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CO_2 Emissions from Brazilian Cement Manufacturing Industry

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ABSTRACT

The cement industry is one of the world's biggest industries and it produces more than 5% of mankind's Carbon Dioxide emissions. The Brazilian industry represents 1.8% of worldly cement production and the State of Minas Gerais 23 % of Brazilian production. This study reviews the Minas Gerais CO_2 emissions from cement making industry. It is conducted with the same measuring and analise procedures adopted by the European comunity and is developed with a global measurement and analisys approach, aiming better solutions in the greenhouse gases reduction and other environmental impacts. With the WBCSD-Cement Sustainability Initiative CO_2 Emissions Inventory Protocol, a specific study will be conducted at the Federal University of Minas Gerais. The CSI spreadsheet will be completed with data from each Brazilian Plant and Company and presented to the scientific community.

INTRODUCTION

The cement industry is a very strategic sector for Carbon Dioxide emission mitigation. Cement is the key ingredient in concrete and concrete is the second most used product on the planet, after water. Sustainability must be seen as a global perspective, and not a regional one. The Brazilian cement industry represents 1.8% of the production in the world. (one of the top 10) .As economies grow and get wealthier, the demand for construction materials such as cement and concrete is booming. This is particularly visible in emerging economies. Science tells us that the world must reduce its emissions of greenhouse gases by at least 80 per cent below 1990 levels by 2050. WWF insists that developed countries show the way to this goal with decisive actions to reduce their emissions by 25-40 per cent below 1990 levels by 2020 while supporting and financing additional emissions reductions in carbon- and energy-intensive sectors in developing nations.

Cement Industry Background

By heating limestone with other materials to about 1450 °C in a kiln, the resulting substance is called "clinker" that subsequently is grounded with other substances to make "Ordinary Portland Cement" often referred to as OPC. And by heating limestone to about 900 °C we make calcium oxide (known as lime). In both cases, the process is known as calcination and it releases carbon dioxide(CO_2) The Calcium Oxide(CAO) has the following chemical equation: $CaCO_3$ + Heat $\rightarrow$ CAO + CO_2 . Hydrated lime then is obtained by reaction with H_2O with the release of heat. CaO + H_2O $\rightarrow$ $CA(OH)_2$ + Heat

The necessary temperature in the kiln is achieved by burning a fuel, which can be: wood, oil, natural gas, coconut gas, coal, recycled such as old tires, waste solvents and lubricants, plastic and other materials. Modern technology, have increased the use of alternative fuels and clinker substitutes.These improvement has contributed to reduce the industry's CO_2 emissions.

Fifty percent off all CO_2 emissions originated at the cement production industry, comes from the basic calcination process of heating the calcium carbonate (limestone) to form lime. 40% comes from usage of fuel and then 10% from electricity usage and transportation. The Portland cement industry causes environmental impacts at all stages of the process. These include dust, gases, noise, vibration, consumption of large quantities of fuel, release of CO_2 and damage to countryside from quarrying. Equipment to reduce dust emissions is widely used. Equipment to trap and separate exhaust gases are coming into increased use. Quarries are re-integrated into the countryside by re-cultivating them after they have been closed down.

Researches from AEA Technology have concluded that the most important environment and health issues facing the cement industry are atmospheric releases (including greenhouse gas emissions, dioxin, NO_x, SO_2, and particulates), accidents and worker exposure to dust. There are 3 categories of CO_2 emission sources in Portland cement manufacture: First: CO_2 derived from decarbonation of limestone. Fairly constant: (minimum around 0.47 kg CO_2 per kg of cement, maximum 0.54, typical value around 0.50 world-wide). Second: CO_2 from kiln fuel combustion. Varies with plant efficiency:(efficient plant 0.24 kg CO_2 per kg cement, low-efficiency as high as 0.65, typical averaging around 0.30). Third: CO_2 produced by vehicles in cement plants and distribution. Almost insignificant. So typical total CO_2 is around 0.80 kg CO_2 per kg finished cement. The tendency for the future is to reduce the First and Second sources by modification of the chemistry of cement, by the use of waste fuels, and by adopting more efficient processes. The concrete, compares quite favorably with other building systems even though cement manufacturing is a very large CO_2 emitter.

