CARBON FOOTPRINT DETERMINATION OF A TURKISH CEMENT FACTORY

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Abstract: Carbon footprint can be defined as the carbon dioxide (CO_2) equivalent of greenhouse gas (GHG) emissions caused by anthropogenic activities (such as transportation, energy generation, services or purchasable products, etc.). The carbon footprint of a facility can be determined due to reasons such as legal obligations, social responsibilities, customer demand, or reduction of GHG emissions. In this study carbon footprint of a cement factory is ascertained. The amount of greenhouse gas emissions from the factory is 1,64 million tons of CO_2 in 2014. 65% of them come from clinker production and the remaining comes from combustion, mainly petroleum coke which has the largest share of approximately 30% of contribution. It will be a good opportunity for the factory to use waste oil and end of life tires (ELT) as alternative fuels to mitigate its the carbon footprint.

Keywords: carbon footprint, cement industry, clinker production, greenhouse gas emission

Introduction

World's rapid industrialization is causing ecologically deterioration gradually. Correspondingly, global climate change has become a major threat to the environment and the economic development of the world (Zhang and Zhang, 2015). In this regard, Kyoto Protocol (KP) is the most important step taken in the worldwide. KP aims to mitigate GHG emissions by obligating developed countries to pay the price for their emissions.

Carbon footprint (CF) can be defined as a measure of total amount of carbon-dioxide (CO_2) released into the atmosphere in the given time frame that is directly or indirectly caused by any activity to provide service or a product. This approach has become a widely used concept in greenhouse gas emissions assessments recently (Andrić, et. Al., 2015).

Carbon footprint calculations are made due to reasons such as legal obligations, social responsibility, customer or investor demands, corporate image, voluntary or mandatory greenhouse gas emission reduction or the participation in the emissions trading mechanisms.

In Turkey calculation of carbon footprint is not an obligation, but it is significant to the facilities for their own emission inventory and to put forward strategies for prevention of climate change. The current legal regulation on the greenhouse gas emissions monitoring is entered into force in 2014 with the name of "Regulation on Monitoring of Greenhouse Gas Emissions (RMGHGE)" (Official Gazette 2014a). This regulation aims monitoring, reporting, and verification of the GHG emissions occurring from the listed activities in its Annex 1.

Turkey's CO_2 emissions were estimated at 363.5 million tons in 2013 and about 18% of it comes from industry. Cement sector is one of the major industrial greenhouse gas emission sources. The aim of this study is to calculate the carbon footprint of a cement factory in Turkey and give suggestions to decrease greenhouse gas emissions. The factory is producing clinker and cement since 2009 with 242,824 m^2 surface area, about 2 million ton/year clinker production capacity and exists in Annex 1 of the regulation (as its capacity exceeds 50 tons daily clinker production.) It is in the top 500 industrial enterprises of Turkey.

Besides Turkish cement sector is in the top 10 in the world and ranked third in Europe with about 71 million tons of production in 2014. Due to the increase of infrastructure and construction activities in Turkey in the last years, cement demand is increasing. Accordingly, the production is expected to be about 100 Mt in 2023 (Url-1)

There are varies international standards and regulations to help users for carbon footprint calculations. However most of the studies in the literature used IPCC Guideline 2006 (IPCC, 2006; Jiang et. Al., 2015; Xu and Lan 2015; Yaka and Güngör, 2015; Cai et al., 2008).

Materials and Methods

For the carbon footprint analysis, all the sources of emissions in the factory have been primarily defined. Emissions are categorized as combustion-sourced and process based. Fuels used for the combustion are domestic lignite, petroleum coke, steam coal, fuel oil, waste oil, end of life tires (ELT) contaminated waste.

Process-based emissions are come from clinker production, the non-carbonate carbon raw material. IPCC (2006) methodology with 2014data is used for the carbon footprint calculations.

Energy balance diagram was set up and accordingly emission sources are defined for the CO_2 emission calculations.
CO_2 emission sources of the factory are given in Table 1.

Table 1: CO_2 emission factors (EF).

Item No	Source	EF	Source
1	Clinker production	0.51 tCO_2/t	IPCC 2006
2	Domestic lignite	99.27 tCO_2/TJ	TURKSTAT, 2014
3	Petroleum coke	92.79 tCO_2/TJ	TURKSTAT, 2014
4	Steam coal	92.79 tCO_2/TJ	TURKSTAT, 2014
5	Fuel oil	76.66 tCO_2/TJ	TURKSTAT, 2014
6	Waste oil	73.3 tCO_2/TJ	Official Gazette 2014b
7	ELT	85 tCO_2/TJ	Official Gazette 2014b
8	Contaminated waste	83 tCO_2/TJ	Personal info, 2016.
9	Raw material: cement clinker non-carbonate carbon	3.664 tCO_2/TJ	Personal info, 2016.

CO_2 emissions are calculated according to IPCC Guideline Tier methodology that is given by Eq. 1 [3].
CO_2 emission=Fuel consumption x emission factor x oxidation ratio Eq.1
where, CO_2 emission, kg emission by fuel type
fuel consumption, consumed fuel, kg, l
emission factor, GHG emission factor by fuel type, kg/TJ
oxidation ratio is assumed 100%.

Results and Discussion

The calculations indicate that the factory released 1.64 M tons of CO2 emissions in 2014, which was %3 of the total industrial GHG emissions of Turkey in 2014. The distribution of the emission sources are given with Fig. 1. 65% of the total emissions come from the process that is clinker production and the remaining 35% comes from combustion, mainly petroleum coke which has the largest share of approximately 30% of contribution. Steam coal is the second important emission source from combustion which has 4% contribution to the total CO_2 emissions.

