PROJEÇÃO DA REDUÇÃO DAS EMISSÕES DE CARBONO ATÉ 2050 DA INDÚSTRIA CIMENTEIRA NO BRASIL

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RESUMO: Este estudo apresenta tendências de projeção entre 2014 a 2050 sobre a redução de CO2 num cenário entre 6°C/ e 2 °C da indústria cimenteira brasileira, propondo alternativas para reduzir, ainda mais emissões de CO2. Alémdisso, busca identificar as barreiras que limitam a adoção dessas alternativas e,com isso, propõe uma série de recomendações, regulamentos, aspectos normativos, entre outros, capazes de potencializar a redução das emissões de carbono. Nesse cenário, a emissão específica pode ser reduzida de 564 kg de cimento CO2/t em 2014 para 375kg em 2050. Como resultado, a indústria alcançaria uma emissão absoluta de 44 Mt em 2050, uma redução de 33% em relação ao "Cenário 6 °C.

PALAVRAS-CHAVE: armazenamento de carbono, clínquer, energia.

PROJECTION OF THE REDUCTION OF CARBON EMISSIONS BY 2050 IN THE CEMENT INDUSTRY IN BRAZIL

ABSTRACT: This study presents projection trends between 2014 and 2050 in the reduction of CO2 in the scenario between 6 °C/ and 2 °C of the Brazilian cement industry, proposing alternatives to reduce even more CO2 emissions. It also seeks to identify the barriers that limit the adoption of these alternatives and, as a result, proposes a series of recommendations, regulations, and normative aspects, among others, capable of enhancing the reduction of carbon emissions.In this scenario, the specific emission can be reduced from 564 kg of cement CO2/t in 2014 to 375 kg in 2050. As a result, the industry would achieve an absolute emission of 44 Mt in 2050, a reduction of 33% in relation to the "Scenario6 °C".

KEYWORDS: Carbon storage, clinker, energy.

INTRODUCTION

Brazil has little housing and infrastructure, the decarbonization of the cement industry generates aligned economic, social, and environmental benefits(INFRAROI, 2022). In this way, it is inevitable to use the world's most consumed material (ROADMAP, 2019). Cement as an essential input is linked to a complexindustry, which globally contributes around 7% of all carbon dioxide emitted by man (SNIC, 2022). The national cement company Mizu in Baraúna/RN, through the co-processing system, stopped burning petroleum coke to replace the mixture of biomass, industrial waste, and crushed tires, evolving from 5% to 35% the thermal replacement ; with this procedure , the company avoided approximately 300,000 t of CO2 between 2019 and 2022 (INFRAROI, 2022). The company Votorantim managed to reduce its carbon dioxide emissions by 25% per ton of cement, the volume went from 763 kg of CO2/ton to 576kg of CO2, and by 2030 it will decrease by 12% , producing 520 kg of CO2 per ton (ANAMACO, 2022). The Agreement at the 21st United Nations Conference on Climate Change (UNFCCC) established guidelines and commitments intended to limit temperatures this century to below 2°C. Based on studies and research, the Brazilian cement industry, in collaboration with the International Energy Agency (IEA), analyzes a series of measures capable of accelerating the transition to a low carbon economy (UNFCCC, 2021). Thus, the content will reduce carbon intensity by 33% by 2050, based on current values (WBCSD, 2018). As a result, the measures focus on four pillars: (I) additions and substitutes for clinker - an intermediate product of cement, through the use of by-products from other activities; (II) alternative fuels, using biomass and waste as energy in place of non-renewable fossil fuels; (III) Energy efficiency measures, through investments in lines and equipment with lower thermaland/or electrical consumption; (IV) innovative technologies such as carbon capture (WBCSD, 2018). In order to present reduction trends until 2050, this study discusses alternatives to minimize CO2 emission rates aimed at the Brazilian cement production process.

MATERIAL AND METHODS

The study was based on a literature review based on the research and selection of scientific articles related to the topic, published between 2014 and 2022, in Scielo (http:// www.scielo.br/) and ScienceDirect (https: www.scielo.br/) databases/www.sciencedirect.com/). Available information from sectoral bodies, National Union of the Cement Industry (SNIC), International Energy Agency (IEA), UN Population Division, World Population Perspectives: The Review, United Nations Department of Economic and Social Affairs, New York.

RESULTS AND DISCUSSION

In the Cement Technological Report (ROADMAP), developed from the repertoire of scientific research, data collection and mathematical models, they capture the current situation and future trends of the Brazilian cement industry, proposing more subsidies to reduce CO2 emission rates cement production process in Brazil by 2050 (ROADMAP, 2019).