1.2 Sustainable Development

The Cement Sustainability Initiative (CSI) is the collective of the 18 global major cement producers that account for about 30% of the world's cement production. Their effort is to pursuit sustainable development for the cement industry, identifying actions cement companies can take to accelerate progress toward sustainable development and providing a framework for other cement companies to become involved. The CSI estimates that 80% of the future emissions from cement plants will take place in developing economies. Many of the issues addressed, cross national and international boundaries.

Cement is a key material for any country's development, but the cement industry has an ecological responsibility that needs to be managed both short and long term. GNR [2006] is a database system on CO_2 and Energy Information of clinker and cement production worldwide. It is aimed to have accurate, up-to-date data in order to aid decision-making. According to the CSI-GNR project, the average CO2 emissions has decreased from 914 kg CO2 / tonne clinker in 1990 to 866 kg CO2 / tonne clinker in 2006. As cement, is the main component of concrete, it is needed for a wide range of construction projects, including housing and public works. It is a key material for any country's economic and social development. The CSI has made Brazil, Russia, India and China a focal point for their effort in reducing CO_2 emissions. CSI members are monitored, measured and reported. Each company member has set individual targets for CO_2 emissions. The CSI companies have a consensus on how to measure results and to ensure the fulfillment of their commitment. They report their progress using comparable methods called Key Performance Indicators (KPIs) and also submit their report to be verified by third party auditors.

WWF [2009] is a document proposing solutions for the cement industry sector that is facing the challenge to sustain its business while decreasing its carbon intensity. WWF's report describes how the cement industry can grow to more than twice its size in volume by 2050 while it reduces its absolute CO_2 emissions by approximately three quarters compared to global emissions in 2007. WWF believes that cement companies around the world must take steps to reduce their carbon footprint today, both in emerging economies and industrialized countries. Developed countries must give support to the actions and the emerging economies must deviate from a business-as-usual development path. To make this possible, sufficient financial resources and technology must be made available from developed countries. The carbon intensity of cement production in industrialized regions, in particular in North America, is sometimes worse than that in emerging economies.

2. METHODOLOGY FOR CALCULATING AND REPORTING CO2 EMISSIONS

CSI [2002] released Agenda for Action, a document that pledged to develop a protocol for measuring and reporting CO_2 emissions from cement manufacturing. This was accomplished in 2003 with CO2 Accounting and Reporting Protocol. WBCSD-CSI [2003]. This protocol comprises a methodology for calculating CO_2 emissions and providing reports. It addresses all direct sources of CO_2 emissions and also the main indirect sources related to the cement manufacturing process. This CO_2 emissions protocol comprises two main elements: The first one is a guidance document and the second one is an excel spreadsheet, which is a practical tool to help cement companies prepare their CO_2 inventories.

Table 1 - CO_2 Emissions Reduction Targets of Some CSI Members - CSI[2002]

Holcim	By 2010 – 20% reduction from 1990 baseline
Lafarge	By 2010 – 20% reduction from 1990 baseline
Heidelberg Cement	By 2010 – 15% reduction from 1990 baseline
Titan	By 2010 – 15% reduction from 1990 baseline
Taiheiyo	By 2010 - 3% reduction from 2000 baseline
Siam Cement Group	By 2010 - Reduction to 670 kg CO_2 / ton cement
Votorantim	By 2012 – 10% reduction from 1990 baseline
Italcementi	By 2012 – reduction to 690 kg CO_2 / ton cement
CEMEX	By 2015 – 25% reduction from 1990 baseline
CRH	By 2015 – 15% reduction from 1990 baseline

An analisys of those targets can lead us to interesting conclusion: The Japanese Taiheiyo Cement commitment of 3% emissions reduction from 2000 baseline seems more significant than the commitment of other corporations with 20% emissions reduction from 1990 baseline, because japanese were already using slag to produce their cement. But above all, those targets are always welcomed, because they are effectively an emission reduction proposal.

