Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 14	No. 3	pp. 633-638	2015

Original Research Paper

Calculation and Estimation of the Carbon Footprint of Paint Industry

Samia Saif*, Anum Feroz, M. Asif Khan*, Sana Akhtar**† and Asim Mehmood***

*Environmental Consultancies and Options (ECO), 31 Commercial Area, 3rd Floor, Cavalary Ground, Lahore, Pakistan

**Department of Environmental Sciences, Kinnaird College for Women, Lahore, Pakistan

†Corresponding author: Sana Akhtar

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 28-10-2014
Accepted: 23-11-2014

Key Words:
Carbon footprint
Paint industry
Greenhouse gas protocol
Direct emissions
Indirect emissions

ABSTRACT

The world's climate is changing rapidly, and these changes are having detrimental impacts on human health and the environment. Major part of it is contributed by the anthropogenic activities. The current study is undertaken for the estimation and calculation of the carbon footprint of the paint industry. In order to find out the greenhouse gas emissions released by the industry, the carbon footprint of the industry was calculated following the greenhouse gas (GHG's) protocol guidelines. The study includes emissions from different sources. Scope 1 emissions account for the direct emissions, these include emissions from industry owned boilers, generators, furnaces and vehicles. The Scope 2 emissions account for the indirect emissions, emitted from purchased electricity and natural gas generation. And Scope 3 emissions include emissions generated from waste disposal and employee business travel. The highest amount of emissions was released from Scope 1 which was 714 tCO_2e followed by Scope 2 emissions which were calculated to be 703.011 tCO_2e and then Scope 3 emissions which were 105.733 tCO_2e. The total carbon footprint calculated for the industry was 2105.733 tCO_2e.

INTRODUCTION

The world today is facing a serious threat of climate change and it has reached up to an alarming level. As life depends on the warmth of the sun being trapped by layer of gasses that surrounds the earth, we now produce so much of these heat trapping gases that the layer is getting thicker, heating the world, changing our climate and threatening our way of life. These phenomena result from the increased emissions of green house gases (GHGs) in the atmosphere due to the excessive consumption and use of fossil fuels and other human activities. The carbon dioxide (CO_2) levels are highest at present since the last 450,000 years. The mascots of climate change are drastically changing the climate and are a serious threat to our planet such as the soaring levels of carbon dioxide, increase in earth average temperature or global warming, altering sea levels, increased volcanic activity, increased flood risks and droughts furthermore, leading to increased potential of health diseases such as malaria, dengue and other vector borne diseases. If this continues to increase, then the extreme effects that we have witnessed will become more frequent, making our planet a more hostile place to live (Sayed 2010).

The best way to cater to this challenge of climate change is to reduce the emission of greenhouse gases into the atmosphere. The Inter-governmental Panel on Climate Change (IPCC) was founded in 1998 to address this global environmental concern. The IPCC focuses on its aim and efforts in order to create awareness of the global warming cause and its impact. The establishment of the international environmental treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) took place in June, 1992. The treaty aimed to work for an environmental cause, by controlling the GHGs concentrations in the atmosphere that it does not imbalance the natural climate system. Furthermore, the UNFCCC strictly demands for reduction of GHGs emissions by the major, and for that very purpose it led to an international agreement called, Kyoto Protocol. The protocol's major feature is to make the member countries reduce their emissions up to the mandatory target (IPCC 2012).

Carbon footprint: There are many definitions proposed for carbon footprint but the most appropriate one was as given by Wright et. al. (2011) as, "A measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest". It is calculated as carbon dioxide equivalent (CO_2e) using the relevant 100-year global warming potential (GWP100) (Kemp et al. 2011).

Study area: The current study was conducted for the estimation and calculation of the carbon footprint of the "paint" industry, located at Lahore and is one of the largest global paint producers. The industry plans to beef up its distribu-

tion network, broaden the purview of company's speciality products, access newer technologies through joint ventures and of course, targeting the urban and semi-urban markets by introducing more products in the lower and middle segment of the paint market. The industry is internationally recognized and produces high quality of paint products. In addition, the industry, in order to show commitment towards environmental compliance has taken into account the national and international demands, the industry has taken several steps to prove its environmental commitment and has considered the calculation and estimation of its carbon footprint as another step forward towards this commitment.

