CARBON FOOTPRINT AND ARCHITECTURE FIRMS: A CASE STUDY APPROACH FOR MITIGATION

by

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Abstract

Almost forty percent of the global energy use and one-third of the global greenhouse gas emission comes from the building industry. Thus, this sector has the largest potential for delivering long term substantial greenhouse gas reduction. (UNEP, 2009)This dissertation starts with the energy auditing of an architectural firm to calculate the amount of energy used. It then expands into addressing the issue on a greater perspective. The whole agenda of the thesis was to develop a strategy to include the building industry in global carbon market.

This thesis was performed in collaboration with nationally recognized, medium-sized mid-western architecture firm. A yearlong internship was completed under this firm, and collaborative research was carried out. To reduce the carbon dioxide emission, it is crucial to be able to measure it. This thesis aims at creating basic guidelines for architecture firms to mitigate its carbon footprint. It also examines the possibilities of carbon footprint mitigation on a bigger scale by proposing a system that would encourage architectural and engineering firms to design and produce more energy efficient buildings. The proposed system deals with calculation and incorporation of creative handprint of an architectural firm and uses the system to rebate its carbon footprint and convert the surplus handprint to a credit in the carbon market. The argument made here is that this scheme is driven by incentives and encourages more architecture and engineering firms to design sustainable buildings. The final proposal links the entire building industry to the carbon market. The proposal made is that a positive handprint of architecture and engineering firms can be converted to carbon credits and traded in the carbon markets.

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Dedication

I would like to dedicate this thesis to my mom for always encouraging me.

Definition of Terms

a) Carbon Footprint:

Carbon footprint is defined as "The measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." (Minx & Wiedmann, 2008)

b) Green House Gas (GHG):

A greenhouse gas, abbreviated GHG, is both natural and human- induced constituents of atmosphere that absorbs and emits radiation within the thermal infrared range. (IPCC, 2008)

c) Operational Carbon

Operational carbon' is a term used to describe the emissions of carbon dioxide during the operational phase of a building. (Steelconstruction.info) It is measured in terms of carbon dioxide emissions. (UNEP, 2009)

d) Carbon Handprint

The term 'handprint' was coined by Gregory A. Norris. (Adjunct Lecturer on Life Cycle Assessment, Harvard School of Public Health) In his paper, 'An Introduction to Handprints and Handprinting.' he describes handprint as beneficial environment and social impacts that we can achieve as an individual or organization through a net positive impact to battle climate change.

e) Carbon Offset

A Greenhouse gas or carbon offset is the unit of carbon dioxide equivalent or (CO2e) that is reduced, avoided or sequestered to compensate for emissions occurring elsewhere. (Kelly, 2010)

f) Emissions Trading and Carbon Trading

Emissions Trading is an economic approach to deal with climate change by providing incentives to those who reduce emission or achieve target. (Stavins, 2001) Carbon Trading is the similar proceeding for carbon dioxide gas. Due to the exchangeability of terms, 'Carbon Trading' in this thesis does mean emission trading.

Chapter 1 - Introduction

1.1) The Carbon Footprint

The concept of carbon footprint comes from ecological footprint which is the measure of human demand on earth's ecosystem. (Ewing, Reed, Galli, Kitzes, & Wackernagel, 2010). The number of planets or resources needed if everyone consumed as one of the countries as shown in the diagram.

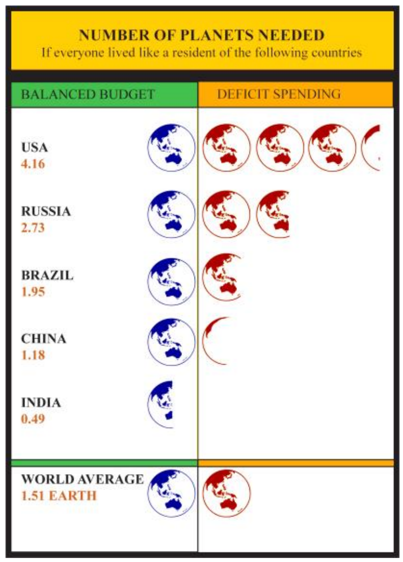

Figure 1:1- Number of planets needed according to world's countries consumption. (Global Footprint Network, 2010)

Almost all the activities that we do and products that we purchase have carbon footprint associated with it. (BP, 2007)Carbon footprint can be calculated as the same way as financial accounting because it is calculating, maintaining and auditing the total amount of carbon footprint data. Various software technologies could be used to measure, track and analyze the carbon footprint. Thus, this thesis tries to calculate carbon footprint of a typical office in Missouri during its operation phase using a carbon footprint calculator.

1.2) Carbon dioxide Production and global warming

There is a significant change in the atmospheric composition of the earth since the industrial era (1800), and this is one of the major causes of climate change. (UNEP, 2009) According to the Fourth-Assessment Report of the IPCC (Intergovernmental Panel on Climate Change, 2007) from 1906 to 2005, the average global temperature had increased by 0.741C among the 100 years, and in the last 50 years increasing about 0.131C per ten years.
The atmospheric carbon dioxide has increased extremely per ppm (parts per million) since the industrial era. (Conway, Tans, & Waterman, 1988)The National Oceanic Atmospheric Administration (NOAA) indicates that the upper-safety limit for atmospheric CO2 is 350 parts per million (ppm) and atmospheric CO2 levels have stayed higher than 350 ppm since early 1988. (Conway, Tans, & Waterman, 1988)This fact is further described in following figure:

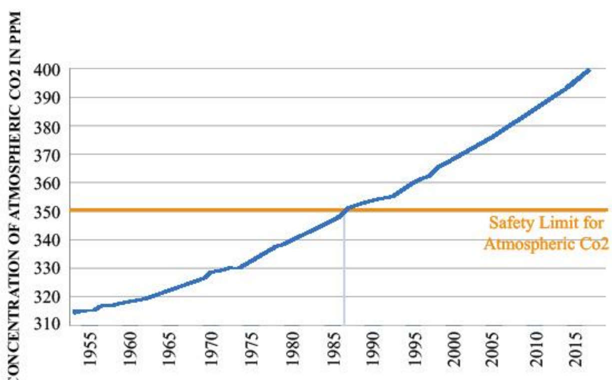

Figure 1:2 Increases in Atmospheric Carbon dioxide since 1995.

(NOAA, from Mauna Loa Observatory)

1.3) Carbon Footprint of Buildings

The building construction industry leaves a huge amount of carbon footprint behind. The process of manufacturing building materials alone comes at a price of very high energy consumption. The construction and operation of buildings account for approximately 40 percent of all U.S. emissions of greenhouse gases and 24% of carbon dioxide emission. (UNEP, 2009) Thus, this sector has the most potential for greenhouse gas mitigation. The most-used building material in the world is concrete and is responsible for the most of the energy consumption. (National Ready Mixed Concrete Association, 2012) The transportation of building materials, processing of resources, and consumption of energy by construction equipment and disposal of waste materials uses a lot of energy. Also, the real opportunities lie in the reduction of operational carbon. More than 90% of the carbon production happens in the operational phase of the building due to heating and cooling of the buildings. (Ochsendorf, 2011) The average carbon footprint of a typical household in U.S. is 48 ton per year. (Jones & Kammen, 2011) Hence, this sector requires special attention as it can help to reduce the carbon footprint in a huge amount. According to US Department of Energy, the consumption of each sector is shown in the figure below:

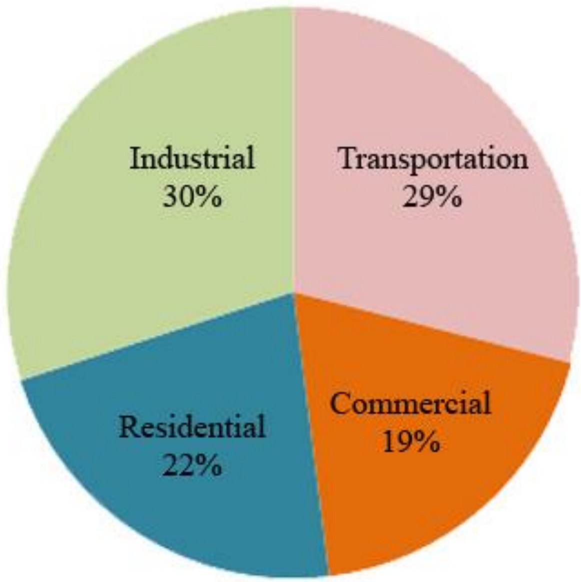

Figure 1:3: Energy Consumption of Different Sectors

(U.S. Department of Energy)

The combination of residential and commercial gives the energy consumption of built environment, and that is the single largest consumer of energy among all sectors. The US Department of Energy Report of 2011 states that commercial buildings represent just under one-fifth of U.S. energy consumption, with office space, retail space, and educational facilities represent about half of commercial sector energy consumption.

The environmental footprint of the building sector includes; 40% of energy use, 30% raw materials use, 25% of solid waste, 25% water use, and 12% of land use. (UNEP, 2009).The GHG emission from the building sector can be divided to two phases, construction phase and operational phase. The GHG emission from operational phase accounts for most of the carbon production as shown in figure 4:9.

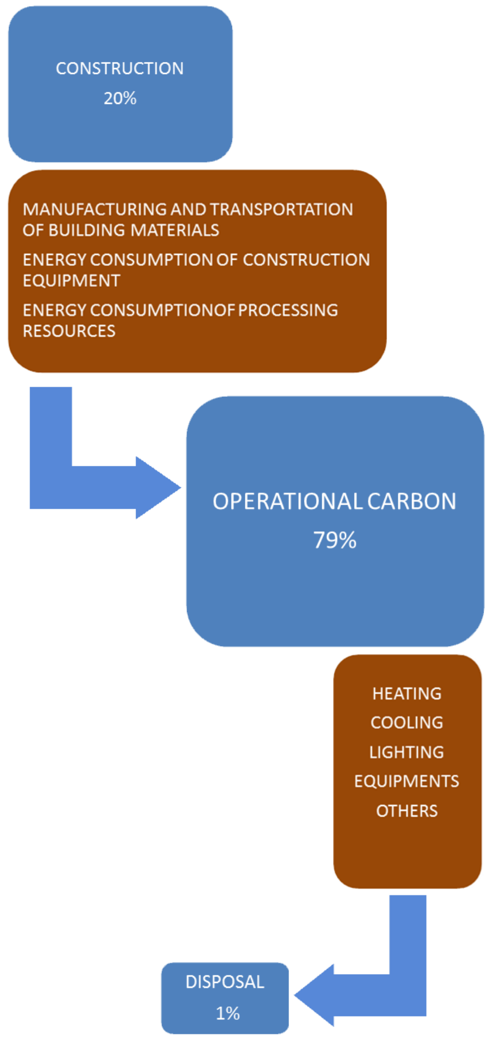

Figure 1:3:1 Flow Chart of Consumption of Energy in Building Construction Process (Wetering & Wyatt, 2010)

1.4) Scope and Limitation of Thesis

The Building Sector has the largest potential for delivering long-term, significant and cost-effective greenhouse gas emissions. (UNEP, 2009)The main purpose of this thesis is to address the potential of the building industry to reduce GHG emissions and finally devise a method that would help reduce the GHG in the building industry. One of the main objectives taken into consideration during the writing of thesis was the Architecture 2030 Challenge. This challenge aspires for the building industry to go carbon neutral by 2030. This thesis aims to deliver a proposition to reduce carbon footprint in the building industry. It provides guidelines to reduce the carbon footprint in architectural office operations, and a proposal has been stated to rebate architectural firm's sustainability for carbon credits. The thesis starts from a narrow point of view of calculating operational carbon and gradually broadens to assess the carbon footprint problem of the building industry. Also, the final proposal needs further research and study of analyzing how it could be implemented in the market for authentic and actual life cycle impact. The data provided relate to the tool used to calculate carbon footprint.

The scope of this paper is limited and does not present a concrete solution to the problem but gives some guidelines to achieve sustainability. As stated earlier in the literature, the operational carbon contributes to almost ninety percent of total carbon footprint in building's life phase. This includes identifying and analyzing areas that contribute to the carbon production. The calculation of operational carbon in typical office building includes a wide range of criteria like energy, water, transportation, waste, pollution, health and wellbeing. The methodology applied for calculating office related carbon footprint is further described in following chapters.

The carbon footprint was calculated for the offices of firm under study located in Mid-West. The entire database for the calculation was provided by the firm and the carbon footprint was calculated by entering the information in Greater Kansas City Carbon Footprint Calculator Tool (GKCCP Tool). The calculation is related to the operational phase of the office and does not include any footprint related to construction of building. The purpose of the thesis is to calculate the amount of carbon footprint the office produces and devise ways to offset that operational carbon.

