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Advances and challenges for the co-processing in Latin American cement industry

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Abstract

Co-processing is an industrial technique of using wastes as a substitute for raw materials and/or fuels, as a way to minimize the consumption of minerals and non-renewable fossil fuels. This paper presents a brief overview on such practices conducted by the cement industry in Latin America. The main issue addressed is co-processing as a contribution to develop a more sustainable scenario in cement production and as a valuable tool in waste management. Cement industries are particularly suitable for wastes co-processing, due to the high temperatures reached inside their kilns, which favor the degradation of toxic compounds formed upon burning of certain wastes. Developed countries, particularly in the European Union, have been replacing fossil fuels by wastes since the 1970's. In the Netherlands, the calorific substitution rate is higher than 80%, while in Austria, Germany and Norway it is over 60%. In Latin America, those values vary between 7 and 20% according to the country. This study has found that the main differences between European and Latin American regions are caused by distinct implementation degrees of waste management chain and by legal requirements and inspection practices of industrial activities. However, the Cement Sustainability Initiative (CSI) estimates that until 2030, the substitution of fossil fuels by wastes in Latin America will reach 25 to 35%. This numbers are the same reached by Denmark, France and Sweden in 2010.

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1. Introduction

Cement is the main component of concrete, which is the most consumed material on Earth (WBCSD, 2009a). Its production reached 3.6 billion of tonnes in 2012 and it is projected to grow by 0.8-1.2% per year, reaching between 3,700 megatonnes (Mt) and 4,400 Mt in 2050 (CEMBUREAU, 2012; WBCSD 2009b).

Besides the amount consumed every year, the production of cement involves heating a mix of limestone, clay and bauxite, at temperatures between 1200°C and 1500°C (Lamas *et al.*, 2013). This process provides the decomposition of calcium carbonate into calcium oxide, which causes high CO_2 emissions. In addition, huge quantity of electricity is required to grinding the raw materials and the finished cement (Edenhofer *et al.*, 2012).

This high energy consumption and the decarbonatation of limestone make the cement industry responsible for approximately 12 to 15% of total industrial energy use (Madlool *et al.*, 2011) and 5 to 7% of the anthropogenic CO_2 emission (Fry, 2013). Actually, each ton of Portland cement produced releases almost one ton of carbon dioxide to the atmosphere (Meyer, 2009). Due to this, a significant effort has been made in terms of researches and new methods developing to reach lower CO_2 emissions (Meyer, 2009; Madlool *et al.*, 2011; CEMBUREAU, 2009; FICEM, 2012). An already well known and broadly used method is the co-processing, technique in which waste is used to replace raw materials and/or fuels (CEMBUREAU, 2009).

According to the European Cement Association, CEMBUREAU, the co-processing of alternative fuels provides a solution in terms of reducing fossil fuel dependency as well as a contribution towards the lowering of atmospheric emissions. The use of alternative raw materials also has numerous benefits, including a reduced need for quarrying and an improved environmental footprint of such activities. Besides this, those substitutions do not have negative impacts on production process emissions, or on the environmental and technical quality of the final product. Furthermore, co-processing is carried out in a safe manner, thus not affecting the health and safety of its workers or neighborhood (CEMBUREAU, 2009).

According to Usón (Usón *et al.*, 2013), the common wastes used worldwide in cement industries are municipal solid waste, meat and bone animal meal, sewage sludge, biomass and end of life tires, but the case of the Netherlands is remarkable. This country reached a replacement ratio of 83%, and approximately 42% comes from sewage sludge. Other industrialized countries show replacement ratios above 60%, as Austria, Germany and Norway. In 2010, the average for the UE-27 was 30.5%.

Despite these excellent numbers, it is important to give attention to developing economies, because it is estimated that they are responsible for 80% of global cement production (WBCSD, 2009c). In Latin America, the main producers are Brazil, Mexico and Argentina. In 2012 they figured among the 20 main cement producers in the world, occupying the 5^{th}, 12^{th} and 18^{th} position, respectively (CEMBUREAU, 2012).

The Intergovernmental Panel on Climate Change (IPCC) says that many industrial facilities in developing nations are new and include the latest technology with the lowest specific energy use. However, many older, inefficient facilities remain in both industrialized and developing countries. Also, in developing countries, there continues to be a huge demand for technology transfer to upgrade industrial facilities to improve energy efficiency and reduce emissions (IPCC, 2007).

