Production and co-processing of Refused Derived Fuel (RDF) in the Brazilian Portland cement industry: technical, economic and environmental aspects

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Keywords: Industrial Solid Waste, Co-processing, Waste to Energy, Energy recovery

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According to Resolution of the National Environmental Council (CONAMA) 499/2020 (CONAMA, 2020), in Brazil, co-processing is one of the final disposal techniques that makes it possible to add value to solid waste. Solid waste with suitable characteristics could be used to constitute a blend to be used as fuel, called Refused Derived Fuel (RDF), which could partially or completely replace the use of fossil fuels or a portion of the raw material (limestone, sand and clay) in the clinker production kilns in the manufacture of Portland cement.

The Energy Efficiency Atlas reports that co-processing will be the main energy transformation route in the Portland cement industry for the coming decades. By the year 2050, the RDF is expected to meet up to 55% of the demand for fuels in this industrial sector. In Germany, for example, there is already a 44% share of RDF as fuel or inputs for the cement industry (EPE, 2021). According to a report published by the Brazilian Portland Cement Association, in 2021, approximately 2.5 million tons were co-processed. Considering the generation of almost 80 million tons of solid waste that same year, it can be said that the use of this alternative is still incipient in Brazil. Some obstacles to increasing the participation of this alternative for energy recovery from solid waste are the high costs of implementation, maintenance and operation of the systems; the shortage of qualified labor; the restrictions imposed by the technical criteria of the cement industry and the RDF quality requirements. Furthermore, the need for strict controls to monitor atmospheric emissions, guaranteeing the safety of workers in the cement industry and the lack of environmental regulations contribute to a scenario of legal and institutional insecurity, which makes it difficult to attract investments.

The implementation of non-generation, selective collection and reverse logistics actions in Brazil is still in the early stages. Therefore, in this transition scenario, the energy recovery of solid waste is one of the important strategies that could face the challenge of providing the population with adequate basic sanitation services and, simultaneously, meeting some of the premises set out in the Development Goals Sustainable Development Goals (SDGs) proposed by the UN, especially SDGs 6 and 10.

This work aims to present an overview of the technological route for energy recovery from industrial solid waste through the production of RDF for co-processing in the clinker production kilns of the Portland cement industries installed in Brazil. Furthermore, the results of an initiative to use the blending – co-processing route carried out between two states in the Brazilian northeast region are presented, emphasizing environmental, technical and economic aspects.

Secondary data and information including legal aspects, quality parameters, number of cement plants with and without co-processing and their distribution in Brazil were used. The documentary analysis was based on legislation related to the areas of solid waste management and co-processing and information present in documents available on the websites of private entities, trade associations and the public administration. Aiming to complement this information, interviews were carried out with experts about current legislation and the identification of the main technical criteria and difficulties related to co-processing in Brazilian territory. The specific objectives of the interviews were: (i) to identify the main technical parameters required and (ii) to collect information on the procedures for preparing "blends" used on a real scale.

Finally, through the analysis of qualitative data provided by an industrial waste management company located in the northeast region of Brazil, three wastes (R1, R2 and R3) were selected to create a blend. The waste selection criteria were based on high calorific value and low ash content or on the presence of some attractive compound or element for the production of Portland cement. Furthermore, to ensure economic attractiveness, the amount and frequency of receipt of this waste were observed. Samples containing approximately 10 kg of each waste were collected and stored in a waterproofed and covered area. Aliquots of R1, R2 and R3 in the proportion of 1:2:1 in mass (kg) on wet basis were mixed and homogenized manually. Aliquots of 100 g of the selected waste and the blend produced were collected and sent for characterization in order to obtain the calorific value, chlorine concentration, humidity, ash, silica and sulfur content. These parameters were defined by the technical sector of the Portland cement industry, which did not require the analysis of organic compounds and heavy metals.

The data shows that there are 98 Portland cement industries distributed in 80 municipalities in 23 Brazilian states, with a nominal production capacity of 94 million tons per year. Among these industries, 55% are in operation and have authorization from regulatory entities to carry out the co-processing of industrial solid waste. Considering the 27 states of the federation, only 5, located in the most industrialized regions of the country, have specific regulations for the production of RDF and co-processing. Therefore, 50% of Brazilian cement industries that can carry out co-processing are located in states that regulate the activity. The parameters considered indispensable by managers of the Brazilian Portland cement industry were Calorific Value, chlorine, ash, sulphur and moisture content.

Even with the criteria defined by national legislation, it is important to establish state regulations that define technical and environmental criteria for the production of RDF. Considering the extent of the Brazilian territory, it is necessary to observe some local conditions to ensure that blending and co-processing do not cause negative environmental impacts on the specific ecosystems of each Brazilian biome. It is also necessary to consider economic and social issues such as those associated with financial aspects and tax incentives for investment. State legislation should not become a bureaucratic obstacle, but rather detail requirements observing the local reality so that control and inspection become effective and can promote quality and safety in blending and co-processing. In Brazilian states in which there is no specific legislation, the Portland cement industries themselves detail the acceptability characteristics of RDF. This definition is incomplete and may make the initiative legally vulnerable, as it only observes standards of operation and impact on the quality of cement produced in these facilities. This definition is incomplete and can cause legal and environmental problems, as it only observes standards of operation and impact on the quality of cement produced in these facilities.

The results of an initiative to use the blending – co-processing route carried out between two states in the Brazilian northeast region revealed that co-processing is still attractive from an economic point of view up to distances of 500 km from the generating source. If the quality of the blend is attractive to the Portland cement industry, there are negotiations to reduce transportation costs that ensure the economic attractiveness of the initiative. The states involved in the initiative do not have specific regulations that determine minimum criteria for blend production. However, the commercial and operational sectors of Portland cement industry reported that the main requirements are the adequacy of the calorific value, low chlorine and ash content. If the blend has a lower calorific value greater than 2,700 kcal/kg, the ash content criterion is not relevant, although it can never exceed 30%.

The sludge from the oil storage tank (R1) presented an inferior calorific power (ICP) equal to 3,400 kcal/kg. However, the ash content was approximately 60%. This value does not make the use of R1 attractive, as cement companies limit the ash content to a maximum of 30%. Therefore, oily sludge of this nature and origin must be mixed with other solid waste that has lower ash contents to meet the recommendations of the Portland cement industry. On the other hand, it is estimated that R1 is promising for use in the blend composition for co-processing, as it has a high silica content (approximately 60%) indicating that it could be incorporated into the cement clinker. The sludge obtained from the production of soybean oil (R2) was the one that presented the most satisfactory results. The ICP was almost twice the value of R1 and the ash content was equal to 1.15%. Furthermore, the generation of this waste is approximately equal to 60 tons per month, which increases the attractiveness and economic viability of the initiative. However, the sludge from the paint industry (R3) had an ash content of 93.6% and a ICP below 500 kcal/kg, therefore cannot be considered an attractive waste for co-processing in the Portland cement industry.

The preliminary economic assessment allowed concluding that higher ICP values may represent an increase in the value of the blend as a RDF. Estimating the commercialization value of the CDR at U$ 20.00 per ton, 40 tons of the blend made with R1 and R2 would pay the production costs of the initiative.

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