



# VCU

Virginia Commonwealth University  
VCU Scholars Compass

---

Theses and Dissertations

Graduate School

---

2017

## Development of My Footprint Calculator

Karthik Mummidiseti

Follow this and additional works at: <https://scholarscompass.vcu.edu/etd>

© The Author

---

Downloaded from

<https://scholarscompass.vcu.edu/etd/4887>

This Thesis is brought to you for free and open access by the Graduate School at VCU Scholars Compass. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of VCU Scholars Compass. For more information, please contact [libcompass@vcu.edu](mailto:libcompass@vcu.edu).

# Copyright

2017

Karthik Mummidiseti

©All Rights Reserved

# Development of My Footprint Calculator

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

By

Karthik Mummidiseti

Bachelor of Technology in Mechanical Engineering – MICT/JNTU, Kakinada, India, 2010

Advisor: Dr. Sama Bilbao y León, Ph.D., MBA

Associate Professor and Director of Nuclear Engineering Programs

Department of Mechanical and Nuclear Engineering  
School of Engineering  
Virginia Commonwealth University  
Richmond, Virginia  
April 2017

## **Dedicated to**

This dissertation is gratefully dedicated

To my parents,

Sister,

Beloved grandparents,

And all of my friends,

Without whom none of my success would be possible.

## Candidate's Certificate

I hereby declare that the work presented in this dissertation is original and was performed by me in the Advanced Nuclear Modeling and Simulation Lab under the supervision of Dr. Sama Bilbao y León, Associate professor in the Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, Virginia. This dissertation work has not been submitted for a degree to any other University or Institution.

---

Karthik Mummidiseti

## Acknowledgements

Firstly, I would like to thank all the people who have helped me and gave moral support in working on my research project.

I would like to thank my supervisor Dr. Sama Bilbao y León for providing me such an opportunity to conduct research under her guidance. I would like to thank the funding agency Dominion Foundation that provided financial support for completing my Masters Research study. I would also like to thank the financial and technical support given to me by the Department of Mechanical and Nuclear Engineering. A very special thanks to Dr. Karla Mossi.

I would like to gratefully acknowledge the designs of Eric Gracyalny, Frank Kostek and Denny Wagner, from Data Directions.Inc, for providing us with the guidance and support during the completion of my work.

In addition, I would like to thank my committee members, Dr. Alberto Cano, Prof. James Miller from VCU for happily agreeing to serve in my committee and sharing their valuable thoughts about my research.

I wish to thank my former and current lab mates for their help and support in completing the tasks, and providing valuable feedback, great environment and positive suggestions.

I would like to extend my support to Dr. Naveen Palapati for helping me during this journey, and providing me with their valuable thoughts and ideas in accomplishing my research tasks. Also, I would like to thank, Dr. Tafreshi, Justin Osborne It Analyst, VCU and ASHRAE Richmond Chapter for their help.

Lastly, I would like to thank again my parents for believing in me and giving me the freedom to pursue my interests and supreme Lords for showering their blessings by giving me good health and strength to sustain at all hard times.

## Table of Contents

<b>Dedicated to</b> .....	iii
<b>Candidate's Certificate</b> .....	iv
<b>Acknowledgements</b> .....	v
<b>Table of Contents</b> .....	vi
<b>List of Figures</b> .....	x
<b>List of Tables</b> .....	xiii
<b>Abstract</b> .....	xiv
<b>1. INTRODUCTION</b> .....	1
1.1. Motivation.....	1
1.2. Expectation .....	3
1.3. Background .....	4
1.4. Problem Statement.....	4
<b>2. LITERATURE</b> .....	7
2.1. Sustainable Consumption.....	11
2.2. Why “Individual Carbon Footprint Calculator”?.....	13
2.3. Description of Different Online Personal Calculators .....	16
2.3.1 World Wildlife Fund Footprint Calculator. ....	16
2.3.2 International Student Carbon Footprint Challenge. ....	16
2.3.3 carbonfootprint.Com - Home Of Carbon Foot Printing.....	17

2.3.4	Cool Climate Calculator – Cool Climate Network .....	18
2.4.	Why “My Footprint Calculator”? .....	24
2.5.	What are the “Development tools”? .....	25
2.5.1	HTML5 .....	26
2.5.2	CSS3 .....	26
2.5.3	PHP .....	26
2.5.4	JavaScript .....	27
2.5.5	JQuery .....	27
2.5.6	MySQLi .....	27
2.5.7	Bootstrap .....	28
2.5.8	Filezilla .....	29
2.5.9	Web Server Software: FatCow .....	29
2.5.10	Text Editor .....	30
3.	WEBSITE DESIGN AND MODELING .....	32
3.1.	Overview on Web Design and Development .....	32
3.1.1	Client Side Design: .....	32
3.1.2	Server Side Design: .....	33
3.1.3	Database Design: .....	33
3.2.	Component wise “My Footprint Calculator” Analysis and Design .....	33
3.2.1	Client Side Design Components .....	33



3.2.2	Server Side Design Components .....	34
3.2.3	Database Design Components .....	34
3.3.	Advantages of “My Footprint Calculator” As a Website.....	34
3.4.	Optimization.....	35
3.5.	Work Flow.....	36
3.6.	Front-end .....	37
3.7.	Back-end.....	39
3.8.	Database Design.....	40
4.	USER EXPERIENCE.....	43
5.	TESTING AND VALIDATION.....	56
5.1.	Functionality Testing.....	56
5.2.	Survey Result Testing .....	78
5.3.	Cross-Browser Testing.....	82
5.4.	Performance Testing .....	83
6.	CONCLUSION .....	86
7.	REFERENCES .....	88
	APPENDIX A.....	94
	APPENDIX B .....	103
	APPENDIX C .....	109
	APPENDIX D.....	125

APPENDIX E .....	134
APPENDIX F.....	140
APPENDIX G.....	142
APPENDIX H.....	146
APPENDIX I .....	148
APPENDIX J .....	150
APPENDIX K.....	151
APPENDIX L .....	152
APPENDIX M .....	153

## List of Figures

Figure 1: An example of the "three pillars" model of sustainable development. [32].....	8
Figure 2: Sustainability Assessment. [36] .....	9
Figure 3: Present and Future Relationship between Economy, Society and Environment. [37]..	10
Figure 4: FatCow hosting architecture.....	30
Figure 5: Server Architecture.....	32
Figure 6: Work Flow Diagram for My Footprint Calculator .....	37
Figure 7: Front-End User Diagram for My Footprint Calculator .....	38
Figure 8: Back-End Admin Diagram for My Footprint Calculator .....	39
Figure 9: Relation Diagram of My Footprint Calculator .....	40
Figure 10: Relation Diagram of My Footprint Calculator Car Query .....	41
Figure 11: MYSQL home page in FatCow Server .....	42
Figure 12: 2016 Look of My Footprint Calculator .....	43
Figure 13: Current Look of My Footprint Calculator.....	44
Figure 14: 2017 Home Page of My Footprint Calculator .....	44
Figure 15: User Operation before Login (Current Look) .....	44
Figure 16: User Operation after Login (Current Look) .....	45
Figure 17: Navigation Bar (Current Look) .....	45
Figure 18: Login Sheet of My Footprint Calculator (Current Look).....	45
Figure 19: Signup Sheet of My Footprint Calculator (Current Look) .....	46
Figure 20: Calculator Page of My Footprint Calculator (Current Look).....	47
Figure 21: Blog Page of My Footprint Calculator (Current Look).....	48
Figure 22: Sample Transportation Survey Page of My Footprint Calculator (Current Look).....	49

Figure 23: Sample Food Survey Page of My Footprint Calculator (Current Look).....	50
Figure 24: Sample Energy Survey Page of My Footprint Calculator (Current Look).....	51
Figure 25: Sample Water Survey Page of My Footprint Calculator (Current Look) .....	52
Figure 26: Sample Trash Survey Page of My Footprint Calculator (Current Look) .....	52
Figure 27: 2017 Sample Transportation Survey Page of My Footprint Calculator.....	53
Figure 28: Sample User Result Page of My Footprint Calculator (Current Look).....	54
Figure 29: Sample User Results Comparison of My Footprint Calculator (Current Look) .....	54
Figure 30: Footer showing Twitter Feed and Latest News (Current Look) .....	55
Figure 31: Database Input Validation.....	56
Figure 32: Sample Vehicle Emission Queries (Current Look).....	79
Figure 33: Rail, Bus and Air Emission Queries (Current Look) .....	80
Figure 34: The Tool Calculated Result for Transportation Queries (Current Look).....	81
Figure 35: Excel Spreadsheet Transportation Queries.....	81
Figure 36: Excel Spreadsheet Stored Values of Transportation Queries.....	81
Figure 37: Excel Spreadsheet Calculated Values of Transportation Emissions .....	81
Figure 38: Chrome Browser View of My Footprint Calculator .....	82
Figure 39: Pingdom Performance Test of My Footprint Calculator.....	84
Figure 40: Speed Test of My Footprint Calculator.....	85
Figure 41: US States CO2 Emission.....	145
Figure 42: US States CO2 Emissions per Capita.....	145
Figure 43: Countries CO2 Emissions per Capita.....	147
Figure 44: Countries CO2 Emissions .....	147
Figure 45: CO2 Emissions per capita and HDI .....	149

Figure 46: Excel Spreadsheet Energy Queries.....	150
Figure 47: Excel Spreadsheet Food Queries .....	151
Figure 48: Excel Spreadsheet Water Queries .....	152
Figure 49: Excel Spreadsheet Trash Queries .....	153

## List of Tables

Table 1: Comparison of calculators on Household Consumption .....	19
Table 2: Comparison of calculators on Energy Consumption .....	20
Table 3: Comparison of calculators on Transportation Consumption .....	21
Table 4: Comparison of calculators on Food & Goods Consumption.....	22
Table 5: Signup Sheet Test .....	57
Table 6: Login Sheet Test.....	57
Table 7: Transportation Survey test .....	58
Table 8: Manual testing of My Footprint Calculator .....	59
Table 9: List of US States by CO2 Emissions .....	142
Table 10: List of Countries by CO2 Emissions .....	146
Table 11: List of Countries by HDI and CO2 Emissions .....	148

## Abstract

### MY FOOTPRINT CALCULATOR

By Karthik Mummidiseti, MS

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

Virginia Commonwealth University, 2017.

Major Director: Dr. Sama Bilbao y León, Ph.D., MBA

Associate Professor and Director of Nuclear Engineering Programs

The Environmental footprint is a very powerful tool that helps an individual to understand how their everyday activities are impacting environmental surroundings. Data shows that global climate change, which is a growing concern for nations all over the world, is already affecting humankind, plants and animals through raising ocean levels, droughts & desertification and changing weather patterns. In addition to a wide range of policy measures implemented by national and state governments, it is necessary for individuals to understand the impact that their lifestyle may have on their personal environmental footprint, and thus over the global climate change. “My Footprint Calculator” ([myfootprintcalculator.com](http://myfootprintcalculator.com)) has been designed to be one the simplest, yet comprehensive, web tools to help individuals calculate and understand their personal environmental impact.

“My Footprint Calculator” is a website that queries users about their everyday habits and activities and calculates their personal impact on the environment. This website was re-designed to help users determine their environmental impact in various aspects of their lives ranging from

transportation and recycling habits to water and energy usage with the addition of new features that will allow users to share their experiences and their best practices with other users interested in reducing their personal Environmental footprint. The collected data is stored in the database and a future goal of this work plans to analyze the collected data from all users (anonymously) for developing relevant trends and statistics.



# 1. INTRODUCTION

## 1.1.Motivation

Our environment is a delicate balance of the physical and biological realms which has developed through a complex evolutionary process over billions of years [1]. This “delicate balance” has enabled the development of vast biodiversity which also includes us humans [2]. We have very effectively used the environment to our advantage for creating better quality of life for humans thus placing ourselves at the top of the ecological ladder [3].

In the quest of human development and greater prosperity, the environment has been the first casualty [4]. Environmental deterioration leads to ecological imbalance which is felt most by animal and plant life [5]. This can be in the form of destruction of their habitats or micro-environment [6]. Additionally, socially and economically under privileged sections of society, are adversely effected because they rely on nature for immediate needs ([7], [8]). During the period from 1975 – 2015, the average global surface temperature increased by 0.2°C and it is projected to exceed 3°C by 2100, which may result in an increase in sea level between 0.58 – 0.98m [9]. The European Commission projected the annual economic consequences due to global deforestation could be equal to USD 3.7 trillion by 2030 ([10], [11]).

The seriousness of the situation can be gauged by frequent fresh water crisis as the scarce fresh water resources are often shared by two or more countries which may lead to more international conflicts [12]. For example, the US director of national intelligence warned that overuse of water could potentially threaten US national security [13]. In addition, dwindling fresh water resources

are leading to decreased agricultural production. It leads to migration from areas of resources scarcity to areas of perceived opportunity eventually weakening governing institutions and putting undue pressure on local human and environmental infrastructures [14]. Furthermore, air pollution is affecting human health. This principally includes the products of combustion from space heating, power generation or transportation. Pollutants from these sources may not only prove a problem in the immediate vicinity of these sources but can travel long distances and have widespread effects [15].

Lately with the increased social awareness about the ecological imbalances created due to rapid industrialization and excessive consumerism, there has been a growing interest in pursuing sustainable development [16]. This includes initiatives from both the civil society and the governments leading to global legislations for correcting the negative impact of human activities on the environment. The 1997 Kyoto protocol international treaty by United Nations Framework Convention on Climate Change (UNFCCC) was the first agreement by which countries committed to reduce greenhouse gas emissions [17]. The 2015 Paris agreement sets out a global action plan to avoid dangerous climate change by limiting global temperature increases to below 2C [18].

Furthermore, many individuals as well as organizations have done great job in promoting sustainable living like the Nature Conservancy which is providing access to information materials useful to reduce individual impact on the planet [19]; EPA promotes by a variety of methods, tools, guidance and programs with-in decision making [20]. All these quantify the environmental impact produced in support of a particular individual activity or organization's operation either directly or indirectly. This includes an ecological footprint calculator that measures human demand on the earth's ecosystems [21]. It is a standardized measure of the

demand for natural capital that may be contrasted with the planet's ecological capacity to regenerate.

As part of my Masters Dissertation thesis I have tried to develop an improved Personal environmental footprint calculator with improved questionnaire for in-depth analysis and greater precision.

## **1.2.Expectation**

There is a serious mismatch between the rate of environmental change and our ability to comprehend it [22]. Countries undergoing rapid industrialization shows greater rate of human transformation which can be observed from their lifestyle and carbon footprint. Current trend of having personal transport and excessive food, water and energy consumption has led to enormous stress on our natural resources which are not unlimited [23]. Consequently, excessive waste generation over last few decades has created huge logistical problem. This has its manifestations in unregulated waste disposal leading to health-related problems [24].

The personal environmental footprint calculator concept is a way to roughly measure the impact of a person's daily and long-term choices on the environment. If we were to assess the impact of our daily lifestyle on our environment using environmental footprint calculator, we would be astonished by the rate at which we are degrading our environment [25]. Additionally, this also serves as the eye opener as to how by making intelligent choices like public transport, sharing or recycling, we can limit the damage. It can also be a beginning of increased awareness about the delicate balance of the planet. Upon using this tool one may be able to better understand the impact of their choices on the earth.

By incorporating these choices in our “My Footprint Calculator” with more simplified, user-friendly and elaborate questionnaires we intend to come-up with more precise impact of our daily routine. This includes water usage pattern, food consumption, energy appliances usage and waste management.

### **1.3.Background**

"My Footprint Calculator" is a web site and mobile app that calculates the environmental impact produced by the user's everyday activities, puts it into perspective, and gives tips on how to reduce each person's impact. The original "Personal Environmental Impact Calculator" was created in 1996 as a class project by a team of University of Wisconsin - Madison graduate students. These students were Sama Bilbao y Leon, Chris Dyson, Stephania Hagemann, Ben Paulos and Mike Rupiper. UW-Madison graduate student Huey Gardner added functionality to the energy calculator in 2006. During the 2012-2013 academic year "My Footprint Calculator" the old "Personal Environmental Impact Calculator" hosted at <http://www.energy.wisc.edu/eic/> moved to <http://www.myfootprintcalculator.com/> and was enhanced and redesigned by a team of Virginia Commonwealth University Computer Science undergraduate students. This team was integrated by Jeff Chow, Trevor Lafalce, Kurtis Orr, Thomas Tomlin and Jeff Honnold. Will Haas, a graduate student in Environmental Sciences, upgraded at the same time all the environmental sciences algorithms used by the calculator.

### **1.4.Problem Statement**

The main aim of this project is sustainability education using “My Footprint Calculator” and is funded by the Dominion Foundation, VCU MNE Department and Data Directions. This involves

performing a revision, expansion and improvement of the calculator to calculate the environmental impact produced by the user's everyday activities, and educate on how to reduce it. Further we would like to make it more attractive to users in particular to middle school, high school and college students.

There are seven main objectives of this project and they are all intimately intertwined and are listed below.

- The questionnaires to gather data about the user's current choices and lifestyle with regards to energy use, water use, transportation, recycling, etc. have been simplified and made more user-friendly.
- The underlying SQL database that drives the tool has been completely redesigned and optimized for fast I/O data access and calculations.
- The results pages have been modified to include informative graphics and diagrams that put in perspective each user's sustainability habits by comparing them with appropriate benchmarks.
- The overall look and design of the website has been changed and modernized. A new logo and associated icons and imagery have been created.
- Up-to-date information about conservation, efficiency and an environmentally friendly lifestyle has been added and appropriately linked in the results page.
- The ability to create personalized user accounts to save each user's results and performance has been added. This feature allows to compare each user's environmental impact against other users, or to assess a user's sustainability improvements over time.

- A forum that allows users to compare results, share lessons learned and successful experiences has been created.

Backed by a detailed set of questions based on scientific evidence and mathematical reasoning, we have tried to contribute towards sustainability education. Through our work, we also intend to cover the gap in studying the role of individuals in environmental sustainability especially in today's consumer driven market economy [26].

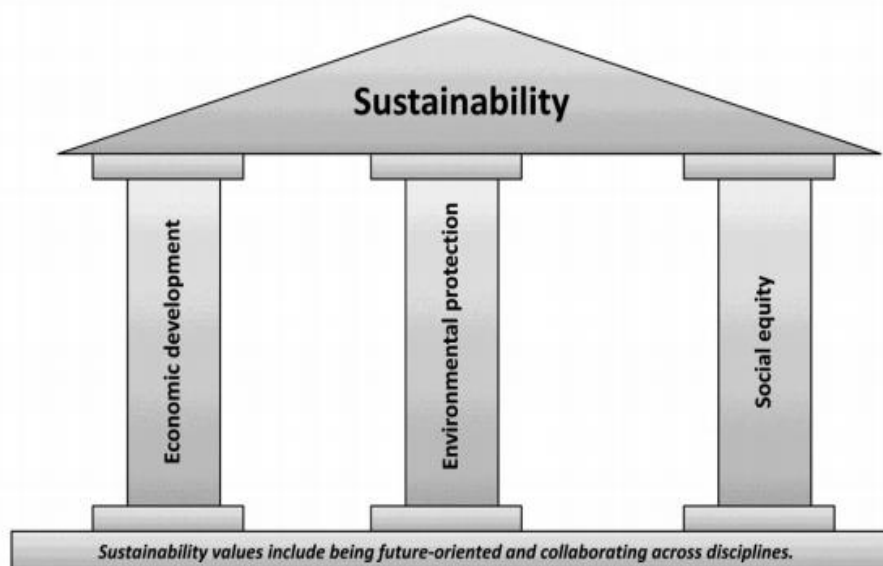
## 2. LITERATURE

The widespread ecological damage due to anthropogenic activities brought to fore the public concern for the environment. A number of environmental concerns, such as threats to biodiversity, pollution, and resource depletion and population growth converged into a movement with both theoretical and political frameworks for ecological concern and action [27]. As an illustration, within the context of climate change, the relationship between carbon dioxide and other greenhouse gases and temperature increases and the remedial action has been known since decades [28].

However, the environmental movement was struggling to gain mainstream momentum; a new theoretically broader terminology encompassing multiple aspects came up. This term ‘sustainability’ was brought into popular use by Lester Brown in his book Building a Sustainable Society, published in 1980 [29]. At the same time in 1980, a major event that is the establishment of World Conservation Strategy by United Nations Environment Program (UNEP) identified the need for long term solutions and the integration of environmental and development objectives. Here as well the program’s strategy mentioned sustainable development. The program in a visionary statement articulated sustainable development as,

*‘This is the kind of development that provides real improvements in the quality of human life and at the same time conserves the vitality and diversity of the Earth. The goal is development that will be sustainable. Today it may seem visionary but it is attainable. To more and more people it also appears our only rational option’.* [30]

Furthermore, a major thrust upon sustainability was laid by the Brundtland Commission report which emphasized the ways in which the world's growing population could meet its needs over the next century. This report defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [31]. This helped in articulating sustainability in a more practical way through its three defined contours social, ecological and economic.



**Figure 1: An example of the "three pillars" model of sustainable development. [32]**

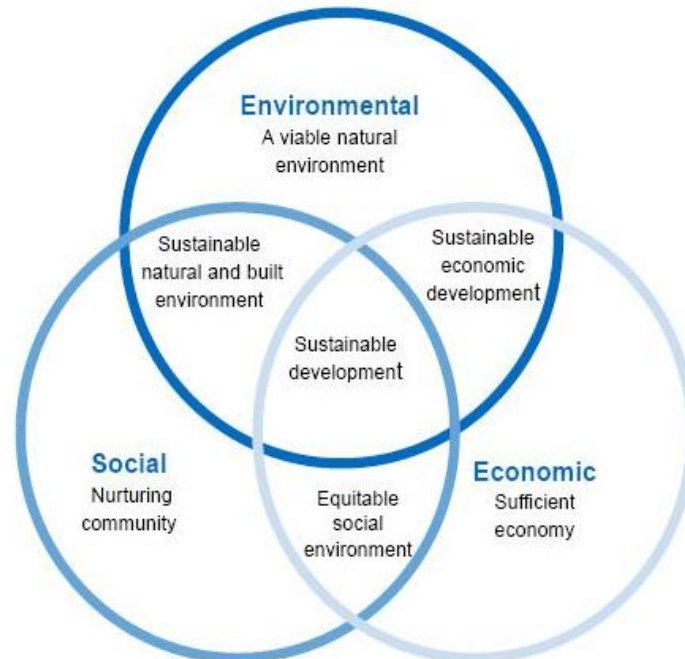
**Environmental sustainability** may be defined as the rate of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. Environmental sustainability can only be supported by sustainable economic growth. This however is an oxymoron as no form of economic growth is indefinite. Thus, sustainability and economic growth cannot go along. This was succinctly explained by noted environmentalist Edward Abbey in his statement



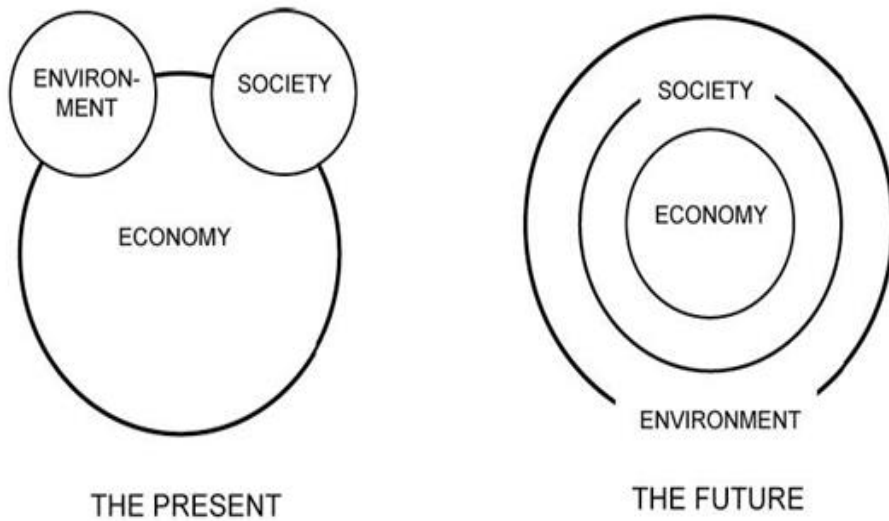
*“Growth for the sake of growth is the ideology of cancer cell” [33]*

**Economic sustainability** involves fiscally responsible decision-making, keeping in mind long-term as well as equitable benefits. This needs both the public and the private sector participation. The projects may be designed in such a way to promote economic growth and sustainability. When good business practices are combined with the social and environmental aspects of sustainability, we can achieve positive results for the greater good of humanity. [34]

**Social sustainability** places us, individuals as the trustees who have the responsibility to create a better society for ourselves as well as future generations. This encompasses human rights, environmental law, and public involvement & participation. Failure to emphasize on the social aspects of decision or action may be detrimental for the efforts to achieve sustainability. [35]



**Figure 2: Sustainability Assessment.** [36]



**Figure 3: Present and Future Relationship between Economy, Society and Environment.**  
[37]

Further support came from *1992 Rio Earth Summit on environment and development*. This summit moved the concept of sustainable development forward in a number of ways. Principle 4 of the Rio Declaration epitomizes this concept by stating that:

*'In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it'.* [38]

The Commission for Sustainable Development (CSD) was set up to ensure that Agenda 21 would have an impact at all levels of governance, which called for national and local sustainable development strategies.

Given the broad consensus for immediate and long-term steps towards sustainability the need of the hour is a concerted effort towards this problem rather than working in silos.

A major drawback of all the major initiatives of sustainability has been lack of coordination and cooperation. Most national and international efforts to solve the problem have focused on one or

the other pillars, but not the three at a time. Major organizations such as United Nations Environmental Programme (UNEP), the environmental protection agencies (EPA) of many nations, and environmental NGOs focus on the environmental pillar while the World Trade Organization (WTO) and the Organization for Economic Cooperation and Development (OECD) focus mostly on economic growth, though the OECD gives some attention to social sustainability, like war reduction and social justice as well. The United Nations has laudably tried to build a general agreement over all the three pillars. Due to severe conflicts of interest between developed and developing countries, this process has been slow. However incremental benefits have been achieved over a period of time. A major contention is also due to the fact that the developing and the poor countries have huge development requirements to uplift their population from poverty and raise their standard of living. It creates a direct conflict between the implementation of sustainability goals and public policy formation in such countries. [39]

The inevitability of the interrelation between the three pillars came out most glaringly during the 2008 economic crisis. Following the economic turmoil, social and environmental programs were the first casualty of budgetary cuts which had cascading effects on environmental sustainability. [40]

Another aspect of sustainability is that it may not bring immediate commercial profits, however it has huge tangible and intangible benefits in the long run. This leaves the whole movement vulnerable and highly dependent upon government or philanthropic support which may be withdrawn anytime. [41]

## **2.1.Sustainable Consumption**

The Oslo Symposium in 1994 defined sustainable consumption and production (SCP) as

*"the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations". [42]*

It aims for optimal resource utilization with minimal wastage. This needs participation from all the stake holders of the society. This process involves constant public outreach to raise awareness about sustainable consumption and educate people about sustainable lifestyle and their benefits. [31]

The challenges in our quest for sustainability are enormous. These are further aggravated by widespread poverty ignorance, illiteracy which tends to impede any progress made in this regard. Further challenges are put up by vested interests that valued commercial benefits over society at large. [43]

Food wastage is one of the major problems, which is mainly restricted to developed and affluent sections of the society. This in turn has implications on the poor and needy. Produce is lost in fields, warehouses, packaging, distribution, supermarkets, restaurants and fridges. By one estimate globally about 1.3 billion tonnes of produce worth about \$1 trillion, is wasted by retailers and consumers every year i.e., one third of all foodstuffs. Huge amount of fresh produce in US is left to rot in the field or dumped due to unrealistic standards. This huge amount of foodstuff may be sufficient to feed millions of people or if this wastage is controlled it might reduce the cost of food which eventually would increase the food accessibility.