Thus, the central questions in this paper are the cement production in Latin America, the current situation of co-processing and the challenges to reach a more sustainable cement industry. First we give a brief overview of the cement industry in Latin America, and then we discuss the status of co-processing for the most expressive cement industries. Finally we discuss the legal requirements concerning the activity and how the waste management chain can enhance the progress in terms of sustainability. Some countries are not discussed due the lack of reliable information. Finally, we analyze the waste management chain, legal requirements and how they can enhance the progress in terms of sustainability.

2. Cement industry in Latin American

The biggest cement producers in Latin America are Brazil, Mexico and Argentina. According to CEMBUREAU, they are the Latin American countries that integrate the list of the 20 biggest producers of cement in the world. Together they were responsible for the production of 120 million of tonnes of cement in 2012 (CEMBUREAU, 2012). Additionally, according to the Federación Interamericana del Cemento, FICEM, Colombia

is another important producer, that, in 2012, reached the same quantity of Argentina cement production (FICEM, (2013). Table 1 summarizes the cement production between 2010 and 2012 in Latin America for the countries that produced more than 5 millions of tonnes in 2012.

Table 1 - Cement production between 2010 and 2012 for the biggest producers of Latin America.

Country	Cement production (millions of tonnes)		
	2010	2011	2012
Brazil	59.2	64.1	68.8
Mexico	34.5	35.4	36.8
Colombia	9.5	10.8	10.9
Argentina	10.4	11.6	10.7
Peru	8.3	8.5	9.8
Venezuela	7.1	7.7	8.3
Ecuador	5.3	5.7	6.0
Chile	4.4	4.6	5.0

Adapted from Informe Estadístico 2013 (FICEM, 2013).

The Brazilian market is composed of many producers and have an installed capacity of cement production of 78 millions of tonnes per year (SNIC, 2013). However, the major Latin American cement company is the Mexican CEMEX, which has only in Mexico 15 factories, responsible for an installed capacity of 29.3 millions of tonnes of cement per year (Sobrinho *et al.*, 2012). CEMEX also has a number of others factories around the world, which totalize an installed capacity of production of 93.7 millions of tonnes (CEMEX, 2013a). Other main producers at Mexico are Holcim, Lafarge and Cementos Moctezuma (CANACEM, 2014).

In the same way, Argentina also has many players in the cement market, but the main producers are Loma Negra (trademark of the Brazilian group Camargo Correa, administered by the holding Intercement) and the Swiss Holcim. The others are local producers and together they correspond to almost half of the installed capacity (Cimento.org, 2014), that totalize 16.8 millions of tons.

Contrary to these, there is Colombia, which is considered an oligarchic market. In 2005 the sector faced accusations of collusion (a non-competitive agreement between companies to disrupt the market's equilibrium). Due to this crisis, smaller producers were forced to close or were absorbed by larger groups. Nowadays, only 3 companies act at Colombian market: Argos, Cemex and Holcim (Aktiva Servicios Financieros, 2013). Besides the Colombian case, there are other markets dominated for few players, like Bolivia, Venezuela and all small countries from Central America. Data from the International Cement Review, indicates that Latin America has 224 cement factories, of which more than 60% are local producers. In Table 2 we present the producers that complete the Latin America cement framework and also act in other countries worldwide.

Table 2 - Latin America main industrial groups.

Group	Origin	Locations worldwide
Argos	Colombia	Colombia and USA
Cemex	Mexico	Argentina, Colombia, Costa Rica, Dominican Republic, El Salvador, Mexico, Nicaragua, Panama, Peru and Phillipines, USA and factories in Asia and Europe
Holcim	Switzerland	Chile, Argentina, Brazil, Colombia, Equador, Costa Rica, Nicaragua, El Salvador, Mexico, Canada, USA and factories worldwide
Intercement	Brazil	Argentina, Paraguay and Brazil and factories in Africa and Portugal
Lafarge	France	Brazil and Equador, Canada, USA and factories in Africa, Asia and Europe
Votorantim	Brazil	Argentina, Bolivia, Brazil, Colombia, Peru, Canada, USA, and factories in Africa, Asia and Europe

Based on Argos (2012); Holcim (2013); Intercement (2012); Lafarge (2014); Votorantim (2014).

