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## A SURVEY OF METHODS TO REDUCE CARBON FOOTPRINT AND MITIGATE CLIMATE CHANGE

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### Abstract

Growing pollution levels, global warming and their effects on all aspects of life are an alarming situation indeed. This calls for greater awareness of the masses and innovation by our generation to combat this deadly situation. Various measures in this stead are already being taken, but public outreach is crucial to their success. Over the years, carbon footprint has emerged as a viable measure for tracking and calculating an individual's or organisation's carbon emissions. Once quantifiable, carbon and other greenhouse gas emissions can be reduced by implementing the various measures proposed over the years. In this paper, the methodologies expected to bring about a substantial improvement in the dire consequences of global warming through the reduction of carbon footprints is discussed.

**Keywords:** Carbon Footprint, carbon emission, energy sources, greenhouse gases, renewable energy.

### 1. Introduction

Pollution comes in many forms, a major one being emission of greenhouse gases. Excessive amounts of gases like Carbon Dioxide, Methane, Nitrous Oxide, Ozone and Chlorofluorocarbons can be damaging to the environment, and cause global warming and climate change. These alarming levels of emission raised a lot of concern across the globe, which led to the development of numerous solutions to tackle the problem. One such solution was the calculation of the Carbon Footprint. Carbon Footprint is a relatively new term that has grown in use rapidly in the past couple of years. It therefore has a surprisingly vague definition, and people are yet to grasp and understand it properly.

Carbon Footprint is essentially defined as "The total set of Greenhouse Gas emissions caused by an individual, event, organization, product etc. and is expressed as Carbon dioxide equivalent". The exact amount of carbon emissions is almost impossible to calculate as it requires a humongous amount of data. Different techniques and strategies are being

introduced each day with improving levels of accuracy. Calculating the carbon footprint can yield to be highly beneficial for an organization having active projects and ongoing energy and environment management. It is only after we have quantified carbon emissions that we can find innovative and profitable solutions to tackle it. This can also be beneficial on the marketing front for an organization, as it helps portray themselves as environment friendly.

Over the years, as the term ‘carbon footprint’ became popular, a lot of work has been put into developing ways to reduce the carbon footprint from various sources. The main purpose of this paper is to provide a comprehensive view on the different types of methods that have developed over the years across various sectors to reduce carbon footprint and lessen the impact of greenhouse gases(GHG).

## **2. Literature Review**

Researchers from as early as 1999 have been trying to study the impact of humans on the environment, and educate the masses too. Many have debated the effects of greenhouse gases on environment, and the developing countries’ role in reducing GHG emissions<sup>[1]</sup>. Rising sea levels and the importance of stabilizing GHG levels in the atmosphere was discussed in a paper<sup>[2]</sup>.

Many were already analyzing the ill effects of air pollutants present around us. In rural India, 436 rural homes were scrutinized and their data was collected regarding the exposures to respirable particulate matter when using gas stoves<sup>[3]</sup>, and also how the carbon monoxide emission levels were found to be on using wood, biofuel, and dung cakes as cooking fuel<sup>[4]</sup>.

Scientists have been looking into renewable sources of energy for more than a few decades. Several papers list out the actual sources, utility and efficiency of each source of energy<sup>[5]</sup>; and debate the pros and cons of using renewable sources of energy<sup>[6]</sup>.

Recently, scientists have defined a new standard of measuring carbon emissions <sup>[7]</sup>. Measuring and quantifying the greenhouse gases produced by different products and representing it as carbon footprint is being done globally. However, there are many discrepancies in its calculation<sup>[8]</sup>. Day to day electricity, too, generates a certain amount of carbon<sup>[9]</sup>. Nationwide, carbon-net trade can be calculated <sup>[10]</sup>. National average per capita footprints vary from 1 ton of CO<sub>2</sub> emissions/year in African countries to approximately 30tonnes/year in Luxembourg and the United States<sup>[11]</sup>.

Consumers are being informed about their carbon footprints while purchasing specific products, and can classify the

product into groups consisting of carbon footprint, water pollution, Sulphur dioxide emission, etc.,<sup>[12]</sup>. It was also found that frequent travelers in Hong Kong, though possessing the insight about the various global warming cues, were less inclined to change their travel plans to reduce carbon emissions. Contrary to them, the infrequent travelers were willing to change their small habits to reduce carbon footprint<sup>[13]</sup>. Many have suggested pocket friendly carbon footprint reduction methods that are effective across all household types and locations<sup>[14]</sup>.

In the industrial sector, various models are to be used to efficiently meet the company goals and at the same time, reduce pollution. Some have proposed several easy to implement models to show how concerns regarding carbon emissions could be integrated into operational decision-making with respect to areas such as acquisition, production and inventory management<sup>[15]</sup>. Road freight transport is one of the major contributors to an increase in carbon footprints and a study was done to see how road freight transport will impact the environment in the future. The relationship between the weight of goods produced/consumed and freight-related CO<sub>2</sub> emissions can be defined with reference to seven key variables. Using this information UK made a target to reduce CO<sub>2</sub> emissions by 80% by 2050 relative to 1990 levels<sup>[16]</sup>. The matter is, indeed, of global concern. It should be our utmost priority to raise awareness among the masses, and appropriate steps must be taken by everyone, starting from the individual level to international levels, in order for us to hand over a safe and healthy earth to the future generations.