Another point of contention is wastage of electricity. By switching to better and energy efficient

appliances we can reduce our energy consumption as well as the carbon dioxide emissions and overall emissions. For example, a global shift to LED lightbulbs may save up the equivalent of 800 million metric tons of CO2 emissions a year, which translates to annual savings of about \$120 billion. [44]

Even though water makes up to 70 percent of the Earth's surface, barely 2.5 percent of it is fit for consumption domestically as well as commercial purposes. Out of that major portion is locked in the Arctic and Antarctica. This leaves a very small amount of water out of the total available for human use. From the beginning, human civilization has prospered along bodies of fresh water. All major cities of the world are situated around fresh water lakes or rivers. This is because of the abundance of fresh water which supports the population. However, with increasing population the pressure on these resources is increasing additionally due to lack of water treatment. Municipal as well as industrial effluents are discharged into the rivers. Even as nature is has robust mechanisms for water replenishment and recycling, the current rate of pollution makes it ineffective. This adversely affects about a quarter of global population which includes more deprived sections who lose large part of their man hours and productivity to gather constituent level water. This cost however is not borne by urban population who get tap water at highly subsidized rates.

## **2.2. Why “Individual Carbon Footprint Calculator”?**

The term “Carbon Footprint” has its genesis in the so called ecological footprint. The Ecological footprint refers to the biologically productive land and sea area required to sustain a given human population expressed as global hectares. [45]

Carbon footprint may be defined as a measurement of the total accumulated carbon dioxide emissions due to anthropogenic activity. The standard unit of measurement for carbon footprints is carbon dioxide equivalents (CO<sub>2</sub>e) [46]. CO<sub>2</sub>e consists of measurements from major greenhouse gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), perfluorocarbons (PFC), hydrofluorocarbons (HFC) and Sulphur hexafluoride (SF<sub>6</sub>). These gases contribute to global warming by accumulating in the atmosphere like a thick, insulating blanket resulting in the greenhouse effect and long term climate changes. [47]

Carbon footprint is measured in CO<sub>2</sub>e rather than carbon dioxide itself in order to include the impact of additional greenhouse gases. CO<sub>2</sub>e is the international standard unit of measurement used for greenhouse gas accounting in businesses, countries, carbon trading, and international agreements like the United Nations Framework Convention on Climate Change (UNFCCC). The international standard unit for CO<sub>2</sub>e is metric tons (tonnes).

The use of the carbon footprint to assess the impact on the environment has enabled qualitative research to be pursued in a standardized and quantitative manner. Further, actionable plans to deal with environmental degradation have been developed on its basis. Correct redressal plans and timely implementation will lead to effective utilization of resources and reduce ecological footprint.

A personal footprint is the emissions caused by an individual's consumption and lifestyle. It is a measure of how a person's lifestyle contributes to climate change. By shrinking their personal footprint, people can limit the effect their lifestyle has on the earth.

Personal footprints normally look at five main issues: transportation, energy, food, water and trash. These categories capture all the major ways personal consumption and lifestyle that can cause greenhouse gas emissions and environmental impact.

A drive to work, a flip of a light switch and a flight out of town often rely on the combustion of fossil fuels like oil, coal and gas. This in turn leads to the emission of greenhouse gases, like CO<sub>2</sub>, that contribute to global warming. Ninety-eight percent of atmospheric CO<sub>2</sub> comes from the combustion of fossil fuels. [48]

The first step towards sustainability is to understand one's own carbon footprint. It helps to identify the major sources of carbon dioxide equivalent emission or unsustainable environmental practices in an individual's daily life. This can be then overcome by following necessary remedial measures by changing one's behavior from the lessons learned.

There are significant benefits, tangible and intangible in measuring and reporting carbon emissions. These are realized by identifying individual consumption and life style changes, which can trickle up into the decision making of businesses and governments based on the influence of individual people.

The use of individual carbon footprint calculator is not suitable for large scale analysis. This is because the individual consumption patterns or carbon footprint cannot be extrapolated to large set of populations such as country or states. Furthermore, personal carbon footprint calculators do not consider imports and exports.

Additionally, such comparisons should be avoided between large geographical units or societies. For example, China may have a very high carbon footprint as compared to the OECD countries however at per capita level the contribution of individuals is very low.

### **2.3.Description of Different Online Personal Calculators**

#### **2.3.1 World Wildlife Fund Footprint Calculator.**

<http://footprint.wwf.org.uk/>

The carbon footprint calculator provided by the World Wildlife fund calculates our footprint score based on a 5-minute questionnaire. The questionnaire consists of questions related to the basic aspects of human life that includes food, travel, home and that are the major sources of carbon dioxide and environmental impact etc.

The questions are primarily concerned with the energy consumption by an individual, means of transport, food expenditure, and monthly expenses on clothing, electronics and also measures taken by an individual to conserve energy. An individual's result is then compared with the world average, and tips are provided to reduce their carbon footprint are provided.

This test is extremely beneficial to every individual as it helps them to evaluate their choice of lifestyle and help them change their habits, which will result in reducing their carbon footprint.

[49]

#### **2.3.2 International Student Carbon Footprint Challenge.**

<http://web.stanford.edu/group/inquiry2insight/cgi-bin/i2sea-r2a/i2s.php?page=fpcalc>

The ISCFCS calculator is one of the most innovative calculators available to calculate an



individual's carbon footprint. It is a student oriented calculator and aims to address the environmental concerns and also find solutions for these environmental challenges.

It consists of 50 questions which pertain to the basic aspects of an individual's life that is food, transportation, home energy and appliances and personal purchases. It asks an individual question regarding their weekly/monthly expenses on food, travel and other household expenses. It also enquires an individual about how much they recycle and reuse products like glass, plastic and paper in their life. At every step, it evaluates an individual's carbon emission levels and compares it with average carbon emission levels in their region as well the world.

In conclusion, it provides an individual's total carbon emission levels and also suggests them to certain changes in their lifestyle which will help them reduce their carbon emission levels and contribute towards building a sustainable planet. [50]

### **2.3.3 carbonfootprint.Com - Home Of Carbon Foot Printing.**

<http://www.carbonfootprint.com/calculator.aspx>

The carbonfootprint.com is another type of carbon footprint calculator. The carbon footprint calculates the annual carbon emission by an individual depending upon his lifestyle. It consists of 6 categories. First the household carbon footprint calculator calculates individual footprint calculator by dividing the amount of energy consumed (in terms of electricity, LPG, heating oil, coal etc.) by the number of people living in the house. Next, the flight carbon footprint calculator allows filling in 3 flight itineraries and calculates the carbon emission. The third is the car carbon footprint calculator which allows filling in details of up to 2 cars and calculates the carbon emission depending on factors like mileage or efficiency of the car. Next is the motorbike carbon footprint calculator which is similar to the car carbon footprint calculator. It also allows filling in

details of up to 2 motorbikes and the carbon emission; calculated on the basis of mileage or efficiency of the bike. Next comes, the public transport footprint calculator which calculates carbon emission on the basis of mileage of the individual on public transport (e.g. bus, coach, commuter train, long distance train, tram, subway and cab). The last is the secondary carbon footprint calculator which calculates carbon emission on the basis of currency spent per year on food and drinks, pharmaceuticals, clothes, textiles shoes, mobile, education etc. Each category consists of individual calculation options and at the end the result of carbon footprint is displayed in terms of metric tons of CO<sub>2</sub>e. [51]

#### **2.3.4 Cool Climate Calculator – Cool Climate Network**

<http://coolclimate.berkeley.edu/carboncalculator>

The Cool Climate footprint calculator is developed by the University of California, Berkeley. This calculator starts by asking an individual their location in USA, the number of people living in their household and the gross annual income of the family. The next segment of the calculator asks information about the number of miles an individual and their family have covered in public transit and air travel in a year. The next segment enquires about expenses of a family on electricity, natural gas and other fuels. It also inquires about the area of the living space an individual lives in and about the average consumption of water by the family per day followed by the next segment which inquires about the average amount of calories consumed per day by a person in terms of meat, dairy products, fruits and vegetables etc. This segment is followed by another segment which asks a person about their expenses on goods and services per month in terms of dollars. The last segment then calculates the carbon footprint in terms of tons CO<sub>2</sub> /

year. It also consists of various pledges to reduce carbon emission and gives us details on the amount of CO<sub>2</sub> saved per year, the number of dollars saved per years etc. [52]

A comparison of different personal footprint calculators for household, energy, transportation, food and goods are reviewed and their differences between each other are presented in the below tables.

**Table 1: Comparison of calculators on Household Consumption**

Calculator	Region	Household		
		Family Size	House Type	House Area
The Nature Conservancy	USA	✓	✓	✓
Conservation International Carbon Calculator	USA & Outside USA	✓		✓
EPA Household Carbon Footprint Calculator	USA	✓	✓	
Australian Greenhouse Calculator	Australia	✓		✓
World Wildlife Footprint Calculator	UK	✓	✓	
Carbonify Calculator	USA & Outside USA		✓	✓
Cool Climate Network	USA	✓		✓

Resurgence Carbondioxide Calculator	USA & Outside USA	✓		
Carbon Footprint Calculator	USA & Outside USA			

**Table 2: Comparison of calculators on Energy Consumption**

Calculator	Energy Consumption					
	Electricity	Natural gas	Propane	Butane	Oil	Coal
The Nature Conservancy	✓					
Conservation International Carbon Calculator	✓	✓	✓		✓	
EPA Household Carbon Footprint Calculator	✓	✓	✓		✓	
Australian Greenhouse Calculator	✓					
World Wildlife Footprint Calculator	✓	✓				✓
Carbonify Calculator	✓					
Cool Climate Network	✓	✓			✓	

Resurgence Carbondioxide Calculator	✓	✓	✓	✓	✓	✓
Carbon Footprint Calculator	✓	✓	✓		✓	✓

**Table 3: Comparison of calculators on Transportation Consumption**

Calculator	Transportation					
	No. of vehicles	Type	Miles per litre	Fuel consumption	Public transport	Air Travel
The Nature Conservancy	✓	✓	✓			✓
Conservation International Carbon Calculator			✓	✓		✓
EPA Household Carbon Footprint Calculator		✓	✓	✓	✓	✓
Australian Greenhouse Calculator		✓	✓		✓	✓
World Wildlife Footprint Calculator	✓			✓	✓	✓
Carbonify Calculator	✓		✓		✓	✓
Cool Climate Network	✓		✓	✓	✓	✓

Resurgence Carbondioxide Calculator	✓	✓	✓	✓	✓	✓
Carbon Footprint Calculator		✓	✓	✓	✓	✓

**Table 4: Comparison of calculators on Food & Goods Consumption**

Calculator	Food & Waste	Goods & Services	Units	Links
The Nature Conservancy		✓	Tons CO2 per year	<a href="http://www.nature.org/greenliving/carboncalculator/index.htm">http://www.nature.org/greenliving/carboncalculator/index.htm</a>
Conservation International Carbon Calculator	✓		Tons CO2 per year	<a href="http://www.conservation.org/act/get_involved/carbon_calculator/Pages/default.aspx">http://www.conservation.org/act/get_involved/carbon_calculator/Pages/default.aspx</a>
EPA Household Carbon Footprint Calculator	✓		Tons CO2	<a href="https://www3.epa.gov/carbon-footprint-calculator/">https://www3.epa.gov/carbon-footprint-calculator/</a>

Australian Greenhouse Calculator	✓	✓	Tons CO2	<a href="http://www.epa.vic.gov.au/AGC/calculator/index.html">http://www.epa.vic.gov.au/AGC/calculator/index.html</a>
World Wildlife Footprint Calculator	✓	✓	Tons CO2 per year	<a href="http://footprint.wwf.org.uk/">http://footprint.wwf.org.uk/</a>
Carbonify Calculator			Tons CO2 per year	<a href="http://www.carbonify.com/carbon-calculator.htm">http://www.carbonify.com/carbon-calculator.htm</a>
Cool Climate Network	✓	✓	Tons CO2 per year	<a href="http://coolclimate.berkeley.edu/calculator">http://coolclimate.berkeley.edu/calculator</a>
Resurgence Carbondioxide Calculator			Tons CO2 per year	<a href="http://www.resurgence.org/resources/carbon-calculator.html">http://www.resurgence.org/resources/carbon-calculator.html</a>
Carbon Footprint Calculator		✓	Metric Tons CO2e per year	<a href="http://calculator.carbonfootprint.com/calculator.aspx">http://calculator.carbonfootprint.com/calculator.aspx</a>

## 2.4. Why “My Footprint Calculator”?

“My Footprint Calculator” is one of the growing numbers of environmental calculators envisioned to broaden and diversify the environmental movement worldwide and to mobilize it as one of the most effective tools to build a healthy sustainable environment and protecting the earth for future generations. At the individual level, we all are contributing to the environmental degradation knowingly or unknowingly. For example every time we turn on a light, travel by car, switch on a TV, or use anything that requires energy.

Identifying the problem is the first step towards finding solution. So, “My Footprint Calculator” has been developed to educate as well as to provide a critical analysis of habitual consumption choices made by individuals. It has a series of surveys used to compile information regarding the user’s consumption in five categories (Transportation, Energy, Water, Food and Trash). Before thinking about efficient ways to reduce our impact on the planet, we must understand our current impact on the environment. So, each category survey has a corresponding model which is used to generate emissions and benchmarking data that is then displayed to the user, along with the information directed to reducing the user’s environmental impact.

In this tool, each type of sustainable category has been individually emphasized. This helps a more focused approach towards each category and the needy remedial measures for creating a sustainable lifestyle. An illustration in this case would be, a person living close to the work place or school need not focus on transportation and concentrate on the rest of the categories like energy, food, water, trash where we can do many things to reduce our impact and save energy and money at the same time.



“My Footprint Calculator” is highly informative and easy to use. Also, it is potentially useful tool for users to encourage bottom-up change in consumption behavior. Furthermore, it helps the user to get engaged with the tool by analyzing their impact from time to time and sharing their experiences with other users. In this process the user gets interested in new information and the impact of individual consumption on society and the environment, and even gets motivated to shift towards a more sustainable behavior. Additionally, “My Footprint Calculator” is also supplemented with additional data from other databases. The results allow the users to compare with their state per capita CO<sub>2</sub>e as well as their and other countries per capita CO<sub>2</sub>e. This way “My Footprint Calculator” allows the comparative analysis for better assessment of one’s lifestyle. “My Footprint Calculator” doesn't involve grand, sweeping gestures but it educates individuals in a small way, such as turning off a light when leaving the room or buying energy-efficient appliances, and powering down computers. Performing these small activities can build up to a reduction of the carbon footprint in the long run.

To put the above ideas and improvements into practice we designed and developed a program for “My Footprint Calculator”. For this purpose, we used many development tools to test and debug our code.

### **2.5.What are the “Development tools”?**

There is a vast selection of open source developing tools available for building a dynamic website. However, for the purpose of this thesis, the tools have been narrowed down only to those necessary for the development of this project. Therefore, this section of the thesis introduces and further describes all the tools and technology implemented into the project at hand.

### **2.5.1 HTML5**

HTML5 is the latest version of HTML (Hyper Text Mark-up Language) released in 2011 by World Wide Web Consortium (W3C). Several of the features of HTML5 such as rich media support, enhanced support for web applications that can interact with the users, their local data, and servers were helpful in designing “My Footprint Calculator”. It helped to create a basic prototype to communicate information over the World Wide Web. The standout advantage for using HTML for developing “My Footprint Calculator” is it was supported by all browsers.

### **2.5.2 CSS3**

CSS (Cascade Style Sheet) is the key file that styles or designs all the HTML modules in a website. It allows the user to separate the website’s HTML content from its style [53]. It brought interactivity and design flexibility for “My Footprint Calculator” development. It makes customization much easier and helped to create different look for each page. It improved website loading time which makes browsing the website faster and enhanced the overall user experience.

### **2.5.3 PHP**

PHP is a recursive acronym for PHP: Hypertext Pre-processor which is widely used as an open source server side scripting language. PHP is executed in the server and embedded in HTML. It is used to manage dynamic content, databases, session tracking [54]. It is used in designing “My Footprint Calculator” because after the PHP code has been interpreted and executed in the server, it returns to the browser in plain HTML format, which gives no information to the client about the used PHP in the codes and helps to secure the website against viruses and threats. It is

compatible with almost all servers available on the market and runs on various computing platforms.

#### **2.5.4 JavaScript**

JavaScript is a popular and commonly used object-oriented dynamic scripting language for dynamic interactivity on websites along with markup language HTML. JavaScript is used in “My Footprint Calculator” to make it a dynamic website as HTML page is a static one without it. JavaScript made the website more interactive and user friendly by providing easy navigation. Its main features are types and operators, core objects, and methods. Its syntax originates from the Java and C languages; hence many structures from these languages also apply to JavaScript.

#### **2.5.5 JQuery**

JQuery is a cross-platform JavaScript library. It is designed to facilitate the use of JavaScript on the client-side scripting of HTML and other interactions on a web page by adding or removing style sheets. It is a free and open-source programming language licensed under the MIT license. JQuery’s syntax makes it easier to navigate a document, select DOM (Document Object Model) elements, create animations, handle events and develop Ajax applications [55]. In this project, jQuery is used alongside with the JavaScript as part of the flexible user interface. The most important reason to use JQuery versus other JavaScript libraries in “My Footprint Calculator” is that it does not take away from the visibility of web page content from the search engines.

#### **2.5.6 MySQLi**

MySQL is an open source SQL (Structured Query Language) relational database management system (RDBMS) which is being developed, distributed and supported by Oracle Corporation.

Similarly, MySQL server is the server used to manage data stored in a computer's database, thus in this project a FatCow server is used in which MySQL handles the database components. There are three MySQL major application programming interface (API) options used for "My Footprint Calculator" database designing which provide connectors to a variety of programming languages, including PHP:

- PHP's MySQL extension
- PHP's MySQLi extension
- PHP Data Objects (PDO) [54]

Each of these extensions has its own advantages and disadvantages. Firstly, the MySQL extension serves the purpose of developing PHP applications that interact with the interface. Next, the MySQLi extension, also known as MySQL improved extension, has been used in order to take advantage of the new features found in MySQL systems versions 4.1.3 and later. The MySQLi extension is object-oriented; provided support for prepared statements, multiple statements and transactions; offers enhanced debugging capabilities; and possess embedded server support. Being an object-oriented interface, the MySQLi extension also provided a procedural interface. Finally, PDO is used as a database abstraction layer especially created for PHP applications.

### **2.5.7 Bootstrap**

Bootstrap is one of the free and open-source front-end web frameworks for designing websites. It helps to level out browser differences for various page elements. It also provides typography, modern look and powerful grid system. Bootstrap is used in "My Footprint Calculator" to scale the website design from the smallest mobile device to high definition displays. It also helped to

avoid spending huge amount of time in writing complex CSS and JavaScript codes. The standout advantage of using bootstrap for “My Footprint Calculator” is its customization and consistency.

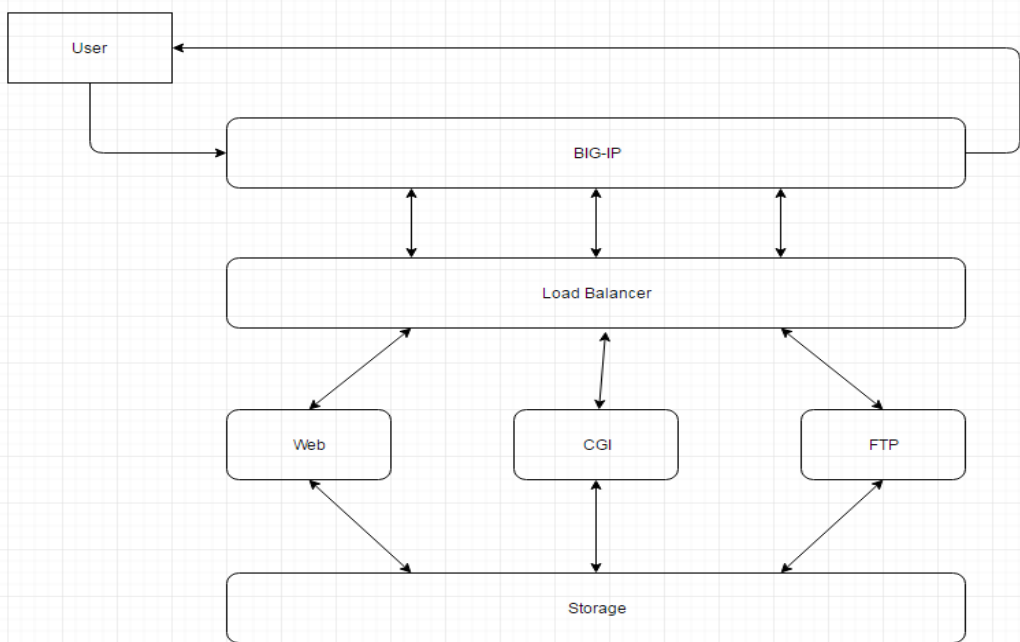
### **2.5.8 Filezilla**

FileZilla is an open source, cross-platform FTP (File Transfer Protocol) application. For the deployment of “My Footprint Calculator” on the Fatcow server, the FileZilla is used as a tool. As “My Footprint Calculator” development was done locally, FileZilla is used in order to host the web application by transferring all the files created during development. During the file transfer all the information related to the transfer, such as speed, queued files, number of files transferred and failed transfer are displayed. Another interesting feature of this tool is that it displays the permissions values set for individual files.

### **2.5.9 Web Server Software: FatCow**

FatCow is an annually paid web hosting service that allows individuals and organizations to make their website accessible via the World Wide Web is used to build and test “My Footprint Calculator”. For “My Footprint Calculator”, FatCow is used to host as it offers stable and redundant hosting environment built on state-of-the-art technologies. By hosting “My Footprint Calculator” in FatCow get supported by dual routers for greater redundancy, NetApp storage clusters for improved reliability, a state-of-the-art Cisco PIX firewall for tighter security, and a new gigabit network connection for better performance. “My Footprint Calculator” is accessed by visitors via fast (OC3), triply redundant Internet connections. As the web and e-mail files are served through a farm of load-balanced Linux machines that utilize Apache Web server software, the site will load quickly and will not be impacted by the performance of any one machine. The end result is a carrier-class shared-hosting infrastructure that offers an extremely reliable and

secure hosting environment for clients. In FatCow the Site data is parsed by load balancers and is then managed by high quality servers, which are split into application pools (Web, FTP, incoming mail, etc.). This type of architecture allows to customize each machine to the service it performs, which means more density per box, and ultimately, faster and more reliable services. The network-attached storage in the FatCow enables any machine to access a customer's data. Every machine is clustered with another identical machine that will seamlessly take over if the primary unit crashes. These units are also backed up to another set of storage units that have a mirror copy of the data in case of disk failure in the primary units. The Front-end network consists of redundant routers connecting to the world over multiple.



**Figure 4: FatCow hosting architecture**

### 2.5.10 Text Editor

There are many available open source text editors that support multiple programming languages, such as PHP, C++, HTML, CSS and others. For web development, text editors such Adobe

Dreamweaver, Notepad, Notepad++, Sublime text, Bluefish and many others can be used. Some of these text editors are free to use, meanwhile, others are purchasable from their official sites. In this project, Notepad++ editor was utilized.

### 3. WEBSITE DESIGN AND MODELING

#### 3.1.Overview on Web Design and Development

“My Footprint Calculator” is a website to explain sustainable lifestyle in a most convenient way to present and disseminate information to the maximum number of people in the world. The web browsers are the means to render the information on a webpage, the basic building blocks of a website which has the basic structure (architecture) written in a web program. It is probably the most economic and the most convenient way to disseminate information all over the world.

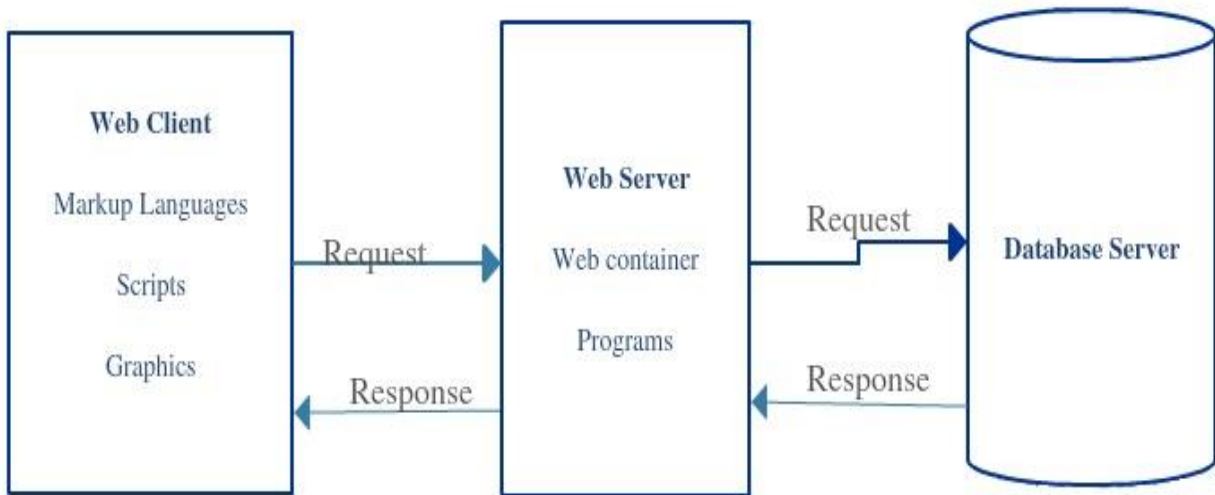


Figure 5: Server Architecture

#### 3.1.1 Client Side Design:

Client Side is the actual interface for the user. The application such as web browser (such as Google Chrome or Safari or Mozilla Firefox) on the user’s machine sends a request to the web server running on the server machine. The web server then either sends an existing page to the



Client machine or generates a new page and sends to the client machine accordingly. The client side web page is typically constructed by HTML, CSS and Java Script.