1.5) Organization of Thesis

This thesis contains the following chapters.

Chapter 2 starts with the explanation of operational carbon and its units of measurement. Also, it gives an overview of Architecture 2030 challenge. The background has been laid by giving a summary about the case study and research carried out during internship. The methodology of footprint calculation is described followed by actual footprint calculation of the design firm under study.

Chapter 3 identifies factors that affect the operational carbon in office spaces. Each of the factors has been described in detail with the impact each of these elements has in footprint calculation. All the factors relate to the GKCCPP Tool except water. Water consumption is calculated from the bills provided by the firm and is shown in the appendix 1.

Chapter 4 states the present methods of carbon mitigation systems available in the market. It gives various other methods that can be applied by the firm under study to mitigate its carbon footprint. Some examples like solar energy implementation also include the budget to implement these ideas.

Chapter 5 provides an overview of the carbon trading business and carbon market. This chapter describes how carbon trading works and lists the opportunities that are available for the building industry in the carbon market. It further explains what tax incentives are provided by U.S. government to homeowners and architects on employing sustainable strategies in their houses and designs.

Chapter 6 contains a proposal to achieve sustainability on a bigger scale. It starts with the definition of handprints and explains how those handprints can be converted to carbon credits so that a market-based cycle can be created to regulate the sustainability in the building industry.

Chapter 7 contains the conclusion of this study. This chapter also contains the limitations of the proposal and actual challenges the proposal could face in terms of implementation. It ends with a suggestion for further research.

Chapter 2 - Operational Carbon in Office Spaces

'Operational carbon' is a term used to describe the emissions of carbon dioxide during the operational phase of a building. (UNEP, 2009) It is measured in terms of carbon dioxide emissions. The main sources of operational carbon are heating and cooling of buildings, lighting, ventilation, water consumption, pump operation and use of appliances such as computers. (UNEP, 2009) Employee transportation has also been included in the measurements for this study. The amount of operational carbon varies in each building and depends on various factors like function and use of building, level of demand and climatic conditions. (UNEP, 2009)For example, data centers consume much more energy than normal offices. According to a U.S. Environmental Protection Agency report, US data centers consumed 61 billion kilowatt-hours of power in 2006. (EPA, 2013) That's 1.5% of all power consumed in the United States and represents a cost of $4.5 billion. (Bouley, 2011)In such situation, government had to make a request to data center agencies to mandate their carbon production. Thus, it is very hard to generalize the amount of operational carbon in buildings but it is important to calculate it. Here are the two charts for a comparison of energy consumption in data centers and typical offices.

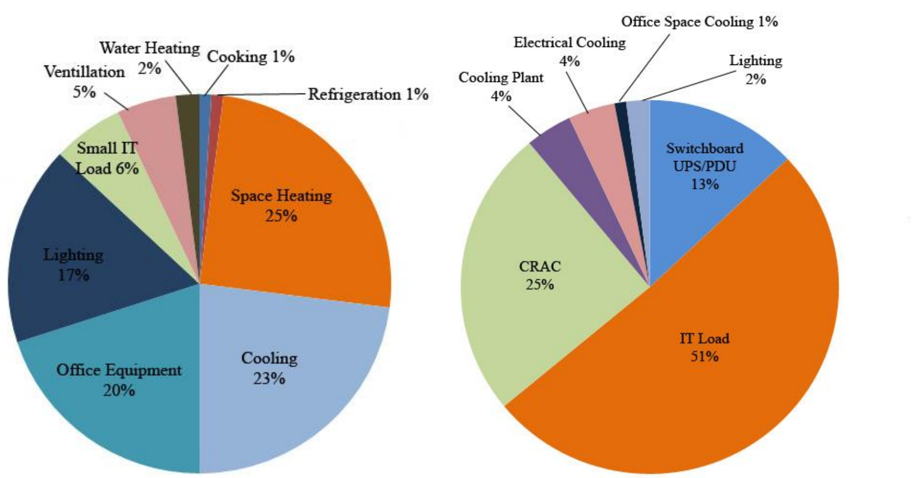

Figure 2:1 Comparison between Energy Consumption Sectors in Normal Office Buildings and Data Center Buildings (Bouley, 2011)

2.1) Architecture 2030 and Architecture Firms

It is possible to make a substantial impact on climate change if we could nullify the GHG emissions from buildings. Since buildings have a longer life span, one efficiently designed building can save tons of carbon dioxide over fifty years. (UNEP, 2009) Architecture 2030 is a non-profit independent organization founded by Edward Mazria. This organization advocates the building sector to be carbon neutral by 2030. It hopes to achieve that goal by attaining 2030 challenge and pursuing following targets. (Mazria & Kershner, 2008)

1.) The dramatic reduction in global fossil fuel consumption and GHG emissions of the built environment by changing the way cities, communities, infrastructure, and buildings, are planned, designed, and constructed.

2.) The regional development of an adaptive, resilient built environment that can manage the impacts of climate change, preserve natural resources, and access low-cost, renewable energy resources.

3.) The fossil fuel usage must be reduced to following targets by consecutive years, which is: 60% in 2010, 70% in 2015, 80% in 2020, 90% in 2025 and 0% in 2030.

Each year in the U.S., we build approximately 5 billion square feet of new building, renovate approximately 5 billion sq. ft. and demolish approximately 1.75 billion sq. ft. of existing buildings. According to Mazria, by the year 2038, three-quarters of the built-environment in the U.S. will be either new or renovated. This transformation of the built-environment over the next 30 years represents an opportunity to dramatically reduce i)The building Sector energy demand and ii) the need for existing conventional coal-fired power plants. (Mazria & Kershner, 2008) One of the main intentions of this study was to see where the firm under study stands in achieving the 2030 challenge in terms of its operations.

The argument made in this study is that to achieve 2030 challenge, we are missing a crucial link in the construction industry loop. The link is to connect design firms to economic circle of carbon emission. Although the Energy Policy Act for Commercial building deduction immensely encourages the industry to design green buildings, this policy only provides returns to home owners and tax incentives like 179D are not getting a good reception in the market. Thus, if we could encourage the architecture firms to embrace a system by providing market-driven incentives then it could make a greater impact on the scenario.

2.2) Case Study Architecture Firm and its Carbon Footprint

The case study was done in a medium-sized architecture firm in mid-west. The firm has offices in three other states. The design firm under study is committed to innovation in architecture and sustainable practice and has designed notable sustainable projects over the three decades. It has an average employee count of 75 in all of its offices.

The firm has been calculating and its carbon footprint since 2005. In the year, 2005, 2006 and 2007, a method developed by consultant of the firm was used to calculate carbon footprint but since year 2008, the firm used carbon footprint calculator provided by greater Kansas City Chamber of Commerce. There are differences between these two tools and both give different results. As part of an internship in the firm, the tool provided by greater Kansas City, Chamber of Commerce called Greater Kansas City Chamber of Commerce's Carbon Footprint Calculator (GKCCPP Tool) was used to calculate carbon footprint of the case study firm of the years 2010, 2011 and 2012. The carbon Footprint for 2009 could not be calculated because no database for 2009 was available. The results were audited and established from 2005 to 2012 and compared, and a comprehensive report was submitted to the firm as part of the internship.

The Greater Kansas City Chamber of Commerce's Carbon Footprint Calculator (GKCCPP Tool) was developed by Cascadia Consulting Group of Seattle, Washington. This calculator calculates carbon footprint for business interested in benchmarking and reducing their greenhouse emission. It requires a database for various areas for calculation of greenhouse gas emission which needs to be entered in the various spreadsheet of the calculator. This tool takes into consideration four sectors of greenhouse gas emission that have a significant impact, and they are energy, transportation, material use and waste disposal. It leaves out water usage and other activities such as cleaning, food usage and maintenance of building. Auditing energy usage of any institution is certainly an effort to combat adverse effects on the environment caused by business operated GHG emission. The firm under study purchased its carbon offset at the market price of $10 per ton of carbon for the year 2005, 2006, 2007 and 2008. The main purpose of calculating the footprint was to buy the respective offset of its operational carbon. The calculation process of the year 2010 is attached in the appendix 2. As part of carbon footprint calculation, the firm has been conducting travel surveys of its employees each year that gives total travel footprint of each employee. The calculations were done during the internship period to find out the annual carbon footprint of the years 2010, 2011 and 2012. The following figure shows the present status of the firm on carbon offset purchase.

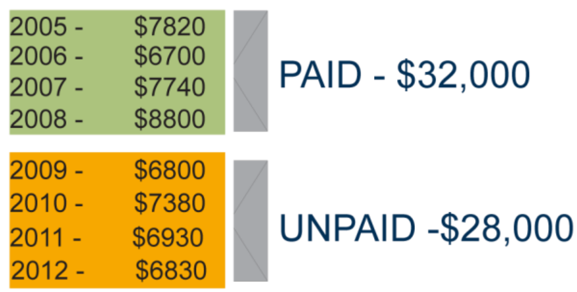

Figure 2:2: Offset Status of Case Study Firm since 2005

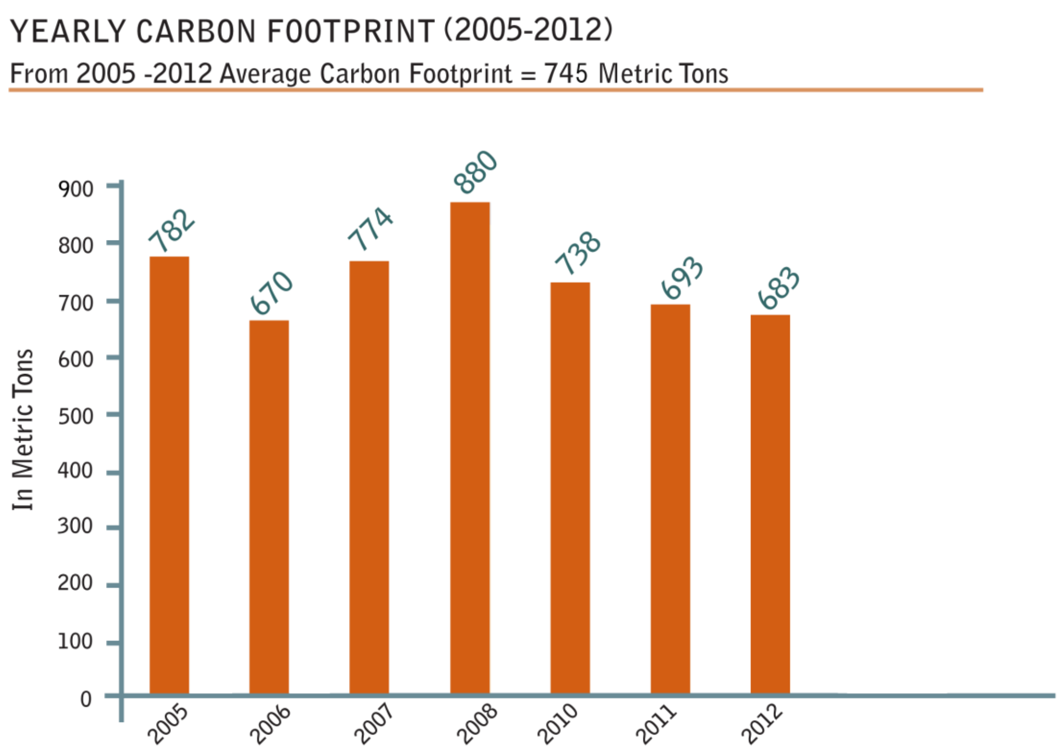

Figure 2:3: Yearly Carbon Footprint of the firm case study firm

Also, a benchmarking exercise was done to examine the firm's energy consumption to other buildings in Mid-West and also compare it to the very efficient building's consumption in USA. The following figure has been established and illustrated for further understanding.