### **3. Methods Used to Reduce Carbon Emission and Carbon Footprint**

The main contributors to carbon emissions can be broadly classified into two sectors-domestic and industrial. Studies have shown that the industrial sector consumes about half the total energy produced in the world. A significant part of the other half is consumed by the domestic sector. Such a high level of energy consumption can be related to the fact that with the progress of time, the demands of people - both in terms of technology and lifestyle - have seen a great leap from humble to extravagant. Although both the industrial sector and the domestic sector have maximized their output, they have not taken into account the effects of their actions on the environment.

#### **3.1 Industrial Sector**

In the industrial sector, various models could be used to efficiently meet the company goals and at the same time, reduce pollution. Some have proposed several easy to implement models to show how concerns regarding carbon emissions could be integrated into operational decision making with respect to areas such as acquisition, production and inventory

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### **3.1.1 Reducing Industrial Sector Energy Consumption in Shanghai**

Taking Shanghai as a case study, several researchers<sup>[17]</sup> have proposed a few steps to reduce carbon emission at the urban level. The paper pictorially shows the continued rise of energy consumption of several countries in the world, and Shanghai over a couple of decades. It also observes that industrial sectors in Shanghai were consuming the maximum percentage of energy. This was also followed by the observation that the levels of carbon emissions have been on the rise since 1990. However, researchers have noticed that the levels of carbon emission intensity in Shanghai have decreased from 84% in 1994 to 57% in 2005. The author cites a few recent trends in saving energy and in reducing carbon emission reduction, including improving industrial structure, optimising energy structure and efficiency and also emphasizing the need to build and grow the various kinds of carbon sinks in Shanghai, and all over the world.

### **3.1.2 Energy Domain and Scientifically Engineered Materials**

Even though Australia doesn't contribute much to the world population, it has a considerable impact on the global levels of GHG. Due to its economic importance and the indirect GHG emissions from the supply chains, the construction sector is one that requires heavy mitigation of carbon emissions. The study<sup>[18]</sup> tracks the Carbon Footprint (CF) from the year 2009 to 2013. It was found that the biggest contributors to CF were electricity, gas and water, and raw materials required in construction processes. Evidently, electricity was the domain where the changes could be brought about the most, and the proposed suggestions included using renewable energy sources. Several new scientifically-devised materials like EWPs, and geopolymer concrete were also suggested for use.

### **3.1.3 Changes to the Carbon Emission Benchmark**

Han and Ji<sup>[9]</sup> bring up a few problems with the current industrial carbon emission benchmarks. Current standards relate strongly to the direct emissions and less to the indirect emissions, which might also cause double counting to a certain extent because of mixed sources. Taking Beijing as a prime example, since it is at the top of carbon emissions trading pilot schemes, the authors have proposed a novel idea – a systematic accounting framework based on input and output

analysis is presented. However, this method may burden the common consumers as a by-product of effectively reducing the carbon emissions.

### **3.1.4 Case Study on UK Industries – Positive Trend of Decreasing Carbon Emission**

The UK industry has a very complex structure, consisting of combinations of more than 350 sub sectors, technologies and various devices. The authors<sup>[20]</sup>conducted various energy analyses, along with studying the energy consumption trends in the Cement subsector and in the Food and Drink subsector. They also observed the positive methods to curb the emissions including fuel switching, several tailored methods in contrast to the ‘one size fits all’ approach, and a drop in energy demands due to energy efficient improvements and structural changes to the organizations.

### **3.1.5 Carbon Footprint as Analyzing Tool in Small and Medium-Size Enterprises**

Even though regulations have been set up, many growing companies face difficulties estimating their emission levels. A paper cites the need to use tools to keep track, and employ methods to mitigate their CF. One such suggested tool<sup>[21]</sup> is the Carbon Footprint analyzer for energy and environmental management. This helps to understand the crucial relationship between energy and economy – enabling companies to take small steps to start saving energy, along with low-cost investments, that can pay off later by helping the world.

## **3.2 Domestic Sector**

The consumption of energy is not restricted to the industrial sector. The domestic sector also contributes significantly to it. According to studies<sup>[22]</sup> about 40% of the total energy consumption in China comes from domestic sector while the figure is as high as 74% in UK. At the same time Japan saw a contribution of 61% of the total carbon footprint from household sectors in 2005.

<sup>[23]</sup>Studies show that with the exponential demand of quality lifestyle, space heating and cooling systems are gaining popularity in urban households. The required infrastructure to support them is taking a toll on the electricity consumption in urban areas. Owing to these, several researchers have come up with innovative alternate energies (renewable energies) to support lifestyle demands.

However, domestic sector consumption requirements extend beyond just household behaviour. Transportation, dietary needs and consumption choices in terms of services and goods is also making a significant contribution on the ever increasing levels of emissions.