### **3.1.2 Server Side Design:**

Server side is the logical controlling part of the website. The web container running under the server machine handles the client request, validates with the server side program (written in PHP, Java Script) and then generates an appropriate page or locates an existing appropriate page and sends that page to the client side. The Server side pages are typically written in PHP, Java Script.

### **3.1.3 Database Design:**

A Database is typically at the back end of the client-server architecture. The data stored in the database is gathered, organized and designed in a sophisticated logical manner (such as RDBMS) and stored in one or more tables. The web server can pull up data with the help of a database server (such as MySQL), fit it into a web page and send it to the client machine.

## **3.2.Component wise “My Footprint Calculator” Analysis and Design**

### **3.2.1 Client Side Design Components**

- Programs use: HTML, CSS, JavaScript.
- Function: Direct Client Interface, Getting user input and do some computation.
- Common interfacing environment: Web browser.
- Objectives: Error free, well formatted layout and text, user interactive, ease of use, informative, cross browser supporting.

### 3.2.2 Server Side Design Components

- Programs use: HTML, CSS, JavaScript, PHP and Database Programs (MySQL) to interact with Database server.
- Environment: IIS, Apache.
- Function: Grabbing the information from client side sent by user, perform some computation, validate input, request access to the database, handle the executed query from the database (Add, Delete, Modify or Access the database) and generate the appropriate webpage to be rendered in the client side.
- Objectives: Error free program-computation, error free execution of server program, scripts and markup language.

### 3.2.3 Database Design Components

- Program use to access: MySQL.
- Design Tools: DBMS / RDBMS.
- Objectives: Reliability of Information stored, well organized or designed logical structure and appropriate relation among entities, following a defined structure such as RDBMS.

### 3.3. Advantages of “My Footprint Calculator” As a Website

- During this latest revision, it was decided to deemphasize the use of an app, and focus all the development work in the website. With our current ability to design screen-size adaptive websites that are user friendly in any device, the usefulness of creating an independent app was not obvious.

- At the present technology users are looking at the internet for gaining knowledge. It is unthinkable to have a platform to promote sustainable lifestyle without a website. To have a poor design or outdated website has a big impact on the users view toward the vision. Providing good information and a well-organized website has a big role in winning users interest on the vision. A well-organized website is the best media to promote sustainable lifestyle by strengthening credibility.
- A well-organized and a user-friendly website can create a very good impression on users. To create it we have to consider the design and color scheme we are using in the website, in addition to loading time and picture arrangements which play a very big role.
- One of the advantages of having a website is that users can visit/use anytime of the day and understand their impact on the environment. As long as our server is running users can visit our website anywhere in the world as long as they have internet access.

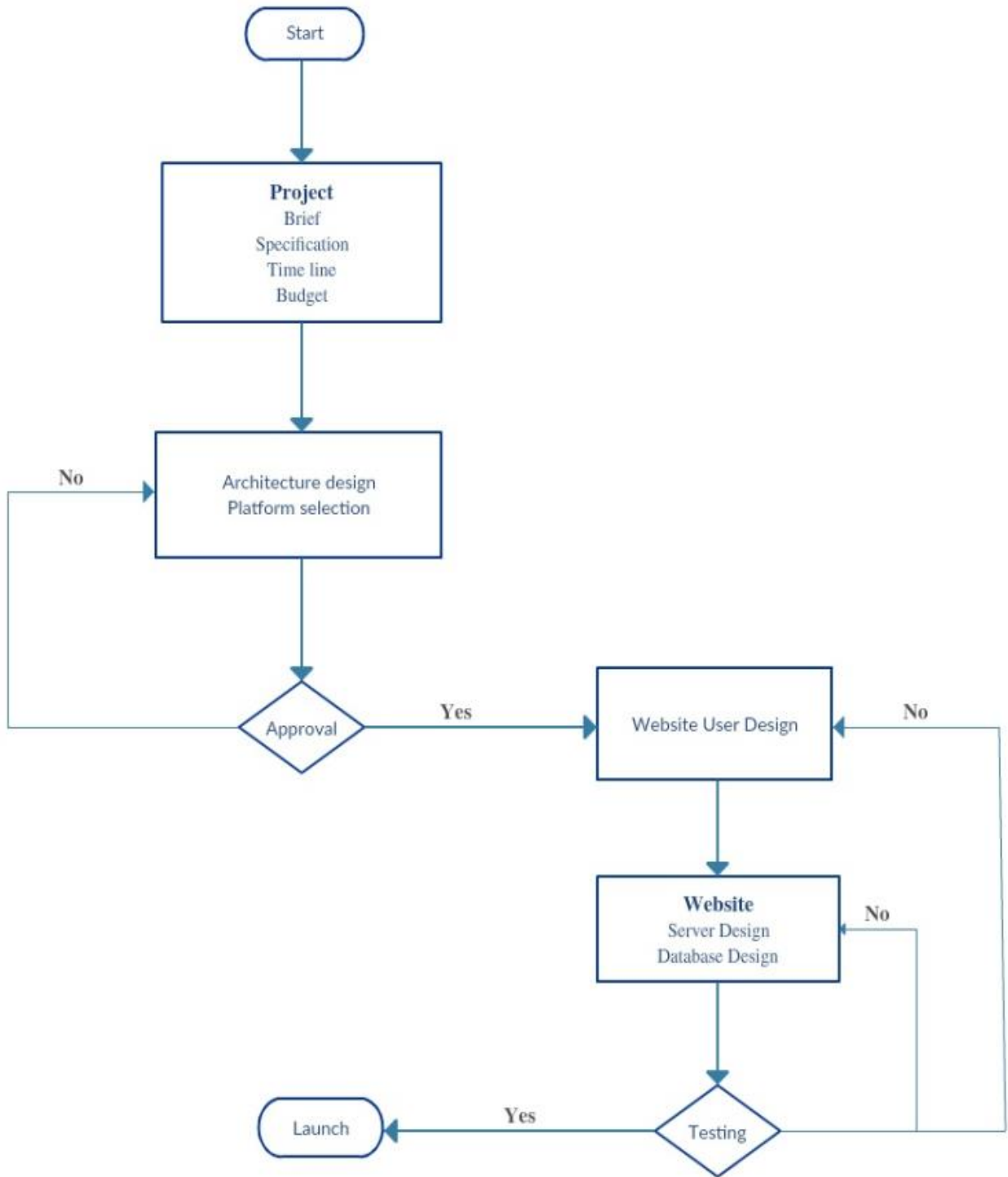
### **3.4.Optimization**

Optimization is defined as to write or rewrite instructions in a program so as to maximize its efficiency and speed in retrieval, storage or execution. In the present day, we have different search engines, devices, operating systems, web browsers, screen sizes etc. Website optimization involves making a website compatible to these different factors that can affect website appearance and factions. There are different platforms for website optimization like browser optimization, search engine optimization, etc. A search engine optimization is a program that searches for and identifies items in a database that correspond to keywords or characters specified by the user, used especially for finding particular information on the internet.

Most people uses daily a major search engines like Google to find information, analyses, etc. Websites that appeal on the first page of a search results inevitably attract more users. Again, if we provide good information, we attract more users, and the combination of quality information, promoting sustainable lifestyle is a right product with a first page result will undoubtedly accomplish the vision to broaden and diversify the environmental movement. This will in then mobilize “My Footprint Calculator” as the most effective tool to build a healthy and sustainable environment. It is an intuitive and inexpensive form of education that promotes the reduction of individual carbon footprint. With website optimization we can promote sustainable lifestyle around the world instantly.

### **3.5.Work Flow**

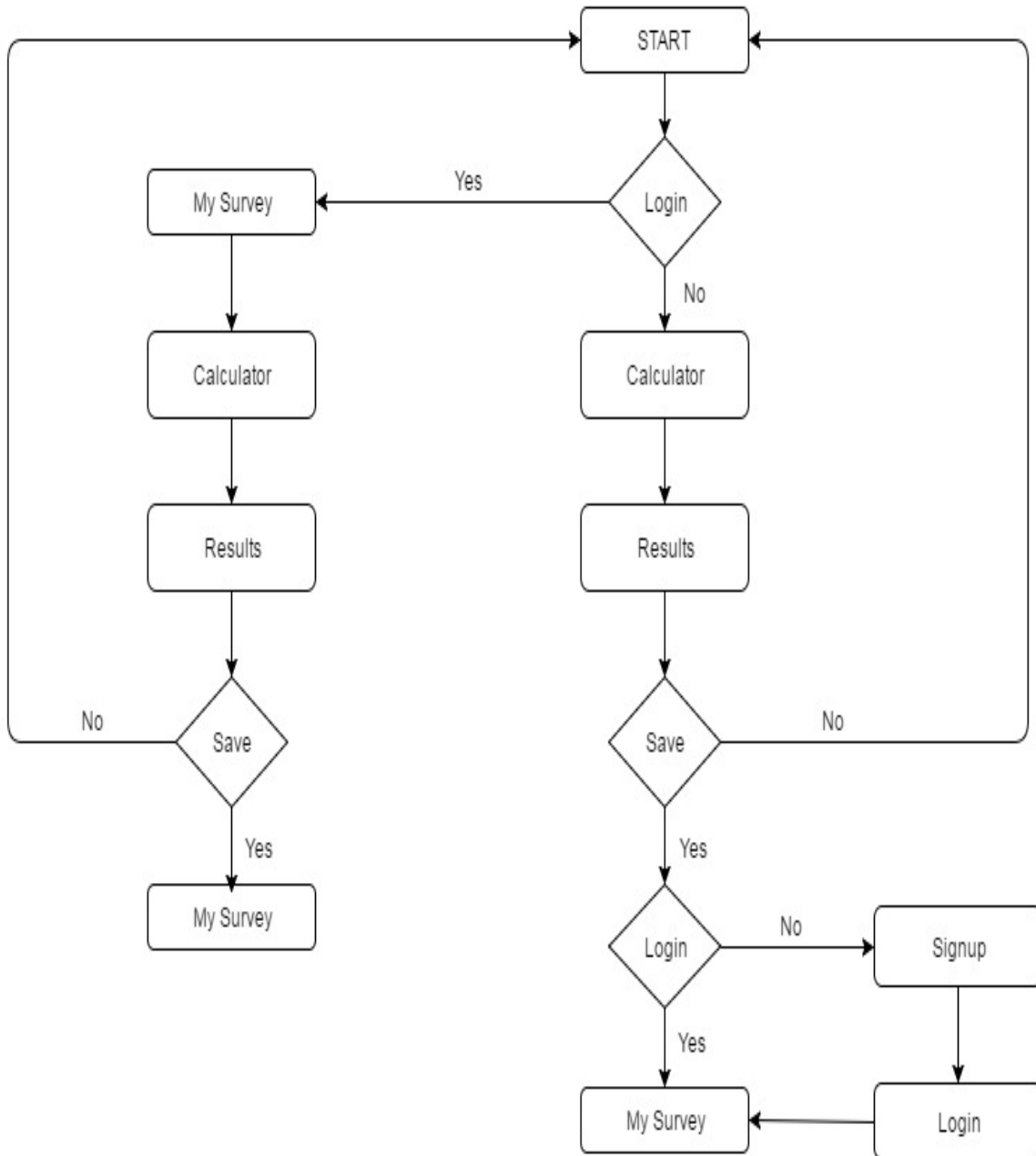
Workflow is often defined as the relationship between the activities in the project as it moves from start to finish. Designing a workflow diagram will help to identify faults and increase the time usage. The diagram below is followed to design and develop “My Footprint Calculator”.



**Figure 6: Work Flow Diagram for My Footprint Calculator**

**3.6.Front-end**

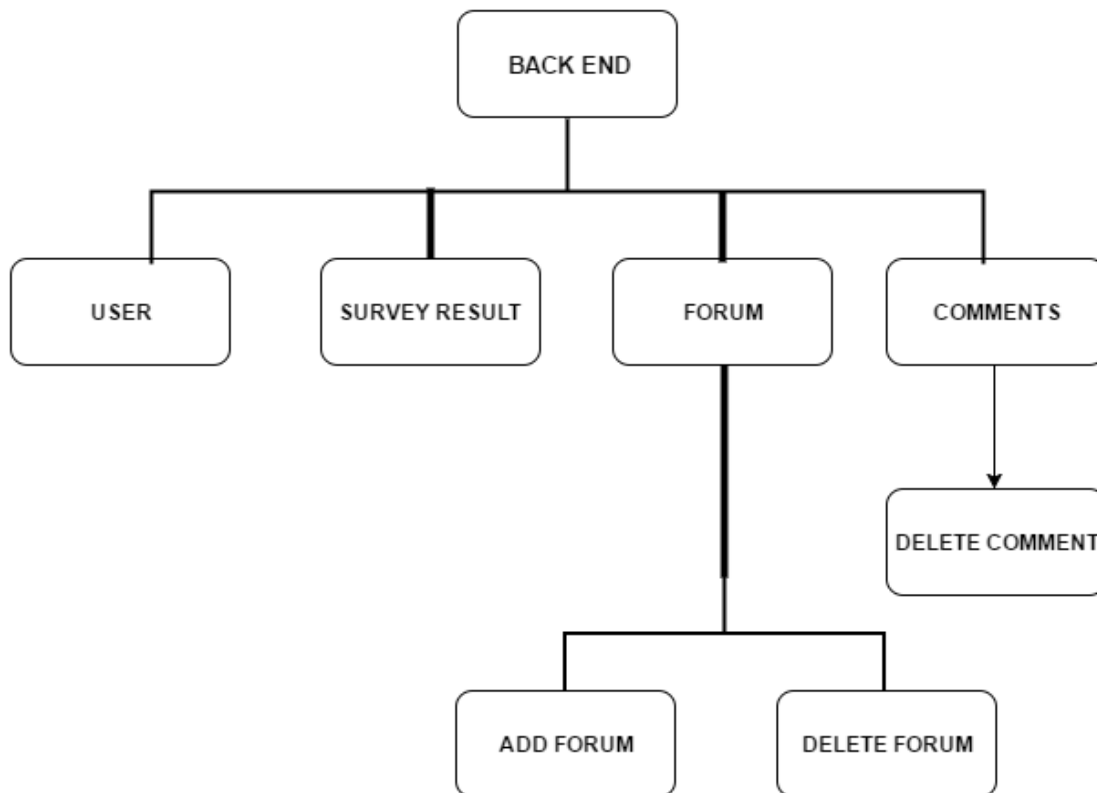
The front-end side has part of the My Footprint Calculator that users can visualize and interact with it. It displays user registration, login / logout, My Survey, Home, About, Calculator, Forum, Contact and Tips pages. Each page has its sub-sections that user walk around.



**Figure 7: Front-End User Diagram for My Footprint Calculator**

- The about page disclose the team behind the development of My Footprint Calculator and their thoughts. It also explains the importance of transportation, food, energy, water and trash in the human lifestyle.
- The calculator page has the five categories of transportation, food, energy, water and trash that promote sustainable lifestyle through the survey questionnaire.
- The forum page shows the five categories as menu and gives an opportunity to the users to choose a type and participate in the existing discussion or start a new thread.
- The contact page displays the contact information for the user to send their ideas / questions / comments to the developers.

### 3.7.Back-end



**Figure 8: Back-End Admin Diagram for My Footprint Calculator**

Back-end side has part of the My Footprint Calculator that is managed by the administrator. Category management, query management, user management, forum management and result management are done by insert, delete, and edit operations.

### 3.8.Database Design

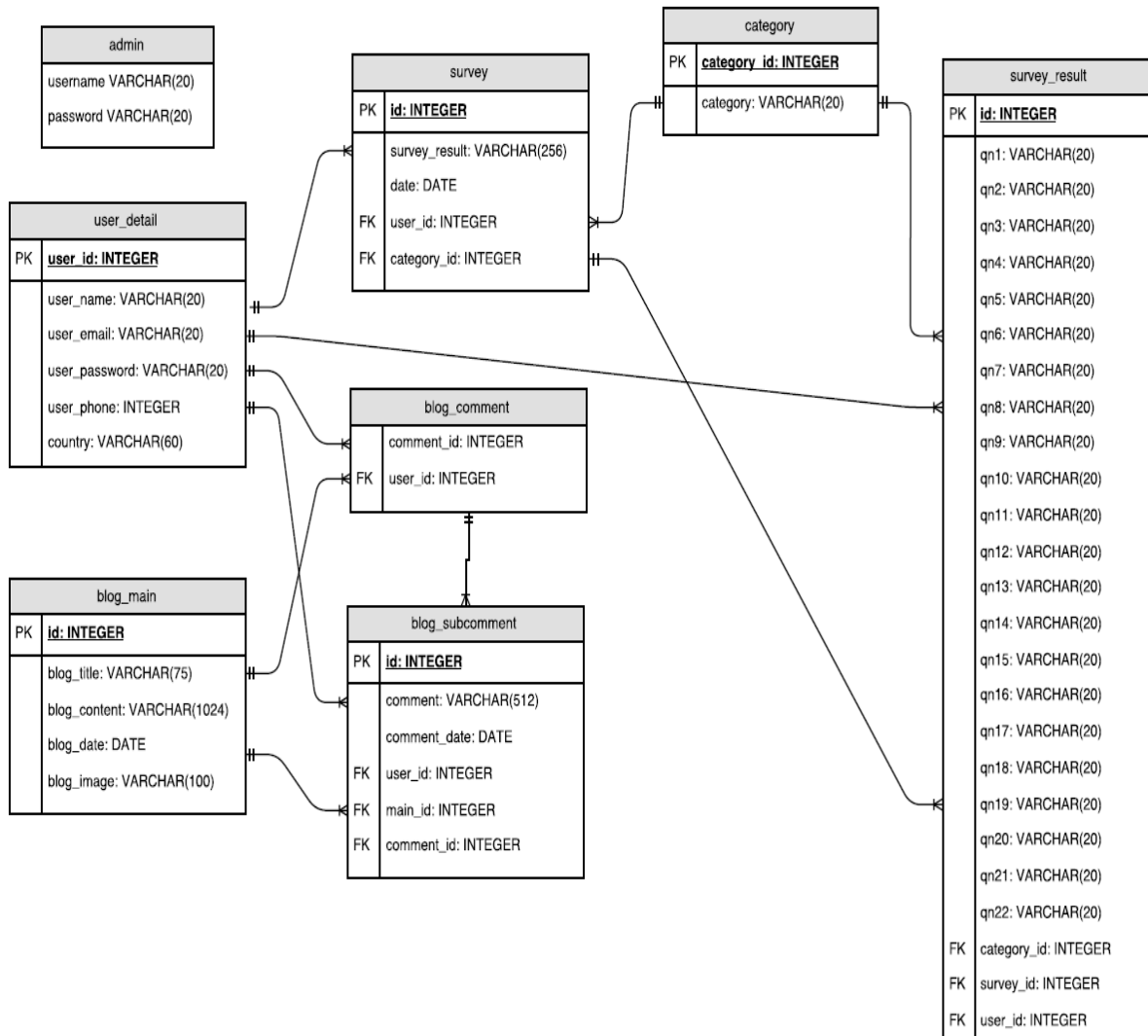
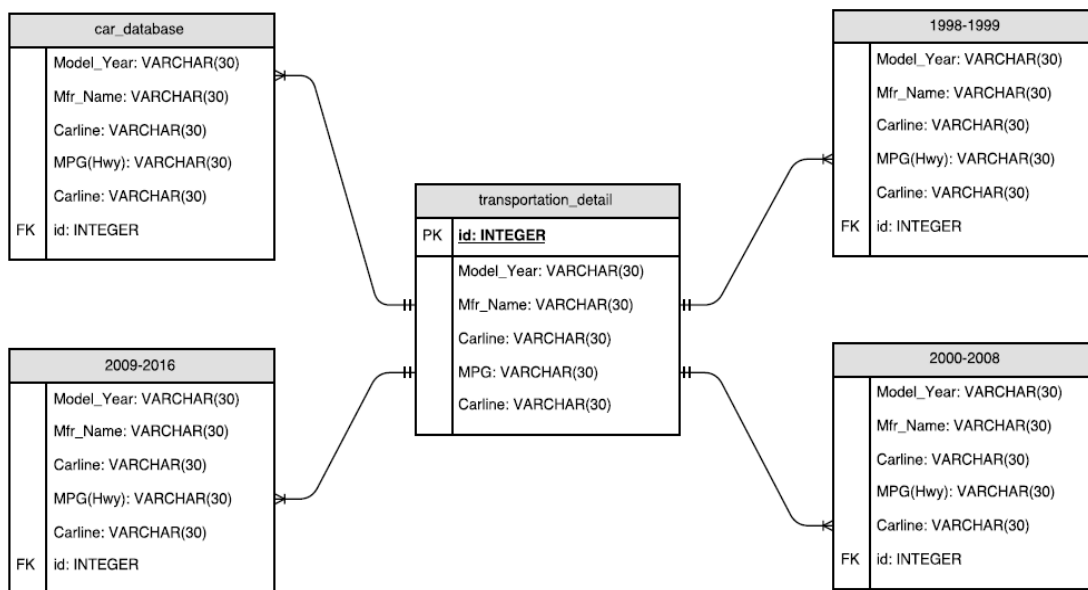


Figure 9: Relation Diagram of My Footprint Calculator

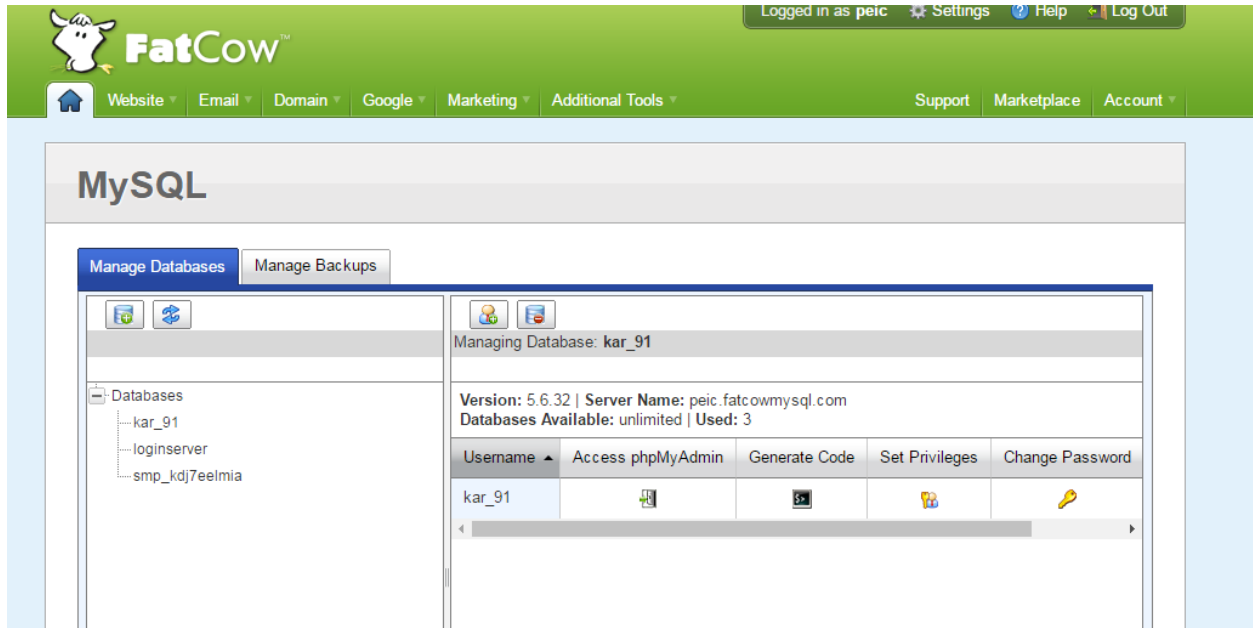




**Figure 10: Relation Diagram of My Footprint Calculator Car Query**

The relational database diagram shown above in Figure 9 gives the blueprint of how the My Footprint Calculator database is constructed. The relationships provided a logical connection between different tables of My Footprint Calculator. Figure 10 shows the flow for a car query to select from a list of various manufacturers and their car model lines.

My Footprint Calculator database is created in the Fatcow webhosting server. Once login into it, we can find the v-deck control panel which is like a home base of the website having a list of icons is a tool. For the creation of a database, click on the My SQL database icon which leads into MYSQL page.



**Figure 11: MYSQL home page in FatCow Server**

By clicking on the Add Database icon, it asks to fill the fields Database Name, Username, Password and Confirm Password. After filling those fields, we can click the “add database” button. It creates the database. From Figure 11, we can observe username kar\_91 database with server name as peic.fatcowmysql.com. Next using Access phpMyAdmin button, will be guided to mysqladmin page. Using generate code button we can generate php code for creating database.

## 4. USER EXPERIENCE

The 2016 homepage looks like as shown in below figure.



**Figure 12: 2016 Look of My Footprint Calculator**

The old look was modified into the current look as shown in figure 13. The homepage user interface consists of header, index and footer php files. For most of the front-end pages the same header and footer files are used. Figure 14 shows the newest look for the site, prepared by Data Directions. This is what we will refer to as the “2017 Look” and it will be the ultimate design.

User operations are designed for users to login and sign in. After user login, user can start a quiz from “Calculator” page or view his previous results in “My Survey” page. This menu appears on the right top of each webpage for easy user access.