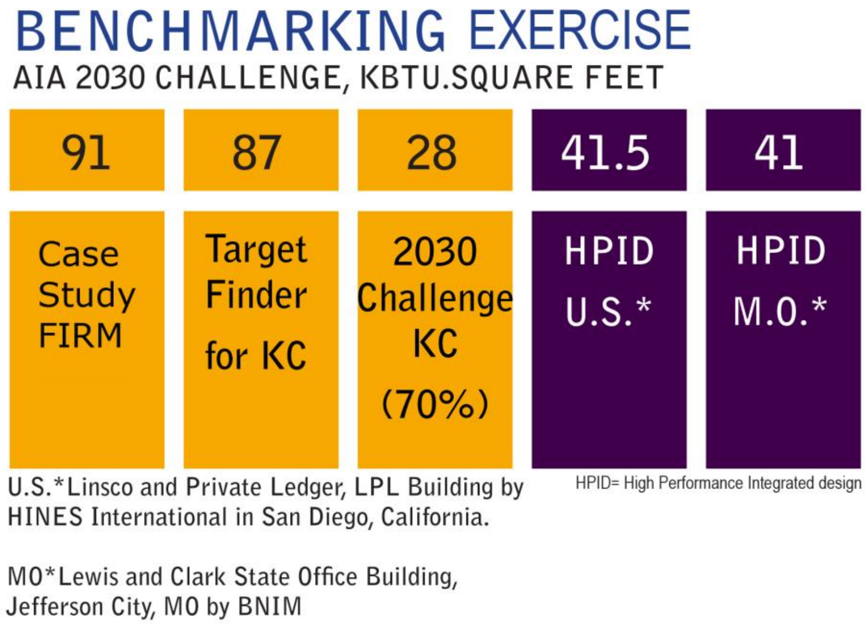

Figure 2:4: Benchmarking the Case Study Firm's Carbon Footprint to other buildings

The above figure indicates that the energy consumption of the firm is below ten percentages of an average Mid-West building's energy consumption. The average KBTU per square feet was calculated by ASHRAE 2001 baseline building's energy consumption. Even the buildings that are labeled as sustainable buildings in USA consume 44 KBTU per square feet and are not net zero in their operation. Thus, the operational energy consumption of the firm has to reduce from 91 KBTU/ square feet to 28 KBTU/ square feet. This target can be achieved in various ways described in following chapters, but there are many barriers. The main barrier is that the firm is in a leased building. In such scenario, it is hard to implement the ideas leading to authority and ownership of the property. One of the ways the firm under study has been neutralizing its carbon is by buying offsets. Over the past eight years, the firm's GHG production is six thousand metric tons produced from 35000 square feet of office area. Although, this also accounts for the carbon dioxide produced due to travelling of employees from house to their work and other office works.

Chapter 3 - Factors that Affect the Operational Carbon

The various factors that were taken into the consideration for the carbon footprint calculation for the case study firm are described in detail in following topics. Most of the factors are the ones indicated in GKCCPP Tool except for water. The calculation of water was done from the bills provided by the firm and the process is described in appendix 1. The results were calculated and converted to metric tons. It is assumed that, of the total carbon footprint, seventy percent is due to building's operation but rest of 30% is due to the employee's activities. As said earlier, the case study firm was responsible for the emission of 6000 metric tons of GHG gases over a period of eight years. The following chart defines the factors from which the GHG emission and energy consumption was made, and the corresponding numbers are in metric tons. Each of the factors is described in detail in following topic.

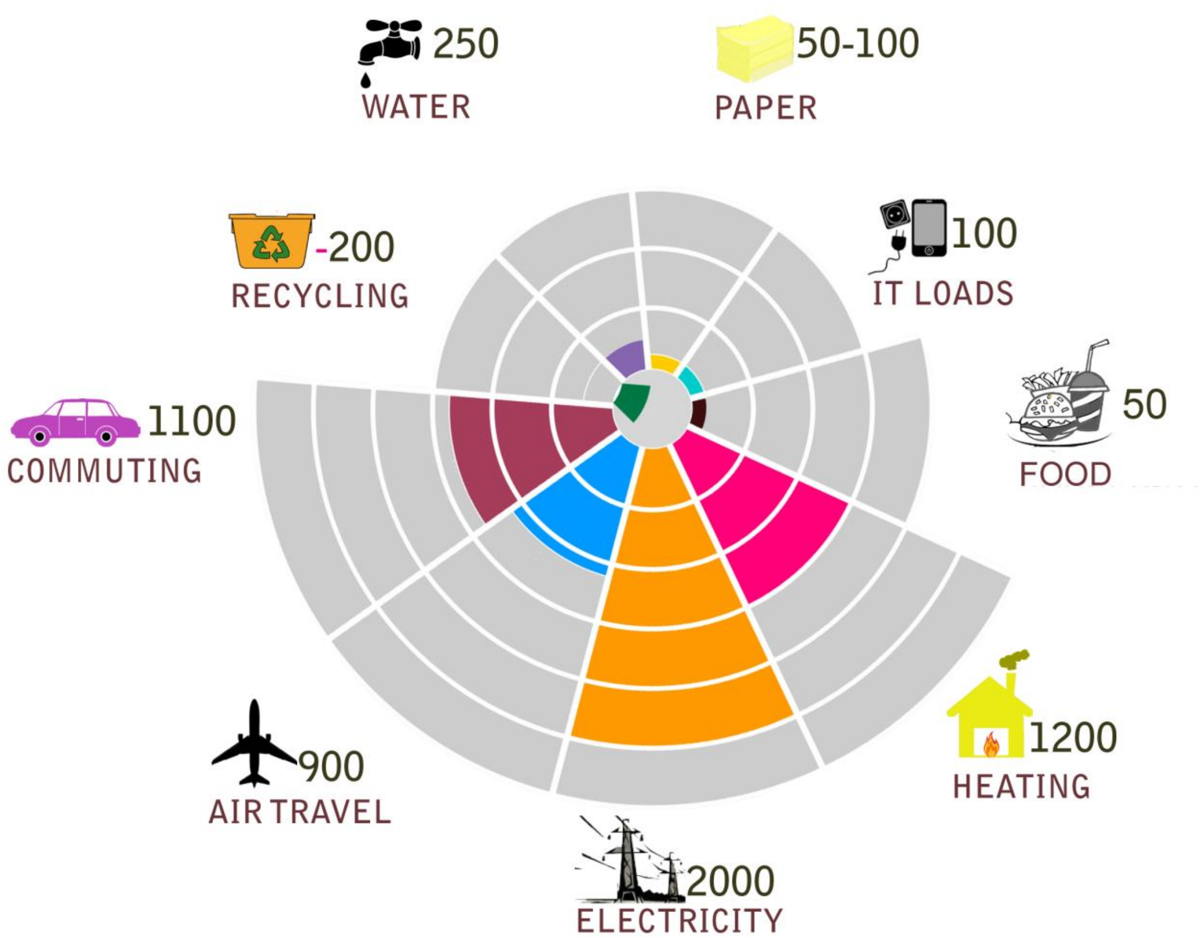

Figure 3:1: Factors that Contribute to Operational Carbon in Office Spaces

3.1) Energy

Our sources of energy are limited.US EPA indicates that there will be a 30% increase in electricity demand by 2035. (International Energy Agency, 2013)The largest footprint in the building operation is created by heating, cooling, lighting and use of other electrical appliances producing 79% of the total footprint during ta normative 100-year lifetime. (UNEP, 2009)The footprint also depends upon the source of energy as coal, electricity, natural gas or steam. (U.S. E.I.A., 2014)For example, if your office is in a state where the main source of energy of the energy is coal then you will have a larger footprint than the state whose main source of energy is natural gas.

In this paper, the energy consumption of the case architectural offices over the period of eight years represented more than 50% of the total carbon footprint, the main sources being heating and cooling of the building. The lighting sector can be regulated heavily, and carbon footprint can be reduced by introducing energy efficient light bulbs. (UNEP, 2009) The introduction of smart grid system can regulate the peak demands and operational carbon to a certain extent. (IEA, 2011)The use of smart sensors can automatically turn off the light when not detecting any motion and it can give the power supplier a better chance to measure your demands, but it is hard to install on a leased building due to proprietary issues. If energy providers could switch to the renewable source of energy as their backup energy supply, then it would help to reduce the carbon footprint of buildings. (Levine & Ürge-Vorsatz, 2007) A discussion paper on International Chamber of Commerce states that energy efficiency is the path to lower carbon economy. (International Chamber of Commerce, 2009)The paper also states that energy audits help companies to monitor their performance and determine the best tool of energy efficiency for implementation.

3.2) Transportation

UNFCCC claims that a total of 27% U.S. GHG emissions in 2011 came from transportation sector and 61% of that GHG was emitted from light duty vehicles.(EPA, 2013) Hence, transportation is one of the major sectors of GHG emission.Almost 20% of the firm's footprint is due to the commuting of employees in personal cars and air transportation. The most commonly used fuel was gas. The widespread use of cars for commuting has leveraged the employees of any office to locate in suburbs and edge of town where they can have an advantage over land, space and development. Some of the transport related cost may be externalized by choosing a city center location.

The most common fuel sources used for vehicle commuting are petroleum, diesel and gasoline. (US EPA, 2013) The choice of fuel affects the carbon footprint generated from vehicles. For example, the carbon intensity of jet fuel is higher than gas used in passenger vehicle. (US EPA, 2013)The use of alternative energy sources can reduce the carbon footprint from petroleum extensively, but their usage is not common. (Hymel, 2006) Also, the footprint depends on fuel efficiency of the vehicle, the greater your vehicle efficiency, smaller is the footprint. The footprint of using a public vehicle is smaller than owning a private vehicle. (U.S. EIA, 2014)

Air travel contributes to huge amount of carbon production worldwide. From the David Suzuki Foundation: "Although aviation is a relatively small industry, it has a disproportionately large impact on the climate system. It presently accounts for 4-9% of the total climate change impact of human activity. One passenger travelling from New York to San Francisco contributes to produce 2200 pound of CO2." (David Suzuki Foundation, 2010)

To calculate the vehicle and air travel impact of the firm under study, an online survey was conducted that accounted their personal travel impact. The survey establishes that a very few employees use public transportation or bike. The air travel mileage data was received from the travel agency. The total mileage was calculated from following categories:

- Commuting with individual vehicle

- Commuting by public transit
- Rental car business trips
- Travel in Corporate Automobiles
- Air Travel

There are various reduction strategies that can be employed to make an impact on carbon footprint due to travel and transportation. These strategies have been suggested by the Greater Kansas City Climate Protection Partnership Tool.

- Instead of travelling from air, electronic meeting technology such as videoconferencing can be used. (GKCCPP Tool)
- One of the programs in San Francisco airport utilizes kiosks to sell carbon offsets to consumers. A person travelling from Los Angeles to San Francisco would produce a quarter of a ton carbon during round-trip, and the cost would be $3-$4. The offset would go to conserve redwood forest. (Environmental, Leader, 2008)
- Essential facilities like bike racks, lockers and shower can be provided to employees who bike to the office. (GKCCPP Tool)
- The proper use of inflated tires would help increase fuel efficiency by reducing rolling resistance and would help reduce over four million tons of carbon that is being released into the atmosphere. (J. Huff, 2013)

3.3) Water Use

Building occupants use 12.2 percent of the total water consumed in the U.S. (EPA, 2013) The US Department of Energy says that from 1985 to 2005, water use in the residential sector closely tracked population growth, while water use in the commercial sector grew almost twice as fast. Water processing requires energy input, as well. In 2005, between 27 billion and 39 billion kWh were consumed to pump, treat, distribute, and clean the water used in the buildings sector, accounting for 0.7 to 1% of net electricity generation. (U.S. Department of Energy, 2011)Water use for operational phase of the building is much more than water usage during construction phase. (UNEP, 2009) One of the main sources consumption is leakage and water dripping from taps. (U.S. Department of Energy, 2011)

To reduce water consumption in buildings, the problem needs to be assessed in design phase. Rainwater harvesting and reclaiming grey water for its reuse would be great tools to conserve water. (Sadia Rahman, 2014) By reducing the amount of water usage, offices not only save money and energy but also offset carbon footprint and obtain the desired sustainability goal.

The carbon calculator that we used to calculate the carbon footprint (Greater Kansas Chamber of Commerce CO2 calculator) did not account the water usage. In this research, the carbon footprint due to water consumption was calculated on the basis of the water bills provided by the firm. (See Appendix 1) Including water usage in carbon calculator is important if the office or an institution wants to be carbon neutral.

3.4) Material Use and Other Uses

The carbon footprint due to material depends upon the type of building and the purpose of the building. (UNEP, 2009) In an architectural office, the material that produces most carbon footprint is paper. For an architectural firm and other administrative offices, the material calculation has been done as per paper use. 100 reams of virgin paper produce 250 kg of carbon dioxide. (GKCCPP Tool) The use of recycled paper reduces the carbon footprint also the paper use can be decreased immensely by the use of digital media. (Sappi Fine Paper North America, 2012)The other source of carbon footprint can be small power plug loads such as those generated from computers and other technology. Footprint is also generated from food consumption in office.