### **3.2.1 Use of Locally Distributed Renewable Energy Sources at a Regional Level**

Locally distributed renewable energy sources are zero and low carbon technologies that are operable at a regional or local level. <sup>[23]</sup> Simon, Jerry and Igor (2008) have proposed renewable energy sources like micro combined heat and power generation (mCHP), fuel cells, Stirling engines and reciprocating engines. All these systems work on the technology of combined heat and power (CHP), which is zero and low carbon technologies on a local scale. While mCHP implements CHP on a micro-technology level, reciprocating engines and Stirling engines reduce emissions based on the type of fuel used. Fuel cells produce electricity electromagnetically by combining hydrogen and oxygen, producing a very low amount of greenhouse gases in the process. Integrating such zero and low carbon technologies can successfully be used to provide space heating and cooling systems in urban households.

### **3.2.2 Use of Renewable Sources for Energy and Household Biogas System in Rural China**

The common renewable sources that can be used to replace the conventional fossil fuels for energy production include biomass, wind energy and solar energy. Biomass is considered a carbon neutral process, as the energy released during the production of energy balances the CO<sub>2</sub> absorbed by the plants during their growth. In fact, studies <sup>[24]</sup> have been conducted on constructing a typical household biogas system with a digester volume of 8m<sup>3</sup>, using a hybrid life-cycle assessment method in rural China. Although this will result in a reduction in CO<sub>2</sub> emissions, research shows that it will take at least 1.78 years to show any positive reduction benefit.

Solar energy used in the form of solar cells (SC) greatly reduces the carbon emissions when compared to traditional sources of heat and electricity generation. <sup>[23]</sup> Studies have shown that the use of third generation SC is economically viable and will also result in the reduction of carbon footprints. Wind energy used for generating electricity produces one of the lowest values of CFP. The only major emission is during the manufacturing and construction of the plant.

### **3.2.3 Policies and Regulations at a National Level**

All over the world, countries have implemented policies to keep a check on the emission of greenhouse gases. The policies come under two major categories – demand side policy practices and supply side policy practices. Demand side policies aim at reducing the overall demand of energy by controlling its expenditure at the consumer side. Demand side policy instruments include carbon tax, FIT (feed in tariff) policy, Cap and Trade policies, Renewable Energy Certificates and Loans and Subsidies. Supply side policies, on the other hand, aim at reducing the emissions by focusing on using

more renewable energy sources. There are many supply side policies implemented across the world, such as standards, targets and regulations, tendering and net metering. Data from the Global Status Report indicates that, by 2014, almost 144 countries worldwide had employed energy policies at the state or national levels.

### **3.2.4 Dietary Changes**

A major portion of GHG emissions is attributed to agriculture. <sup>[25]</sup> In UK, about 1/5<sup>th</sup> of the total GHG emissions can be attributed to emissions from the consumption of food alone. However, over time, studies have proved that GHG emissions due to plant-based food items are much lower than that due to meat-based food items. In fact, the emission from meat-based food items accounts to almost double the amount of emissions. Although the emissions can be reduced during the farming stage - by using alternate technology - the most efficient reduction can be achieved by changing the consumption pattern. It has been concluded that a positive climatic change can be brought about by maintaining a healthy sustainable diet and reducing the intake of animal-based and other meat-based products.

### **3.2.5 Consumption Choices**

Consumption can broadly be classified into five categories- food, shelter, travel, goods and services. A substantial potential for climate change mitigation is perceived by our consumption choices. Giving in to the low cost investments and ease of implementation, consumption choices can prove to be very influential in carbon footprints. <sup>[26]</sup>Bastien, Detlef and Edgar (2014), in their work,projected that wisely-made consumption choices can let us achieve the 2 degree climate change by 2050. While simple change in lifestyle in the case of food can reduce emissions, utilization of the sufficiency strategy in the choice of travel can significantly contribute to climate change mitigation. Sufficiency strategy stresses on using low-intensive travel choices; for example, driving a car gently accounts for low GHG behaviourwhen compared to driving the same car extensively. The total energy consumed at home - including the electricity used and food preparation at home (cooking) - is classified under shelter. Strict lifestyle choices and user behaviour should be able to achieve low GHG behaviour in these cases.

## **4. Conclusion**

We have observed, after reviewing the diverse works of various researchers, that the world faces critical levels of greenhouse gases and an ever-increasing threat from carbon emission. However, we also notice that numerous methodologies have been proposed, varying from increasing our carbon sinks, importance of carbon sequestration, and a

strong emphasis on the use of renewable energy sources. Herein, the steps taken to reduce emissions in two main sectors

- industrial and domestic sectors - were shown, and we see the projected positive trends. Case studies from around the world show us that innovative ideas are in high demand, and that even small steps to reduce the carbon emissions in small and medium-sized companies are important. Ideas such as improving the emission benchmarks and policies, changing dietary choices, and common, day to day, consumer choices contribute their own bit. Individuals need to be educated and should strive to reduce their carbon footprints; industries and factories contribute significantly towards the carbon emissions and should use more ecofriendly equipments and techniques for production. But to bring a favorable change, every individual, organization, and industry needs to work towards a greener future.

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