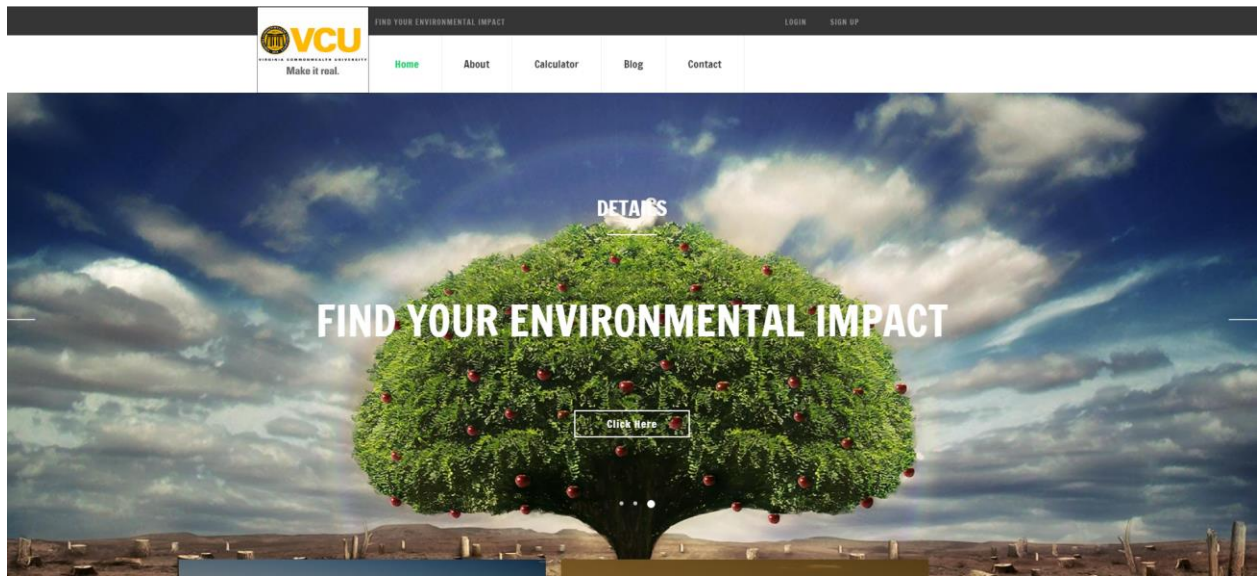


Figure 13: Current Look of My Footprint Calculator

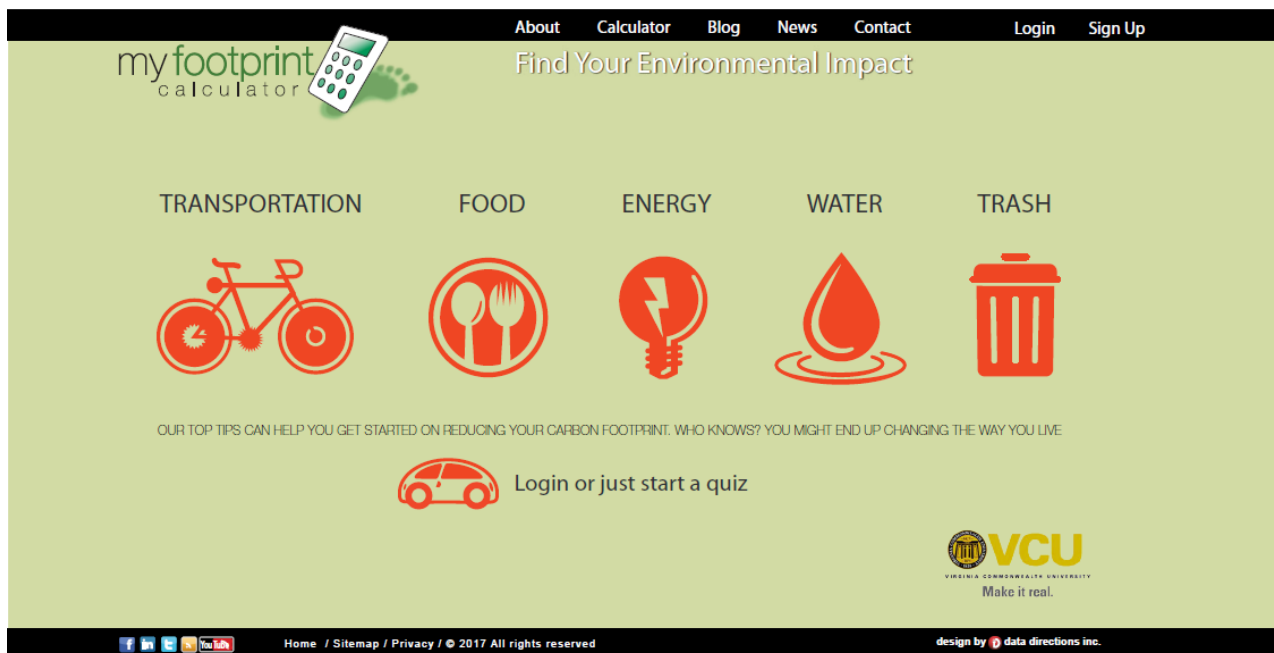


Figure 14: 2017 Home Page of My Footprint Calculator

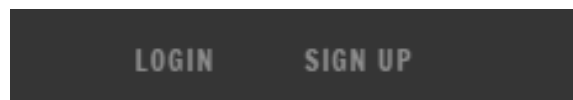


Figure 15: User Operation before Login (Current Look)



**Figure 16: User Operation after Login (Current Look)**



**Figure 17: Navigation Bar (Current Look)**

The navigation bar is the panel that contains links to the key sections of the website.

A login form with a title "LOGIN" and a small asterisk icon on the right. Below the title is a horizontal line. The form contains two labels: "Email:" and "Password:", each followed by a rectangular input field.

**Figure 18: Login Sheet of My Footprint Calculator (Current Look)**

## SIGN UP

\*

**Name:**

**Email:**

**Select Country:**

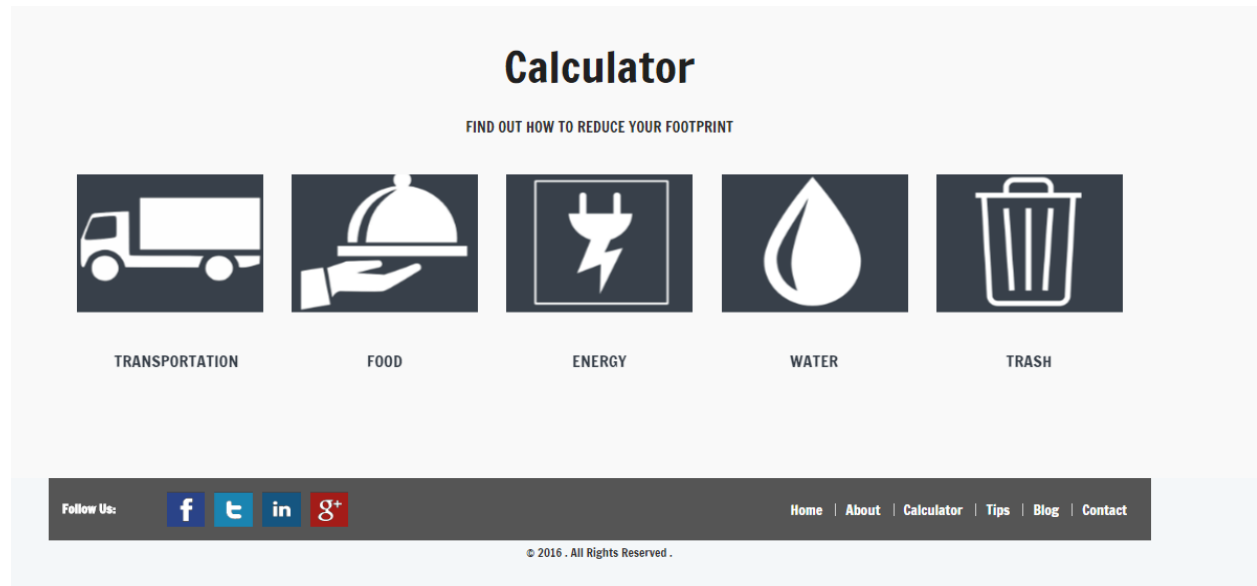
**Password:**

**Confirm Password:**

**Phone Number:**

Sign Up

**Figure 19: Signup Sheet of My Footprint Calculator (Current Look)**



**Figure 20: Calculator Page of My Footprint Calculator (Current Look)**

The “Calculator” page displays the five categories of sustainable lifestyle. These categories help the users to find their personal environmental impact over atmosphere.

The blog page helps the users to interact, discuss about the environmental issues, and generate ideas on a topic or on a reading. It also helps the users to create an informal discussion space to raise questions and raise thoughts. It is an effective platform to exchange ideas and information with others who have the same interests. If the user wants to take part in any discussions they need to sign up as a member first.



**Figure 21: Blog Page of My Footprint Calculator (Current Look)**

The sample streamlined questionnaire for transportation can be seen in Figure 22. The transportation survey includes questionnaires for common vehicle emissions, rail travel emissions, bus travel emissions and air travel emissions. After the user submits his response by clicking “show survey result” button, the user will be transferred to the transportation results page. In the transportation results page the summation of all these type questionnaires is done in the background and the total emissions from transportation habits are displayed. Here the user can either save his survey or delete his survey by clicking on the respective buttons. If the user wants to save his survey results, the tool checks the user login status; if not logged-in it requests the user to login. Once the system confirms that the user is logged-in, the results are saved into the database. In the next step the user can either check his survey results in the “My Survey”



page or continue with another category of sustainable lifestyle or logout from the system. Similarly, other categories also have an improved questionnaire.

## Transportation

FIND OUT HOW TO REDUCE YOUR FOOTPRINT

### 1. Common Vehicle

**Qn 1. When traveling (as a driver or a passenger) what is the vehicle most commonly used?**

Select an option

**Qn 2. How many miles/kilometers do you travel in the most commonly used vehicle during a typical week?**

Select a unit

0 to 3000

**Qn 3. How many miles/kilometers per gallon does your vehicle get during a typical week?**

Model Year :  MFR Name :  Carline :  MPG :

--Select year--

**Qn 4. While traveling in the most commonly used vehicle, what percentage of the time do you travel with other passengers?**

%

0 to 100

**Qn 5. When traveling with others in the most commonly used vehicle, how many people besides you are typically in the vehicle?**

X people

1 to 6

**Figure 22: Sample Transportation Survey Page of My Footprint Calculator (Current Look)**

# Food

FIND OUT HOW TO REDUCE YOUR FOOTPRINT

## 1. Calories

Qn 1. How many calories do you eat in atypical day?

 cal

## 2. Beef

Qn 2. How often do you eat beef?

## 3. Chicken

Qn 3. How often do you eat chicken?

## 4. Pork

Qn 4. How often do you eat pork?

**Figure 23: Sample Food Survey Page of My Footprint Calculator (Current Look)**

The food survey includes calories, beef, chicken, pork, fish, dairy, shopping, organic, food waste and frozen emission questionnaires covering all day to day eating habits of a common user.

The energy survey includes residency, heating, cooling, dish washing, laundry, and water heating, refrigerator, lighting, computer and television emission questionnaires covering all day to day energy usage activities of a common user.

# Energy

FIND OUT HOW TO REDUCE YOUR FOOTPRINT

## 1. Residency

Qn 1. How many people live in your house?

Qn 2. Do you live in?

Qn 3. What is the square footage of your residence?

 sq. ft.

## 2. Heating

Qn 4. When heating your home, at what temperature do you set your thermostat?

Qn 5. Approximately how many hours per day do you heat your home?

Qn 6. Approximately how many months per year do you heat your home?

Qn 7. What method do you use to heat your home?

**Figure 24: Sample Energy Survey Page of My Footprint Calculator (Current Look)**

The water survey includes shower, toilet, washing machine, dish washer, swimming pool, lawn and source of water emission questionnaires covering all day to day water consuming activities of a common user.

The trash survey includes cans, newspapers, plastic, and glass bottle, mixed paper, waste and purchasing emission questionnaires covering major recycling items of a common user. After the user submits his responses by clicking “show survey result” button, the same process will be continued as explained in transportation.

# Water

FIND OUT HOW TO REDUCE YOUR FOOTPRINT

## 1. Shower

Qn 1. How many baths do you take per week?

 baths

Qn 2. How many showers a week do you take?

 showers

Qn 3. How long does your typical shower last?

 minutes

Qn 4. Do you use a high efficiency showerhead?

## 2. Toilet

Qn 5. What type of toilet does your place of residence use?

Qn 6. Do you take any measures to reduce the amount of leakage in your toilet (such regularly replacing the seals)?

Figure 25: Sample Water Survey Page of My Footprint Calculator (Current Look)

# Trash

FIND OUT HOW TO REDUCE YOUR FOOTPRINT

## 1. Cans

Qn 1. How many aluminum cans (soda, juice, beer, ect.) do you purchase during a typical week?

 X Cans per week

Qn 2. What percentage of these cans do you recycle?

 1 100 X%

## 2. Newspapers

Qn 3. How many newspapers do you purchase during a typical week?

 X Newspapers per week

Qn 4. What percentage of these newspapers do you recycle?

 1 100 X%

Figure 26: Sample Trash Survey Page of My Footprint Calculator (Current Look)

The total emissions of each category will be displayed in their respective results. The calculations of total emissions for each category are shown in the Appendix section. The

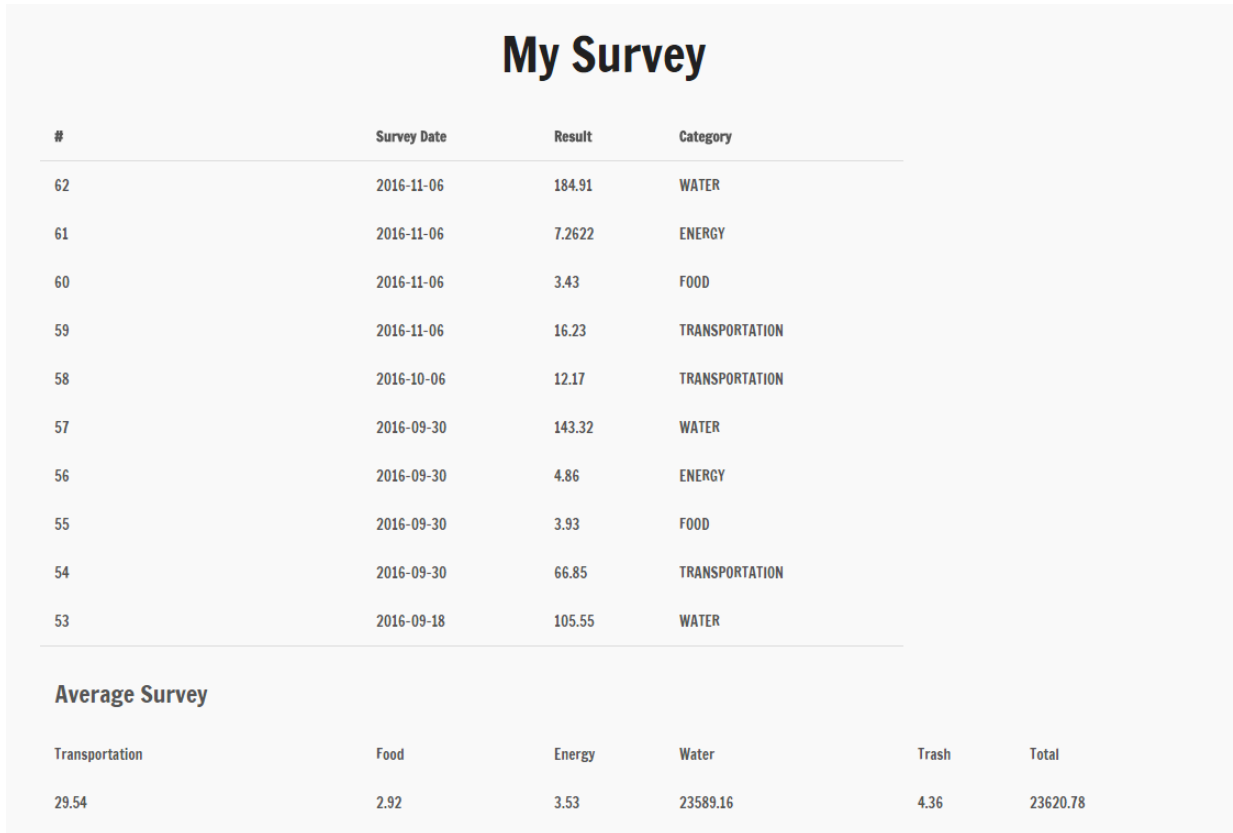
methodology used for the calculation of emissions are followed on the standards of Environmental Protection Agency (EPA) and United Nations Environment Programme (UNEP).

The questionnaires make users understand the fact that “the more you consume, the greater your carbon footprint is”. By knowing their carbon footprint, they can understand how the environment is impacted and try to identify ways to lead a sustainable lifestyle.

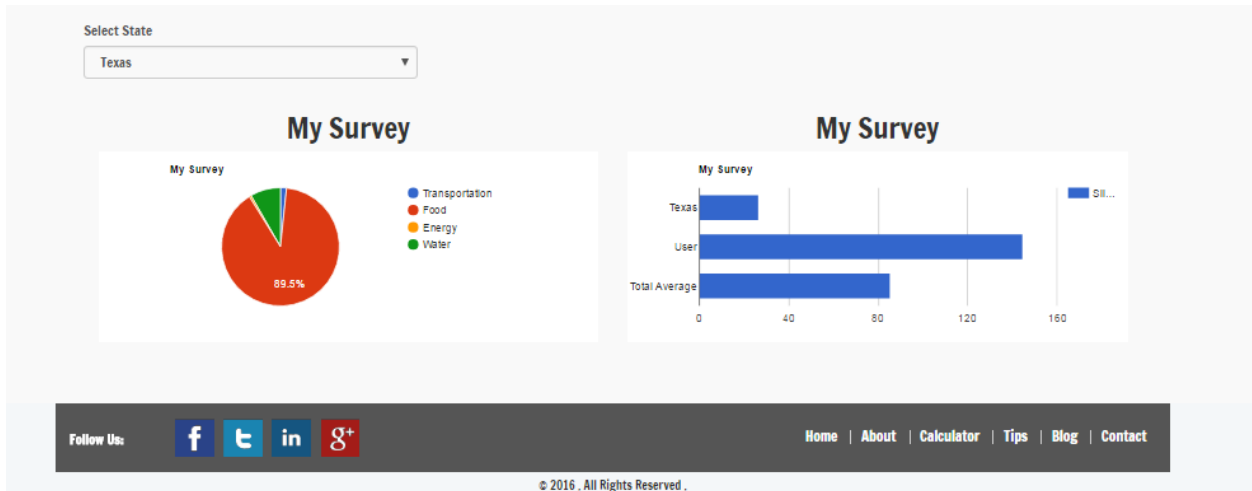
The screenshot displays the 'my footprint calculator' website interface. At the top, there is a navigation menu with links for 'About', 'Calculator', 'Blog', 'News', 'Contact', 'Login', and 'Sign Up'. The main heading is 'Find Your Environmental Impact'. Below this, there are tabs for 'Transportation', 'Food', 'Energy', 'Water', and 'Trash', with 'Transportation' currently selected. The page features a red bicycle icon and the text 'TRANSPORTATION Find Out How To Reduce Your Footprint'. The survey is divided into two sections: 'I Common Vehicle' and 'II Rail Travel'. The 'Common Vehicle' section contains five questions with corresponding input fields: 1. 'When traveling (as a driver or a passenger) what is the vehicle most commonly used?' with a dropdown menu. 2. 'How many miles/kilometers do you travel in the most commonly used vehicle during a typical week?' with a range slider from 1 to 100 and a unit dropdown. 3. 'How many miles/kilometers per gallon does your vehicle get during a typical week?' with fields for 'Model Year', 'MFR Name', 'Carline', and 'MPG'. 4. 'While traveling in the most commonly used vehicle, what percentage of the time do you travel with other passengers?' with a range slider from 1 to 100%. 5. 'When traveling with others in the most commonly used vehicle, how many people besides you are typically in the vehicle?' with a range slider from 1 to 6. A 'Show Survey Result' button is located at the bottom right of the survey area. The footer includes social media icons, a copyright notice '© 2017 All rights reserved', and the text 'design by data directions inc.'.

**Figure 27: 2017 Sample Transportation Survey Page of My Footprint Calculator**

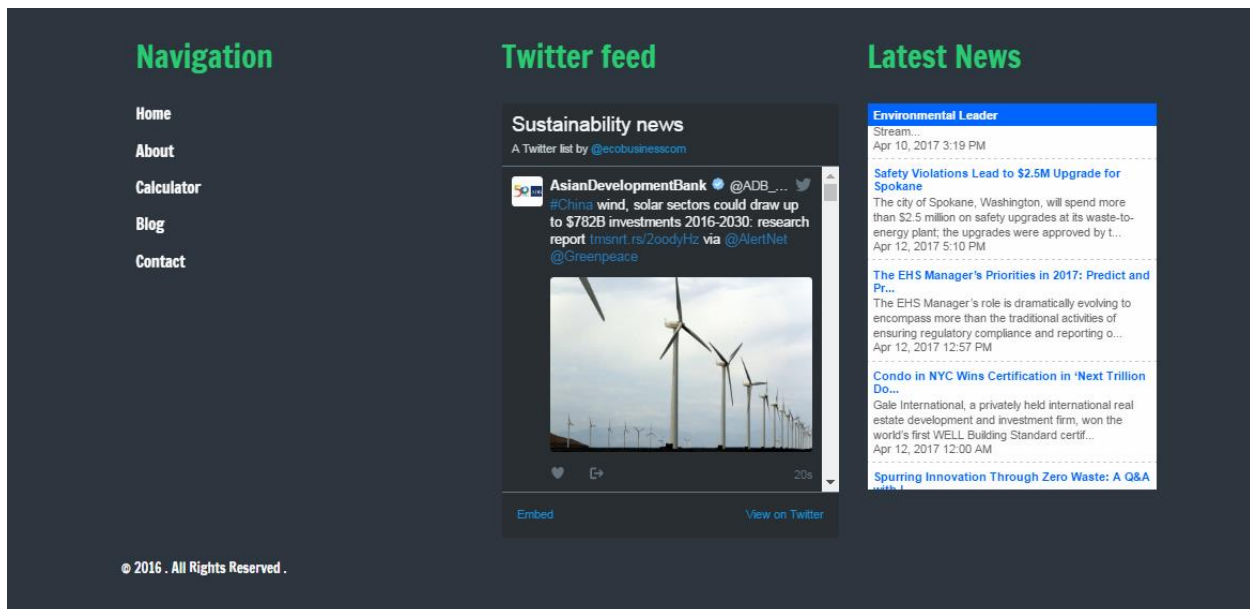
“My Survey Results” page shows all the important categorized statistics information of the user’s survey. It shows the ten most recent surveys taken by the user and the average of the five categories individually. The average EPA survey of five categories of the user is represented in a pie chart. Users can also compare their results with a selected state in a bar graph. The results are represented in more intuitive graphic to make it understand much easier for users.



**Figure 28: Sample User Result Page of My Footprint Calculator (Current Look)**



**Figure 29: Sample User Results Comparison of My Footprint Calculator (Current Look)**

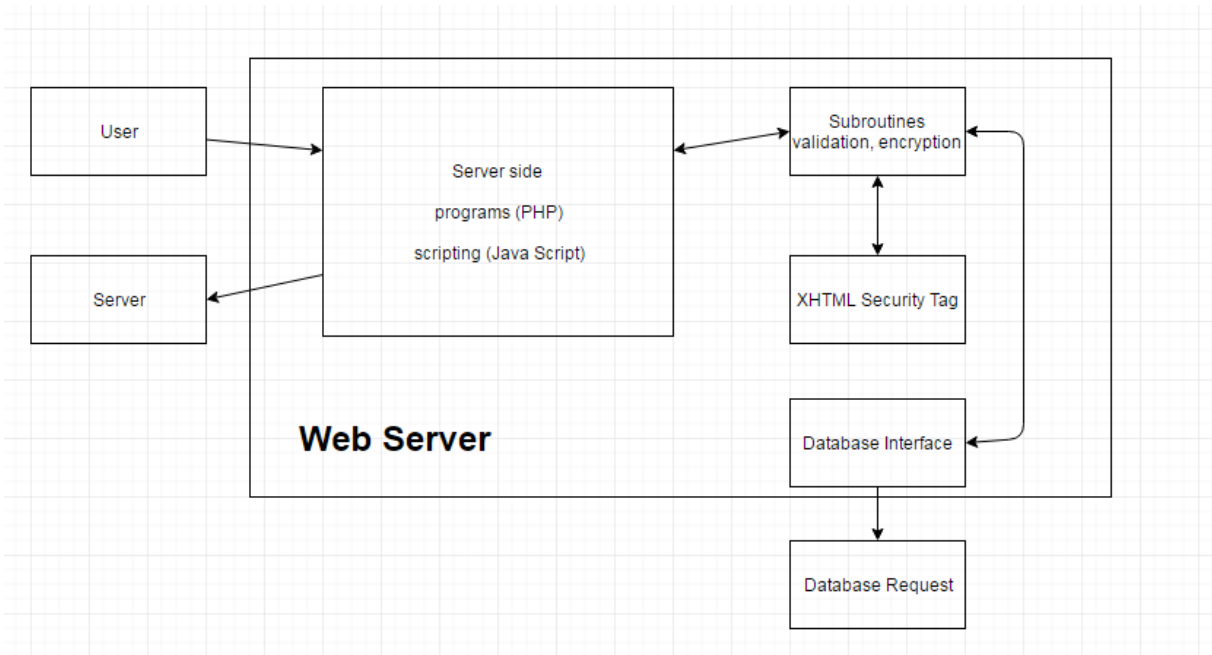


**Figure 30: Footer showing Twitter Feed and Latest News (Current Look)**

The footer section of home page includes the latest news and a twitter feed on relevant environmental issues from all over the world.

## 5. TESTING AND VALIDATION

Software testing is done using manual or automated means for running a process. It is aimed to test whether the software satisfies the desired requirements [56]. For providing high quality, software systems should offer more importance on consistency and integrity [57]. Server page codes are not visible to the users, so the best approach is to validate the inputs on the server side as well. Figure 31 presents some very crucial validation fields on server side below.



**Figure 31: Database Input Validation**

### 5.1. Functionality Testing

There are several types of evaluation techniques used to assess the integrity and quality of a website, such as functionality testing, performance testing [58]. It also depends on the skills and expertise of testers [59]. Functionality testing is used to verify that a piece of software is providing the same output as required by the end-user. Typically, it involves evaluating and



comparing each function with the requirements. The detailed functionality testing for signup sheet, login, and survey are shown in below tables.

**Table 5: Signup Sheet Test**

File path	Test case	Test result	Operation procedure
/header.php	Name: test Email: <a href="mailto:test@gmail.com">test@gmail.com</a> Select Country: India Password: 1234 Confirm Password: 1234 Phone Number: 987654321	After filled in all required information, signup successfully	Go to Home page
	Name: Email: Select Country: Password: Confirm Password: Phone Number:	If Name, Email, Password, Phone Number are empty, signup fails	

**Table 6: Login Sheet Test**

File path	Test case	Test result	Operation procedure
-----------	-----------	-------------	---------------------

/header.php	Email: test@gmail.com Password: 1234	After filled in all required information, login successfully	Go to Home page
	Email: Password:	If Email, Password are empty, login fails	

**Table 7: Transportation Survey test**

File path	Test case	Test result	Operation procedure
/transportation.php	Q1: Conventional Car Q2: 150, Units: Miles Q3: 22 Q4: 25 Q5: 2 Q6: 100, Units: Miles Q7: 50, Units: Miles Q8: 1000, Units: Miles	After filled in all required information, survey submit successfully	Go to the transportation result page.
	Q1: Conventional Car Q2: 150, Units: Q3: 22 Q4: 25 Q5: 2 Q6: 100, Units:	If units are empty, survey submission fails	

	Q7: 50, Units:		
	Q8: 1000, Units:		

Manual testing of the website is done and a detail procedure is shown with id's starting with MTC (Manual test Case). The columns are created with names test case ID, test title, description of the test, steps followed, expected outcome, actual outcome and finally status.