3.5) Recycle and Waste Disposal

When any household or office or commercial establishment recycles its waste or disposes it correctly then it will have a positive impact on carbon footprint. (Talukdar, Banthia, & Islam, 2011)A publication by UNEP states that the correct disposal of waste is when damages associated with waste is avoided by treating waste as a resource. (UNEP, 2013) For example incineration of hazards is not only the wrong way to dispose waste but also it brings danger to human life. In the case study firm, an average of 25 metric tons of carbon was offset from the total carbon production. The most important step in recycling would be to separate materials in different containers. (The Scottish Government, 2012)Thus, it has been a common practice to place blue bins for metals and plastics and green bins for paper. Although recycle industry is growing, US dumps almost 60% of its waste to landfills. (EPA, 2014) In 2011, Americans generated about 250 million tons of trash and recycled almost 87 million tons of this material, equivalent to a 34.7 percent recycling rate. (EPA, 2014)Kansas State University has a recycling program that has plans to recycle 50% of its waste by 2015. In 2012 it recycled 25% of its waste. (Kansas State University Recycling Committee, 2011)Recycling programs are very effective in colleges as we can involve students and teachers to take part in it. But recycling is costly than disposing the waste in landfill so most of the waste end up in landfill. (Lave, Hendrickson, M. Conway-Schempf, & C. McMichael, 1999) In GKCCPP tool, three categories of waste management have been provided which are disposal of waste, recycling and food yard waste composting. Since it is a leased building, the firm does not carry out food yard waste composting.

Chapter 4 - Methods of Mitigation Available to Offset GHG for the Case Study Firm

As a part of solution to the problems of carbon footprint production many solutions were suggested to the case study firm. To be carbon neutral, you either have to get your energy from renewable sources or have carbon-fuel-generated energy through other means. (The Carbon Trust, 2010)Being said that, each of the solutions is described in detail in following topics.

4.1) Buying Offsets

A carbon offset is an investment in a project or activity that reduces GHG emissions or sequesters (stores) carbon from the atmosphere. (Kelly, 2010) Carbon offsets are used to compensate for GHG emissions from your own activities. (EPA, 2008) The offset can be bought from the market at the price of $10 per metric tons. (Conte & Kotchen, 2010) The present carbon market offers numbers of retailers and it is vital for the firm to do a good research to make the right choice. The choice can also be made to offset carbon locally or in the international market as well as to non- profit or for- profit. But it would be best to offset locally in renewable energy business because it would give most prominent results. For example, an offset done to build a local park would benefit the location of the office as well.

World Resource Institute, in its publication 'The Bottom Line on Offsets', states that most of the businesses and organizations in the US buy GHG offset to meet the voluntary commitments to reduce GHG emissions. They mostly offset it in the voluntary market. The paper also states that in order to generate offsets, a project must be a response to the incentives provided by a carbon offset market. According to WRI, purchasing and retiring (that is, not re-selling) high-quality offsets can be a useful component of an overall voluntary corporate emissions reduction strategy once internal abatement opportunities have been realized. (Kelly, 2010) In the case study firm, this has been the path applied to offset carbon. The firm has been auditing its carbon footprint since 2005. The firm paid for its footprint during 2005 to 2008. The offsets were bought at market price of 10 dollars per metric ton.

4.2) Reforestation

It is the most rudimentary form of carbon footprint mitigation based on a very simple fact that trees mitigate carbon dioxide to give oxygen. Trees are a renewable resource, and they can capture and store carbon. (World Resources Institute, 2008) According to US Department of Energy, Energy Information Administration, "The amount of carbon dioxide equivalent a tree will offset depends on many factors, such as the type of tree, where it is planted and the amount of room it has to grow. "A tree can absorb as much as 48 pounds of carbon dioxide per year and can sequester 1 ton of carbon dioxide by the time it reaches 40 years old." (Evans, 2000)With the present rate of carbon production in the case study firm, it needs to plant 740 trees every year and make sure that those trees live for 100 years.

4.3) Photo Voltaic Panels

The existing electricity demand of the case study firm is 350 kilo watts. We can offset the carbon footprint generated from heating and cooling the building by generating the electricity from photo voltaic cells. (IPCC, 2007)Also, there are two ways to apply this method. We can either buy it by paying for it upfront or lease it. (The Office of the Ohio Consumers' Counsel (OCC) .Both the options have been described in detail in the following topics. The calculations were done on an online based calculator called 'Solar-Estimate'. (Solar Estimate, 2000)

4.3.1) Cash Purchase

The following table has been established for the demand of 350 kilo wattage. The calculations were done on an online based calculator called 'Solar-Estimate'.

Table 4-1: Calculation of cost for Cash Purchase of PV Cells

Executive Summary: Cash Purchase	
Gross cost:	$1,046,760
Federal Tax Credit (30% of Net Cost at Installation)	$314,028
Net Cost of System after rebates and incentives:	$732,732
Pay Back Time:	9.54 years
Internal Rate of Return (IRR) on Investment:	10.48%

For 350 kilo wattage to be covered we need an area of 39000 square footage and that amount of land is not only hard to find in downtown (urban) areas but also unaffordable. Thus, the major challenge lies in finding space to put up all the photo voltaic cells. With further research, it can be determined if we could install it along the façade of the building because with the advancement in technologies, it would be possible.

4.3.2) Zero down Leased Option

The following table has been established for the demand of 350 kilo wattage. The calculations were done on an online based calculator called 'Solar-Estimate'.

Table 4-2: Calculation of cost for Leased Option of PV Cells

EXECUTIVE SUMMARY - Zero Down Leased Option	
Original Monthly Utility Bill:	$6,400
New Monthly Utility Bill:	$0
Monthly Lease Payment:	$4,947
Monthly Savings after Lease Costs:	$1,453
Monthly Profit/Loss Year 1:	$17,430
Total Profit/Loss over the life of the system after all repayments:	$435,762

The firm do have the option of leasing photo voltaic cells but leasing is not same as owning photo voltaic cells but it adds up to the building's property value. A "Solar Lease" is when someone else owns the solar energy equipment (usually the leasing company). And you pay a monthly payment to lease it for the lease term (usually 10-15 years). Often the lease payment escalates (increases) over time. These lease payments may be wholly or partially balanced by lower electric utility bills. (Lopez, 2014)A solar electric (PV) system produces electricity to help lower your electric bills, usually through net metering. (solarestimate.org, 2000)

Thus, with the leasing option, the firm can save as much as 1500 dollars in utility bill per month and reduce the carbon footprint by substantial amount. This is one of the best options suggested to be applied by the firm but this comes under a condition that lease amount do not go inflated over the time and become more than utility bill. With more research done in this option the firm could certainly figure out if this is a good option to be applied.

4.4) Wind Energy

The wind energy is also calculated for existing electricity demand of the firm. The amount of energy required is 350 kilo watts. The calculations were done on an online based calculator called 'Solar-Estimate'. But although we would be investing for 350 kilo watts, due to non-dependency of wind, we can depend on only 55% of present demand which is 200 kilo wattage. Thus, the following table has been established for wind power. (solarestimate.org, 2000)

Table 4-3: Calculation of cost for Wind Energy

EXECUTIVE SUMMARY - cash purchase	
Average wind speed:	12.8 mph
Gross cost:	$900,000
Federal Tax Credit (30% of Net Cost at Installation)	$270,000
Net Cost of System after rebates and incentives:	$630,000
Pay Back Time:	9.2 years
Internal Rate of Return (IRR) on Investment:	7.3%
Payback for loan @ 6.5% apr:	30 years

The calculations show that the return for the photo voltaic cells is more than that of the wind. Also, since we can depend only on 55% of the demand we need to arrange for some backup power sources.

4.5) Personalizing Carbon Footprint

It is assumed in this study that 70% of the total carbon footprint is due to building operations but since we are counting carbon footprint from transportation, we can say that 30% is externally generated footprint, primarily employee transit. Hence, the proposal made here is to make carbon footprint a personal choice. An average employee at the case study firm travels 300 miles every year and emits 3.0 metric tons of GHG gases. (GKCCPP Tool) If an average employee wants to offset their travel footprint then, they can do that by paying for the offset. With the present market value, employees would pay 30 dollars to offset their carbon footprint due to driving from work to the house. It would not include travel made for other reasons except work-related travels. Also, it would help to encourage employees to use bike or public vehicles if they feel comfortable and safe using it. Another option would be to have the company offer to offset employee carbon production as a benefit or recruitment tool. Many people want to offset carbon voluntarily and business and organizations are offsetting it largely for offset commitment. Hence, it is a good idea to for the companies to present employee offset as a benefit or recruitment tool.

Chapter 5 - The Carbon Trading and Carbon Market

The emissions trading scheme was introduced to the world to fight global climate change. The history of emissions trading can be traced back to the United Nations Framework Convention on Climate Change (UNFCC). This is an international environmental treaty which came into effect in 1994. (Gilbertson & Reyes, 2009) It gave birth to the formation of Kyoto Protocol, which was negotiated in Japan in 1997. (Gilbertson & Reyes, 2009) Some countries abide by the protocol while some did not. Since United States is not in the list of countries to follow Kyoto protocol, it has a voluntary market. Also, the main policy in U.S. is to subsidize non-fossil fuels, and the policy may be different in each state. (Kossoy & Guigon, 2012)

Many forms of trading available and the global carbon have been designed around trading schemes. The carbon market is regulated by carbon financing where an organization can pay another organization for a given amount of Green House Gas (GHG) emission reduction. The emission reduction credits can be investments to projects that help reduce greenhouse gas in developing countries, given that they meet international standards. The current carbon market is worth 176 billion dollar while it was 92 billion in 2009. (Kossoy & Guigon, 2012) The global carbon market is highly unregulated because the economy of the carbon market is completely dependent on policies. Some countries follow one policy while the other follows another. (Kossoy & Guigon, 2012)However, the two main elements of emission trading are: i.) One would be charged for producing carbon that can be paid to the carbon market, and the other is ii) One can be paid for not producing carbon that can be accepted in many forms of incentives. These principles can be traded in the carbon market as emission reductions that are based on projects and also as allowance in emissions. The current carbon market is composed of compliance markets and voluntary markets. There are many tools that keep the global market running like Emission Trading, Clean Development Mechanism and Joint Implementation. Also, the units in which the trading is carried out are the Certified Emission Reduction (CERs) and Emission Reduction Units (ERUs). (Brohé, Eyre, & Howarth, 2009)

5.1) Types of Carbon Market

In general, there are two types of carbon markets;

1.) The compliance market

2.) The voluntary market.

(Brohé, Eyre, & Howarth, 2009)

The compliance market makes it obligatory for the emitters to reduce their carbon. The basis of the compliance market was the Kyoto Protocol. The Kyoto Protocol was enforced in 16 of February 2005. It developed a cap and trade system for its abiding countries in the form of an agreement to reduce their GHG emissions. (Brohé, Eyre, & Howarth, 2009)The various mechanisms of through which the Kyoto Protocol operates is described below in the figure.

