

A Review on Carbon Footprint Assessment

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Abstract- The world is experiencing deteriorating climatic changes which are significantly resulting from the increased emission of greenhouse gases. A carbon footprint is the total greenhouse gas (GHG) emissions caused by an individual, event, organization, service or product, expressed as carbon dioxide equivalent. A company or organization can estimate its contribution to global climate change by calculating its carbon footprint. GHGs can trap differing amounts of heat in the atmosphere, meaning they have different relative impacts on climate change. Climate change and carbon footprint are fundamental topics of industrial sustainability assessment and sustainable development policy making. Governments in many countries have started to make disclosure of the carbon footprint of a product or process an essential requirement for many industries. In this paper the concept of carbon footprint, its significance and environmental impacts and carbon management for an organization are discussed. This paper also suggests further research directions for carbon footprint assessment for product as well as organization.

Key Words: carbon footprint, emissions, life cycle assessment, climate change, greenhouse gases

1. INTRODUCTION

Currently world community is facing climate change as one of the most prominent issue at local, national and global level. Climate change is a long term effect which is affected over a wide area and results into seasonal changes which are measured over long span of time. Climate change includes global warming and adverse environmental impacts like melting glaciers, heavier rainstorms, or more frequent drought, frequent and intense heat waves, destructive hurricanes, etc. The most instant and obvious effect of global warming is the increase in temperatures around the world. Over the past 130 years (1880-2012), the globally averaged combined land and ocean surface temperature has increased by 0.85°C and is projected to continue to rise at a rapid rate [4]. Therefore we, as a responsible global community should be conscious about the threat of warming on the entire planet.

Researchers have found greenhouse gas emissions as primary cause of global warming. According to the different climate models, it is estimated that earth surface temperature will increase in the range of 1.6 up to 5.8°C by end of this century in line with current rates of population growth and GHG emissions [4]. Researchers also say that highest portion of greenhouse gas are emitting due to anthropogenic activities [4]. The Kyoto Protocol, an international agreement on climate change, has identified six greenhouse gases as Carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Hydro fluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF₆) [6]. In this list, CO₂ is considered to be the most significant contributor to climate change issues [6]. Hence, carbon accounting has become important aspect to assess anthropogenic activities and thereby to reduce GHG emissions. Thus, the concept of carbon footprint rises to quantify GHG emissions due to certain activity or process.

1.1 CONCEPT OF CARBON FOOTPRINT

Carbon footprint is widely used in carbon emission analysis at different scales of the products, individuals/households, organizations, cities, countries scales [3]. Carbon footprint is basically the calculation of the total amount of the emissions in terms of carbon-dioxide of a specific activity, population or system, in view of all the comprising storage and sink within the spatial and temporal edge of the system, activity or population under study [7]. It can be defined as a measurement of the total GHG emissions caused directly and indirectly by an individual, an organization, event or product and is expressed as a carbon dioxide equivalent (CO₂e) [4]. Carbon footprint assessment is a methodology to estimate total

amount of GHG emissions from a product across its life cycle from production of raw material used in its manufacture to disposal of the finished product (excluding in-use emissions). The generalized formula to calculate CFP can be given as,

$$E = Q \times E.F.$$

Where; E= emissions from the emissions source in kg CO₂-e per year

Q = activity data e.g. quantity of fuel used

E.F. = emission factor for emissions source

Calculating carbon footprint is necessary step to understanding company's contribution to global warming so they can identify ways to reduce it and will help to know the energy saving potential. It may also lead to long term financial gain and reducing climate change impact. Plus, consumers are increasingly interested in transparency about the environmental impacts of the brands they buy from and products they use. Consumers support the idea of a recognizable label to demonstrate that the products have been made with a commitment to measuring and reducing their carbon footprint [6]. Thus by calculating carbon footprint and publically disclosing CFP details of their products, organizations can improve the public satisfaction and build a positive market image.

Governments in many countries are taking steps to reduce GHG emissions through national policies that include the introduction of emissions trading programs, voluntary programs, carbon or energy taxes, and regulations and standards on energy efficiency and emissions [8]. As a result, companies must be able to understand and manage their GHG risks if they are to ensure long term success in a competitive business environment and to be prepared for future national or regional climate policies [8]. In Copenhagen meet on climate change held in 2009, the Indian government has agreed to fully support carbon footprint reduction policies.

1.2 CARBON FOOTPRINT ASSESSMENT

Reviewing recent literature regarding carbon footprint study, it reveals for quantifying carbon footprint, first it is necessary to determine whether the CFP assessment is to be done for a specific product or a specific organization. The calculation of carbon footprint of any product or organization is based on the concept of life cycle assessment. Life cycle assessment (LCA) is a globally accepted approach to quantify the environmental impacts of products or processes. According to ISO 14044 definition, LCA is a technique to address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave) [5]. A key challenge in estimating the carbon footprint (as in LCA in general) is to determine the scope of the system to be assessed that is what activities should be included in the assessment. Depending on the character of the study and the question(s) that it is intended to answer, many different choices are available, some more relevant than others for a given situation [1].