**Table 8: Manual testing of My Footprint Calculator**

Test Case ID	Test title	Description	Steps	Expected Results	Actual results	Status
MTC01	Login test	Testing Login functionality of My Footprint Calculator	1. Open www.myfootprintcalculator.com on web browser	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
			2. Click on login	One webpage which gives an email form	Get a webpage providing form for login	Pass

			3. Type valid email id in email field			
			4. Enter correct password in password field			
			5. Click on login	User is logged into My Footprint Calculator account	Logged into My Footprint Calculator account	Pass
MTC02	User Interface	Application is opened	Verify website	It should display header, footer, navigation and logos of My Footprint Calculator	It displayed header, footer, navigation and logos of My Footprint Calculator	Pass

MTC03	About button test	Functionality of About button	Click on About button	It should display the informatio n about My Footprint Calculator	It displayed the informatio n about My Footprint Calculator	Pass
MTC04	Calculator button test	Functionality of Calculator button	Click on Calculator button	It should display the five categories survey icons	It displayed the five categories survey icons	Pass
MTC05	Tips button test	Functionality of Tips button	Click on Tips button	It should display the tips page of My Footprint Calculator	It displayed the tips page of My Footprint Calculator	Pass

MTC06	Blog button test	Functionality of Blog button	Click on Blog button	It should display the five categories discussion tabs of My Footprint Calculator	It displayed the five categories discussion tabs of My Footprint Calculator	Pass
MTC07	Contact button test	Functionality of Contact button	Click on Contact button	It should display informatio n on how to contact My Footprint Calculator	It displayed informatio n on how to contact My Footprint Calculator	Pass
MTC08	Transport ation Survey test	Functionality of Transportatio n survey	1. Click on Calculator	Calculator page is opened	Calculator page opened	Pass

			2. Click on Transportation	Transportation survey page is opened	Transportation survey page opened	Pass
			3. Submitting responses to common vehicle questions			
			4. Submitting responses to rail travel question			
			5. Submitting response to bus travel question			
			6. Submitting response to air travel question			
			7. Click on Show survey button	Transportation	Transportation	Pass

				result is opened	result opened	
			8. Save/Delete survey	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
MTC09	Food Survey test	Functionality of Food survey	1. Click on Calculator	Calculator page is opened	Calculator page opened	Pass
			2. Click on Food	Food survey page is opened	Food survey page opened	Pass
			3. Submitting responses to calories questions			
			4. Submitting responses to beef question			



			5. Submitting response to chicken question			
			6. Submitting response to pork question			
			7. Submitting response to fish question			
			8. Submitting response to diary question			
			9. Submitting response to shopping question			
			10. Submitting response to organic question			
			11. Submitting response to food			

			waste and frozen question			
			12. Click on Show survey button	Food result is opened	Food result opened	Pass
			13. Save/Delete survey	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
MTC10	Energy Survey test	Functionality of Energy survey	1. Click on Calculator	Calculator page is opened	Calculator page opened	Pass
			2. Click on Energy	Energy survey page is opened	Energy survey page opened	Pass
			3. Submitting responses to			

			residency questions			
			4. Submitting responses to heating question			
			5. Submitting response to cooling question			
			6. Submitting response to dish washing question			
			7. Submitting response to laundry question			
			8. Submitting response to water heating question			
			9. Submitting response to refrigerator question			

			10. Submitting response to lighting question			
			11. Submitting response to computer question			
			12. Submitting response to television question			
			13. Click on Show survey button	Energy result is opened	Energy result opened	Pass
			14. Save/Delete survey	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
MTC11	Water Survey	Functionality of Water	1. Click on Calculator	Calculator page is	Calculator page	Pass

	test	survey		opened	opened	
			2. Click on Water	Water survey page is opened	Water survey page opened	Pass
			3. Submitting responses to shower questions			
			4. Submitting responses to toilet question			
			5. Submitting response to washing machine question			
			6. Submitting response to dish washer question			
			7. Submitting response to swimming pool			

			question			
			8. Submitting response to lawn question			
			9. Submitting response to source of water question			
			10. Click on Show survey button	Water result is opened	Water result opened	Pass
			11. Save/Delete survey	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
MTC12	Trash Survey test	Functionality of Trash survey	1. Click on Calculator	Calculator page is opened	Calculator page opened	Pass

			2. Click on Trash	Trash survey page is opened	Trash survey page opened	Pass
			3. Submitting responses to cans questions			
			4. Submitting responses to newspapers question			
			5. Submitting response to plastic question			
			6. Submitting response to glass bottle question			
			7. Submitting response to swimming pool question			

			8. Submitting response to mixed paper question			
			9. Submitting response to waste question			
			10. Submitting response to purchasing question			
			11. Click on Show survey button	Trash result is opened	Trash result opened	Pass
			12. Save/Delete survey	My Footprint Calculator home page is opened	My Footprint Calculator home page opened	Pass
MTC13	Transportation	Functionality of	1. Click on Blog	Blog page is opened	Blog page opened	Pass



	discussion tab test	Transportatio n discussion tab				
			2. Click on Transportation	Transport ation discussion page is opened	Transport ation discussion page opened	Pass
			3. Read responses			
			4. Reply to comments	Replied comment is posted	Replied comment posted	Pass
			5. Leave new comment	New comment is typed	New comment typed	Pass
			6. Upload picture	Picture is uploaded	Picture uploaded	Pass
			7. Click post button	Comment is posted	Comment posted	Pass

MTC14	Food discussion tab test	Functionality of Food discussion tab	1. Click on Blog	Blog page is opened	Blog page opened	Pass
			2. Click on Food	Food discussion page is opened	Food discussion page opened	Pass
			3. Read responses			
			4. Reply to comments	Replied comment is posted	Replied comment posted	Pass
			5. Leave new comment	New comment is typed	New comment typed	Pass
			6. Upload picture	Picture is uploaded	Picture uploaded	Pass
			7. Click post button	Comment is posted	Comment posted	Pass

MTC15	Energy discussion tab test	Functionality of Energy discussion tab	1. Click on Blog	Blog page is opened	Blog page opened	Pass
			2. Click on Energy	Energy discussion page is opened	Energy discussion page opened	Pass
			3. Read responses			
			4. Reply to comments	Replied comment is posted	Replied comment posted	Pass
			5. Leave new comment	New comment is typed	New comment typed	Pass
			6. Upload picture	Picture is uploaded	Picture uploaded	Pass
			7. Click post button	Comment is posted	Comment posted	Pass

MTC16	Water discussion tab test	Functionality of Water discussion tab	1. Click on Blog	Blog page is opened	Blog page opened	Pass
			2. Click on Water	Water discussion page is opened	Water discussion page opened	Pass
			3. Read responses			
			4. Reply to comments	Replied comment is posted	Replied comment posted	Pass
			5. Leave new comment	New comment is typed	New comment typed	Pass
			6. Upload picture	Picture is uploaded	Picture uploaded	Pass
			7. Click post button	Comment is posted	Comment posted	Pass

MTC17	Trash discussion tab test	Functionality of Trash discussion tab	1. Click on Blog	Blog page is opened	Blog page opened	Pass
			2. Click on Trash	Trash discussion page is opened	Trash discussion page opened	Pass
			3. Read responses			
			4. Reply to comments	Replied comment is posted	Replied comment posted	Pass
			5. Leave new comment	New comment is typed	New comment typed	Pass
			6. Upload picture	Picture is uploaded	Picture uploaded	Pass
			7. Click post button	Comment is posted	Comment posted	Pass

MTC18	My Survey tab test	Functionality of My Survey tab	1. Click on My Survey button	My Survey page is opened	My Survey page opened	Pass
			2. Check saved surveys			
			3. Check average of surveys			
			4. Select state to select	State is selected	State selected	Pass
			5. Compare user values with state and total average			

## 5.2.Survey Result Testing

It is very important to check the calculations of the five category surveys manually. So, the survey's results are cross checked with excel spread sheets using visual basic code by recreating the database type storage. The sample methodology used to calculate the survey results is shown below. The codes used to create are showed in the Appendix.

Case Study:

Commonly used vehicle: Conventional\_Hybrid\_Car

Miles travel during a typical week: 59

Miles per gallon vehicle get: 24

Percentage of time travel with other passengers in commonly used vehicle: 25

People besides you are typically in: 2

**1. Common Vehicle**

**Qn 1. When traveling (as a driver or a passenger) what is the vehicle most commonly used?**  
Type 1: If Conventional/Hybrid Car --> using gasoline

**Qn 2. How many miles/kilometers do you travel in the most commonly used vehicle during a typical week?**  
0 to 59 Miles

**Qn 3. How many miles/kilometers per gallon does your vehicle get during a typical week?**  
Model Year: 2008 MFR Name: GMC Carline: ACADIA FWD MPG: 24

**Qn 4. While traveling in the most commonly used vehicle, what percentage of the time do you travel with other passengers?**  
0 to 20 %

**Qn 5. When traveling with others in the most commonly used vehicle, how many people besides you are typically in the vehicle?**  
1 to 2 X people

**Figure 32: Sample Vehicle Emission Queries (Current Look)**

$$\text{Conventional Car Emissions} = \frac{59 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 11.7612 * 10^3 \frac{\text{gCO}_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{24 \frac{\text{Miles}}{\text{Gallon}} * (1 + 2 + 25 * 0.01) \text{ pass}} = 0.47 \frac{\text{Metric\_tonCO}_2}{\text{pass - Year}}$$

**2. Rail Travel**

Qn 6. How many miles/kilometers a week do you typically travel by train/subway/tram?

0 to 29 Miles

**3. Bus Travel**

Qn 7. How many miles/kilometers a week do you typically ride in a bus?

0 to 35 Miles

**4. Air Travel**

Qn 8. How many miles/kilometers a year do you typically travel by airplane?

0 to 1807 Miles

Show Survey Result

**Figure 33: Rail, Bus and Air Emission Queries (Current Look)**

Miles travel by train/subway/tram during a typical week: 29

$$\text{Rail Emissions} = 29 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.137 * 10^3 \frac{\text{gCO}_2}{\text{pass - Mile}} * 1.1 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}} = 0.23 \frac{\text{Metric\_tonCO}_2}{\text{pass - Year}}$$

Miles travel by bus during a typical week: 35

$$\text{Bus Emissions} = 35 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.055 * 10^3 \frac{\text{gCO}_2}{\text{pass - Mile}} * 1.1 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}} = 0.11 \frac{\text{Metric\_tonCO}_2}{\text{pass - Year}}$$

Miles travel by airplane during a typical week: 1807

$$\text{Plane Emissions} = \frac{1807 \frac{\text{Miles}}{\text{Year}} * 0.08 * 0.8 * 19.14 * 10^3 \frac{\text{gCO}_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{0.6 \frac{\text{Miles}}{\text{Gallon}}} = 3.69 \frac{\text{Metric\_tonCO}_2}{\text{Year}}$$

From the above calculations of vehicle, rail, bus and plane emissions, total emissions are calculated by summation of those values.



Total Emissions = Vehicle emissions + Rail emissions + Bus emissions + Plane emissions

Total emissions = 0.47 + 0.23 + 0.11 + 3.69 = 4.50 Metric ton CO2/pass-year

**Transportation Result**

**Your transportation habits produce 4.02 metric tons of CO2 each year!**

**Figure 34: The Tool Calculated Result for Transportation Queries (Current Look)**

	Questions	Answers
1	When traveling (as a driver or a passenger) what type of vehicle do you commonly use?	Conventional_Hybrid_Car
2	How many miles/kilometers do you travel in the most commonly used vehicle during a typical week?	59
3	How many miles/kilometers per gallon does your vehicle get during a typical week?	24
4	While traveling in the most commonly used vehicle, what percentage of the time do you travel with other passengers?	20
5	When traveling with others in the most commonly used vehicle, how many people besides you are typically in the vehicle?	2
6	How many miles/kilometers a week do you typically travel by train/subway/tram?	29
7	How many miles/kilometers a week do you typically ride in a bus?	35
8	How many miles/kilometers a year do you typically travel by airplane?	1807
		Submit

**Figure 35: Excel Spreadsheet Transportation Queries**

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
6	Conventional_Hybrid_Car	59	24	20	2	29	35	1807

**Figure 36: Excel Spreadsheet Stored Values of Transportation Queries**

VehicleEmission	RailEmissions	BusEmissions	PlaneEmissions	TotalEmissions
0.47	0.23	0.11	3.69	4.50

**Figure 37: Excel Spreadsheet Calculated Values of Transportation Emissions**

The formulas used to calculate Total emissions are attached in Appendix A, B, C, D & E. Similarly other sustainable lifestyle categories total emissions were calculated using test matrix. A test matrix is simply a spreadsheet testing. Excel spreadsheet Food, energy, water and trash queries are attached to Appendix section.

### 5.3. Cross-Browser Testing

Cross browser testing is a process to test web applications in multiple browsers to make sure the application is working consistently without compromising on quality. It is performed to check the functionality and working. In the web design and development field, responsive web design is followed where the application is responded to the user's behavior and different environments. The running of cross-browser tests has been conducted on different browsers like Google Chrome, Mozilla Firefox, Internet Explorer, Opera and Apple Safari.

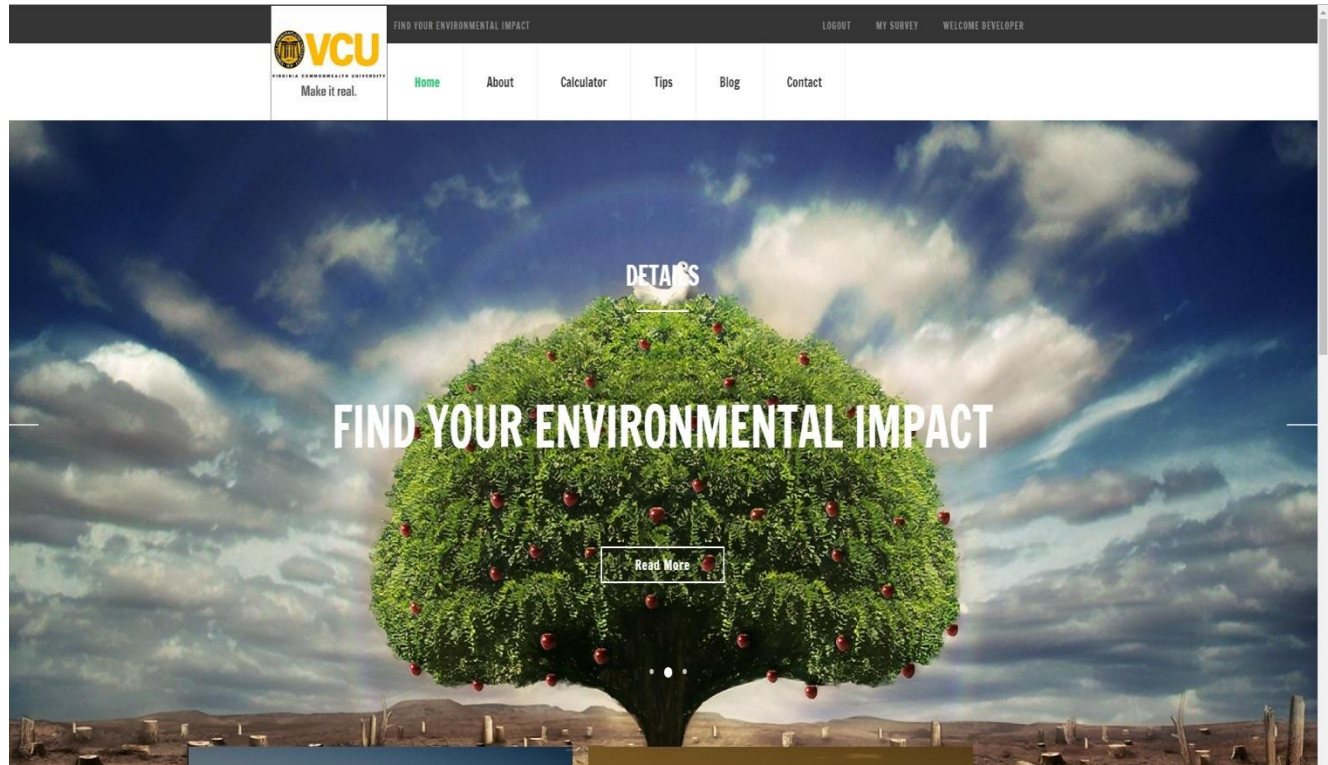


Figure 38: Chrome Browser View of My Footprint Calculator

It was observed that the website functionality and styles across multiple browser platforms, operating systems is same and there were no potential discrepancies. The main aspects of doing this test are to check whether CSS styles are rendering differently across browsers or their versions.

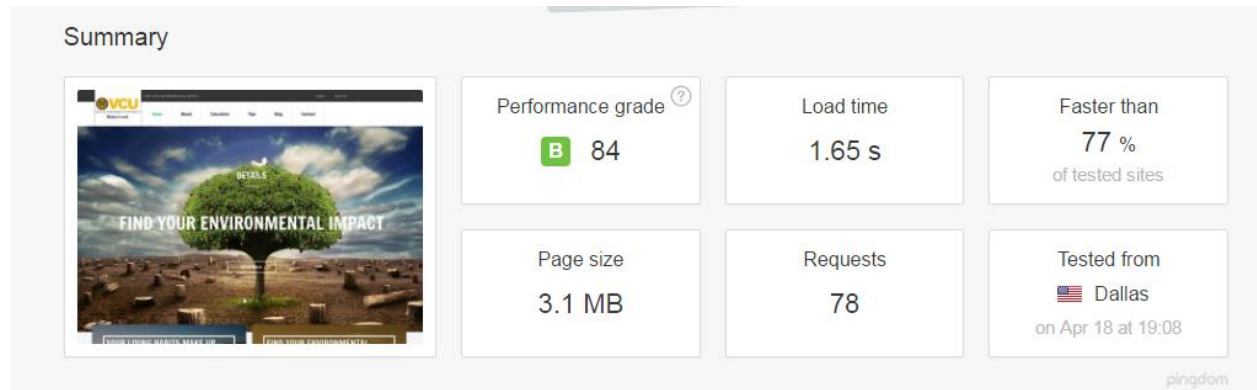
The Cross Browser Testing has been performed using [WhatIsMyScreenResolution.com](http://WhatIsMyScreenResolution.com) and [browsershots.org](http://browsershots.org). As the user switches from their desktop to laptop to ipad, the web application automatically switches to accommodate for user's preferences.

#### **5.4.Performance Testing**

The site speed has been checked in the google Chrome. As we can observe in Figure 40 the network panel records information about each network operation on a page which includes HTTP request, response headers, cookies, detailed timing data, etc.

The request table consist columns of Name, Status, Type, Initiator, Parser, Redirect, etc. As we can observe that the network table highlights DOMContentLoaded and Load which are shown at the bottom of the network table. Load has taken 1.52s which is fired when a page has fully loaded whereas DOMContentLoaded has taken 838ms is fired when initial markup of a page has been parsed. The timeline displays a vertical yellow line indicating when the frame got captured. The results are very important as website visitors tend to care more about speed than all the important things we want to add to our websites. Additionally, page loading time is becoming a more important factor when it comes to search engine rankings.

The reliability of the code has been checked with couple of online available tools like [validator.w3.org](http://validator.w3.org), [onlinewebcheck.com](http://onlinewebcheck.com) and [nibbler.silktide.com](http://nibbler.silktide.com).



**Figure 39: Pingdom Performance Test of My Footprint Calculator**

From pingdom speed test we can observe that My Footprint Calculator is faster than 77% of the web. The average load time of the website is 1.65s with page size of 3.1 MB. The HTTP requests are counted as 78. The performance grade of My Footprint Calculator is 84.

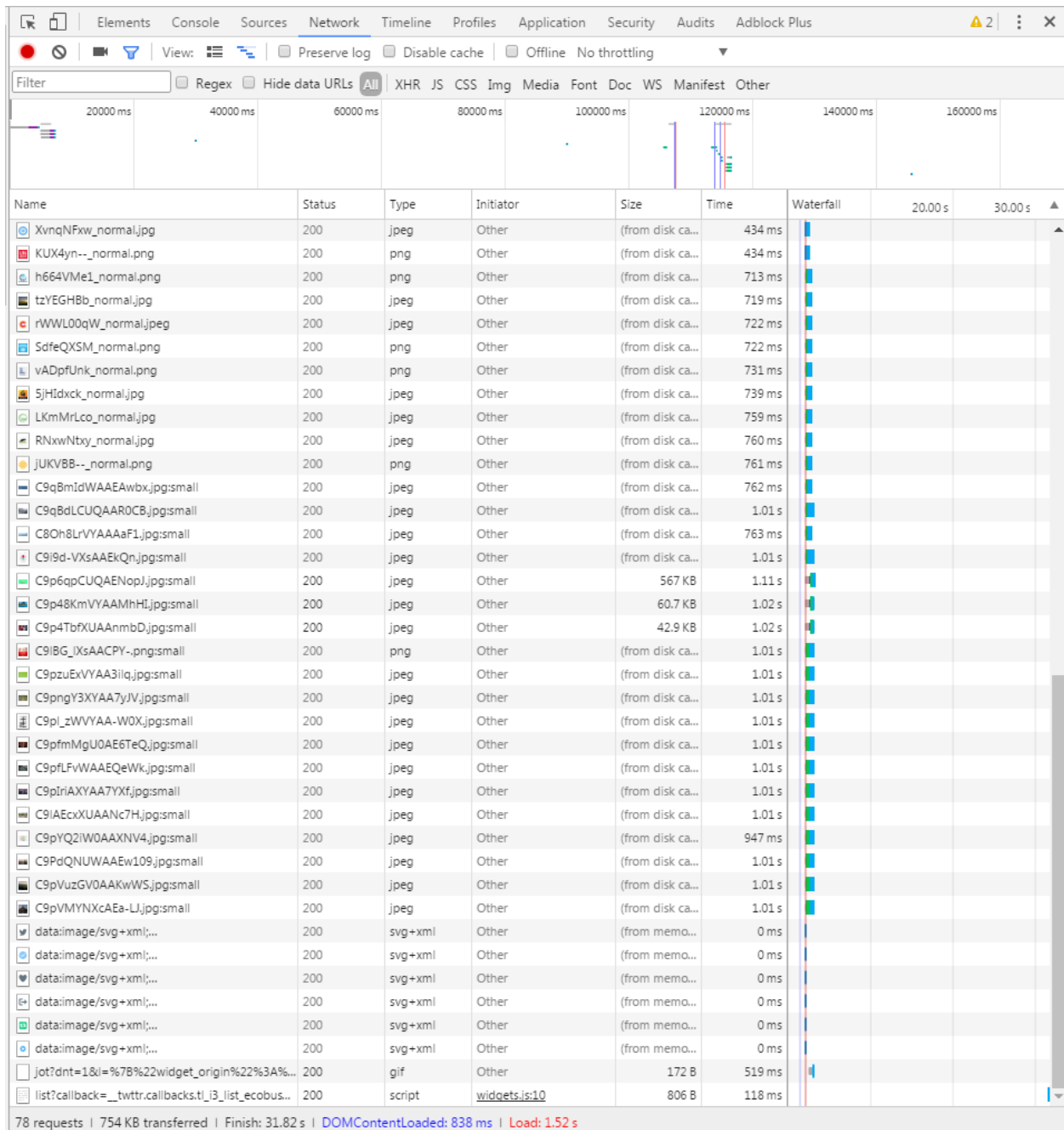


Figure 40: Speed Test of My Footprint Calculator

## 6. CONCLUSION

“My Footprint Calculator” is an attractive and user-friendly platform dedicated to promote awareness and education on sustainable lifestyles. Using information about the daily routine of the individuals to calculate their environmental impact, this tool helps users to reduce their ecological footprint. The design, expansion and improvement of the overall framework of the tool was done to make it appealing to teenagers and the youth.

The streamlined questionnaire for the five categories transportation, food, energy, water and trash have been setup taking into account most of the day to day activities which impact our environment directly or indirectly. In Appendixes A, B, C, D and E one can find the details on how we calculated the data and the sources that we consulted for each question in the calculator. The code used to develop the tool is gone through manual testing following the processes of functionality testing, cross-browser testing, interface testing, performance testing and calculation testing using excel worksheets.

In addition, a database is also created to store the user response and further utilized for analysis. This involves statistical application to develop relevant trends and modeling them to predict future outcomes to prevent negative effects of environmental degradation. In this regard, we would like to mention that utmost care has been taken to protect users’ privacy.

The tool includes a discussion forum that can help the teachers and students to address the environmental objectives more effectively. It encourages the users to participate in the discussion, which eventually helps them to provide direction and maintain focus for leading a sustainable lifestyle. It even helps the admin to reframe the questionnaire more effectively and

include more lifecycle emissions inherent in different forms of energy, food, water, trash and transportation.

The tool also has a feature of checking the last 10 surveys taken and average of his performances which is shown in the form of intuitive graphic display. The user can also compare his average carbon emissions with other states emissions which are provided by Environmental Protection Agency (EPA).

In conclusion, we expect our tool to enhance the quality of assessment of day to day activities of the individuals and motivate them to contribute towards a better tomorrow.

## 7. REFERENCES

- [1] D. L. Johnson *et al.*, “Meanings of Environmental Terms,” *J. Environ. Qual.*, vol. 26, no. 3, p. 581, 1997.
- [2] G. Handl and E. Deutsch, “United Nations Audiovisual Library of International Law Declaration of The United Nations Conference On The Human Environment (Stockholm Declaration), 1972 And The Rio Declaration On Environment And Development, 1992.”
- [3] R. Keles, “The Quality of Life and the Environment Selection and peer-review under responsibility of Centre for Environment- Behaviour Studies (cE-Bs), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia,” *Procedia -Social Behav. Sci.*, vol. 35, pp. 23–32, 2012.
- [4] “Earth ‘entering new extinction phase’ - US study - BBC News.” [Online]. Available: <http://www.bbc.com/news/science-environment-33209548>. [Accessed: 09-Feb-2017].
- [5] I. R. Noble and R. O. Slatyer, “The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances,” *Vegetatio*, vol. 43, no. 1–2, pp. 5–21, Dec. 1980.
- [6] V. H. DALE *et al.*, “Climate Change and Forest Disturbances,” *Bioscience*, vol. 51, no. 9, p. 723, 2001.
- [7] “Poverty and Environment | UN Environment.” [Online]. Available: <http://web.unep.org/regions/roa/regional-programmes/poverty-and-environment>. [Accessed: 09-Feb-2017].
- [8] “Poverty and Affluence and Environmental Impact | Issues in Physics and Society.” [Online]. Available: <https://physicsandsocietybc.wordpress.com/2013/04/30/poverty-and-affluence-and-environmental-impact/>. [Accessed: 09-Feb-2017].



- [9] Intergovernmental Panel on Climate Change, *Climate Change 2013*. 2013.
- [10] “Combatting tropical deforestation: the REDD+ initiative | Climate Action.” [Online]. Available: [http://ec.europa.eu/clima/policies/forests/deforestation\\_en](http://ec.europa.eu/clima/policies/forests/deforestation_en). [Accessed: 09-Feb-2017].
- [11] “The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation Final report.”
- [12] “Water Scarcity: Environmental Implications | Water Shortage Problems.” [Online]. Available: <http://growingblue.com/implications-of-growth/environmental-implications/>. [Accessed: 09-Feb-2017].
- [13] “Why global water shortages pose threat of terror and war | Environment | The Guardian.” [Online]. Available: <https://www.theguardian.com/environment/2014/feb/09/global-water-shortages-threat-terror-war>. [Accessed: 09-Feb-2017].
- [14] “Environmental Scarcity and the Outbreak of Conflict.” [Online]. Available: <http://www.prb.org/Publications/Articles/2001/EnvironmentalScarcityandtheOutbreakofConflict.aspx>. [Accessed: 09-Feb-2017].
- [15] M. Kampa and E. Castanas, “Human health effects of air pollution,” *Environ. Pollut.*, vol. 151, no. 2, pp. 362–367, 2008.
- [16] D. E. Er, “Consumerism, Nature, and the Human Spirit.”
- [17] “KYOTO Protocol to the United Nations Framework Convention on Climate Change,” 1998.
- [18] “Adoption of the Paris Agreement,” 2015.
- [19] “Nature Conservancy | Protecting Nature, Preserving Life.” [Online]. Available: <http://www.nature.org/>. [Accessed: 09-Feb-2017].