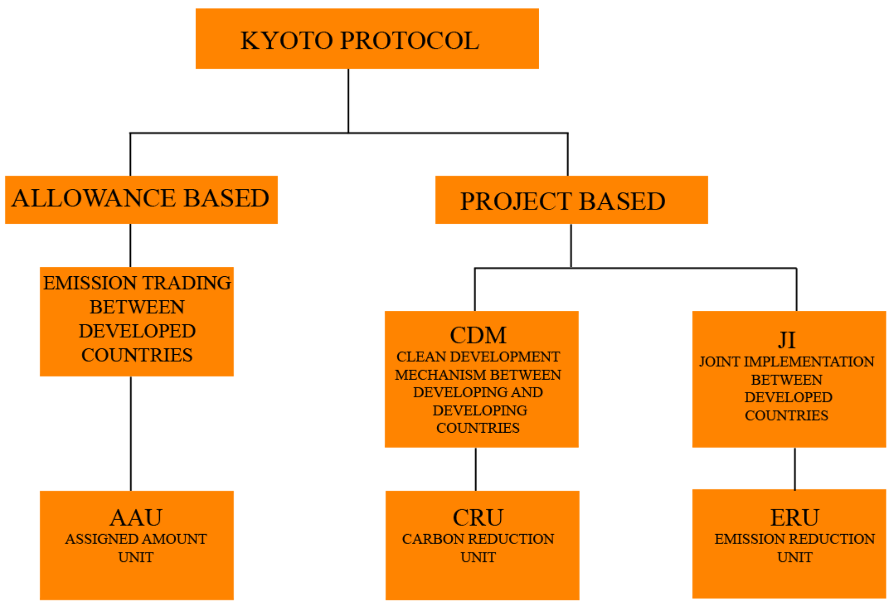

Figure 5:1: Kyoto Protocol Mechanism (Wohlgemuth, 2007, UNFCC)

The voluntary carbon market is a platform to trade and offset GHG emissions. The volunteers offset their emissions in the form of Verified Emission Reduction (VERs) and are not regulated by Kyoto Protocol or other compliance regulation. The emissions are measured by units of VERs and quantified in terms of carbon dioxide equivalents. These are measured by internationally agreed on method. The driving force behind voluntary market is company's desire to show Corporate Social Responsibility (CSR) and have a green branding and good ethical values. Although voluntary market is highly unregulated, it is one of the growing markets of 21st century. (Brohé, Eyre, & Howarth, 2009)

5.2) Carbon Markets in USA

On August 2008, United States Government Accountability Office submitted a report on carbon offsets to Congressional Requesters. The report states that as compared to EU ETS, United States does not have a thriving compliance market since the market of USA is a voluntary market and does not have much control from Federal Level. According to this report, almost all the offsets are purchased from a voluntary market and are project based and the mechanism employed in the US market for the evaluation of the offset is through quality assurance developing standard for verification and monitoring. Third-party verification may also do it. The report suggests that there are more than 600 organizations that makeup the carbon market in US and the offsets can be either bought or sold from regional or national carbon market like Chicago Climate Exchange (CCX) or it may also be traded internationally through web sites. For example, a CCX participant in USA may qualify for credits for emission reduction in one of its projects. So, the reduction may be traded in CCX retail market and requires third-party verification for the quality assurance of emission reduction. The CCX market can also track purchases and sales of offset since the participants are supposed to use registry system. (U.S. Government Accountability Office, 2008) A typical carbon market flow diagram in shown in the following figure:

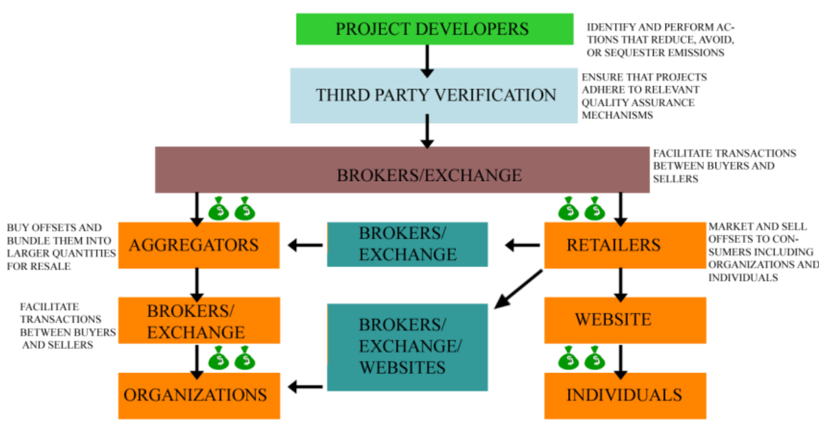

Figure 5:2: Typical Flow Diagram of How Carbon Market Works in USA

Source: U.S. Government Accountability Office, 2008 and GAO based on Ricardo Bayon, Amanda Hawn, and Katherine Hamilton, Voluntary Carbon Markets

5.5) Federal Tax Credit and Architects and Engineering Firms

Hymel in her article states that, "Tax incentives, if properly structured, can play a valuable role in moving the United States toward a sustainable energy future." (Hymel, 2006) In one of the study, it was estimated that tax incentives for new energy efficient homes, energy efficient upgrades to existing homes, and energy efficient upgrades to new and existing commercial buildings could save eleven quadrillion Btus of energy through 2025, ultimately saving consumers over $88 billion during the same period. (Hymel, 2006) For this study, only the incentives that seem pertinent to building designers is explained in brief. It is done to see how an architecture firm can benefit from tax incentives that are related to buildings. The following two topics describe two main tax credits that can be helpful for an architecture firm.

5.5.1) Residential Renewable Energy Tax Credit

In the USA, the federal, state and the local government provides tax credits and discounts to homeowners to switch to alternative renewable sources of energy. (Nadel, Prindle, & Brooks, 2005) It was initiated by 'The Energy Policy Act of 2005' and was initially applied to solar-electric systems, solar water heating systems and fuel cells. (Nadel, Prindle, & Brooks, 2005) In 2008, 'The Energy Improvement and Extension Act' included small wind-energy systems and geothermal heat pumps to the system, and one other key revision extended the system up to December 31, 2016. (The U.S. Government Printing Office, 2011) In 2009, the maximum credit amount for all eligible technologies (except fuel cells) was removed by 'The American Recovery and Reinvestment Act.' (The U.S. Government Printing Office, 2011) The federal tax credit provision often makes it possible for the taxpayer to purchase renewable energy system for lower prices than conventional ones. (Gilbert E. Metcalf, 2007) The Residential Renewable Energy Tax Credit of 2012 states that under the federal tax credit allows the taxpayer to claim 30% of the cost of a qualified system. The rebate is provided off the federal taxes through an Investment Tax Credit (ITC). Under the federal tax credit system, following are the systems in which maximum credit is allowed (Residential Renewable Energy Tax Credit, 2012).

- i.) Solar-electric property
- ii.) Solar water-heating property
- iii.) Fuel cell property
- iv.) Small wind-energy property

v.) Geothermal heat pumps

Thus, an architect or engineering firm can make use of information on federal tax credits to encourage their clients to employ the renewable system in the new and old home construction and design. This act can be performed for ethical and sustainable parameters as well. But The Federal Residential Renewable Energy Tax Credit does not provide any incentives to architects and engineering firms. (Residential Renewable Energy Tax Credit, 2012) This would rather be a client's decision. This credit is not applicable to tenants hence is not so useful for the case study firm, who perform from a rented property. (Brohé, Eyre, & Howarth, 2009)

5.5.2) Section 179 D of Tax Return

When talking about incentives in USA, section 179D-deduction tax incentive may particularly interest architects and engineering firms. It was created by 'The Energy Policy Act of 2005' (Public Law 109-58) for constructing energy efficient commercial buildings and codified in 26 U.S.C sect;179D, Section 1331, the Commercial Building Tax Deduction. IRS states that this deduction may be claimed for building built from January 1, 2006 to December 31, 2013. (IRS & Bernardini, 2006)

The following information is an excerpt from Internal Revenue Bulletin: 2006-26, titled 'Deduction for Energy Efficient Commercial Buildings'. The buildings that qualify for 179D are:

Section 1331 of H.R. 6 provides that energy-efficient commercial building property is defined as property that is:

i.) Installed on or in any building located in the United States that is within the scope of Standard 90.1-2001, Energy Standard for Buildings Except Low-Rise Residential Buildings, of the American Society of Heating, Refrigerating, and Air Conditioning Engineers and the Illuminating Engineering Society of North America;

ii.) Installed as part of (i) the interior lighting systems, (ii) the heating, cooling, ventilation, and hot water systems, or (iii) the building envelope; and

iii.) Certified as being installed as part of a plan designed to reduce the total annual energy and power costs of interior lighting systems, heating, cooling, ventilation, and hot water systems of the building by 50 percent or more when compared to a reference building, which meets the minimum requirements of Standard 90.1-2001 (which came into effect on April 2, 2003).

The architecture and engineering firms can claim this deduction for three parts of their own business and government buildings. (Commercial Building Tax Deduction Coalition, 2010)These are the criteria that qualify.

i.) If architecture and engineering firms happen to own their buildings and make improvements to it. (Commercial Building Tax Deduction Coalition, 2010)

ii.) If architecture and engineering firms make improvements as tenants to the leased property. (Commercial Building Tax Deduction Coalition, 2010)

iii.) Architecture and engineering firms can claim this deduction for government or public buildings they have designed that qualify for 179D deductions in the time period of January 1, 2006 to December 31, 2013. This allocation would require actual written agreement signed by the government agency under penalty of perjury. This allocation may be split among multiple partners. For example, if the mechanical design is subcontracted from the rest of the design, then deduction may be split among various providers. Also, this particular criterion is only for the 'design' and installation, repair and maintenance is not considered design. (Commercial Building Tax Deduction Coalition, 2010)

According to Internal Revenue Bulletin: 2006-26, this deduction cannot exceed the cost of the property itself and is subject to a cap. The notice also states that this deduction allows owners of energy efficient commercial property to deduct up to $1.80 per square foot of the building's cost in the first year. To qualify for this, the building must show 50% overall reduction in energy use compared to 2001 ASHRAE baseline and also a partial deduction up to $0.60 per square foot can be claimed for the three systems of the buildings that IRS has identified. (Zerbe, 2011)They are:

1. Interior lighting system;
2. Heating, cooling, ventilation, and hot water systems; and
3. Building envelope.

The cost can also be segregated over the period if there is remaining balance after immediate deduction. (Commercial Building Tax Deduction Coalition, 2010)

Thus, although USA provides incentives for architects and homeowners to fight their carbon footprint, this research argues that these incentives are not connected to the international carbon trading market. If we could devise market-based incentives for architects and engineering firms, then there would be more participation in the design of sustainable buildings on a global basis. Also, the 179D is a tax deduction and not a credit and these incentives do not provide the firms as well as homeowners with dollar to dollar value of their investment. (BKD LLP Webinar, 2013) These are incentives limited to federal, local and state standards of USA and are unaffected by the market fluctuations. (BKD LLP Webinar, 2013)

Chapter 6 - Proposal - Calculating Positive Carbon Handprint Activities of Architecture Firm

A proposal has been suggested in this thesis to battle the carbon footprint of the building industry by calculating positive carbon handprint activities of architecture firm. The argument made here is that without economic approach from federal level, it is very hard to reduce the carbon footprint of building industry. Although the concept of using policies in the energy market is not new, this study argues such policy should exist for architectural firms. Here, the concept of Ed Mazria to go carbon neutral by 2030 has been incorporated with the idea of Greg Norris's handprint. This thesis tries to achieve the goal set by Mazria by following the concept of Norris. The proposal has been explained in four topics, which are as follows:

6.1) Introduction to Handprint

The term 'handprint' was coined by Gregory A. Norris. (Adjunct Lecturer on Life Cycle Assessment, Harvard School of Public Health) In his composition, 'Introduction to Handprints and Handprinting', he describes handprint as beneficial environment and societal impacts that we can accomplish as an individual or organization through a net positive impact to battle climate change. He argues that the handprint is to live and leave a net-positive effect to outdo our footprint. He also states that there is no certain and scientific method to calculate the handprint, and it is very true because we do not have defined parameters to calculate both footprint and handprint. In this report, handprint is a major idea that helps us determine the sustainability strategy.

In his paper, Greg A. Norris argues that today's world is more about healing than avoiding harm. Thus, he develops the concept of handprint which accounts the same analogy as footprint, but calculating footprint is a very depressing act. It always reminds about the bad impact that we make and handprint reflects a positive incentive to perform more good. The major problem is counting our handprint because it is subtle to count the good that you do as a consumer rather than counting your footprint. Although, handprint and footprint can both be calculated by Life Cycle Assessment based database, it is very difficult to apply it in reality.

(Graham, 2003)Besides, in the words of Greg Norris, "Hand printing includes accounting for changes which occur outside of the scope of the footprint."

This study explores greater opportunities for handprint calculation. Throughout this paper, we talked about the carbon footprint produced from the building industry, and the proposal shall be established in the same arena. We have several calculators to count tentative footprint of the building industry, but no such scheme exists to calculate the handprint of the construction industry. This research indicates that overall impact that can be caused if a connection could be made between footprint and handprint of the building industry linking both of them into the international carbon market.

6.2) Opportunity for an architecture firm

When examining the solutions about how we can cut the carbon footprint from the building industry, one the major associate in the construction chain is allowed out, and that is architecture and construction firms. Even though, all the sectors that adopt sustainability play a vital role in making a big dent in carbon footprint production, architects and designers could embrace sustainability at the design phase of the building and cause a major change in energy consumption over the lifetime of the building. (Mazria & Kershner, 2008) Thus, a huge opportunity lies in the building industry to make a major change in the carbon footprint of the building industry. Going green, and designing zero-energy houses have been a major component of achieving sustainability in our industry. (UNEP, 2009)The method has been used and taught in wide scale to the practitioners, but not every firm or architecture accepts it in full, and it is the bitter truth of the 21st Century. (UNEP, 2009) For the case study firm, which encourages and practices sustainability in every possible fashion, ethical values come all the way to the forefront, but there may be other firms which are lacking enough encouragement to practice sustainability in construction and design.