3. Co-processing in Latin American

From the companies mentioned in Table 2, Cemex has an outstanding position in terms of co-processing. For two consecutive years they have been recognized with a Global Cemfuels Award for Alternative Fuels Using Company of the Year (CEMEX, 2013b). Despite this, Cemex recognizes that the use of alternative fuels is highest in Europe. For example, in 2009 they reached substitution taxes of 26% at Spain. The taxes were even better at United Kingdom (40%) and Germany (48%), but the Mexican taxes for the same year were 8% (CEMEX, 2009). The company attributes this to local regulations of waste management. According to Cemex "in many countries, our alternative fuels substitution rate is low, far below its real potential. The reason is that our technical know-how must be matched by appropriate waste management regulations" (CEMEX, 2013c).

For Argos, the current situation is the same. Two plants in USA present substitution rates of 15% and 23%, while plants in Colombia still are being prepared to begin co-processing in a plan of three years (2013-2015) (Argos, 2012). Holcim has kept its global substitution rates around 12% between 2010-2012 (Holcim, 2013), and it is important to highlight that the company has been responsible for developing and improving co-processing in many countries. In 2003, Holcim and Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) started a partnership agreement that led to the development of guidelines for the utilization of waste materials in the cement industry. These guidelines are particularly designed to improve waste management in developing countries. At the end of 2005 the partners entered into a second three-year lasting co-operation to advance the implementation of the guidelines which was successful in more than 20 countries until now (Holcim, 2014).

Intercement closed 2012 with 9% substitution rate. The goal is to reach 32% until 2017. The strategy includes (1) investments in knowledge; (2) adequacy the structure to receive, store and destroy the wastes; and (3) sharing success experiences among company facilities. Here, they highlight the Candiota facility, at Brazil, that reached 37% substitution rate in 2012 (Intercement, 2012). Besides this, in 2005, Cimpor (which is an Intercement business) created together with Lafarge a joint-venture specialized in waste management and co-processing: the Ecoprocessa. Its main objective is foster co-processing in the 11 factories of the companies. In 2013 Lafarge's global substitution rate was 10%, but in Brazil, the number was almost 13%. Additionally, the Lafarge Cantagalo facility was the pioneer in co-processing urban waste from the selective collect.

In this scenario, the Brazilian company Votorantim also plays an important role. The company practices co-processing since early 90s and more than 90% of the facilities are authorized to receive wastes to co-processing (Votorantim, 2014). It is also important to say these six companies are members of the "Cement Sustainability Initiative", which is a sector-project of the World Business Council for Sustainable Development. There are another 18 industries spread worldwide participating of this project, which is a global effort for the pursuit of sustainable development in the cement industry (CSI, 2014).

The presence of these companies in Latin America and its participation in a global project like CSI cooperates for the development and implementation of co-processing in countries whose waste management provided by the local governments is weak or ineffective.

4. Waste management and legal requirements

International companies, whose market share is increasing, usually adopt their own internal standards throughout the world, using best available technologies when building new facilities. Actually, from a technical point of view, all kiln types are suited for co-processing, however, older, polluting, and less integrated technologies are gradually being phased out due to stricter standards and/or voluntary best practices (GTZ-Holcim, 2006).

Countries as Brazil, Colombia, Costa Rica, Mexico and others have standards, regulations and laws for co-processing and waste management. Obviously, these regulations vary according to each country, but basically, they prohibit using untreated urban waste, hospital waste and from health services, radioactive, organochlorine, pesticides and others related (FICEM, 2012).

Besides the environmental dimensions of the co-processing, it is necessary to take into account the social dimensions of this practice. The technique can create risks to the health of workers and surrounding population if it is not properly used. Additionally, health and safety have been the major concerns in hazardous waste management.

Therefore, modern waste management should include (i) technical efficiency in terms of environmental protection, (ii) economic efficiency in terms of cost feasibility, and (iii) social acceptability (Kikuchi and Gerardo, 2009).