2.1 Minas Gerais – Brasil - WBCSD - CSI Case Study

According to SNIC [2009], the State of Minas Gerais represents 23 % of the Brazilian cement production industry. Brazilian cement industry has 10 plants with 65 production units over the country. With capacity to produce 63 million tonnes of cement per year, generating approximately 2.7 millions tonnes of waste material. The average CO_2 emissions factor from Brazilian companies represented is 610 kg CO_2 / ton of clinker. And according the WBCSD [2009], the average CO_2 emissions factor from several cement companies is 862 kg CO_2 / ton of clinker. And from SNIC [2009]. The following charts shows Brazilian CO_2 Emissions comparing WBCSD [2009] to SNIC [2009] factors.

2.1.1 – Cement Production And CO2 Emissions By Region

Table 2 – Production By Region

PRODUCTION (x1000 tonnes)		**CO2 emissions**	
REGION	**CEMENT**	**SNIC**	**CSI**
North	1,618	559	790
Northeast	9,399	3,248	4,589
Middle west	5,221	1,804	2,549
Southeast	23,690	8,186	11,567
South	6,661	2,302	3,252
Total	**46,589**	**16,098**	**22,748**

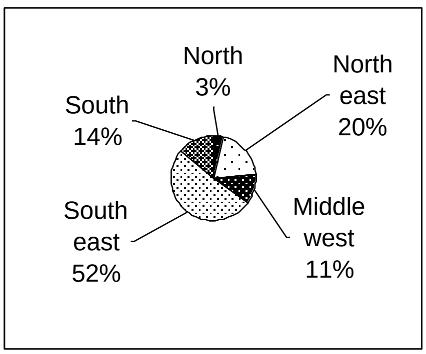

Fig. 1 - Production by Region

2.1.2 - Cement Production And CO2 Emissions By Plant

Table 3 – Production by Plant

PRODUCTION (x1000 tonnes)		**CO2 emissions**	
PLANT	**CEMENT**	**SNIC**	**CSI**
Votorantim	19,401	6,704	9,473
Joao Santos	5,548	1,917	2,709
Cimpor	4,393	1,518	2,145
Holcim	3,591	1,241	1,753
Camargo Correa	3,349	1,157	1,635
Lafarge	2,670	923	1,304

Ciplan	1,319	456	644
Itambe	938	324	458
Others	5,380	1,859	2,627
Total	**46,589**	**16,098**	**22,748**

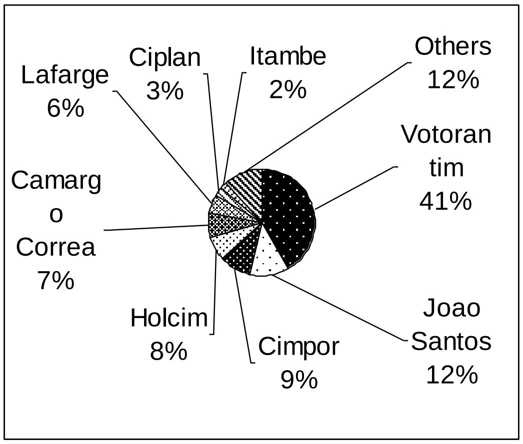

Fig. 2 – Production By Plant

2.1.3 - Cement Production And CO2 Emissions By Cement Type

According to EN [2000], CEM I-Portland Cement, comprises up to 5% of minor additional constituents. CEM II-Portland-composite cement comprises up to 35% of other single constituents. CEM III-Blast Furnace Cement has Portlant cement and higher percentages of blastfurnace slag. CEM IV-Pozzolanic Cement is Portland cement and up to 55% of pozzolanic constituents. CEM V-Composite Cement, has Portland Cement and a low percentage of blastfurnace slag and pozzolana or fly ash. Constituents that are permitted in Portland-composite cements are blastfurnace slag, silica fume, natural and industrial pozzolans, silicious and calcareous fly ash, burnt shale and limestone.