The ground for architects not practicing sustainability may be many; such as client’s requirements, budget of the project, and lack of technology to employ designs and so on. (Willis, 2000)But one of the major factors is that there is not enough incentive for practicing sustainable architecture. Most of the firms practice it because they understand the sensitivity and value related to sustainable practice and others perform it for ethical reasons. The other reason is the persistent attitude and behavior of the building industry and lack of leadership to influence the practice. (American Institute of Architects, 2012) In the USA, incentives like 179D tax deduction exists, but is not in practice because it is very difficult, and time consuming to get an allocation. (BKD LLP Webinar, 2013)

This study argues that to create a sustainable drive in architects, the industry needs something more than the ethical drive of the designers. There is a need of market-driven strategy that would make architects and architecture firms to become involved in sustainable practice. The trend that we have seen in years is that there is a lack of incentive in the market and discourages many of the practitioners to give up green design. (American Institute of Architects, 2012) If the market drives the industry in a sustainable way, and so much of the carbon footprint that would be made from the building industry would decrease.

Hence, the proposal has been made for the greater good of the industry. Besides, the proposal is not only limited to the building industry in the USA but can be applied to the international market if taken the right measures with it. The proposal is further described in following topics.

6.3) Architecture Firm's Handprint

Creative handprint has a vital role in this research proposal. As stated earlier, creative handprint is the account of the good that we do in our society that aids to fight carbon footprint. (Greg A. Norris, 2009)This study argues that by counting an architectural firm or architect's handprint, a major change in footprint can be brought about. So how does one calculate a carbon footprint? The answer to that question is very complex, and not a substantial method has been proposed in this paper, but further study can be carried out in this field.

To calculate an architecture firm's creative handprint, the following methodology has been applied in this study. The first work done was to find out the average benchmark energy consumption of buildings of that particular state. It was performed by comparing the buildings to

ASHRAE 2001 energy consumption baseline of buildings. Likewise, the database from the U.S. Energy Information Administration was used to find the average energy consumption for particular projects. (US EIA, 2012) The handprint was calculated for the case study firm. Since the firm had the calculation report of sustainability since 2010, the database for those building's energy consumption was taken from there. But, this is a projected data, so the whole objective of using this data was to exemplify the process. Hence, the handprint is not the actual figures for the firm, it is a projected figure.

From the report's database and the firm's annual carbon footprint report, following figure has been drawn.

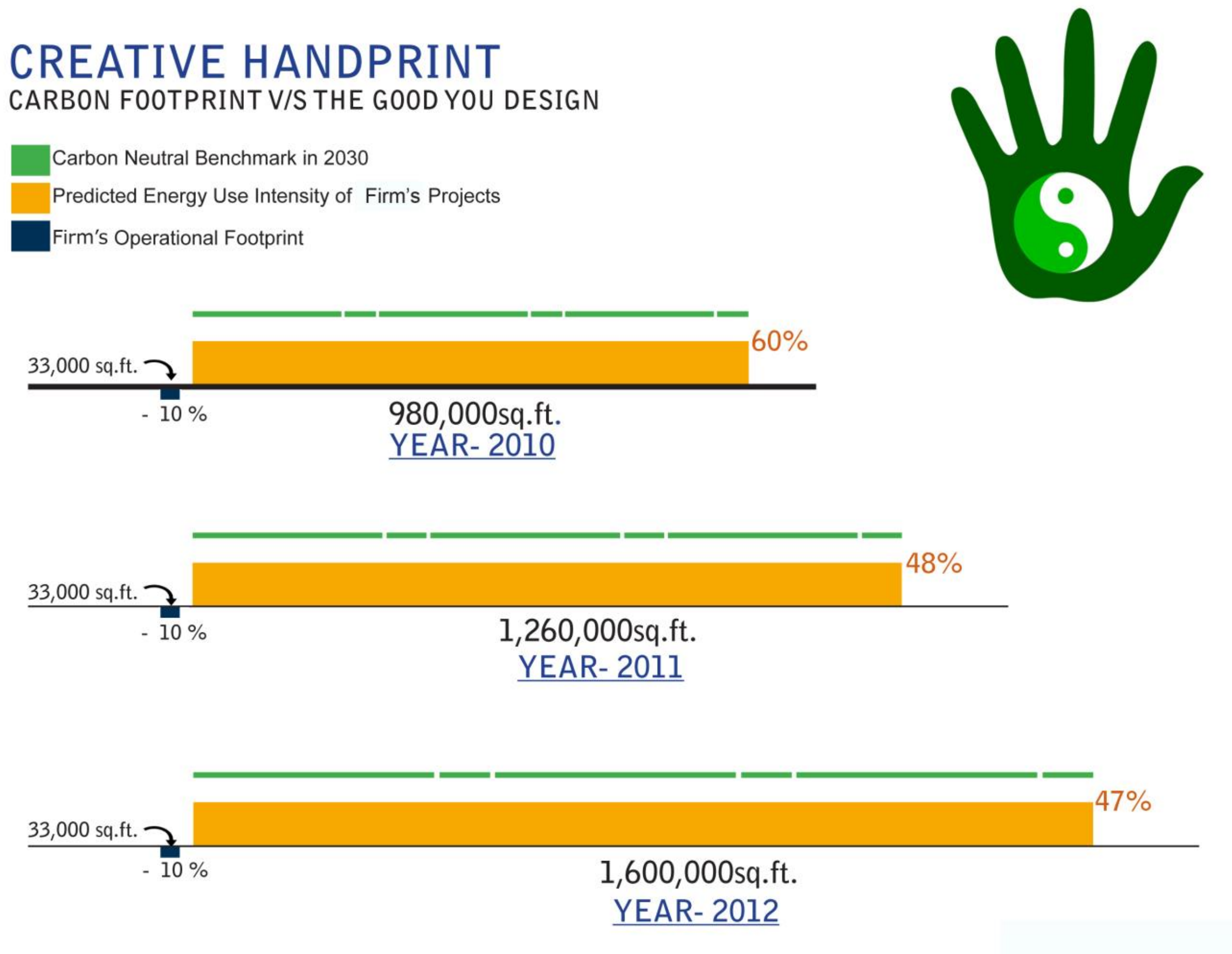

Figure 6:1: Proxy Calculation of Handprint of an Architectural Firm

NOTE: This is a projected data, so the whole objective of using this data was to exemplify the process. Hence, the handprint is not the actual figures for the firm, it is a projected figure.

This chart shows the tentative handprint of the firm in years 2010, 2011 and 2012. The black line is the average energy consumption of a typical building in Missouri. The blue bar is the firm's own operations in 33,000 square feet and is below 10% of an average building in Missouri. The green line is the zero-energy emission targets for 2030 architecture challenge. The yellow bar horizontally covers the area of the square footage of buildings designed by the firm that touched the periphery of sustainability, and vertical bar describes how much better those buildings we designed as compared to an average benchmark in Missouri. Thus, the yellow bar could be assumed as the creative handprint of the case study firm.

6.4) Proposal to Embrace Sustainability on Bigger Scale

Despite the advancement in technology and accessibility to knowledge, the energy use in building remains the same. (Levine & Ürge-Vorsatz, 2007)This is imputable to the fact that the only knowledge driven economy cannot produce effective changes so to achieve the desired outcome, we need some upstanding method. (Levine & Ürge-Vorsatz, 2007)This study suggests how a method based on footprint and handprint calculation of the architecture industry can make a substantial change in carbon footprint reduction of the building industry. However, this proposal is in its inception phase and requires extensive study if to be embraced by as a system.

Here, the proposal is to plug in the handprint and the footprint of the architectural or engineering firm to the global carbon market. Architectural and engineering firms can calculate their handprint and compare that to their carbon footprint. The first rule to sustainability would be that your handprint should always be higher than your footprint. If that is the case, then the remaining handprint can be converted to carbon credits. This is based on the principle of carbon trading that one is getting paid for not bringing out the GHG gases, and the firm would be given credit for designing as many sustainable buildings. The calculation can be done if a methodology could convert the handprint of the architectural and engineering firms to a number that could help calculate the credit. For example, in figure 5:1 we can see how the firm compares its handprint to its own footprint. Besides, the most significant step in preparing the methodology is to create a benchmark for determining the medium energy use of ordinary buildings in general. This may be referred from ASHRAE or other authentic parameters that exist in a particular state or area.

These carbon credits can then be sold along the carbon market to get capital. The advantage of this arrangement would be that your credit would give a market value like that of the stock, and this may give an opportunity for architecture firms take part in this scheme.

The proposal is to go globally so that firms that are not only in the USA but those all over the world could take a share in the interchange. Thus, there would be a vital need to launch a common global market for this process. This can be achieved by preparing a global protocol for the building industry all over the world. The process and proposal is further described in the following figure:

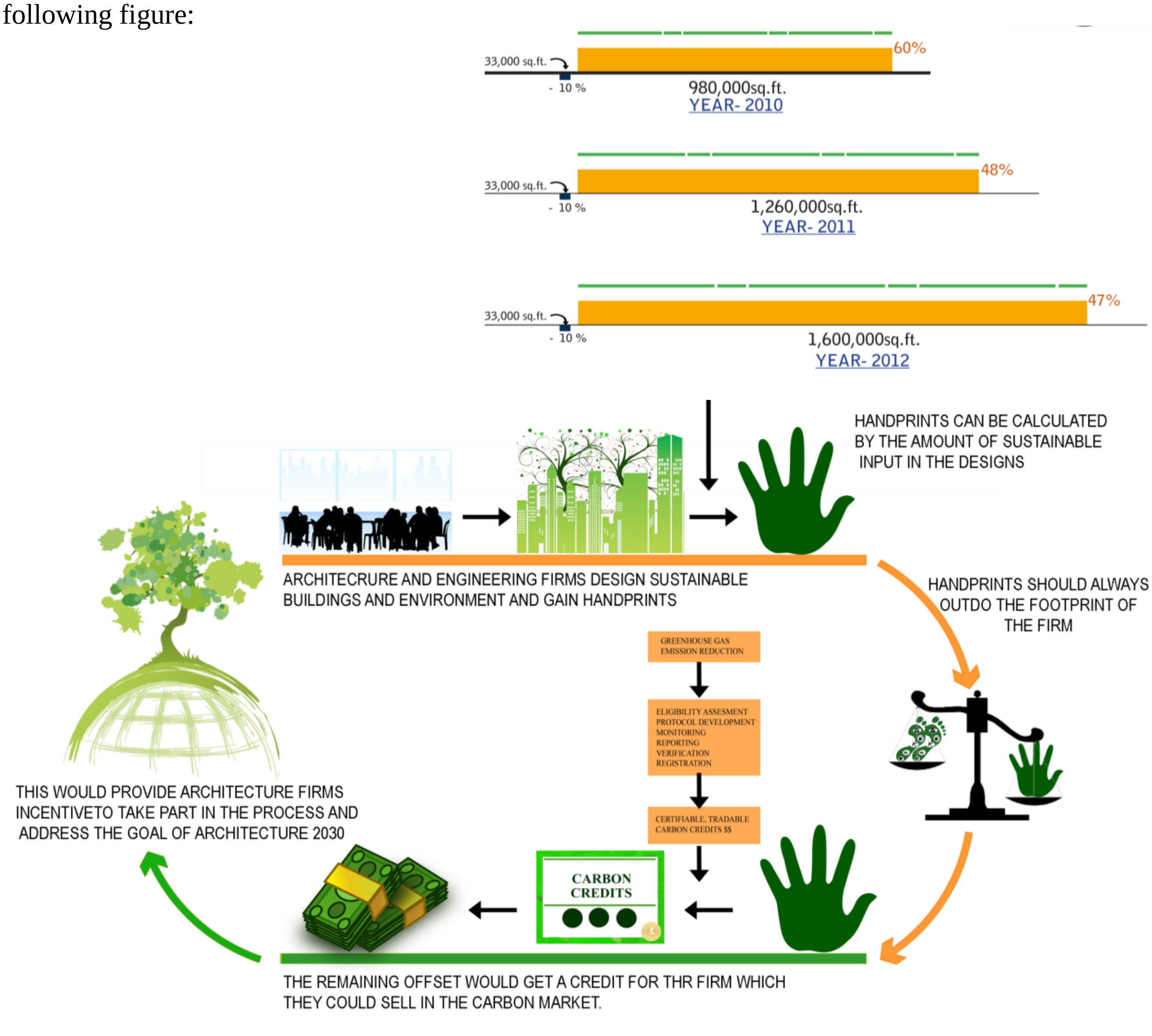

Figure 6:2: Figure of Proposal for Architecture and Engineering Firms To Take Part in Global Carbon Market and Achieve Architecture 2030 Goals.

