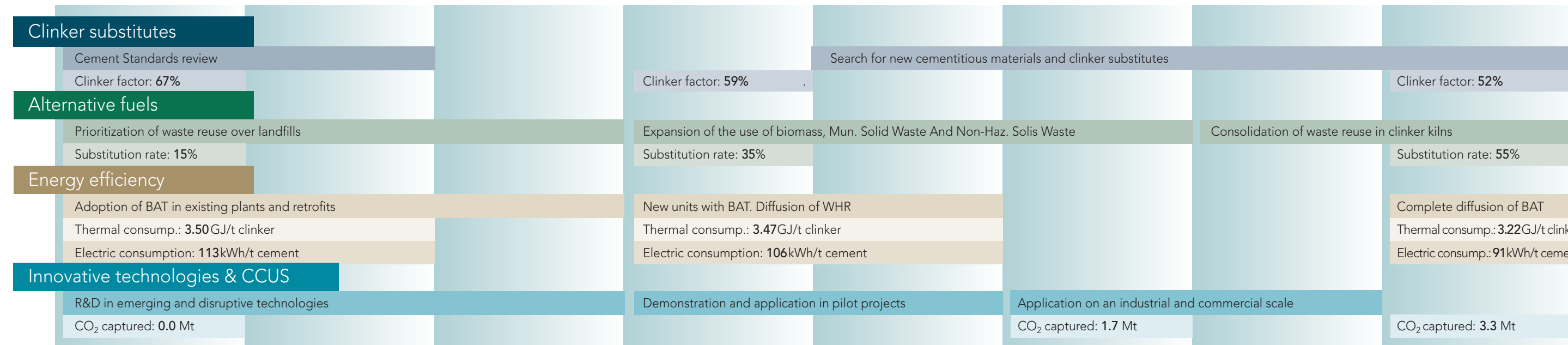
Source: IEA modelling developed for this project. © OECD/IEA, 2016.

CO2 emissions reduction comparing "2°C Scenario" with "6°C Scenario"



Source: IEA modelling developed for this project. © OECD/IEA, 2016.

Roadmap milestones



Roadmap scenarios

The "6°C Scenario", which serves as the reference scenario for this Roadmap, is an extension of current production trends, without any effort by government, industry or the general public to reduce emissions. Although hypothetical, in this scenario the emissions intensity would remain constant and, due to the increase of the cement production, the absolute emission could reach 66 Mt of CO₂ in 2050.

On the other hand, the "2°C Scenario" examines means of achieving deep cuts in carbon emissions, enough to frame the Brazilian cement industry in a context of global warming limited to 2°C by 2050. In this scenario, the emission intensity could be reduced from 564 kg CO₂/t cement in 2014 to 375 kg in 2050. Thus, the industry would achieve an absolute emission

of 44 Mt in 2050, a reduction of 33% when compared to "6°C Scenario".

In terms of cumulative emission over the whole period (2014 to 2050), comparing both scenarios, it would be possible to avoid the emission of about 420 Mt of CO₂ from the adoption of the measures suggested in this Roadmap. The main alternative to this reduction is to increase the use of Clinker Substitutes, with potential to mitigate 290 Mt of CO₂ between 2014 and 2050 (or 69%). The use of less carbon-intensive Alternative Fuels, as the sector migrates from petcoke to biomass and waste, could contribute 55 Mt CO₂ of total reduction (13%). Energy Efficiency measures and the use of Innovative Technologies such as CCUS would respond with 38 Mt CO₂ each one (9%).

Key indicators for the Brazilian cement industry by 2050

	2014	2°C				6°C			
		2020	2030	2040	2050	2020	2030	2040	2050
Cement production [Mt]	71	62	87	126	117	62	87	126	117
Clinker factor [clinker to cement ratio]	0.67	0.66	0.59	0.54	0.52	0.67	0.67	0.67	0.67
Thermal intensity [GJ/t clinker]	3.50	3.49	3.47	3.38	3.22	3.50	3.49	3.46	3.44
Electrical intensity [kWh/t cement]	113	110	106	95	91	111	108	101	99
Alternative fuel use [% of thermal substitution rate]	15%	22%	35%	45%	55%	15%	15%	15%	15%
CCUS [Mt CO ₂ /year]	-	-	-	1.7	3.3	-	-	-	-
Gross emission [Mt CO ₂ /year]	40	34	42	52	44	35	49	71	66
Emission intensity [t CO ₂ /t cement]	0.56	0.53	0.48	0.41	0.38	0.56	0.56	0.56	0.56

Note: Values shown are for low-demand variants of the scenarios. Alternative fuel use includes biomass as well as renewable and non-renewable waste. Electricity intensity of cement production does not include reduction in the demand for purchased electricity from waste heat recovery equipment or electricity used in carbon capture equipment. Direct CO₂ intensity refers to net CO₂ emissions, after carbon capture.

Source: IEA modelling developed for this project. © OECD/IEA, 2016.