- [20] “United States Environmental Protection Agency | US EPA.” [Online]. Available: <https://www.epa.gov/>. [Accessed: 09-Feb-2017].
- [21] “Data - Global Footprint Network.” [Online]. Available: <http://www.footprintnetwork.org/resources/data/>. [Accessed: 09-Feb-2017].
- [22] E. U. Weber and P. C. Stern, “Public Understanding of Climate Change in the United States.”
- [23] “The Age of Social Transformation.” [Online]. Available: <http://www.theatlantic.com/past/docs/issues/95dec/chilearn/drucker.htm>. [Accessed: 09-Feb-2017].
- [24] L. Rushton, “Health hazards and waste management,” *Br. Med. Bull.*, vol. 68, no. 1, pp. 183–197, Dec. 2003.
- [25] “Your Ecological Footprint: Defining, Calculating, and Reducing Your Environmental Footprint : TreeHugger.” [Online]. Available: <http://www.treehugger.com/culture/your-ecological-footprint-defining-calculating-and-reducing-your-environmental-footprint.html>. [Accessed: 09-Feb-2017].
- [26] C. Banbury, R. Stinerock, and S. Subrahmanyam, “Sustainable consumption: Introspecting across multiple lived cultures,” *J. Bus. Res.*, vol. 65, pp. 497–503, 2012.
- [27] M. R. (Martin R. Perrow and A. J. Davy, *Handbook of ecological restoration*. Cambridge University Press, 2002.
- [28] Manne and Robert, “Comment: After Copenhagen,” *Mon.*, no. Mar 2010, p. 8, 2010.
- [29] D. W. Orr, “Ecological Literacy: Education And The Transition To A Postmodern World,” *SUNY Ser. Constr. Postmod. thought*, p. 210, 1992.
- [30] I. Numerisation - [www.numerisation.ch](http://www.numerisation.ch), “World Conservation Strategy Living Resource

Conservation for Sustainable Development IUCN WWF,” 1980.

- [31] G. Brundtland, “Report of the World Commission on Environment and Development: Our Common Future,” *Oxford Pap.*, vol. Report of, p. 400, 1987.
- [32] D. Turner, “Sustainability and Library Management Education,” *J. Sustain. Educ.*, vol. 7, 2014.
- [33] “Edward Abbey: A Solitary Voice in the Wilderness | WilderUtopia.com.” [Online]. Available: <http://www.wilderutopia.com/politics/advocates/edward-abbey-a-solitary-voice-in-the-wilderness/>. [Accessed: 17-Feb-2017].
- [34] “Sustainable economic development assessment (SEDA) | Elefante.” [Online]. Available: <http://elephant.eburo.org/sustainable-economic-development-assessment/>. [Accessed: 11-Apr-2017].
- [35] S. Woodcraft, L. Caistor-arendar, T. Hackett, and S. Peter, “Design For Social Sustainability new communities.”
- [36] “What is Sustainability? | SustainVU | Vanderbilt University.” [Online]. Available: [https://www.vanderbilt.edu/sustainvu/who-we-are/what-is-sustainability/#.T\\_tgQeilsb4.pinterest](https://www.vanderbilt.edu/sustainvu/who-we-are/what-is-sustainability/#.T_tgQeilsb4.pinterest). [Accessed: 11-Apr-2017].
- [37] B. Giddings, B. Hopwood, and G. O ’brien, “Environment, Economy and Society: Fitting Them Together Into Sustainable Development,” *Sustain. Dev. Sust. Dev.*, vol. 10, pp. 187–196, 2002.
- [38] UNCED, “United Nations Conference on Environment & Development Rio de Janerio , Brazil , 3 to 14 June 1992,” *Agenda 21*, p. 351, 1992.
- [39] “The Three Pillars of Sustainability.” [Online]. Available: <http://www.thwink.org/sustain/glossary/ThreePillarsOfSustainability.htm>. [Accessed: 17-

- Feb-2017].
- [40] J. Clapp, E. Helleiner, A. E. Hester, T. Homer-Dixon, I. H. Rowlands, and L. Swanston, “Environmental Sustainability and the Financial Crisis: Linkages and Policy Recommendations.”
- [41] “Sustainability as a Strategy | CSCMP Cincinnati Roundtable.” [Online]. Available: <http://cincicscmp.org/sample-page/128-2/>. [Accessed: 17-Feb-2017].
- [42] O. Ottawa, “International Processes on Sustainable Consumption and Production A Background Paper for the North American Sustainable Consumption and Production Workshop on Green Building.”
- [43] L. Bizikova *et al.*, “Sustainable Consumption and Production Indicators For The Future SDGS Acknowledgments,” 2015.
- [44] “Rise and Shine: Lighting the World with 10 Billion LED Bulbs | Department of Energy.” [Online]. Available: <https://energy.gov/articles/rise-and-shine-lighting-world-10-billion-led-bulbs>. [Accessed: 11-Apr-2017].
- [45] F. Schaefer, U. Luksch, N. Steinbach, J. Cabeça, J. Hanauer, and WWF, “Ecological Footprint and Biocapacity: The world’s ability to regenerate resources and absorb waste in a limited time period,” *Eur. Comm. Rep.*, pp. 1–10, 2006.
- [46] E. G. Hertwich and G. P. Peters, “Carbon Footprint of Nations: A Global, Trade-Linked Analysis,” *Environ. Sci. Technol.*, vol. 43, no. 16, pp. 6414–6420, Aug. 2009.
- [47] C. M. Jones and D. M. Kammen, “Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities,” *Environ. Sci. Technol.*, vol. 45, no. 9, pp. 4088–4095, May 2011.
- [48] “Glossary.” [Online]. Available:

- <http://cms.fayettein.schooldesk.net/MediaCenter/ProjectsPathfinders/CarbonFootprintsWebquest/Glossary/tabid/105533/Default.aspx>. [Accessed: 28-Apr-2017].
- [49] “WWF Footprint Calculator.” [Online]. Available: <http://footprint.wwf.org.uk/>. [Accessed: 15-Mar-2017].
- [50] “ISCFC: Calculate Your Carbon Footprint.” [Online]. Available: <http://web.stanford.edu/group/inquiry2insight/cgi-bin/i2sea-r2a/i2s.php?page=fpcalc>. [Accessed: 15-Mar-2017].
- [51] “carbonfootprint.com - Carbon Footprint Calculator.” [Online]. Available: <http://www.carbonfootprint.com/calculator.aspx>. [Accessed: 15-Mar-2017].
- [52] “CoolClimate Calculator.” [Online]. Available: <http://coolclimate.berkeley.edu/carboncalculator>. [Accessed: 15-Mar-2017].
- [53] “CSS Basics – Everything you ever wanted to know about the basics of CSS.” [Online]. Available: <http://www.cssbasics.com/>. [Accessed: 15-Mar-2017].
- [54] “PHP Tutorial.” [Online]. Available: <https://www.tutorialspoint.com/php/>. [Accessed: 15-Mar-2017].
- [55] “jQuery Foundation.” [Online]. Available: <https://jquery.org/>. [Accessed: 15-Mar-2017].
- [56] M. J. Harrold, “Testing: A Roadmap.”
- [57] J. Pan, “Software Testing, Dependable Embedded Systems,” 1999.
- [58] F. Shull and R. Tesoriero, “Study Guide to Accompany Shari Lawrence Pfleeger’s Software Engineering: Theory and Practice.”
- [59] A. W. B. & K. C. Wallnau, “A Framework for Systematic Evaluation of Software Technologies,” *IEEE Softw.*, 1996.

## APPENDIX A

### Transportation

How you get around can have a big impact on the environment. Cars, trucks, and other passenger vehicles spew out 20 percent of U.S. carbon dioxide (CO<sub>2</sub>) emissions. CO<sub>2</sub> is a major contributor to global warming. Passenger vehicles are the largest sources of carbon monoxide (a poisonous gas).

This survey looks at a few of your major transportation environmental impacts. It looks at your contributions to carbon dioxide, carbon monoxide pollution.

#### 1. Common vehicle

1) When traveling (as a driver or a passenger) what type of vehicle do you commonly use?

Type 1: if Conventional/Hybrid Car ----→ using gasoline

Type 2: if Electric Car/Bike ---→ using battery/biodiesel b100/ethanol e100

Type 3: if SUV//Truck/Van----→ using gasoline

Type 4: if Motorcycle----→ using gasoline

2) How many miles/kilometers do you travel in the most commonly used vehicle during a typical week?

A: 1) X Miles per week                      or              2) X Kilometers per week

Keep slider in the range 0 to 2000 Miles.

Keep slider in the range 0 to 3000 Kilometers.

3) How many miles/kilometers per gallon does your vehicle get during a typical week?

A: 1) X Miles per gallon                      or            2) X Kilometers per gallon

Keep box to type value

For entering Miles per gallon value into the box, the following databases can be used

<http://www.fueleconomy.gov/mpg/MPG.do?action=browseList> ----→ database for cars

<http://www.fuelly.com/car> ----→ database for Cars

<http://www.fuelly.com/truck> ----→ database for Trucks

<http://www.fuelly.com/motorcycle> ----→ database for Motorcycles

4) While traveling in the most commonly used vehicle, what percentage of the time do you travel with other passengers?

A: X %

Keep slider in the range 0 to 100 percentage.

5) When traveling with others in the most commonly used vehicle, how many people besides you are typically in the vehicle?

A: X people

Keep slider in the range 0 to 6 people.

Type 1:

<http://www.eia.gov/oiaf/1605/coefficients.html>

Unleaded gasoline emits 8.91 kg of CO<sub>2</sub> per gallon.

[http://www.carbonindependent.org/sources\\_car.html](http://www.carbonindependent.org/sources_car.html)

CO2 emission rates need to be scaled up by an addition of 32%.

$$CO_2 \text{ Emissions} = (8.91 * 0.32) + 8.91 = 11.7612 \text{ kg of } CO_2 \text{ per gallon.}$$

$$\text{Conventional Car Emissions} = \frac{Q2 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 11.7612 * 10^3 \frac{\text{g}CO_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{Miles}}{\text{Gallon}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{Metric\_ton}CO_2}{\text{pass - Year}}$$

$$\text{Conventional Car Emissions} = \frac{Q2 \frac{\text{km}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 3.10698 * 10^3 \frac{\text{g}CO_2}{\text{l}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{km}}{\text{l}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{g}CO_2}{\text{pass - Year}}$$

Type 2:

<http://www.eia.gov/oiaf/1605/coefficients.html>

Electrical cars emit 0 kg of CO2 per gallon.

$$CO_2 \text{ Emissions} = 0 \text{ kg of } CO_2 \text{ per gallon.}$$

$$\text{Electrical Car Emissions} = \frac{Q2 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0 * 10^3 \frac{\text{g}CO_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{Miles}}{\text{Gallon}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{Metric\_ton}CO_2}{\text{pass - Year}}$$



$$\text{Electrical Car Emissions} = \frac{Q2 \frac{\text{km}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0 * 10^3 \frac{\text{gCO}_2}{\text{l}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{km}}{\text{l}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{Metric\_tonCO}_2}{\text{pass} - \text{Year}}$$

Type 3:

<http://www.eia.gov/oiaf/1605/coefficients.html>

Unleaded gasoline emits 8.91 kg of CO2 per gallon.

[http://www.carbonindependent.org/sources\\_car.html](http://www.carbonindependent.org/sources_car.html)

CO2 emission rates need to be scaled up by an addition of 32%.

$$\text{CO}_2 \text{ Emissions} = (8.91 * 0.32) + 8.91 = 11.7612 \text{ kg of CO}_2 \text{ per gallon.}$$

$$\text{Van Emissions} = \frac{Q2 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 11.7612 * 10^3 \frac{\text{gCO}_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{Miles}}{\text{Gallon}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{Metric\_tonCO}_2}{\text{pass} - \text{Year}}$$

$$\text{Van Emissions} = \frac{Q2 \frac{\text{km}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 3.10698 * 10^3 \frac{\text{gCO}_2}{\text{l}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{Q3 \frac{\text{km}}{\text{l}} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{\text{Metric\_tonCO}_2}{\text{pass} - \text{Year}}$$

Type 4:

<http://www.eia.gov/oiaf/1605/coefficients.html>

Unleaded gasoline emits 8.91 kg of CO2 per gallon.

[http://www.carbonindependent.org/sources\\_car.html](http://www.carbonindependent.org/sources_car.html)

CO2 emission rates need to be scaled up by an addition of 32%.

$$CO_2 \text{ Emissions} = (8.91 * 0.32) + 8.91 = 11.7612 \text{ kg of } CO_2 \text{ per gallon.}$$

$$Motorcycle \text{ Emissions} = \frac{Q2 \frac{Miles}{Week} * 52.143 \frac{Week}{Year} * 11.7612 * 10^3 \frac{gCO_2}{Gallon} * 10^{-6} \frac{Metric\_ton}{g}}{Q3 \frac{Miles}{Gallon} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{Metric\_tonCO_2}{pass - Year}$$

$$Motorcycle \text{ Emissions} = \frac{Q2 \frac{km}{Week} * 52.143 \frac{Week}{Year} * 3.10698 * 10^3 \frac{gCO_2}{l} * 10^{-6} \frac{Metric\_ton}{g}}{Q3 \frac{km}{l} * (1 + Q5 + Q4 * 0.01) \text{ pass}} = X \frac{Metric\_tonCO_2}{pass - Year}$$

## 2. Rail Travel

6) How many miles/kilometers a week do you typically travel by train/subway/tram?

A: 1) X Miles or 2) X Kilometers

Keep slider in the range 0 to 500 Miles.

Keep slider in the range 0 to 800 Kilometers.

<https://carbonfund.org/how-we-calculate/>

On average long distance trains (i.e., intercity rail) emit 0.137 kgs CO<sub>2</sub>e per passenger mile.

Add 10% to the total mileage of the trip to account for potential detours, stop-overs, and other issues that may arise in a trip.

$$\text{Rail Emissions} = Q6 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.137 * 10^3 \frac{\text{gCO}_2}{\text{pass - Mile}} * 1.1 * 10^{-6} \frac{\text{Metric - ton}}{\text{g}} = X \frac{\text{Metric - tonCO}_2}{\text{pass - Year}}$$

$$\text{Rail Emissions} = Q6 \frac{\text{km}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.085 * 10^3 \frac{\text{gCO}_2}{\text{pass - km}} * 1.1 * 10^{-6} \frac{\text{Metric - ton}}{\text{g}} = X \frac{\text{Metric - tonCO}_2}{\text{pass - Year}}$$

### 3. Bus Travel

7) How many miles/kilometers a week do you typically ride in a bus?

A: 1) X Miles or 2) X Kilometers

Keep slider in the range 0 to 500 Miles.

Keep slider in the range 0 to 800 Kilometers.

<https://carbonfund.org/how-we-calculate/>

On average, bus trips emit 0.055kgs CO<sub>2</sub>e per passenger mile.

Add 10% to the total mileage of the trip to account for potential traffic jams, detours, and pit-stops that may arise in a trip.

$$\text{Bus Emissions} = Q7 \frac{\text{Miles}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.055 * 10^3 \frac{\text{gCO}_2}{\text{pass - Mile}} * 1.1 * 10^{-6} \frac{\text{Metric - ton}}{\text{g}} = X \frac{\text{Metric - tonCO}_2}{\text{pass - Year}}$$

$$\text{Bus Emissions} = Q7 \frac{\text{km}}{\text{Week}} * 52.143 \frac{\text{Week}}{\text{Year}} * 0.034 * 10^3 \frac{\text{gCO}_2}{\text{pass} - \text{km}} * 1.1 * 10^{-6} \frac{\text{Metric} - \text{ton}}{\text{g}} = X \frac{\text{Metric} - \text{tonCO}_2}{\text{pass} - \text{Year}}$$

#### 4. Air Travel

8) How many miles/kilometers a year do you typically travel by airplane?

A: 1) X Miles or 2) X Kilometers

Keep slider in the range 0 to 50000 Miles.

Keep slider in the range 0 to 80000 Kilometers.

**110 mpg (per occupied seat) and 0.6 mpg (for entire plane)** citing USDT statistics in the Wall Street Journal, August 12, 2010. 21.095 pounds CO2 per gallon jet fuel (US Energy Information Association; EIA)

Jet fuel pounds CO2 per gallon is doubled that value to account for non-CO2 greenhouse gases released as airlines emissions (Kollmuss & Crimmins, 2009. Carbon Off-setting & Air Travel. Stockholm Environment Institute)

Extra 8% emissions associated with jet fuel refining (UN Climate Neutral Network)

80% airlines occupancy (i.e. 20% seats empty; US Bureau Transportation Stats 2009)

$$\text{Plane Emissions} = \frac{Q8 \frac{\text{Miles}}{\text{Year}} * 0.08 * 0.8 * 19.14 * 10^3 \frac{\text{gCO}_2}{\text{Gallon}} * 10^{-6} \frac{\text{Metric} - \text{ton}}{\text{g}}}{0.6 \frac{\text{Miles}}{\text{Gallon}}} = X \frac{\text{Metric} - \text{tonCO}_2}{\text{pass} - \text{Year}}$$

$$\text{Plane Emissions} = \frac{Q8 \frac{\text{km}}{\text{Year}} * 0.08 * 0.8 * 5.056 * 10^3 \frac{\text{gCO}_2}{\text{l}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{0.2551 \frac{\text{km}}{\text{l}}} = X \frac{\text{Metric\_tonCO}_2}{\text{pass - Year}}$$

Don't forget that your transportation habits have many other environmental impacts. This survey, for example, does not measure the CO, N<sub>2</sub>O, CH<sub>4</sub> and CFCs you might be leaking from your vehicle's air conditioner. It doesn't account for the plastic and other non-recycled materials that will be dumped into landfills when your car finally dies. It doesn't even measure many other vehicles emissions such as air toxics, particulates, and evaporative hydrocarbons. It also ignores acid rain producing sulfur dioxides from the electric plants that power the trains or subways you ride. Finally, it ignores road construction, auto making, oil production pollution, and many other more indirect environmental impacts of your transportation choices.

Even the environmental impacts we do measure are based on very conservative assumptions. We used the emission standards that the EPA uses to certify vehicles. These standards assume that you maintain your car regularly, that your emission control systems does not break down, that your catalytic converter is always warm, and that you do little stop-and-go driving. In the real world, these assumptions are often not true. Most people probably produce much more tailpipe pollution than this test suggests. However, reliable data for predicting real-world emissions for specific vehicles does not exist.

$$\text{Total Transportation Emissions} = 1+2+3+4 \frac{\text{Metric\_tonCO}_2}{y}$$

1: Common Vehicle = Q1

2: Rail Travel = Q6

3: Bus Travel = Q7

4: Air Travel = Q8

## APPENDIX B

### Food

A large proportion of human emissions come from food production. The food choices that you make have a wide range of effects on the world around you. Local foods, and those derived from sustainable sources require far less resources and energy to produce and transport. Plant and smaller animal products require a great deal less water and other expenditures than the production of beef and processed foods. Complete the following survey to track and compare your food derived footprint.

#### 1. Calories

1) How many calories do you eat in atypical day?

A: X kcal

#### 2. Beef

2) How often do you eat beef?

$$\text{Type 1: Multiple meals a day} = 14.1 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 1.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 2: Once a day} = 14.1 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.75 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 3: A few times weekly} = 14.1 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.5 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 4: A few times a month} = 14.1 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 5: Never} = 14.1 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

<http://www.dailymail.co.uk/femail/article-2722815/Daily-calorie-intake-countries-world-revealed-surprise-U-S-tops-list-3-770.html>

<http://shrinkthatfootprint.com/food-carbon-footprint-diet>

Daily calorie intake of US with people here consuming an average daily calorie intake of 3,770 cal

Beef CO<sub>2</sub> equivalents per kilocalorie is 14.1

### 3. Chicken

3) How often do you eat chicken?

$$\text{Type 1: Multiple meals a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 1.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 2: Once a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.75 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 3: A few times weekly} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.5 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 4: A few times a month} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 5: Never} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$



<http://shrinkthatfootprint.com/food-carbon-footprint-diet>

Chicken CO<sub>2</sub> equivalents per kilocalorie is 3.8

#### 4. Pork

4) How often do you eat pork?

$$\text{Type 1: Multiple meals a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 1.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 2: Once a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.75 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 3: A few times weekly} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.5 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 4: A few times a month} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 5: Never} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

<http://shrinkthatfootprint.com/food-carbon-footprint-diet>

Pork CO<sub>2</sub> equivalents per kilocalorie is 3.8

#### 5. Fish

5) How often do you eat fish?

$$\text{Type 1: Multiple meals a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 1.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 2: Once a day} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.75 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 3: A few times weekly} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.5 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 4: A few times a month} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 5: Never} = 3.8 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

<http://shrinkthatfootprint.com/food-carbon-footprint-diet>

Fish CO<sub>2</sub> equivalents per kilocalorie is 3.8

## 6. Dairy

6) How often do you drink milk or eat dairy products (cheese, yogurt, etc.)?

$$\text{Type 1: Multiple times a day} = 4.5 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 1.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 2: Once a day} = 4.5 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.75 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 3: A few times weekly} = 4.5 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.5 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 4: A few times a month} = 4.5 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0.25 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

$$\text{Type 5: Never} = 4.5 \frac{\text{gCO}_2\text{e}}{\text{kcal}} * 365 \frac{\text{day}}{\text{year}} * Q1 \frac{\text{kcal}}{\text{day}} * 0 * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

<http://shrinkthatfootprint.com/food-carbon-footprint-diet>

Dairy CO<sub>2</sub> equivalents per kilocalorie is 4.5

## 7. Shopping

7) Where do you obtain your produce?

$$\text{Type 1: Grocery Store} = 0.5 \frac{\text{Metric\_ton}}{\text{year}}$$

$$\text{Type 2: Farmers Market} = 0.25 \frac{\text{Metric\_ton}}{\text{year}}$$

$$\text{Type 3: Grow it yourself} = 0 \frac{\text{Metric\_ton}}{\text{year}}$$

<http://www.greeneatz.com/foods-carbon-footprint.html>

[http://www.carbonindependent.org/sources\\_food.html](http://www.carbonindependent.org/sources_food.html)

Around 11% of the greenhouse emissions involved in food production is linked to food transportation to grocery stores.

Around 5% of the greenhouse emissions involved in food production is reduced by buying at farmers market.

## 8. Organic

8) How much of the food that you eat is organic?

$$\text{Type 1: None} = 0.7 \frac{\text{Metric\_ton}}{\text{year}}$$

$$\text{Type 2: Some} = 0.5 \frac{\text{Metric\_ton}}{\text{year}}$$

$$\text{Type 3: Most} = 0.2 \frac{\text{Metric\_ton}}{\text{year}}$$

$$\text{Type 4: All} = 0 \frac{\text{Metric\_ton}}{\text{year}}$$

[http://www.carbonindependent.org/sources\\_food.html](http://www.carbonindependent.org/sources_food.html)

Organic food can reduce an individual's carbon footprint by 0.7 tonnes CO2 equ.

## 9. Food Waste & Frozen

9) What percentage of your food ends up as waste?

A: X %

<http://shrinkthatfootprint.com/the-big-footprint-of-food-waste>

In USA, average food wastage is about 110 kg

$$Waste = [110 - (Q9 * 0.01 * 110)] * 10^3 \frac{gCO_2e}{year} * 10^{-6} \frac{Metric\_ton}{g}$$

10) What percentage of your food is packaged frozen?

A: X %

<http://www.mapsofworld.com/world-top-ten/world-top-ten-frozen-food-consumer-countries.html>

In USA, average food frozen is about 14.2 kg

$$Frozen = [14.2 - (Q10 * 0.01 * 14.2)] * 10^3 \frac{gCO_2e}{year} * 10^{-6} \frac{Metric\_ton}{g}$$

$$Total\ Food\ Emissions = Q2 + Q3 + Q4 + Q5 + Q6 + Q7 + Q8 + Q9 + Q10 \frac{Metric\_tonCO_2}{y}$$

## APPENDIX C

### Energy

Each day, you make dozens of energy-related decisions. Some of these decisions are based on comfort and convenience, and others may take into account the impact in your gas or electric bill. When making choices about appliance use, it is important to know how much it costs to operate a certain appliance, not only in dollars but in environmental impact.

Some appliances cost very little to operate, but others cost a lot. If you use efficient appliances, you can enjoy their service without worrying about your bill or the amount of pollutants that their use puts into the environment.

The following questions will give you an idea of what appliances consume the most energy in your home, and hopefully your answers to these questions will give you some insight as to which appliances deserve your energy-savings efforts.

#### 1. Residency

1) How many people live in your house?

A: X people

2) Do you live in?

Type 1: An apartment/condo

Stories: 1; Walls: 2

Type 2: An attached one-story house

Stories: 1; Walls: 2

Type 3: An attached two-story house

Stories: 2; Walls: 4

Type 4: An attached three-story house

Stories: 3; Walls: 6

Type 5: A detached one-story house

Stories: 1; Walls: 4

Type 6: A detached two-story house

Stories: 2; Walls: 8

Type 7: A detached three-story house

Stories: 3; Walls: 12

3) What is the square footage of your residence?

A: X sq ft

h = 10 ft; Height of one story

$$A = \left[ \sqrt{\frac{Q3}{Stories}} * 10 * Stories * Walls \right] + \sqrt{\frac{Q3}{Stories}}$$

## 2. Heating

4) What method do you use to heat your home?

Type 1: Electric

Type 2: Gas

Type 3: Fuel Oil

Type 4: Wood

Type 5: No Heat

5) When heating your home, at what temperature do you set your thermostat?

A: 1) X degrees Fahrenheit (or) 2) X degrees Celsius

6) Approximately how many hours per day do you heat your home?

A: X Hours

7) Approximately how many months per year do you heat your home?