Product carbon footprint:

When we consider a specific product manufactured e.g. a cotton T-shirt, for quantifying total GHG emissions for the product, all life cycle phases of a product need to be considered, like, raw material extraction, production of raw materials, production processes of the main product, transportation, distribution and retail, use and finally end of life. GHG emissions, embodied in all stages from cradle to grave, have to be included for the assessment of the CFP, although sometimes the measurement is confined to the cradle to gate stage alone depending on the scope and boundary selected for a study.

Carbon footprint assessment for an organization:

CFP assessment for an organization is a bit different than the product carbon footprinting. When we consider a textile industry as an organization for calculating their CFP the total industrial activities need to be taken into account. First we have to select a base year with reference to which the CFP calculation will be done. The emission factors and methods for CFP calculation for organization are not appropriate for a full life-cycle assessment or product carbon footprinting. These factors only include direct emissions from activities, and do not include all sources of emissions required for a full life-cycle analysis.

To quantify and report GHG emissions, organizations need data about their activities (e.g., quantity of fuel used). They can then convert this into information about their emissions (measured in tones of CO₂-e) using appropriate emission factors.

2. GENERAL PROCEDURE FOR CFP ASSESSMENT

According to the GHG protocol following are the main steps for assessment of both product CFP and organizational CFP.

2.1 Establishment of the organizational boundary:

Generally, organizational operations vary in their legal and organizational structures; they may include wholly owned operations, incorporated and non-incorporated joint ventures, subsidiaries, etc. In setting organizational boundaries, a suitable approach should be selected by organization for consolidating GHG emissions as a first step. Defining the system boundaries clearly, is crucial to obtaining comparable data and results.

2.2 Establishment of the operational boundary:

Subsequent to the assessment of the organizational boundary, the operational boundary should be set. This involves identifying emissions associated with its operations, categorizing them as direct and indirect emissions. GHG emission of different operations will be categorized under three "scopes" (scope 1, scope 2, and scope 3) to help to delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organizations and different types of climate policies. They are described as follows.

Scope 1: Direct GHG emissions from sources owned or controlled by the company (ie, within the organizational boundary). e.g., emissions from combustion of fuel in vehicles owned or controlled by the organization.

Scope 2: Indirect GHG emissions from the generation of purchased energy (in the form of electricity, heat or steam) that the organization uses.

Scope 3: Other indirect GHG emissions occurring because of the activities of the organization but generated from sources that it does not own or control (e.g., air travel and employee commuting data).

2.3 Data collection:

A crucial aspect of CFP assessment is data collection. To quantify and report GHG emissions, organizations need data about their activities (e.g., quantity of fuel used). Major portion of data is primary data and shall be collected from selected units through interviews observations, company records etc. The activity data shall be collected from all activities within the defined physical and operational boundaries for specified period.

2.4 Quantify and reporting GHG emissions:

The data collected is then converted into information about their emissions (measured in tones of CO₂-e) using emission factors. i.e. CFP of each emission sources and activities will be calculated in kgCO₂e/year by multiplying activity data with appropriate emission factor. These factors are calculated ratios relating GHG emissions to a proxy measure of activity at an emissions source. The IPCC guidelines (IPCC, 1996) refer to a hierarchy of calculation approaches and techniques ranging from the application of generic emission factors to direct monitoring.

3. STANDARDS AND TECHNICAL GUIDES RECOMMENDED FOR CFP ASSESSMENT

1. ISO 14067:2018 - Greenhouse Gases Carbon Footprint of Products Requirements and Guidelines for Quantification and Communication.
2. ISO 14064: 2018 - Greenhouse Gases Specifications with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
3. The Green House Gas Protocol 2004 - A Corporate Accounting and Reporting Standard, World Resources Institute and World Business Council for Sustainable Development

Above standards give comprehensive guidance on the core issues of GHG monitoring and reporting at an organisational level, including:

Principles of monitoring and reporting

Setting organisational boundaries
Setting reporting boundaries
Establishing a base year
Managing the quality of a GHG inventory
Content of a GHG report.

4. CONCLUSION

Rapidly changing global climate change can be recognized as one of the major reasons for this increased level of attention. The increasing trend of carbon emission research articles indicates the enhanced attention towards this domain of the researchers. This is a further indication that carbon emission research domain has become a highly popular domain amongst the global researchers. An organizational carbon footprint measures the GHG emissions from all the activities across the organization, including energy used in buildings, industrial processes and company vehicles. Besides quantifying organization's total GHG impact, a CFP analysis will provide the organization with a comprehensive GHG inventory, allowing it to identify and target reductions from its major emissions sources. Thus carbon footprint assessment will help to find out possible mitigation measures to reduce carbon emissions and thereby improve air quality. This paper recommends implementing life cycle analysis method and use of ISO 14067 for product carbon footprinting. And for organizational carbon footprinting GHG protocol and ISO 16064 should be referred. The carbon footprint assessment leads to achieve carbon neutrality and carbon management for organization as well as individual level.

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