Chapter 7 - Conclusion

7.1) Conclusion

This dissertation seeks to offer a solution to carbon footprint reduction in the construction industry. Since this thesis was performed in collaboration with an architectural firm, the major focus is to reduce carbon footprint of the firm and relate it to the general architectural office scenario. The methodology followed was based on the carbon calculator called The Greater Kansas City Chamber of Commerce's Carbon Footprint Calculator (GKCCPP Tool). The components of measurement of the operational carbon are energy, travel, water, food and waste. (UNEP, 2009) Although it only incorporates operational carbon footprint of the office, the calculation is vital to reach the sustainable goal. It is a fact that the main reason of operational carbon is due to the energy consumption from carbon-rich sources like coal. (EPA, 2008) In a building's lifetime of 100 years, 90% of the carbon footprint is created by operational phase, and only 10-8% is attributed to its constructional phase. (Wetering & Wyatt, 2010) During the internship period, it was concluded that the firm's headquarter office was performing 10% below an average mid-western office. (Refer to figure 2:4) Carbon footprint was audited from 2006 to 2012, and the amount of money was calculated to offset the footprint by buying offset credits. (Refer to figure 2:2)This report includes suggestions and ways for the case study firm to be carbon neutral by 2030 by analyzing different options like energy from solar cells and wind turbines, offsetting footprint through reforestation and getting employees to offset their share of footprint.

This was the first part of the report. In the second part, a study was done to examine what possibilities are there for the building industry to embrace sustainability on a bigger scale. It starts with the definition of handprint which, in this thesis, is supposed as the amount of sustainable design that an architecture or engineering firm designs. The theory behind this proposal is the principle of the carbon market, which indicates that the establishment is paid for producing less carbon. Thus, the proposal is to convert the handprint of the architectural firms to carbon credits which can be traded in carbon markets. This proposal is in the inception phase and needs further exploration if it needs to be turned into the market system. The proposal is made on the assumption that this is a better incentive system for the building industry. It helps in achieving 2030 challenge, and if we could develop a global market, all the firms and architects around the world could participate in the system.

This proposal establishes that it is very important to calculate the footprint of one's own operation to be a sustainable business. The final proposal made on converting handprint of architecture firms to carbon credits have a plenty limitations to it. In this research, a rough calculation is done to show what could be the firm's creative handprint. We would need a concrete methodology to calculate the exact amount of the handprints. Also, another strategy is required to develop an accurate calculator that would convert the handprint to carbon credits. There are also plenty restrictions to market such proposal. The first restriction to this implementation would be the lack of such policy and lack of such market. Since, the proposal contains establishment and alterations in policy, the process would require the involvement of authority figures like the United Nations. This also requires the invention of carbon offset schemes from government level for trading carbon credits. One of the most significant factors to consider is the analysis of cost-effectiveness that is involved in the mechanism. The mechanism should be able to bring forth a reasonable price for the carbon credits that are generated. Besides, the proposal is just an approximation, and we do not possess any old examples to consult to. What is offered here is a cap and trade scheme that is centered on the building industry based on the past examples like Kyoto protocol or EU ETS. Therefore, we cannot determine on how effective the proposal would be or how could it impact the building industry.

So, concluding this work, we can state that this is a minor measure towards a bigger policy development to address global climate alteration. This proposal could be one of the means to achieve the Architecture 2030 challenge. An important determinant of accomplishment in diminishing greenhouse gasses from the building industry lies in the limit of governments and different stakeholders in the building sector to outline also actualize the policies adequately. Overall, it addresses the need of the building industry to become a participant in the global carbon market economy so that the challenge of being carbon neutral can be achieved. (UNEP, 2009)Although, this research was initiated to furnish solutions to a particular firm to cut its carbon footprint, a proposal on a bigger scale hopes to make architecture and the building industry more aware of their potential.

7.2) Future Area for Research

This proposal requires extensive study and research for further implementation in the market. For further implementation, this proposal needs to be studied for potential market establishment. This would also require analyzing its effectiveness to impact the building industry. The first step is to devise a methodology to calculate the handprint of the architecture business correctly and the second step is to design a correct method to compute how handprints could be converted to amounts of carbon credits. This would require technical incorporation from other areas such as software and programming for effective development of the method. After the conversion of handprint into appropriate carbon credits, the proposal needs to be studied for its feasibility in the carbon market. Broad knowledge and expertise are required to design the features for new carbon policy for effective marketing. Plenty of carbon markets exist in the present economy, and broad examination is required to find a method to integrate this proposal in the global carbon market or to find a new market for the building industry itself. This would also include the development of carbon trading mechanism and study of cost related to its operation. It is crucial to determine what the present demand of credits in the carbon market is because the chief objective of this proposal is to be able to sell the credits of the building industry in carbon markets.

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Appendix 1:
Calculation of Water Footprint

From the case study firm's water bill following table has been deduced for year 2010.

MONTHS	WATER BILL	SEWER
JAN	911	1722
FEB	911	
MAR	1108	
APR	820	
MAY	1923	
JUNE	1820	
JULY	1563	
AUGUST	1776	
SEPT	1736	
OCT	1171	
NOV	1084	
DEC	1822	
TOTAL	**16645**	**1722**

From Kansas City MO Water Services

5169 gallons= $20.95

$ 16645 = 5610 x 16645/20.95

= 93378450/20.95

=4457205 gallon/year

From EPA's greenhouse gas calculator

Metric tons of carbon = no. of gallon of water/ 24495

= 181.96 metric tons

We have assumed water's footprint to be 250 metric tons because water is also used for maintenance and sewer.

Appendix 2:

Calculation of 2010 Carbon Footprint of the Case Study Firm by Greater Kansas City

In this appendix, the actual calculations from the GKCCP tool are shown for the year 2010. This gives the total amount of carbon footprint of the case study firm except water and food consumption.

Carbon Footprint Calculator

Company Information Worksheet

THE CHAMBER
Greater Kansas City Chamber of Commerce

Please enter information about your company below. These data are essential for other calculations to work correctly. If you have more than 5 facilities, you can "unhide" additional rows (between rows 16 and 112) to accommodate up to 100 facilities. Capacity for more facilities is also available on other pages by unhiding the appropriate rows.

COMPANY INFORMATION

Facility info

	Facility Name (if applicable)	**Avg. # of employees (FTEs)**[1]	**Facility type**	**Electricity Provider** *(see below for definitions of service areas outside Kansas City area)*	**Facility heat source**[2]
Facility 1	Office in Kansas City	59	Office - Other professional	Kansas City Power & Light	electric
Facility 2	Office in Des Moines	6	Office - Other professional	MROW	gas
Facility 3	Office in Houston	2	Office - Other professional	ERCT	electric
Facility 4			(select from list)	(select from list)	(select from list)
Facility 5			(select from list)	(select from list)	(select from list)
Total		**67**			

1 - Please enter number of full-time-equivalent employees averaged over the year
2 - This is used primarily to estimate savings potential; if you have mixed sources of heat select the source that provides the majority of the heat

Fleet info (company-owned vehicles)

	Average efficiency (miles per gallon)
Gasoline	56
Diesel	
Biodiesel (B100)	

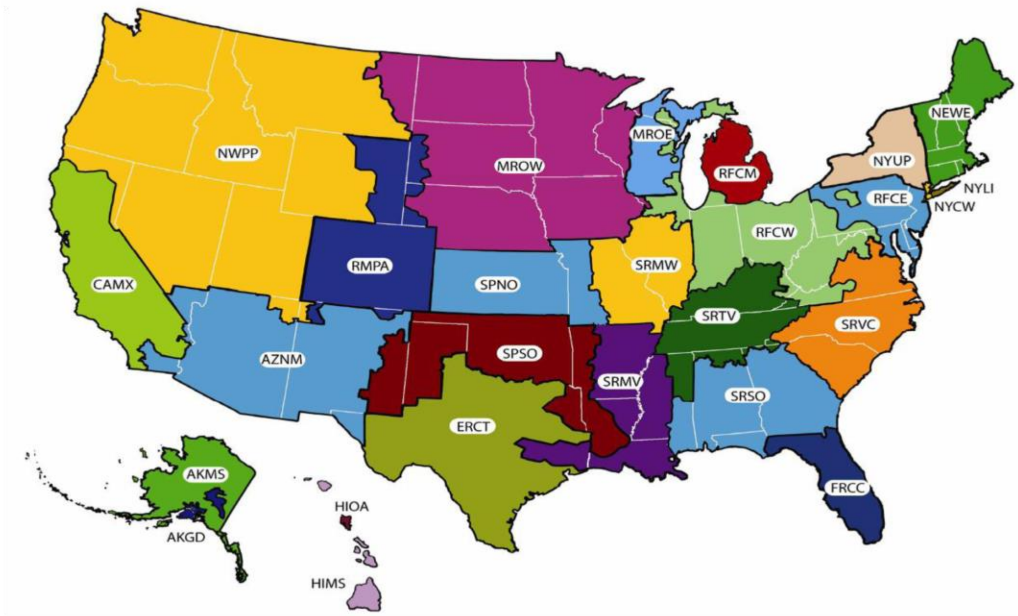
(Please revise figures at left if known. Doing so will increase the accuracy of your footprint but is not absolutely necessary. If you don't have any fleet vehicles of the fuel type listed then please leave the efficiency number as-is.)

Additional Info

Describe any special conditions or notes about how you completed this carbon inventory *(for your own, future reference)*

Service Areas *(used to estimate electricity emissions for U.S. facilities)*

Use the drop-down menu above (under "Electricity Provider") in combination with the map below to identify the location of each facility that is outside the Kansas City area. If your facility is outside the U.S., you can select the country directly from the drop-down menu above.



Carbon Footprint Calculator

Transportation Worksheet

THE CHAMBER
Greater Kansas City Chamber of Commerce

The interface below allows you to enter data about your company and employee's transportation patterns. These data will be used to estimate CO_2 emissions from these activities, which are presented on the *Results* worksheet.

Data Gathering: For information on Business Travel, work with your office manager, fleet manager, facilities manager, accounting, or travel departments to gather travel records (gallons and/or miles), reimbursement forms, and company credit card receipts. If these are unavailable, conduct an internal survey of employees.

For information on Employee Commuting, a survey of employees will be necessary. The Chamber of Commerce is providing a pre-made SurveyMonkey online employee commute survey that may be useful. See the *SurveyMonkey* worksheet (or tab) in this tool for more information.

TRANSPORTATION DATA

	Business Travel per Year		AND	Employee Commuting per Year (◉ Use data below ○ Use SurveyMonkey)	
	Value	Units		Value	Units
Cars & Trucks (Company-owned fleet)					
Gasoline (enter miles travelled or gallons used)	50,568	miles			(select from list)
Diesel (enter miles travelled or gallons used)		(select from list)			(select from list)
Biodiesel (B100)*		(select from list)			(select from list)
Cars & Trucks (Employee-owned or rental)					
Gasoline (enter miles travelled or gallons used)	19,073	miles		288,484	miles
Diesel (enter miles travelled or gallons used)		(select from list)			(select from list)
Biodiesel (B100)*		(select from list)			(select from list)
Train					
Regional (e.g., Amtrak)		miles			miles
Subway (in other cities)		miles			miles
Bus					
Kansas City Area Transportation Authority		miles		8,250	miles
Unified Gov't of Wyandotte County		miles			miles
Johnson County Transit operated by Laidlaw		miles			miles
Other		miles			miles
Air Travel					
Enter total miles travelled in each flight category					
Short trips (<300 miles per flight leg, e.g. Omaha, St. Louis)	285,476	miles			
Medium (300-1000 miles per flight leg, e.g. Chicago, Denver)		miles			
Long (>1000 miles per flight leg, e.g. West or East Coast)	24,629	miles			

Tip:
If you are using the pre-m online Survey Monkey co survey, see the two *SurveyMonkey* and *SurveyMonkey Process* worksheets and do not er below. Results will auton be calculated based on y survey data and presente *Results* worksheet with m detailed results on the *SurveyMonkey Process* worksheet.

Please note that flights are divided into "short, medium, and long" based upon the distance of each leg of the flight. These are important to break out because shorter flights have different per-mile emissions factors than longer flights.

*** Note regarding biodiesel:** The only option currently presented for biodiesel fuel is B100 (100% biodiesel). If you use another blend, you may record a proportional share of the fuel in the B100 and Diesel categories. For example, if you use 100 gallons of B20, you could record 20 gallons in B100 and 80 gallons in diesel. Although this oversimplifies the actual emissions of the blend, it is offered here as an alternative to listing several possible biodiesel blends. Note that the emissions for B100 biodiesel are assumed to be zero, based on a simplified life cycle analysis and following the lead of the Seattle Climate Partnership. However, there is much debate about how to assess the true life-cycle emissions from biodiesel use.