Thus, the rules concerning to what wastes can be employed and the limits of atmospheric emission of pollutants should be well defined and strictly met and inspected. In this way, many efforts have been made in Latin America. At Brazil, for instance, there is a law specifically about co-processing since 1999, but the lack of infrastructure for waste management, hinders its practice. In fact, in 2007, 800.000 tonnes of industrial wastes were co-processed in the country, but it corresponds only to 30% of all industrial wastes produced that year. The main kind of wastes used are contaminated soil, tires, oily sludge, used catalysts, adhesives, resins, latex, rubberized and contaminated materials as paper plastics and woods (Construção Total, 2008).

At Costa Rica, a properly regulation about co-processing was developed in 2004 due to the Holcim Costa Rica S.A. interest in co-processing industrial wastes. Before this, industrial waste was collected from private companies and co-disposed at environmentally sound handling and disposal of waste material in their cement kilns. Thenceforth, in a joint effort between the cement manufacturers and the Ministry of Health, a regulation that permits the co-processing of used solvents (halogen free), waste oil, waste tires and rubber scrap and plastics (except PVC) was implemented (GTZ-Holcim, 2006).

But while Latin American countries are developing laws and strategies regarding industrial waste co-processing, many European countries are co-processing not only industrial wastes, but also municipal wastes (Aranda Usón *et al.*, 2013). Considering the amount of municipal wastes generated every day and the disposal problems in developing countries, co-processing is a good way to run out these wastes. The main issue is that from an ecological, technical and financial point of view, the co-processing of unsorted municipal waste is not recommended. Mixed municipal waste must be sorted in order to obtain defined waste streams of a known quality. Due to this, co-processing municipal waste should be regarded as an integrated part of municipal solid waste management (GTZ-Holcim, 2006).

Pioneer in this field in Latin America, Cemex co-process the inorganic materials from urban solid waste (FIRSU®) since 2012. Paper, plastics and textiles that cannot be recycled are sorted, shredded and then used as an alternative fuel in Cemex's cement kilns. In 2013, 84.000 tonnes of FIRSU® were co-processed in 8 cement plants and they aim to roll out the system to the other seven Mexican cement plants by 2016 (Louise Fordham, 2014)]. Besides this enhancement by private sector, also the Camara Nacional del Cemento (CANACEM) has signed individual accords to the Secretaría del Medio Ambiente y Recursos Naturales de México, and to Petróleos Mexicanos in respect to using wastes from the petroleum industry in the cement production (CANACEM, 2014).

As regional actions, FICEM created a working group focused on climate change and co-processing in 2010. The group is composed by experts from all the associated countries and has as goal preparing the Latin American cement industry for future regulatory frameworks on climate change, foster co-processing and support the development of legislation that encourages responsible co-processing (FICEM, 2012).

Another interesting initiative is the Guidelines on Co-processing Waste Materials in Cement Production, from GTZ-Holcim Public Private Partnership. As known, Holcim holds majority and minority interests in many countries in Latin America (Table 2) and this kind of effort stimulates co-processing practice in the region. These Guidelines are based on an approach that aims specifically to reduce existing waste problems in developing countries and encourage the use of waste as an alternative source for primary energy and virgin raw materials in cement kilns (GTZ-Holcim, 2006).

It is expected that these actions can stimulate the resolution of some waste management problems in developing countries. The main issue is creation and execution of integrated strategies for waste management, and obviously, for this, is necessary to implement and execute laws regarding waste issues and co-processing. Uncontrolled waste disposal still is the cheapest way to run out the wastes, but it is not safe for the environment or human health. The alternative of co-processing brings environmental and social benefits, avoiding the consumption of fossil fuels and giving a properly destination for municipal or hazardous wastes. For this reasons, co-processing is a win-win relation and must be encouraged and enhanced.

4. Conclusions

The high energy consumption by cement industries has been a central issue in respect to environmental questions as fossil fuel consumption and climate change. Due to this, co-processing is a win-win alternative, avoiding fossil fuel consumption and at the same time providing an adequated destiny to many kinds of wastes.

It is known that co-processing best practices happen in European countries. It happens due to a well-defined regulation and the good waste management, with roles from society, companies and government well defined. However, the presence in Latin America of multinational companies, as CEMEX and Holcim, has been promoting the use of wastes as fuels.

In many countries, governments and industry are reaching agreements and developing strategies and regulations to improve waste management and stimulate the co-processing, similar to what happens in Europe. Despite many problems, mostly associated to the incorrectly destination of wastes, Latin America has potential to increase co-processing due the amount of waste generated every year and its cement production.

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