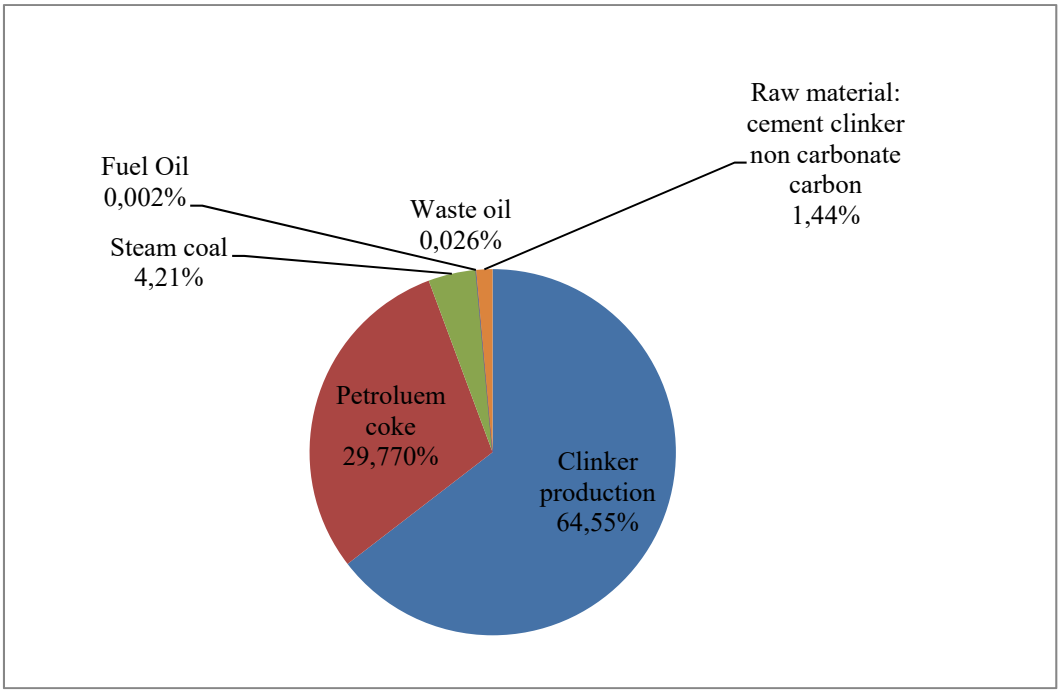

Fig.1: CO_2 Emission distribution of the cement factory.

Conclusion

Cement industry is one of the major industries for mitigation of the GHG emissions since it is the main emission sources in Turkey, as in the world. In this study the emissions are calculated according to the Tier 1 approach of the IPCC methodology. Thus process emission factor of the factory is the default value. In the future study factory specific CO2 emission factor may be calculated to get more certain values to evaluate. Since the major combustion emissions come from petroleum coke and steam coke, it will be a good opportunity for the factory to use waste oil and ELT as alternative fuels to mitigate its the carbon footprint.

Acknowledgements

The author would like to thank Sevgi Üçkan Environmental Chef of Traçim Çimento A.Ş. for the data supply of this study.

References

Andrić, I., Zghal, N. J., Santarelli, M., Lacarrière, B., Coree, O.L., 2015. Environmental performance assessment of retrofitting existing coal fired power plants to co-firing with biomass: carbon footprint and emergy approach, Journal of Cleaner Production 103, 13-27.

Cai, W., Wang, C., Chen, J., Wang, K., Zhang, Y., & Lu, X. (2008). Comparison of CO2 emission scenarios and mitigation opportunities in China's five sectors in 2020. *Energy Policy*, *36*(3), 1181–1194. http://doi.org/10.1016/j.enpol.2007.11.030

IPCC 2006. Guidelines for National Greenhouse Gas Inventories "Stationary Combustion," pp. 6-13.

Jiang, X. Z., Zheng, D., Mi, y. 2015. Carbon footprint analysis of a combined cooling heating and power system, Energy Conversion and Management, 103 (2015) 36–42.

Official Gazette 2014a, Regulation on Monitoring of Greenhouse Gas Emissions, No. 29003.

Official Gazette 2014b, Notification on Monitoring and Reportin of Greenhouse Gas Emissions, No. 29068

Personal information, 2016, Cement factory GHG Emissions monitoring plan, 2015.

TURKSTAT (Turkish Statistical Institute); 2014. National Greenhouse Gas Inventory Report 1990-2012.

Url-1. https://www.ekonomi.gov.tr/portal/content/conn/UCM/.../dDocName:EK-221758, TC.The Ministry of Economy, Sector Reports, Cement Sector, 2016,

Xu, X., Lan, Y., 2015. A comparative study on carbon footprints between plant- and animal-based foods in China, Journal of Cleaner Production, accepted manuscipt. DOI: 10.1016/j.jclepro.2015.10.059.

Yaka, İ.F., Güngör,A. 2015. "Determination of Carbon Footprint of Akdeniz Üniversity Health Services Vocational High School", 3rd Anatolian Energy Symposium, 1-3 October 2015. Muğla.

Zhang, S., Pang B., Zhang, Z., 2015. Carbon footprint analysis of two different types of hydropower schemes: comparing earth-rockfill dams and concrete gravity dams using hybrid life cycle assessment, Journal of Cleaner Production,.103, 854-862.