MATERIALS AND METHODS

The methodology adopted for calculating the carbon footprint of the paint industry is in line with the GHG protocol corporate standard; these are international standards of GHG that serve as an accounting tool and provide guidelines for companies and organizations who are interested and willing to quantify their GHG emissions.

The following steps were taken in to account to establish the GHG list of the paint industry. The operational boundaries were set in accordance with the GHG protocol guidelines. The following three 'Scopes' were considered to conduct the study:

Scope 1: Direct GHG emissions

Scope 2: Indirect GHG emissions

Scope 3: Other Indirect GHG emissions

The next phase in the study was related to collecting the data required for the respective calculations. All the data related to the processes involved within the system boundary was collected. Both primary and secondary data were collected for comprehensive calculation of carbon footprint.

By taking into consideration all the data and information gathered in the steps mentioned earlier, this step involved the calculation of the carbon footprint. The obtained concentrations of all the GHGs were converted into CO_2e figures which were then added up to give the carbon footprint expressed as CO_2e.

Following method was used to calculate the carbon footprint:

a. Converting the data into greenhouse gas emissions by multiplying the activity data by the emission factor for the activity. This gave GHG emissions per functional unit of product.

b. GHG emissions data were converted into CO_2e emissions by multiplying the individual figures by the relevant global warming potential (GWP) factor.

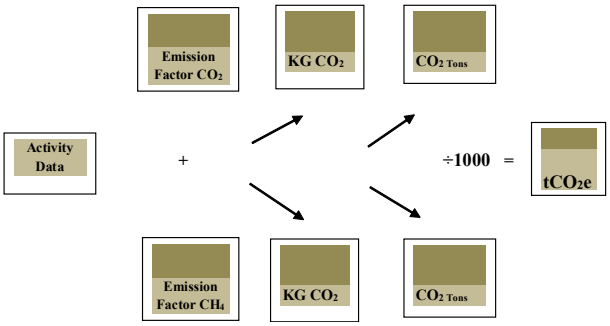

Fig. 1: Carbon footprint calculations (Authors).

The following method (Fig. 1) was adopted in order to calculate the results:

Carbon emissions are usually classified on a very basic level into two categories, direct and indirect emissions. And according to the GHG emissions they are defined as such, direct GHG emissions are the ones that are released from a source which is owned or controlled by the reporting body. While the indirect emissions are the ones that are resulting from a source which is owned or controlled by another entity but is a consequence of the activities of the reporting body.

These two categories are further defined into three levels, viz. Scope 1, Scope 2 and Scope 3 emissions. These emissions are calculated in the tabular results (Tables 1-3) in order to find out the industry's GHG emission rates for base year 2013-2014.

Scope 1 emissions include all the direct emissions which are released by a source owned or controlled by the company. Table 1 shows the calculation for Scope 1 emissions; it indicates the activity data for two types of combustion sources, i.e., mobile and stationary, diesel and petrol are the two types of fuel used by the industry to carry out its on-site and off-site operations. Table 1 shows the total carbon dioxide equivalent for each of the two fuels along with their yearly activity data. The tCO_2e for diesel is 525 and for petrol it is 189, it is calculated by multiplying the value of each of the fuel's yearly consumption with the standard value emission factors of CO_2 and CH_4 which gives kg of CO_2, which are further converted into tones in order to calculate the tCO_2e. As the unit for diesel consumed is litres, so the emission factors for CO_2 and CH_4 have been applied on liquid basis (www.ghgprotocol.org/calculation-tools/alltools).

Fig. 2 illustrates the summary of Table 1. Generators and boilers are the main stationary fuel combustion sources used by the industry in order to meet their energy needs. The industry owns 3 generators and 4 boilers. The generators

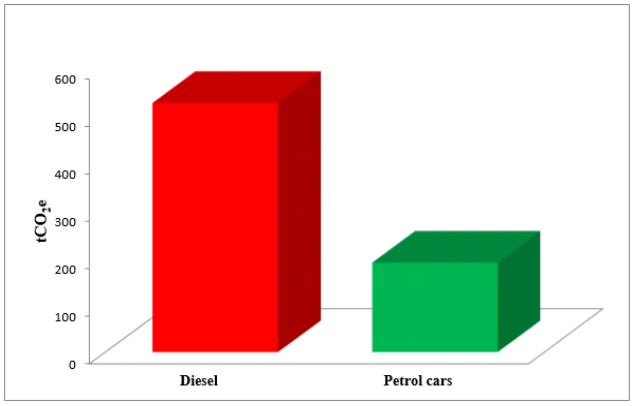

Fig. 2: Scope 1 emissions (tCO_2e) of paint industry.