A: X months

## HEAT LOSS

Windows: Vertical double glazed window with 3 plastic films ("Low-E" coated) and heavy gas filling

Walls: 10 inches (250 mm) – brick

<http://www.greenhomegnome.com/energy-loss-homes-insulation/>

% wall = 0.75; Percent of heat loss through walls, floor. Roof/attic

% window = 0.25; Percent of heat loss through windows, doors

[http://www.engineeringtoolbox.com/heat-loss-transmission-d\\_748.html](http://www.engineeringtoolbox.com/heat-loss-transmission-d_748.html)

$$U_{\text{wall}} = 0.36 \frac{\text{Btu}}{h(^{\circ}\text{F})(\text{ft})^2}; \quad \text{Overall heat transfer coefficient for the walls}$$

$$U_{\text{window}} = 0.06 \frac{\text{Btu}}{h(^{\circ}\text{F})(\text{ft})^2}; \quad \text{Overall heat transfer coefficient for the windows}$$

$$T_c = 40^{\circ}\text{F}$$

$$D = 30.42 \frac{\text{days}}{\text{month}}$$

$$Cp_{\text{air}} = 0.241 \frac{\text{Btu}}{\text{lb} (^{\circ}\text{F})}; \quad \text{Specific heat of air for infiltration}$$

$$\rho_{\text{air}} = 0.072 \frac{\text{lb}}{(\text{ft})^3}; \quad \text{Density of air for infiltration}$$

[http://www.daviddarling.info/encyclopedia/A/AE\\_air\\_change.html](http://www.daviddarling.info/encyclopedia/A/AE_air_change.html)

$$\text{ACPH} = 0.5; \quad \text{Air changes per hour}$$

<http://www.horizonservicesinc.com/reference/tips-articles/ratings-explained>

$$\text{HSPF} = 7.7; \quad \text{Heating Season Performance Factor}$$

<http://asm-air.com/heating/what-is-afue-annual-fuel-utilization-efficiency/>

$$\text{Electric\_eff} = 1; \quad \text{AFUE for electric furnaces}$$

$$\text{Gas\_eff} = 0.9; \quad \text{AFUE for gas furnaces}$$

$$\text{FO\_eff} = 0.83; \quad \text{AFUE for fuel oil furnaces}$$

$$\text{Wood\_eff} = 0.55 \quad \text{AFUE for firewood furnaces}$$

$$\text{Heat Loss through Walls} = 0.75 * 0.36 \frac{\text{Btu}}{(\text{hour})(^{\circ}\text{F})(\text{ft})^2} * A(\text{ft})^2 * (Q5 - 40)(^{\circ}\text{F})$$



$$\text{Heat Loss through Windows} = 0.25 * 0.06 \frac{\text{Btu}}{(\text{hour})(\text{°F})(\text{ft})^2} * A(\text{ft})^2 * (Q5 - 40)(\text{°F})$$

$$\text{Heat Loss from Infiltration} = \frac{0.072 \frac{\text{lb}}{(\text{ft})^3} * Q3(\text{ft})^2 * h(\text{ft}) * 0.241 \frac{\text{Btu}}{\text{lb}(\text{°F})} * (Q5 - 40)(\text{°F})}{0.5(\text{hour})}$$

$$\text{Heat Loss} = [(\text{Heat Loss through Walls}) + (\text{Heat Loss through Windows}) + (\text{Heat Loss from infiltration})] \frac{\text{Btu}}{h}$$

$$\text{Heat Time} = \frac{Q6 \frac{\text{hour}}{\text{day}} * 30.42 \frac{\text{day}}{\text{month}} * Q7 \frac{\text{month}}{\text{year}}}{Q1}$$

<https://carbonfund.org/how-we-calculate/>

Type 1:

$$\text{Electric} = \frac{\text{Heat Loss} \frac{\text{Btu}}{h} * \text{Heat Time} \frac{h}{y} * 0.000293 \frac{\text{kWh}}{\text{Btu}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{\text{HSPF} * \text{Electric\_eff}}$$

Type 2:

$$\text{Gas} = \frac{\text{Heat Loss} \frac{\text{Btu}}{h} * \text{Heat Time} \frac{h}{y} * 10^{-5} \frac{\text{therm}}{\text{Btu}} * 0.005 \frac{\text{Metric\_tonCO}_2}{\text{therm}}}{\text{Gas\_eff}}$$

Type 3:

$$\text{Fuel Oil} = \frac{\text{Heat Loss} \frac{\text{Btu}}{\text{h}} * \text{Heat Time} \frac{\text{h}}{\text{y}} * 0.000007 \frac{\text{gallon}}{\text{Btu}} * 10.15 * 10^3 \frac{\text{gCO}_2}{\text{gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{\text{FO\_eff}}$$

Type 4:

$$\text{Wood} = \frac{\text{Heat Loss} \frac{\text{Btu}}{\text{h}} * \text{Heat Time} \frac{\text{h}}{\text{y}} * 0.000293 \frac{\text{kWh}}{\text{Btu}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}}{\text{Wood\_eff}}$$

Type 5:

*No heat = 0*

### 3. Cooling

8) What method do you use to cool your home?

Type 1: Window Air Conditioning Unit

Type 2: Central Air Conditioning

Type 3: Fans

Type 4: No cooling

9) When cooling your home, at what temperature do you set your thermostat?

A: 1) X degrees Fahrenheit (or) 2) X degrees Celsius

10) Approximately how many hours per day do you cool your home?

A: X Hours

11) Approximately how many months per year do you cool your home?

A: X months

$$T_h = 95 \text{ }^\circ\text{F}$$

[http://www.compactappliance.com/Buyers-Guide%3A-Air%3A-BTU,-EER,-%26-SEER/BUYERS\\_GUIDE\\_AIR\\_BTU.html](http://www.compactappliance.com/Buyers-Guide%3A-Air%3A-BTU,-EER,-%26-SEER/BUYERS_GUIDE_AIR_BTU.html)

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

- SEER = 12; Seasonal Energy Efficiency Ratio
- pr\_fan = 0.075 kWh per hour; Fan power rating
- CC = 12000; Cooling capacity for window units (BTU/hr)
- EER = 10; Energy efficiency ratio for window units
- Quantity\_wu = 4 Average window units
- Quantity\_f = 6 Average fan units

$$\text{Cool Loss through Walls} = 0.75 * 0.36 \frac{\text{Btu}}{(\text{hour})(^\circ\text{F})(\text{ft})^2} * A(\text{ft})^2 * (95 - Q9)(^\circ\text{F})$$

$$\text{Cool Loss through Windows} = 0.25 * 0.06 \frac{\text{Btu}}{(\text{hour})(^\circ\text{F})(\text{ft})^2} * A(\text{ft})^2 * (95 - Q9)(^\circ\text{F})$$

$$\text{Cool Loss from Infiltration} = \frac{0.072 \frac{\text{lb}}{(\text{ft})^3} * Q3(\text{ft})^2 * h(\text{ft}) * 0.241 \frac{\text{Btu}}{\text{lb}(^\circ\text{F})} * (95 - Q9)(^\circ\text{F})}{0.5(\text{hour})}$$

$$\text{Cool Loss} = \left[ (\text{Cool Loss through Walls}) + (\text{Cool Loss through Windows}) + (\text{Cool Loss from infiltration}) \right] \frac{\text{Btu}}{h}$$

$$\text{Cool Time} = \frac{Q_{10} \frac{\text{hour}}{\text{day}} * 30.42 \frac{\text{day}}{\text{month}} * Q_{11} \frac{\text{month}}{\text{year}}}{Q_1}$$

Type 1:

$$\text{Window Unit} = \frac{4 * CC \frac{\text{Btu}}{h} * \text{Cool Time} \frac{h}{y} * 0.000293 \frac{\text{kWh}}{\text{Btu}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{g}}{EER}$$

Type 2:

$$\text{Central Unit} = \frac{\text{Cool Loss} \frac{\text{Btu}}{h} * \text{Cool Time} \frac{h}{y} * 0.000293 \frac{\text{kWh}}{\text{Btu}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{g}}{SEER}$$

Type 3:

$$\text{Fan Unit} = 6 * pr\_fan \left( \frac{\text{kWh}}{h} \right) * \text{Cool Time} \frac{h}{y} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{g}$$

Type 4:

$$\text{No Cool} = 0$$

#### 4. Dish Washing

12) If you use a dishwasher, how many loads do you wash per week?

A: X Loads per week

13) Do you use energy efficient dishwasher?

Type 1: Yes

Type 2: No

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Dishwasher: energy saver cycle = 0.5 kWh per load

Dishwasher: normal cycle = 2.17 kWh per load

Type 1:

$$\text{Dish Washer} = 0.5 \frac{\text{kWh}}{\text{load}} * Q12 \frac{\text{load}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

Type 2:

$$\text{Dish Washer} = 2.17 \frac{\text{kWh}}{\text{load}} * Q12 \frac{\text{load}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

## 5. Laundry

14) If you use a washer/dryer how many loads do you clean per week?

A: X Loads per week

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Clothes dryer = 4 kWh per load

Warm wash, cold rinse = 2.3 kWh per load

Hot wash, hot rinse = 6.3 kWh per load

$$Laundry = \left[ \left( 2.3 \frac{kWh}{load} * \frac{2}{3} \right) + \left( 6.3 \frac{kWh}{load} * \frac{1}{3} \right) + \left( 4 \frac{kWh}{load} \right) \right] * Q_{13} \frac{load}{week} * 52.143 \frac{week}{year} * 0.5543 * 10^3 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

## 6. Water Heating

15) How is your water heated?

Type 1: Electric

Type 2: Gas

Type 3: Unheated

16) Average daily water usage?

A: X gallons per day

<http://energy.gov/eere/femp/energy-cost-calculator-electric-and-gas-water-heaters-0>

Hot water usage estimates:

- Average shower (8 minutes) = 10 gallons of hot water
- Average clothes washer (one load) = 7 gallons of hot water
- Average dishwasher (one load) = 6 gallons of hot water
- Average kitchen faucet flow = 2 gpm
- Average bathroom faucet flow = 0.5 gpm
- Average daily usage = 64 gallons of hot water.

Electric energy factor = 0.92

Gas energy factor = 0.61

Type 1:

$$\text{Water Heating} = \frac{Q16 \frac{\text{gallon}}{d} * 365 \frac{d}{y} * 0.264 * 10^3 \frac{\text{gCO}_2}{\text{gallon}} * 10^{-6} \frac{\text{Metric\_ton}}{g}}{0.92}$$

Type 2:

$$\text{Water Heating} = \frac{Q16 \frac{\text{gallon}}{d} * 365 \frac{d}{y} * 1.249 \frac{\text{therm}}{\text{gallon}} * 0.005 \frac{\text{Metric\_tonCO}_2}{\text{therm}}}{0.61}$$

Type 3:

$$\text{Water Heating} = 0$$

## 7. Refrigerator

17) What type of refrigerator do you own?

Type 1: Older Model

Type 2: High Efficiency Model

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Freezer (manual defrost), 15 cu. Ft = 90 kWh per month

Energy Star Refrigerator, 14 cu. Ft = 34.5 kWh per month

Type 1:

$$\text{Refrigerator} = 90 \frac{\text{kWh}}{m} * 12 \frac{m}{y} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{g}$$

Type 2:

$$\text{Refrigerator} = 34.5 \frac{\text{kWh}}{m} * 12 \frac{m}{y} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{g}$$

## 8. Lighting

18) What type of light bulbs do you use?

Type 1: Incandescent

Type 2: Fluorescent

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Incandescent bulb (100W) = 0.08 kWh per hour

Fluorescent bulb (27W) = 0.027 kWh per hour

Type 1:

$$\text{Lighting} = 0.08 \frac{\text{kWh}}{\text{h}} * 7 \frac{\text{h}}{\text{d}} * 365 \frac{\text{d}}{\text{y}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

Type 2:

$$\text{Lighting} = 0.027 \frac{\text{kWh}}{\text{h}} * 7 \frac{\text{h}}{\text{d}} * 365 \frac{\text{d}}{\text{y}} * 0.5543 * 10^3 \frac{\text{gCO}_2}{\text{kWh}} * 10^{-6} \frac{\text{Metric\_ton}}{\text{g}}$$

## 9. Computer

19) If you use a desktop computer, how many hours do you use per day?

A: X hours per day

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Desktop Computer = 0.05 kWh per hour



Sleep mode = 0.006 kWh per hour

$$Desktop = (0.25 + 0.006) \frac{kWh}{h} * Q19 \frac{h}{d} * 365 \frac{d}{y} * 0.5543 * 10^3 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

20) If you use a laptop computer, how many hours do you use per day?

A: X hours per day

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

Laptop Computer = 0.05 kWh per hour

Sleep mode = 0.002 kWh per hour

$$Laptop = (0.05 + 0.002) \frac{kWh}{h} * Q20 \frac{h}{d} * 365 \frac{d}{y} * 0.5543 * 10^3 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

## 10. Television

21) If you use a television, how many hours do you use per day?

A: X hours per day

<http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart>

40" - 49" LCD = 0.012 kWh per hour

Standby = 0.005 kWh per hour

$$TV = (0.012 + 0.005) \frac{kWh}{h} * Q21 \frac{h}{d} * 365 \frac{d}{y} * 0.5543 * 10^3 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

## 11. Electricity

22) Do you take measure to conserve or reduce your energy usage, such as turning off appliances and lights when not in use?

Type 1: Yes

Type 2: No

<https://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3>

Average annual electricity consumption for a U.S. residential utility customer was 10,932 kWh

<http://money.howstuffworks.com/personal-finance/budgeting/how-much-save-unplugging-appliances.htm>

Type 1:

$$\text{Electricity Consumption} = 0.1 * 10932 \frac{kWh}{y}$$

Type 2:

$$\text{Electricity Consumption} = 10932 \frac{kWh}{y}$$

23) Where do you get your electricity?

Type 1: Coal Power Plant

Type 2: Gas Power Plant

Type 3: Nuclear Power Plant

Type 4: Renewable Power Plant

<http://timeforchange.org/co2-emission-nuclear-power-stations-electricity>

Coal = 1000 gram per kWh electricity

Gas = 330 gram per kWh electricity

Nuclear = 90 gram per kWh electricity

Renewable = 10 gram per kWh electricity

Type 1:

$$Coal = Q22 \frac{kWh}{y} * 1000 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

Type 2:

$$Gas = Q22 \frac{kWh}{y} * 330 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

Type 3:

$$Nuclear = Q22 \frac{kWh}{y} * 90 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

Type 4:

$$Renewable = Q22 \frac{kWh}{y} * 10 \frac{gCO_2}{kWh} * 10^{-6} \frac{Metric\_ton}{g}$$

$$Total\ Energy\ Emissions = 2+3+4+5+6+7+8+9+10 \frac{Metric\_tonCO_2}{y}$$

2: Heating = Q7

3: Cooling = Q11

4: Dish Washing = Q13

5: Laundry = Q15

6: Water Heating = Q17

7: Refrigerator = Q18

8: Lighting = Q19

9: Computer = Q20 + Q21

10: Television = Q22

## APPENDIX D

### Water

There are many regional differences in the amount of water used. In the West, most of the water is used for irrigation, while in the East more water is used by industry. Residential water use is affected not only by water conservation equipment, like low flow showerheads, but by personal actions, like the amount of time you spend in the shower.

The following questions will give you an idea about how you are doing at conserving water. Most of the questions deal with the type of water fixtures and appliances you have. Choose the answer that best describes your household.

#### 1. Shower

1) How many baths do you take per week?

A: X baths

<http://water.usgs.gov/edu/qa-home-percapita.html>

A "full tub" varies, but 36 gallons is average amount considered.

$$Bath = 36 \frac{\text{gallon}}{\text{bath}} * Q1 \frac{\text{bath}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}}$$

2) How many showers a week do you take?

A: X showers

3) How long does your typical shower last?

A: X minutes

4) Do you use a high efficiency showerhead?

Type 1: Yes

Type 2: No

<http://water.usgs.gov/edu/qa-home-percapita.html>

Old showers used to use up to 5 gallons of water per minute.

Type 1

$$\text{Shower} = Q2 \frac{\text{shower}}{\text{week}} * 5 \frac{\text{gallon}}{\text{min ute}} * Q3 \frac{\text{min ute}}{\text{shower}} * 52.143 \frac{\text{week}}{\text{year}}$$

Type 2

$$\text{Shower} = Q2 \frac{\text{shower}}{\text{week}} * 5 \frac{\text{gallon}}{\text{min ute}} * Q3 \frac{\text{min ute}}{\text{shower}} * 52.143 \frac{\text{week}}{\text{year}}$$

## 2. Toilet

5) What type of toilet does your place of residence use?

Type 1: Older Model (installed prior to 1992)

Type 2: Typical Model

Type 3: High Efficiency Model

<http://www.conserveh2o.org/toilet-water-use>

If your toilet was installed prior to 1992, then it likely uses 3.5-7 GPF.

Type 1:

Consumption: 5 GPF

Average flushes per day: 5

$$\text{Older Model Toilet} = 5 \frac{\text{gallon}}{\text{flush}} * 5 \frac{\text{flush}}{\text{day}} * 365 \frac{\text{day}}{\text{year}}$$

Type 2:

Consumption: 1.6 GPF

Average flushes per day: 5

$$\text{Typical Model Toilet} = 1.6 \frac{\text{gallon}}{\text{flush}} * 5 \frac{\text{flush}}{\text{day}} * 365 \frac{\text{day}}{\text{year}}$$

Type 3:

Consumption: 1.28 GPF

Average flushes per day: 5

$$\text{Higher Efficiency Model Toilet} = 1.28 \frac{\text{gallon}}{\text{flush}} * 5 \frac{\text{flush}}{\text{day}} * 365 \frac{\text{day}}{\text{year}}$$

- 6) Do you take any measures to reduce the amount of leakage in your toilet (such regularly replacing the seals)?

Type 1: Yes

Type 2: No

Water leaks account for approximately 14% of all water use in the average.

Type 1:

$$\text{Toilet} = [Q4 - (Q4 * 0.14)] \frac{\text{gallon}}{\text{year}}$$

Type 2:

$$\text{Toilet} = [Q4 - (Q4 * 0)] \frac{\text{gallon}}{\text{year}}$$

### 3. Washing Machine

7) What type of clothes washing machine does your place of residence have?

Type 1: Older Model (installed prior to 1992)

Type 2: Typical Model

Type 3: High Efficiency Model

<http://www.consumerenergycenter.org/residential/appliances/washers.html>

Type 1:

Consumption: 40 GPW

Average loads per year: 300

$$\text{Older Model Washing} = 40 \frac{\text{gallon}}{\text{load}} * 300 \frac{\text{load}}{\text{year}}$$

Type 2:

Consumption: 27 GPW

Average loads per year: 300

$$\text{Typical Model Washing} = 27 \frac{\text{gallon}}{\text{load}} * 300 \frac{\text{load}}{\text{year}}$$



Type 3:

Consumption: 14 GPW

Average loads per year: 300

$$\text{Higher Efficiency Model Washing} = 14 \frac{\text{gallon}}{\text{load}} * 300 \frac{\text{load}}{\text{year}}$$

#### 4. Dish Washer

8) How do you wash dishes?

Type 1: By Hand with a sink full of water

Type 2: By Hand with running water

Type 3: With a typical dishwasher

Type 4: With a high efficiency dishwasher

<http://water.usgs.gov/edu/qa-home-percapita.html>

<https://www.cityutilities.net/resident/pgms/watertips.htm>

Type 1:

Consumption: 18 GPC

Average loads per year: 150

$$\text{Hand Washing} = 18 \frac{\text{gallon}}{\text{cycle}} * 150 \frac{\text{cycle}}{\text{year}}$$

Type 2:

Consumption: 27 GPC

Average loads per year: 150

$$\text{Hand Washing} = 27 \frac{\text{gallon}}{\text{cycle}} * 150 \frac{\text{cycle}}{\text{year}}$$

Type 3:

Consumption: 16 GPC

Average loads per year: 150

$$\text{Hand Washing} = 16 \frac{\text{gallon}}{\text{cycle}} * 150 \frac{\text{cycle}}{\text{year}}$$

Type 4:

Consumption: 6 GPC

Average loads per year: 150

$$\text{Hand Washing} = 6 \frac{\text{gallon}}{\text{cycle}} * 150 \frac{\text{cycle}}{\text{year}}$$

9) If you use a dishwasher, what is the typical load size?

$$\text{Type 1: Full} = Q7 \frac{\text{gallon}}{\text{year}} * 1$$

$$\text{Type 2: Half Full} = Q7 \frac{\text{gallon}}{\text{year}} * 2$$

$$\text{Type 3: With a few dishes} = Q7 \frac{\text{gallon}}{\text{year}} * 3$$

## 5. Swimming Pool

10) Do you have a swimming pool?

Type 1: Yes

Type 2: No

<http://www.gracelinks.org/240/outdoor-water-use-at-home>

Assume pool is covered

6000 GPY for filling evaporated

Type 1:

$$Pool = [18000 + 6000] \frac{\text{gallon}}{\text{year}}$$

Type 2:

$$Pool = 0$$

## 6. Lawn

11) Do you water your lawn?

Type 1: Yes → Go to Q11

Type 2: No → Go to Q12

12) If you water your lawn, how large is the area being watered?

Type 1: Large (700 square feet or more)

Type 2: Medium (300 to 700 square feet)

Type 3: Small (300 square feet or less)

<http://www.urbanplantations.com/newsletter/water-conservation-fruit-and-vegetable-gardens-vs-lawns>

<http://www.lowes.com/projects/gardening-and-outdoor/make-watering-easier/project>

The **EPA states** that 50% of outdoor water is wasted

Average water lawns require: 0.623 gallons per square feet x 50% inefficiency = 0.935 GP sqft

Type 1:

$$Lawn = 700sq\_feet * 0.935 \frac{gallon}{(sq\_feet)(week)} * 52.143 \frac{week}{year}$$

Type 2:

$$Lawn = 500sq\_feet * 0.935 \frac{gallon}{(sq\_feet)(week)} * 52.143 \frac{week}{year}$$

Type 3:

$$Lawn = 300sq\_feet * 0.935 \frac{gallon}{(sq\_feet)(week)} * 52.143 \frac{week}{year}$$

## 7. Source of Water

13) Where do you get your water?

Type 1: Municipal Water System

Type 2: A Well

Type 3: A Cistern

Type 4: Other

Total Water Emissions:  $1+2+3+4+5+6 \frac{gallons}{y}$

1: Shower = Bath + Shower

2: Toilet = Q6

3: Washing Machine = Q7

4: Dish Washer = Q9

5: Swimming Pool = Q10

6: Lawn = Q12

## APPENDIX E

### TRASH

The environmental impact of this consumption varies with how much recycling and composting is done in your region. The primary impacts are natural resource use, energy use, and the air emissions associated with energy use. The following questions will give you an idea how your purchasing and disposal methods affect your personal environmental impact.

#### 1. Cans

1) How many aluminum cans (soda, juice, beer, ect.) do you purchase during a typical week?

A: X Cans per week

2) What percentage of these cans do you recycle?

A: X %

<http://www.madehow.com/Volume-5/Aluminum.html>

Cincinnati Magazine - Aug 2008 - Page 123 - Google Books Result

It takes about 4 lb (2 kg) of bauxite to produce 1 lb (0.5 kg) of aluminum metal.

$$Bauxite = 4 * 1.18 \frac{lbCO_2}{can} * [(Q1) - (Q1 * Q2)] \frac{can}{week} * 52.143 \frac{week}{year} * 454 \frac{g}{lb}$$

$$Can = 1.08 \frac{kWh}{can} * [(Q1) - (Q1 * Q2)] \frac{can}{week} * 52.143 \frac{week}{year}$$

## 2. Newspapers

3) How many newspapers do you purchase during a typical week?

A: X Newspapers per week

4) What percentage of these newspapers do you recycle?

A: X %

[http://www.answers.com/Q/What is the average number of pages in a newspaper](http://www.answers.com/Q/What_is_the_average_number_of_pages_in_a_newspaper)

<http://www.justanswer.com/general/0i9ya-weight-average-daily-newspaper.html>

A large daily paper is approximately 40 pages in volume in the United States.

Assuming 300 pages per week

Paper has an embodied energy of 10 kWh per kg.

1 page weighs= 0.096 oz  $\Rightarrow$  300 page weighs= 28.8 oz

1 oz = 28.3495 grams  $\Rightarrow$  28.8 oz= 816.5 g

$$\text{Newspaper Consumed} = 1.8 \frac{\text{lbCO}_2}{\text{paper}} * [(Q3) - (Q3 * Q4)] \frac{\text{paper}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Newspaper} = 8.25 \frac{\text{kWh}}{\text{paper}} * [(Q3) - (Q3 * Q4)] \frac{\text{paper}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}}$$

## 3. Plastic

5) How many plastic containers (bottles, jugs, packaging, ect) do you purchase during a typical week?

A: X Plastic containers

6) What percentage of these containers do you recycle?

A: X %

[http://waste360.com/mag/waste\\_profiles\\_garbage\\_highdensity](http://waste360.com/mag/waste_profiles_garbage_highdensity)

Cincinnati Magazine - Aug 2008 - Page 123 - Google Books Result

$$HDPE \text{ Resin} = 2.81 \frac{lbCO_2}{container} * [(Q5) - (Q5 * Q6)] \frac{container}{week} * 52.143 \frac{week}{year} * 454 \frac{g}{lb}$$

$$Plastic = 2.55 \frac{kWh}{container} * [(Q5) - (Q5 * Q6)] \frac{container}{week} * 52.143 \frac{week}{year}$$

#### 4. Glass Bottle

7) How many glass bottles do you purchase during a typical week?

A: X Glass Bottles

8) What percentage of these bottles do you recycle?

A: 1) X %

Cincinnati Magazine - Aug 2008 - Page 123 - Google Books Result

$$Glass \text{ Bottle} = 1.16 \frac{lbCO_2}{bottle} * [(Q7) - (Q7 * Q8)] \frac{bottle}{week} * 52.143 \frac{week}{year} * 454 \frac{g}{lb}$$

$$Glass = 1.05 \frac{kWh}{bottle} * [(Q5) - (Q5 * Q6)] \frac{bottle}{week} * 52.143 \frac{week}{year}$$

#### 5. Mixed Paper



9) How many clean mixed paper packages (note paper, cereal boxes, junk mail, etc.) do you buy during the typical week?

A: X Packages

10) What percentage of your clean mixed paper (note paper, cereal boxes, junk mail, ect.) do you recycle?

A: X %

<http://www.lowtechmagazine.com/what-is-the-embodied-energy-of-materials.html>

[http://www.answers.com/Q/How\\_much\\_does\\_your\\_average\\_box\\_of\\_cereal\\_weigh](http://www.answers.com/Q/How_much_does_your_average_box_of_cereal_weigh)

**To produce 1 kilogram of paper 6.95 kWh energy is required.**

**1 cereal package weighs 14 oz**

$$\text{Mixedpaper Consumed} = 0.875 \frac{\text{lbCO}_2}{\text{paper}} * [ (Q9) - (Q9 * Q10) ] \frac{\text{paper}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Mixedpaper} = 2.75 \frac{\text{kWh}}{\text{paper}} * [ (Q9) - (Q9 * Q10) ] \frac{\text{paper}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}}$$

## 6. Waste

11) How many bags of household trash do you dispose of weekly?