The “6 °C Scenario”, which serves as a reference for the Roadmap, is largely an extension of current production practices, with no effort by the government, industry, or the general public to reduce CO2 emissions (Albuquerque et al, 2020). Hypothetically, specific emissions remain constant in this scenario, and due to the increase in cement production, the absoluteemission could reach 66 Mt of CO2 in 2050 (ROADMAP,2019). However, the “2°C Scenario” examines ways to achieve deep cuts in carbon emissions, enough to frame the Brazilian cement industry in a context of global warming limited to 2°C by 2050 (Albuquerque et al, 2020). The respective scenarios are referenced in table 1.

Table 1. Carbon emission scenarios 2014-2050 CO 2 emission scenarios

Scenarios	2014	2050
6 ^{O}C	286KgCO2/t MtCO2	564 gCO2/t 66MtCO2
2 ^{O}C	286KgCO2/t MtCO2	375KgCO2/t 44MtCO2

In this scenario, the specific emission can be reduced from 564 kg of CO2/t of cement in 2014 to 375 kg in 2050. As a result, the industry obtains an absolute emission of 44 Mt in 2050 and a reduction of 33% concerning “Scenario 6 °C” (ANAMACO, 2022). In terms of emissions accumulated between 2014 and 2050, comparing the two scenarios, it will be possible to avoid the emission of about 420 Mt of CO2 from adopting the measures suggested in this study according to (ROADMAP, 2019). The main alternative for this reduction is Clinker Substitution, with the potential to mitigate 290 Mt of CO2 between 2014 and 2050 (or 69%) and use of less carbon intensive alternative fuels, as the sector migrates from petroleum coke to biomass and waste could contribute with 55 Mt of CO2 of this total (13%), if these interventions do not occur, absolute emissions from cement production in Brazil will reach around 66 Mt CO2 by 2050, an increase of 64% compared to 2014 levels 40 Mt CO2 (ROADMAP, 2019). According to Votorantim, between 1990 and 2020, the company managed to reduce its carbon dioxide emissions per ton of cement by 25% and intends to reduce by 12% by 2030 by co-processing the replacement of fossil fuel with biomass, waste tires, industrial and urban waste tires, a volume that went from 763 kg of CO2/ton of cement to 576kg of CO2 (ANAMACO, 2022). Using the same process, the national cement plant Mizu in Baraúna/RN started to implement the mixture of Biomass, industrial waste,

and crushed tires in its production ovens and managed to advance from 5% to 35% the thermal replacement, no longer burning the petroleum coke (INFRAROI, 2022). In this way, the company avoided approximately 300,000 t of CO2 between 2019 and 2022 (INFRAROI, 2022).

The mitigation potential of activated alkaline materials based on blast furnaces lag and fly ash reduces between 40 and 80% of emissions corresponding to Portland cement (ROADMAP, 2019). Table 2 contains emission factors based on regional hydraulic cement production emission values considered in estimating the mitigation potential (kg of CO2 per kg of material produced).

Table 2. Emission factors

Material Value	Value
clinker + plaster	0,86
calcined clay	0.2-0.35
limestone filling	0.008
sodium silicate	0.90-1.8
RBP	0.79
BYF	0.62-0.66

For BYF (belite / ferrite) clinkers, the critical materials are bauxite and other minerals with a high alumina content, of which the Al2O3 fraction is 16.4% (Gartner, 2011). The Al2O3 content in bauxite is around 40%, and bauxite resources are estimated at 55 to 75billion tons (RITTER, 2014). Today, 91% of bauxite production is concentrated in 15 countries, mainly Australia, China, Brazil and Malaysia and India; the price of exports to US ports is $30-46 (RITTER, 2014). If all current bauxite extraction were diverted to BYF cement, it would be possible to produce around 650 Mt of S.K. Ritter, Making Competition with aluminum for bauxite and regional availability of materials are limiting factors. Table 3, brings the reduction performance between 2014 to 2050.

Table 3. Slag and fly ash availability reduction scenario

	2014	2020	2030	2040	2050
Clinker Factor	25%	28%	39%	41%	45%
fly ashes	28%	30%	39%	41%	42%
Blast furnace slag	22%	26%	32%	35%	38%
limestone filer	0%	10%	20%	25%	30%

CONSIDERATIONS

The mitigation potential of activated alkaline materials based on blast furnaces lag and fly ash reduces between 40 and 80% of emissions corresponding to Portland cement. However, there are some barriers such as the production of bauxite concentrated at 91% in other countries, such as Australia, China, Malaysia, and India; the price of exports is a limiting factor. However, Brazilian companies can already reduce carbon emissions by applying the co- processing method with a percentage advance from 5% to 35% in thermal substitution.

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