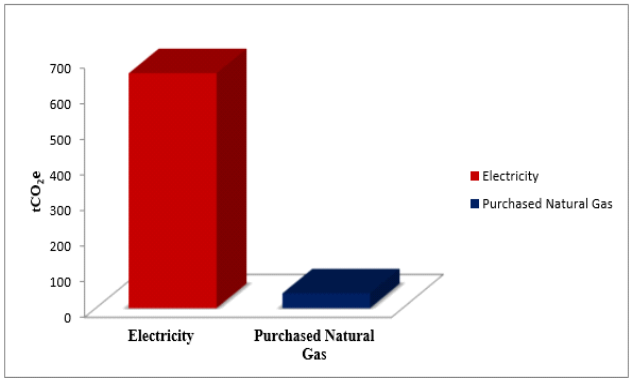

Fig. 3: Scope 2 emissions (tCO_2e) of paint industry..

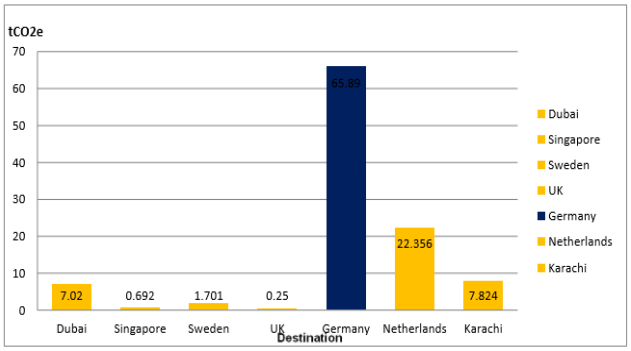

Fig. 4: Scope 3 emissions (Air travel-tCO_2e) of paint industry.

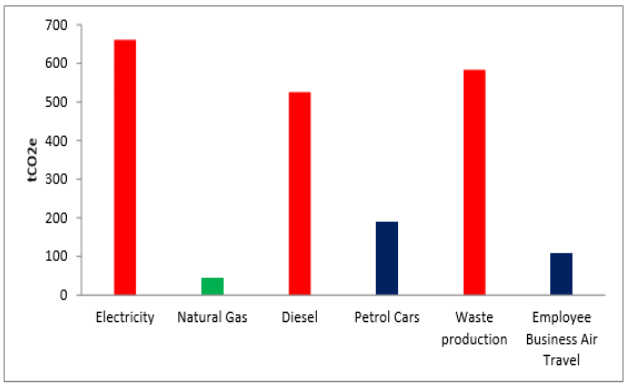

Fig. 5: tCO_2e emissions by source of paint industry.

solely run on diesel and were on operational mode in the base year. They cover an area of up to 1126 sq. ft. The operational boilers are mainly auxiliary boiler and waste heat recovery boilers which utilize waste (the industry's wastewater treatment sludge is burnt in the boiler). The paint industry in order to run the power production house in base year 2013-2014 utilized about 196436 litres of diesel. The industry owned transportation vehicles also come under the category of Scope 1 emissions. As per the industrial data, the industry owns around 50-60 vehicles which include 1000CC to 1800CC cars, motor bikes and trucks, and these vehicles run on petrol only. Thus, the emission factors are considered on liquid basis as the fuel consumption is in litres i.e., 83,000 litres (Table 1). In order to achieve the final emissions for Scope 1, both stationary and mobile emissions, were added up, which gave a total emission of 714 tCO_2e.

The Scope 2 emissions are the indirect emissions, they account for purchased electricity and natural gas emissions. According to the GHG protocol guidelines, the purchased electricity accounts for the electricity that is either purchased or brought by any source or mean into the industrial organizational boundary. This particular paint industry purchases electricity from Pakistan's major authoritative power distribution body, Water and Power Development Authority (WAPDA). Pakistan's 65% of electricity is said to be produced from fossil fuels. The paint industry requires electricity throughout its paint manufacturing process as all the machines are running solely on electricity and all the processes require electricity to carry on with their activity. The electricity emissions in tCO_2e turned out to be 660.822. The Table 2 indicates the Scope 2 emission data as discussed above.