A: X Bags

[http://www.eia.gov/energyexplained/?page=biomass\\_waste\\_to\\_energy](http://www.eia.gov/energyexplained/?page=biomass_waste_to_energy)

<http://www.apartmenttherapy.com/reader-survey-how-much-househo-71891>

**4.4 pounds** trash the average American produces daily.

**Bags of garbage on average considered are 3 bags per week.**

$$\text{Bags Consumed} = 10 \frac{\text{lbCO}_2}{\text{bag}} * [(Q11) - (Q11 * Q12)] \frac{\text{bag}}{\text{week}} * 52.143 \frac{\text{week}}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

## 7. Purchasing

12) How often do you typically purchase new clothes?

$$\text{Type 1: Daily} = 1102 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 2: Weekly} = 157 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 3: Monthly} = 36 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 4: Rarely/Recycled} = 3 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

13) How often do you typically purchase new household furnishings (including electronics, kitchenware, hardware, decorations, etc.)?

$$\text{Type 1: Daily} = 2000 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 2: Weekly} = 286 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 3: Monthly} = 66 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

$$\text{Type 4: Rarely/Recycled} = 6 \frac{\text{lbCO}_2}{\text{year}} * 454 \frac{\text{g}}{\text{lb}}$$

<http://www.livescience.com/13835-carbon-footprint-daily-activities.html>

\$1,200 clothing purchased and you're up to almost 0.5 metric tons of carbon dioxide per year.

\$1,000 furniture purchase once a year and you're up to almost a ton of carbon dioxide per year.

$$\text{Total Trash Emissions: } 1+2+3+4+5+6+7 \frac{g}{y} * 10^{-6} \frac{\text{Metric\_ton}}{g}$$

## APPENDIX F

### Transportation Visual Basic Code

```
Private Sub CommandButton1_Click()  
q1_answer = Sheets("Transportation").Range("C3")  
q2_answer = Sheets("Transportation").Range("C5")  
q3_answer = Sheets("Transportation").Range("C7")  
q4_answer = Sheets("Transportation").Range("C9")  
q5_answer = Sheets("Transportation").Range("C11")  
q6_answer = Sheets("Transportation").Range("C13")  
q7_answer = Sheets("Transportation").Range("C15")  
q8_answer = Sheets("Transportation").Range("C17")
```

```
    If q1_answer = "" Then  
        MsgBox "Fill in Q1"  
        Exit Sub  
    End If
```

```
    If q2_answer = "" Then  
        MsgBox "Fill in Q2"  
        Exit Sub  
    End If
```

```
    If q3_answer = "" Then  
        MsgBox "Fill in Q3"  
        Exit Sub  
    End If
```

```
    If q4_answer = "" Then  
        MsgBox "Fill in Q4"  
        Exit Sub  
    End If
```

```
    If q5_answer = "" Then  
        MsgBox "Fill in Q5"  
        Exit Sub  
    End If
```

```
    If q6_answer = "" Then  
        MsgBox "Fill in Q6"  
        Exit Sub  
    End If
```

```
    If q7_answer = "" Then  
        MsgBox "Fill in Q7"  
        Exit Sub
```

```

End If

If q8_answer = "" Then
    MsgBox "Fill in Q8"
    Exit Sub
End If

row_number = 1
Do
DoEvents
row_number = row_number + 1
    item_in_review = Sheets("TransportationResponses").Range("A" & row_number)
Loop Until item_in_review = ""

last_transaction_id = Sheets("TransportationResponses").Range("A" & (row_number - 1))

Dim next_transaction_id As Integer
next_transaction_id = last_transaction_id + 1

Sheets("TransportationResponses").Range("A" & (row_number)) = next_transaction_id
Sheets("TransportationResponses").Range("B" & (row_number)) = q1_answer
Sheets("TransportationResponses").Range("C" & (row_number)) = q2_answer
Sheets("TransportationResponses").Range("D" & (row_number)) = q3_answer
Sheets("TransportationResponses").Range("E" & (row_number)) = q4_answer
Sheets("TransportationResponses").Range("F" & (row_number)) = q5_answer
Sheets("TransportationResponses").Range("G" & (row_number)) = q6_answer
Sheets("TransportationResponses").Range("H" & (row_number)) = q7_answer
Sheets("TransportationResponses").Range("I" & (row_number)) = q8_answer

Sheets("Transportation").Range("C3") = ""
Sheets("Transportation").Range("C5") = ""
Sheets("Transportation").Range("C7") = ""
Sheets("Transportation").Range("C9") = ""
Sheets("Transportation").Range("C11") = ""
Sheets("Transportation").Range("C13") = ""
Sheets("Transportation").Range("C15") = ""
Sheets("Transportation").Range("C17") = ""

End Sub

```

## APPENDIX G

**Table 9: List of US States by CO2 Emissions**

Rank	Jurisdiction	Annual CO2 emissions (millions of metric tons)	Percentage of total emissions	Population (estimate of 2014)	Percentage of total population	CO2 emissions per capita (metric tons)
-	<b>States Total</b>	<b>5,434</b>	<b>100.00%</b>	<b>318,857,056</b>	<b>100.00%</b>	<b>17.04</b>
1	Texas	709	13.04%	26,956,958	8.45%	26.29
2	California	359	6.61%	38,802,500	12.17%	9.26
3	Pennsylvania	242	4.46%	12,787,209	4.01%	18.94
4	Illinois	233	4.29%	12,880,580	4.04%	18.12
5	Ohio	229	4.21%	11,594,163	3.64%	19.75
6	Florida	227	4.18%	19,893,297	6.24%	11.41
7	Louisiana	207	3.81%	4,649,676	1.46%	44.5
8	Indiana	203	3.74%	6,596,855	2.07%	30.81
9	New York	170	3.13%	19,746,227	6.19%	8.61
10	Michigan	162	2.97%	9,909,877	3.11%	16.31
11	Georgia	139	2.56%	10,097,343	3.17%	13.76
12	Kentucky	138	2.53%	4,413,457	1.38%	31.19
13	Missouri	131	2.42%	6,063,589	1.90%	21.66
14	North Carolina	126	2.31%	9,943,964	3.12%	12.64

15	Alabama	121	2.24%	4,849,377	1.52%	25.05
16	New Jersey	114	2.10%	8,938,175	2.80%	12.78
17	Oklahoma	104	1.92%	3,878,051	1.22%	26.92
19	Tennessee	103	1.89%	6,549,352	2.05%	15.69
18	Virginia	103	1.90%	8,326,289	2.61%	12.42
20	Wisconsin	101	1.85%	5,757,564	1.81%	17.47
21	West Virginia	97	1.79%	1,850,326	0.58%	52.47
22	Minnesota	94	1.73%	5,457,173	1.71%	17.24
23	Arizona	93	1.71%	6,731,484	2.11%	13.79
24	Colorado	91	1.67%	5,355,866	1.68%	16.95
25	Iowa	83	1.53%	3,107,126	0.97%	26.78
26	South Carolina	74	1.37%	4,832,482	1.52%	15.39
27	Washington	73	1.35%	7,061,530	2.21%	10.4
28	Kansas	70	1.28%	2,904,021	0.91%	23.97
29	Arkansas	69	1.26%	2,966,369	0.93%	23.13
30	Wyoming	65	1.20%	584,153	0.18%	111.55
31	Utah	64	1.19%	2,942,902	0.92%	21.9
33	Mississippi	64	1.17%	2,994,079	0.94%	21.28
32	Massachusetts	64	1.18%	6,745,408	2.12%	9.49
34	Maryland	62	1.14%	5,976,407	1.87%	10.38
35	North Dakota	55	1.02%	739,482	0.23%	74.81
36	Nebraska	52	0.95%	1,881,503	0.59%	27.51
37	New Mexico	50	0.92%	2,085,572	0.65%	24.07

38	Oregon	38	0.70%	3,970,239	1.25%	9.56
39	Nevada	37	0.68%	2,839,099	0.89%	13.02
41	Alaska	35	0.64%	736,732	0.23%	47.17
40	Connecticut	35	0.65%	3,596,677	1.13%	9.77
42	Montana	32	0.59%	1,023,579	0.32%	31.51
43	Hawaii	18	0.33%	1,419,561	0.45%	12.82
44	Maine	17	0.31%	1,330,089	0.42%	12.52
45	Idaho	17	0.31%	1,634,464	0.51%	10.18
46	South Dakota	15	0.28%	853,175	0.27%	17.91
47	New Hampshire	15	0.27%	1,326,813	0.42%	11.25
48	Delaware	13	0.25%	935,614	0.29%	14.24
49	Rhode Island	11	0.20%	1,055,173	0.33%	10.08
50	Vermont	6	0.11%	626,562	0.20%	9.38
51	District of Columbia	3	0.06%	658,893	0.21%	4.55



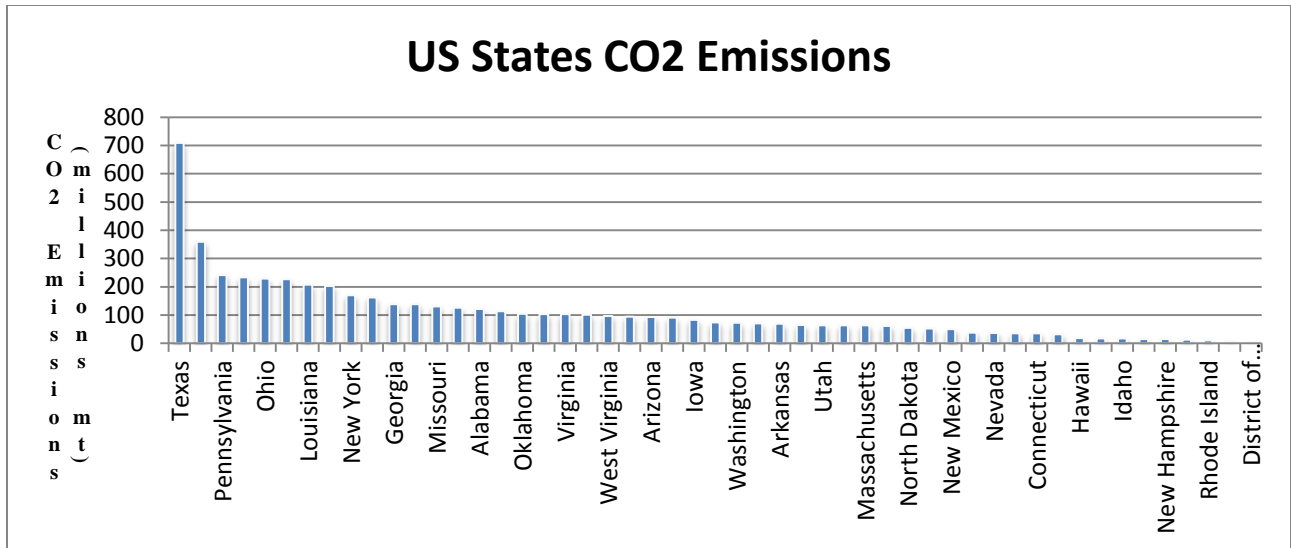


Figure 41: US States CO2 Emission

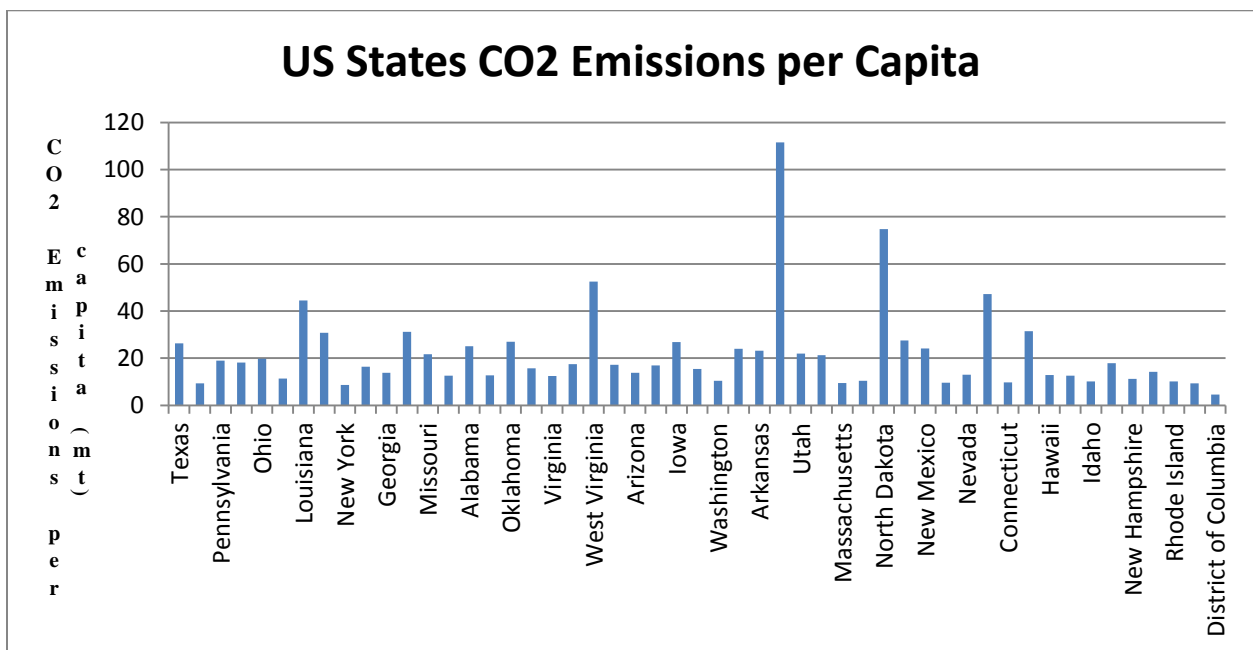
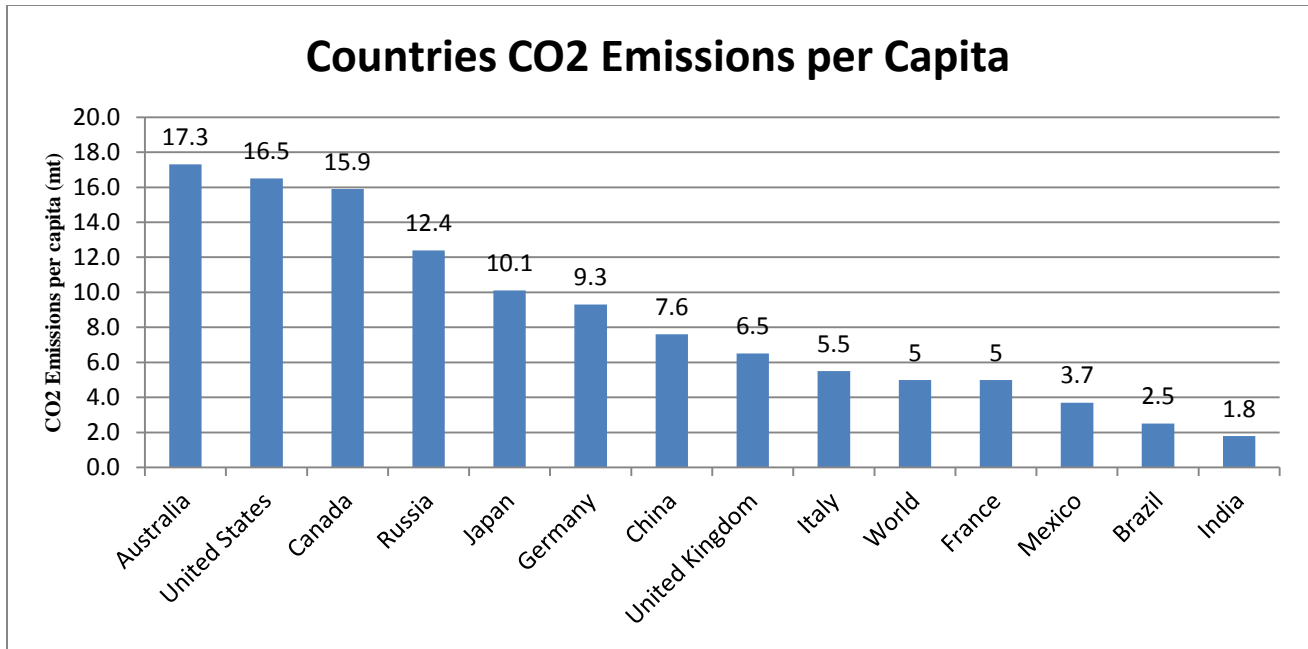


Figure 42: US States CO2 Emissions per Capita

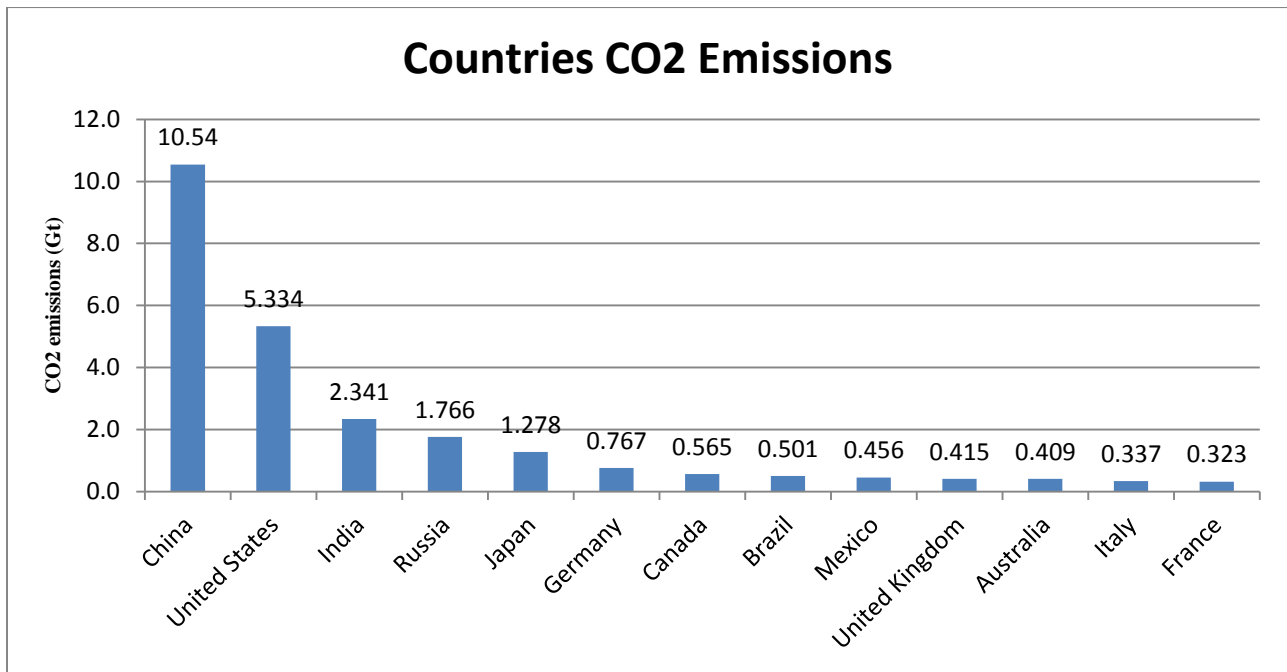
## APPENDIX H

**Table 10: List of Countries by CO2 Emissions**

Rank	Country	CO2 emissions (kt)	CO2 emissions (Gt)	Percentage of CO2 emissions	Emissions per capita (mt)
18	Australia	409,000	0.409	1.15%	17.3
2	United States	5,334,000	5.334	14.95%	16.5
11	Canada	565,000	0.565	1.58%	15.9
5	Russia	1,766,000	1.766	4.95%	12.4
6	Japan	1,278,000	1.278	3.58%	10.1
7	Germany	767,000	0.767	2.15%	9.3
1	China	10,540,000	10.54	29.55%	7.6
17	United Kingdom	415,000	0.415	1.16%	6.5
21	Italy	337,000	0.337	0.94%	5.5
	<b>World</b>	<b>35,669,000</b>	<b>35.669</b>	<b>100%</b>	<b>5</b>
22	France	323,000	0.323	0.91%	5
15	Mexico	456,000	0.456	1.28%	3.7
12	Brazil	501,000	0.501	1.40%	2.5
4	India	2,341,000	2.341	6.56%	1.8



**Figure 43: Countries CO2 Emissions per Capita**

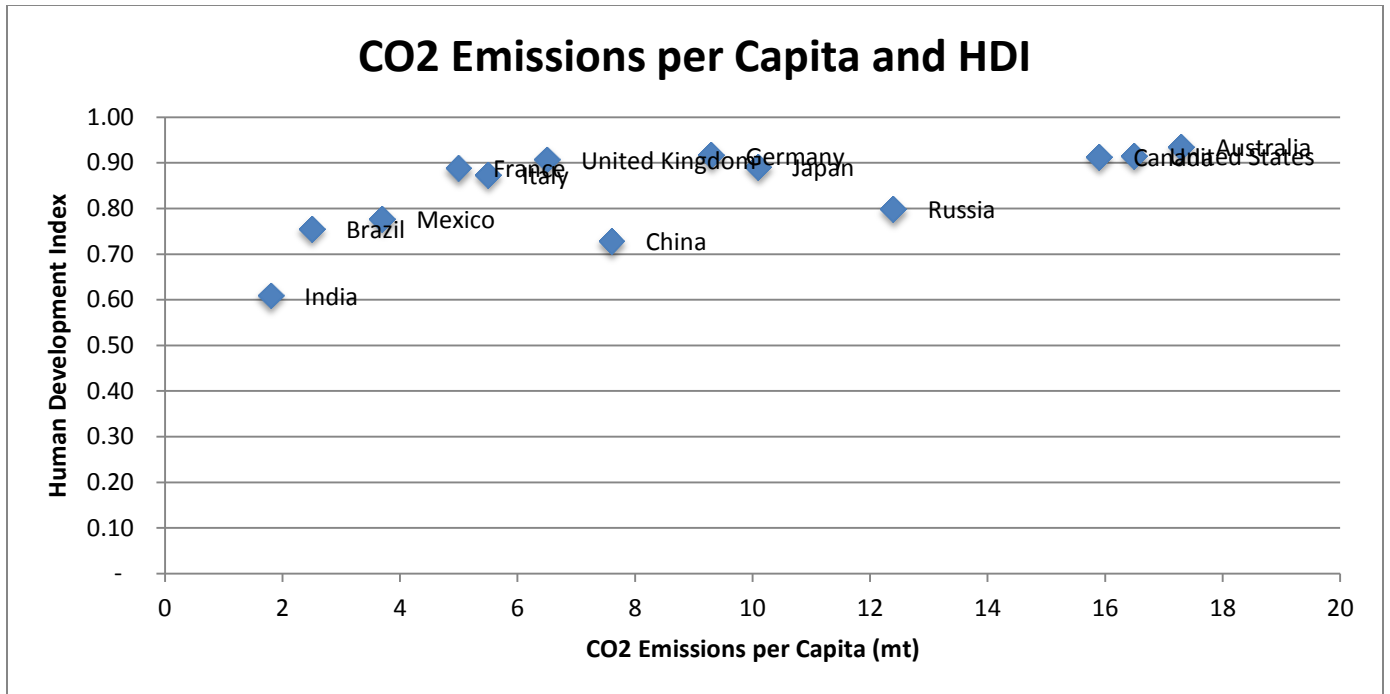


**Figure 44: Countries CO2 Emissions**

## APPENDIX I

**Table 11: List of Countries by HDI and CO2 Emissions**

<b>Rank</b>	<b>Country</b>	<b>CO2 emissions (kt)</b>	<b>CO2 emissions (Gt)</b>	<b>HDI</b>	<b>Emissions per capita (mt)</b>
1	China	10,540,000	10.54	0.73	7.6
2	United States	5,334,000	5.334	0.92	16.5
4	India	2,341,000	2.341	0.61	1.8
5	Russia	1,766,000	1.766	0.80	12.4
6	Japan	1,278,000	1.278	0.89	10.1
7	Germany	767,000	0.767	0.92	9.3
11	Canada	565,000	0.565	0.91	15.9
12	Brazil	501,000	0.501	0.76	2.5
15	Mexico	456,000	0.456	0.78	3.7
17	United Kingdom	415,000	0.415	0.91	6.5
18	Australia	409,000	0.409	0.94	17.3
21	Italy	337,000	0.337	0.87	5.5
22	France	323,000	0.323	0.89	5



**Figure 45: CO2 Emissions per capita and HDI**

## APPENDIX J

### Energy Spreadsheet Questionnaires

	Questions	Answers	Units
1	How many people live in your house?		
2	Do you live in?		
3	What is the square footage of your residence?		
4	When heating your home, at what temperature do you set your thermostat?		
5	Approximately how many hours per day do you heat your home?		Hours
6	Approximately how many months per year do you heat your home?		Months
7	What method do you use to heat your home?		
8	When cooling your home, at what temperature do you set your thermostat?		
9	Approximately how many hours per day do you cool your home?		Hours
10	Approximately how many months per year do you cool your home?		Months
11	What method do you use to cool your home?		
12	If you use a dishwasher, how many loads do you wash per week?		
13	Do you use an energy efficient dishwasher?		
14	If you use a washer/dryer how many loads do you clean per week?		
15	How do you dry your laundry?		
16	Average daily hot water usage?		Gallons
17	How is your water heated?		
18	What type of refrigerator do you own?		
19	Which type of light bulb below is mostly used in your home?		
20	If you use a desktop computer, how many hours do you use per day?		Hours
21	If you use a laptop computer, how many hours do you use per day?		Hours
22	If you use a television, how many hours do you use per day?		Hours
		Submit	

**Figure 46: Excel Spreadsheet Energy Queries**



## APPENDIX L

### Water Spreadsheet Questionnaires

	Questions	Answers
1	How many baths do you take per week?	
2	How many showers a week do you take?	
3	How long minutes does your typical shower last?	
4	Do you use a high efficiency showerhead?	
5	What type of toilet does your place of residence use?	
6	Do you take any measures to reduce the amount of leakage in your toilet (such regularly replacing the seals)?	
7	What type of clothes washing machine does your place of residence have?	
8	How do you wash dishes?	
9	If you use a dishwasher, what is the typical load size?	
10	Do you have a swimming pool?	
11	If you water your lawn, how large is the area being watered?	
12	Where do you get your water?	
		Submit

**Figure 48: Excel Spreadsheet Water Queries**



## APPENDIX M

### Trash Spreadsheet Questionnaires

	Questions	Answers
1	How many aluminum cans (soda, juice, beer, ect.) do you purchase during a typical week?	
2	What percentage of these cans do you recycle?	
3	How many newspapers do you purchase during a typical week?	
4	What percentage of these newspapers do you recycle?	
5	How many plastic containers (bottles, jugs, packaging, ect) do you purchase during a typical week?	
6	What percentage of these containers do you recycle?	
7	How many class bottles do you purchase during a typical week?	
8	What percentage of these bottles do you recycle?	
9	How many clean mixed paper packages (note paper, cereal boxes, junk mail, etc.) do you buy during the typical week?	
10	What percentage of your clean mixed paper (note paper, cereal boxes, junk mail, ect.) do you recycle?	
11	How many bags of household trash do you dispose of weekly?	
12	How often do you typically purchase new clothes?	
13	How often do you typically purchase new household furnishings (including electronics, kitchenware, hardware, decorations, etc.)?	
		Submit

**Figure 49: Excel Spreadsheet Trash Queries**