Carbon Footprint Calculator

Energy Worksheet

THE CHAMBER
Greater Kansas City Chamber of Commerce

Please enter data below using only one of the three methods for each facility (leave data cells blank for the methods you aren't using). You may, however, use a different method for each facility. Note that Method 1 is the most preferred method and Method 3 is the least preferred. All data should cover a one year period.

Data gathering: For buildings and facilities you own, contact your facilities manager or accounting department. For facilities you lease, contact your building manager or landlord. This may take a few calls and it will be important to know the square footage of your office space. For

ENERGY USE DATA

More accurate → Less accurate

Tip: Be sure to enter data in the units specified. Also, don't forget to specify your facility location and heat source on the *Company_Info* tab.

	Method 1: Energy Purchased Directly (Use if you know energy use (from bills or building)	OR	Method 2: Building Averages (Use if you can acquire energy use data for the entire building (e.g., from building management) but not for your company's space)				OR	Method 3: Simple Estimation (Use if you cannot acquire any energy data particular to your business or building)		
	Energy purchased directly		Total facility energy use	Company area (square feet)	Total building area (square feet)	Estimated energy use by company		Similar facility energy use (per square foot)	Company area (square feet)	Estimated energy use by company
Office in Kansas City										
Natural Gas (therms)						-				-
Electricity (kWh)	412,733					-				-
Steam (thousand lbs)	1,367					-				-
Office in Des Moines										
Natural Gas (therms)	2,407					-				-
Electricity (kWh)	7,505					-				-
Steam (thousand lbs)						-				-
Office in Houston										
Natural Gas (therms)						-				-
Electricity (kWh)	70,014					-				-
Steam (thousand lbs)						-				-
Facility 4										
Natural Gas (therms)						-				-
Electricity (kWh)						-				-
Steam (thousand lbs)						-				-
Facility 5										
Natural Gas (therms)						-				-
Electricity (kWh)						-				-
Steam (thousand lbs)						-				-

Carbon Footprint Calculator

Materials Worksheet

THE CHAMBER
Greater Kansas City Chamber of Commerce

Please enter data below using only one of the three methods for each facility. Leave data cells as-is (blank) for the methods you aren't using. However, for the method you selected, be sure to enter in the information on each type of paper used. If there is a paper type at a facility that you didn't use, be sure to enter a zero; otherwise, the tool will use industry averages for that paper type). Note that Method 1 is the most preferred method and Method 3 is the least preferred. All data should cover a one year period.

Data gathering: Your office manager or accounting dept. should have purchase records with this information. If you need more information regarding recycled content, your supplier (e.g., Corp. Express, Staples, New Leaf Paper) should be able to provide this information to you in its quarterly summary.

MATERIAL PURCHASING DATA

More accurate ← → Less accurate

	Method 1: Actual Material Purchases (Use if you know the quantity of paper purchased)			OR	Method 2: Estimates Based on Cost (Use if you know the cost (but not quantity) of paper purchased)			OR	Method 3: Estimates Based on Industry Averages (Use if you don't know the quantity or cost of paper purchased)
	Quantity	Units	Average Recycled Content		Cost	Average Cost per Ream	Sheets (estimated)		Sheets (estimated) *(Assumes all employees are office employees)*
Office in Kansas City									
Paper, virgin		(select from list)	0%			$ 3.00	-		531,000
Paper, 30% recycled		(select from list)	30%			$ 3.00	-		53,100
Paper, 100% recycled		(select from list)	100%			$ 4.00	-		5,900
Paper, other		(select from list)	50%			$ 3.00	-		-
Office in Des Moines									
Paper, virgin		(select from list)	0%			$ 3.00	-		54,000
Paper, 30% recycled		(select from list)	30%			$ 3.00	-		5,400
Paper, 100% recycled		(select from list)	100%			$ 4.00	-		600
Paper, other		(select from list)	(enter)			$ 3.00	-		-
Office in Houston									
Paper, virgin		(select from list)	0%			$ 3.00	-		18,000
Paper, 30% recycled		(select from list)	30%			$ 3.00	-		1,800
Paper, 100% recycled		(select from list)	100%			$ 4.00	-		200
Paper, other		(select from list)	(enter)			$ 3.00	-		-
Facility 4									
Paper, virgin		(select from list)	0%			$ 3.00	-		-
Paper, 30% recycled		(select from list)	30%			$ 3.00	-		-
Paper, 100% recycled		(select from list)	100%			$ 4.00	-		-
Paper, other		(select from list)	(enter)			$ 3.00	-		-
Facility 5									
Paper, virgin		(select from list)	0%			$ 3.00	-		-
Paper, 30% recycled		(select from list)	30%			$ 3.00	-		-
Paper, 100% recycled		(select from list)	100%			$ 4.00	-		-
Paper, other		(select from list)	(enter)			$ 3.00	-		-

You can unhide rows if you have more than five facilities.

Other Materials

If you would like to include upstream, manufacturing emissions associated with other materials and know their quantities and emissions factors, enter them below.

	Item	Quantity	Units	Emission Factor	Units	Mg CO_2
1	(enter item name)	0	pounds	0	$kgCO_2/lb$	0
2	(enter item name)	0	pounds	0	$kgCO_2/lb$	0
3	(enter item name)	0	pounds	0	$kgCO_2/lb$	0
4	(enter item name)	0	pounds	0	$kgCO_2/lb$	0
5	(enter item name)	0	pounds	0	$kgCO_2/lb$	0

For reference, following are some upstream, manufacturing emission factors for common materials/products.
--Computers: 28 kgCO2/lb
--Books: 1.1 kgCO2/lb
--Fibreboard: 0.2 kgCO2/lb (e.g., some furniture)
--Carpet:2.0 kgCO2/lb

Carbon Footprint Calculator

Waste Worksheet

THE CHAMBER
Greater Kansas City Chamber of Commerce

Please enter data below using only one of the three methods for each facility. Note that Method 1 is the most preferred method and Method 3 is the least preferred. All data should cover a one year period.

Data gathering: Your accountant or office manager may have waste disposal bills. Facilities managers may all track waste disposal and recycling. If your firm has used the services of the Resource Venture, then use the same information.

WASTE DISPOSAL AND RECYCLING DATA

More accurate → Less accurate

	Method 1: Actual Data from Waste Bills (Use if your bills show tons or volume of service)		Method 2: Estimates using Waste Bills (Use if your bills show dollars only)		Method 3: Estimates using industry averages (Used automatically if you don't use Method 1 or 2)
	Quantity	Units	Annual Cost	Tons (estimated)	Tons (estimated)
Office in Kansas City					
Waste disposed		(select from list)		-	55
Recycling		(select from list)		-	14
Food/yard waste composting		(select from list)		-	-
Office in Des Moines					
Waste disposed		(select from list)		-	6
Recycling		(select from list)		-	1
Food/yard waste composting		(select from list)		-	-
Office in Houston					
Waste disposed		(select from list)		-	2
Recycling		(select from list)		-	0
Food/yard waste composting		(select from list)		-	-
Facility 4					
Waste disposed		(select from list)		-	-
Recycling		(select from list)		-	-
Food/yard waste composting		(select from list)		-	-
Facility 5					
Waste disposed		(select from list)		-	-
Recycling		(select from list)		-	-
Food/yard waste composting		(select from list)		-	-

You can unhide rows if you have more than five facilities.

Carbon Footprint Calculator

Results

THE CHAMBER
Greater Kansas City Chamber of Commerce

This worksheet summarizes results of the carbon footprint assessment based on inputs entered on the *Company Info*, *Transportation*, *Energy*, *Materials*, and *Waste* worksheets. Emission estimates from current practices are directly below, followed by options to test the impacts of possible CO_2-reduction scenarios. (further below). All results are reported as metric tons of CO_2. These figures should be interpreted as CO_2 "equivalents", because although most of these emissions are actual CO_2, some of the emissions are from methane (from waste disposed in landfills).

SUMMARY OF CURRENT ANNUAL PRACTICES

Overall emissions: **738 metric tons of CO_2** (Mg CO_2) annually, 11.0 metric tons of CO_2 per employee

COMPANY EMISSIONS FOOTPRINT

Transportation

	Miles Traveled (Business Travel)	Miles Traveled (Commuting)	CO_2 (Metric Tons)
Car & Truck	69,641	288,484	130.28
Airplane	310,106	-	72.95
Train	-	-	-
Bus	-	8,250	3.53
Subtotal	*379,747*	*296,734*	*206.75*

Energy Use

	Quantity	Units	CO_2 (Metric Tons)
Natural gas	2,407	therms	12.77
Electricity	490,252	kWh	381.48
Steam	1,367	thousand lbs	153.06
Subtotal			*547.31*

Materials Purchased

	Quantity	Units	CO_2 (Metric Tons)
Paper	670,000	sheets	3.40
Other	-	pounds	-
Subtotal			*3.40*

Waste Generation

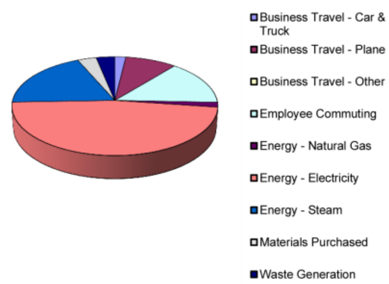
	Quantity	Units	CO_2 (Metric Tons)
Disposed	63	tons	26.25
Recycled	16	tons	(45.48)
Composted	-	tons	-
Subtotal	*78*	*tons*	*(19.22)*

EMISSIONS REDUCTION POTENTIAL*

Footprint and Reduction Potential

	Footprint (Metric Tons CO_2)	Reduction Potential* (Metric Tons CO_2)	Relative Reduction Potential (% of total)
Business Travel - Car & Truck	15.6	15.6	2%
Business Travel - Plane	72.9	72.9	9%
Business Travel - Other	0.0	0.0	0%
Employee Commuting	118.2	118.2	15%
Energy - Natural Gas	12.8	12.8	2%
Energy - Electricity	381.5	381.5	47%
Energy - Steam	153.1	153.1	19%
Materials Purchased	3.4	26.8	3%
Waste Generation	-19.2	26.3	3%
Total	738.2	807.1	100%

Relative Reduction Potential



Carbon Footprint Calculator

Results

***Emission reduction potential** is the amount of greenhouse gas emissions that can be reduced through actions taken by your organization. Note that the reduction potential for electricity, materials, and waste may be different than your footprint in these categories.

For example, for materials, the reduction potential lies primarily in the ability to sequester carbon in forests by using fewer trees for paper. The emission reductions associated with reducing virgin paper use or switching to a higher recycled content paper are substantial.

For waste, the reduction potential is primarily in recycling, and is also due in large part to the benefits of forest carbon sequestration. By supplying recycled paper to markets, businesses can help avoid the use of trees for paper, thereby sequestering carbon. However, because the fraction of each business' waste that is recyclable paper (or other recyclables) is unknown, the "reduction potential" for waste is set simply as the emissions from disposal.

ACTION PLANNING

The interface below allows you to test the overall impact of potential CO_2-reduction strategies. Please change the numbers in the outlined cells to reflect the scenario you wish to test.

Sector and Action		Estimated Annual CO_2 Reduction (metric tons)
Transportation		
Commuting	employees transition from Car to Bus	#VALUE!
Business travel	Reduce number of airplane trips or miles by: 0 %	0.00
Business fleet	Increase average fleet efficiency from: 56 mpg to 30 mpg	-3.72
Energy Use		
Fluorescent bulbs	Use compact fluorescents (CFLs) to replace: 0 75-watt incandescent bulbs	0.00
Thermostat setting	Reduce office thermostat setting by: 0 degree(s) (winter only)	0.00
Materials Purchased		
Office paper	Switch to: 30% recycled paper from virgin for 0 boxes (10 reams)	0.00
Double-sided printing/copying	Use duplex printing to reduce office paper use by: 0 %	0.00
Waste Generation		
Increase recycling	Of the company's waste, divert an additional 0 % to recycling	0.00

Reductions, total of above:	**#VALUE!**	metric tons CO_2
Current total emissions:	**738.2**	metric tons CO_2
Hypothetical total emissions with above reductions :	**#VALUE!**	metric tons CO_2
Percentage reduction from current total:	**#VALUE!**	

The chart below displays your current carbon footprint alongside your carbon footprint assuming the actions above have been taken. The exception is for electricity, for which the chart depicts *reduction potential*, as discussed above, for both the current and future scenarios.

Current and Possible Future Emissions
(Assuming actions detailed above)