The paint industry requires electricity throughout its paint manufacturing process as all the machines are running solely on electricity and all the processes require electricity to carry on with their activity. The Scope 2 also accounts for the purchased natural gas owned by the source other than the company or industry itself. Annex 4 of the GHG Protocol was utilized to get CO_2 emission factor per unit of energy (mmBTU) for calculating CO_2emissions from the fossil fuels which was 53.02 respectively. The calculated emission for natural gas was 42.189 tCO_2e whereas the

Table 1: Data monitored for Scope 1 emission.

Scope 1 Emissions								
		Fuel Type	Activity Data	Unit Type	Emission Factors	kg CO2	CO_2 Tonnes	tCO_2e
Direct Emissions	Stationary Fuel Combustion	Diesel	196436.0	Liters	CO_2 2.67	524482.12	524.482	525
			//	//	CH_4 0.0003612	70.95	0.071	
	Mobile Fuel Combustion	Petrol Cars	83,000.00	Liters	CO_2 2.271	188,493	188.493	189
			//	//	CH_4 0.00032782	27.2	0.0272	
	Total Emissions							714

Table 2: Data Calculated for Scope 2 emissions.

	Scope 2 Emissions					
	Quantity Consumed By the Facility	Activity Data	Conversion Factors Unit Type	Emission Factors (CO_2)	Kg\ CO2	Emission (tCO_2e)
Direct Emissions	Electricity	1446000.00	kWH	0.457	660,822	660.822
	Purchased Natural Gas	795.7325	MMBTU	53.02	42,189.73	42.189
	Total					703.011

Table 3: Data calculated for indirect emissions (Scope 3).

	Scope 3 Emissions					
	Number of Return Flights	Origin	Destination	CO_2 Emissions for One Return Flight	Total CO_2 Emission (kg CO_2)	tCO_2e
Employee Buisness Travel	27	Lahore	Dubai	260	7020	7.02
	2	Lahore	Singapore	481	692	0.692
	3	Lahore	Sweden	567	1701	1.701
	5	Lahore	UK	50	250	0.25
	110	Lahore	Germany	599	65890	65.89
	36	Lahore	Netherlands	621	22356	22.356
	48	Lahore	Karachi	163	7824	7.824
Total Emissions						105.733

total Scope 2 emissions calculated were 703.011 tCO2e.

Scope 3 accounts for the employee business travel for the industrial purposes. The CO_2 emission factor for employee air travel for base year 2013-2014 was computed and the parameters taken under consideration included the number of passengers, number of return flight (one return flight equal to two visits), and the origin and destination of the flight. An online emission calculator was used to calculate the carbon footprint of the relative flight. The online calculator used formulas based on UK Defra specifications for all short, domestic and long haul flights from a flight origin to its destination as calculated in Table 3, in order to get carbon emissions in $kgCO_2e$. These returned flight emissions were then multiplied with the total number of flights

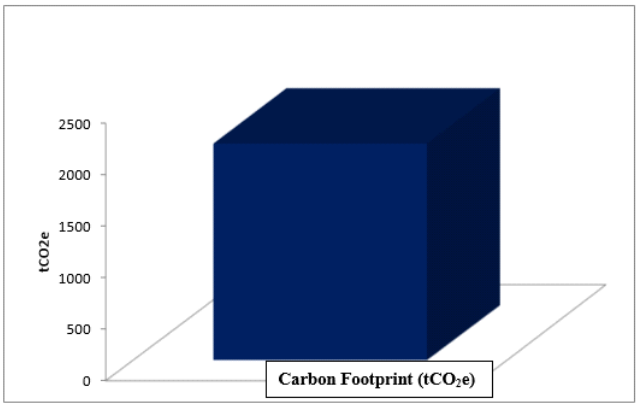

Fig. 6: Carbon Footprint of Paint (tCO_2e).

from an origin to a destination as calculated in Table 3. (www.travelnav.com./flight-emissions; Bhatia, 2008).