Table 4 – Production by Cement Type

CEMENT PRODUCTION (x1000 tonnes)		% CLINKER
TYPE	CEMENT	empirical
CEM I	1,034	90
CEM II	29,754	60
CEM III	7,659	26
CEM IV	3,876	54
CEM V	3,211	90
White	115	60
Adjusts	940	60
Total	46,589	

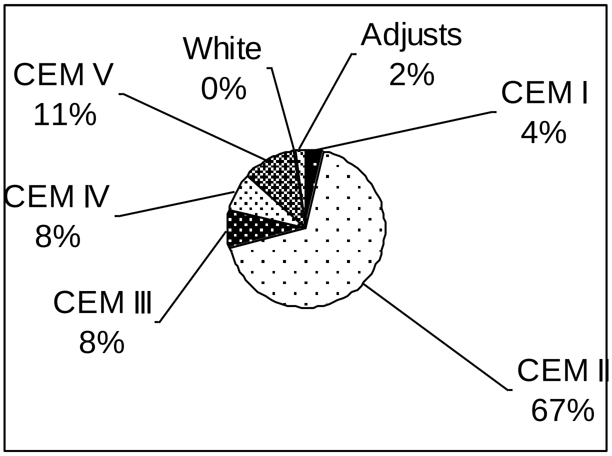

Fig. 3 – Production By Cement Type

2.1.4 - Cement Production And CO2 Emissions In Minas Gerais

Table 5 – Production by State

PRODUCTION (x1000 tonnes)		**CO2 emissions**	
STATE	**CEMENT**	**SNIC**	**CSI**
Minas Gerais	10,849	3,749	5,297
Other states	35,740	12,349	17,451
Total	**46,589**	**16,098**	**22,748**

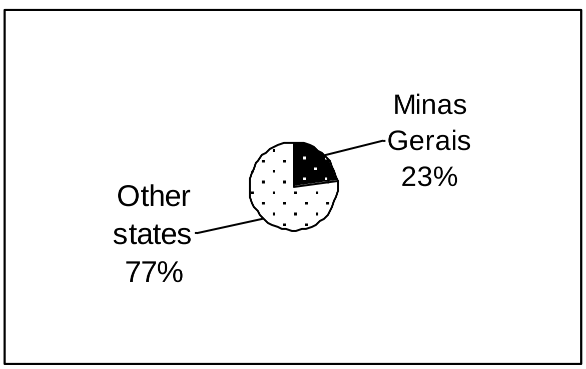

Fig.4 – Production By State

The percentage of clinker in each type of cement is an empirical data. A specific study will be carried on at the Department of Civil Engineering in Federal University of Minas Gerais. This study will comprise also the WBCSD-CSI [2003] protocol for CO2 Accounting and Reporting Standard for the Cement Industry when the spreadsheet will be completed with data from Brazilian companies plants. Than, those data will be presented to the scientific community.

Based on the displacement of Sindicato Nacional da Indústria de Cimento SNIC [2009], calculations were made to estimate 56.6 % for the average percentage of clinker in the Brazilian Portland Cement. Because of that, a more specific study must be conducted, and it will be done to obtain more precise calculations of CO2 emissions and emission rights as well as performance indicators at company and plant levels and for the various cement types. The 56.6 % empirical data was obtained by comparing the total CO2 emissions by plant and by region, with the total emissions by cement type.

3. RECOMMENDATIONS

Based on the WBCSD-Cement Sustainability Initiative CO2 Emissions Inventory Protocol, it will be conducted at the Civil Engineering Department of Federal University of Minas Gerais, the calculation of CO2 emissions, and emission rights, calculation of Performance indicators, Total Absolute and specific emissions, for each Brazilian Plant and Company.

4. ACRONYMS AND GLOSSARY

CSI	Cement Sustainability Initiative (WBCSD)
WBCSD	World Business Council for Sustainable Development
WWF	World Wildlife Fund
GNR	Getting the Numbers Right (this is a database from CSI)
SNIC	Sindicato Nacional da Indústria de Cimento

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