The Table 4 gives the tCO_2e sources which are mainly responsible for GHG emissions, electricity is to be mainly responsible for the major emissions because it is used in high quantity by the industry as all the industrial activities are dependent on electricity supply. Second major emissions, result from use of diesel which is used in the industrial generators, followed by petrol and air travel emissions which are responsible sources for greenhouse gas emissions in the respective paint industry.

The Table 5 calculates the overall total carbon footprint for the paint industry, by summing up all the Scopes or the emissions that were within the operational boundaries. The graphical representation in Fig. 7 depicts the Scope-wise emissions. Here, Scope 1 emissions (direct emissions) are the highest and top the graph and are responsible for maximum emissions, followed by Scope 2 (indirect emissions) lesser than Scope 1 but greater than Scope 3 emissions. Hence, the final carbon foot print of the respective paint industry calculated for the base year 2013-2014 was 2105.733 tCO_2e.

Table 4: tCO_2 emission by source.

Source	tCO2 Emissions
Electricity	660.822
Natural Gas	42.189
Diesel	525
Petrol Cars	189
Waste production	583
Employee Business Air Travel	105.733

Table 5: GHG inventory/carbon footprint tCO_2e of the facility.

GHG Inventory	Emissions (tCO_2e)
Scope 1 Emissions	714
Scope 2 Emissions	703.011
Scope 3 Emissions	105.733
Industrial Waste	583
Carbon Footprint	2105.733

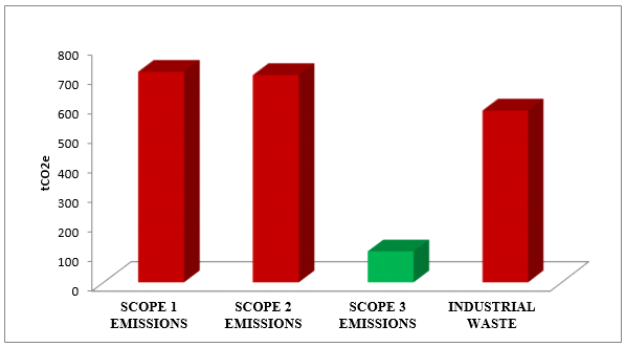

Fig. 7: GHG inventory (tCO_2e) of the selected paint industry.

EXCLUSIONS

Various exclusions were made in the present study because of the issues related to uncertainty and also because the study does not intends to calculate the carbon footprint in terms of a life cycle assessment of the end product, but instead measures that of the industrial unit while considering the physical boundaries defined earlier. Following activities do not form part of the system boundaries:

a. Direct emissions from fugitive and process sources due to high level of uncertainty.
b. Production and extraction of purchased materials and fuels
c. Waste/recycling phase due to its high level of uncertainty
d. Purchased materials or goods transportation
e. Employees commuting to and from work
f. Purchased fuels transportation
g. Sold products transportation

CONCLUSION

As per the relevant computations, the carbon footprint of the paint industry for the year 2013-2014 was estimated to be 2015.733 tCO_2e. Breaking down of the carbon footprint with respect to the Scopes brings up the Scope 1 emissions to be majorly responsible for adding a large chunk to the total carbon footprint i.e., 714 tCO_2e. These emissions are followed by the Scope 2 emissions i.e., 703.011 tCO_2e and Scope 3 emissions i.e., 105.733 tCO_2e respectively.

The combustion of the electricity was found to be contributing the most in the industry's total carbon footprint. The total carbon footprint when divided by the total industrial paint production output unfolds that 15 kg of CO_2e

emissions occur on every one tin of the paint produced and steps are required by the relevant authorities to be taken to reduce the carbon footprint by creating carbon reduction targets and in the process taking part and showing commitment towards the abatement of GHGs in the atmosphere.

REFERENCES

Bhatia, P. 2008. Methodologies for measuring the carbon footprint. ICTs and Climate Change, International Symposium, London, pp. 1-23.

GHG Protocol, [Internet] Retrieved on November 20, 2012. Available from www.ghgprotocol.org

http://www.travelnav.com. /flightemissions.

IPCC, [Internet] Retrieved on December 22, 2012. Available from www.ipcc.ch.

Kemp, S., Williams, I. and Wright, L.A. 2011. Carbon foot printing: Towards a universally accepted definition. Carbon Management, 2(1): 61-72.

Sayed, A. H. 2011. Changing environmental pattern and its impact with special focus on Pakistan. Pakistan Eng. Congr., 28: 80-92.