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Sustainability and Transportation at WPI

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SUSTAINABILITY AND TRANSPORTATION AT WPI

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Abstract

This project was developed for Worcester Polytechnic Institute in Worcester, Massachusetts. As part of a campus-wide sustainability effort, this project looks at how the WPI community can reduce their carbon footprint by driving less. A general survey to gather data about the community's driving habits was used to estimate the annual carbon dioxide emission caused by transportation. The results make a convincing appeal that carpooling is one of the easiest and best ways the University can reduce its carbon footprint.

Acknowledgements

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Emmanuel was responsible for writing the drafts and finalizations of the executive summary, literature review on carpooling and ridesharing databases, methodology, results, and recommendations. He edited the analysis section, literature review and part of recommendations.

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Neda was responsible for writing the draft and finalizations of the abstract, acknowledgments, literature review on carbon dioxide emissions and carbon footprinting, transportation, part of the recommendations, and references.

TABLE OF CONTENTS

List of Figures

Ch. 1

Ch. 2

Ch. 3

Ch. 4

Ch. 5

List of Tables

Ch. 2

Ch. 4

Ch. 5

Executive Summary

"Sustainability and Transportation at WPI" is a project that was undertaken to assess the impact of carbon dioxide emissions by the WPI community as a result of transportation, and explores ways of reducing this impact. The project was initiated as part of sustainability efforts at WPI to change the old habits of the community doing things that are not environmentally friendly to a more environmentally conscious community. This project had the obligation of further promoting environmentally responsible behaviors that are already being addressed by several groups and projects at the university.

One of the first tasks of this work was to investigate the need for carbon footprint reduction at WPI, and how this could be achieved. Published literature was reviewed on carbon footprint and all the details about it. These included definitions, sources, effects on the environment, and alternatives for reduction. As part of reduction alternatives, ridesharing was identified as one of the best options to be considered. Having identified this option, further work was done to assess the feasibility of implementing such a system for the university. The team did some research into carpooling as a carbon dioxide emission reduction option by finding out whether other institutions and universities had been successful in using it.

After researching what other colleges and institutions had done, the project team came up with an outline of what had to be done in order to achieve the project objective. The group had to estimate WPI's transportation-related carbon footprint. To do this, a campus-wide survey was designed by the group and administered to the entire WPI community, including faculty members, staff members, and graduate and undergraduate students. The goal of the survey was

to gather data about the driving habits of the members of the university so that it could be used to calculate the carbon footprint of commuters that drive to the campus daily. Some of the questions asked on the survey were to find the distance and number of times people drive to campus, the year, make and model of their cars, and their zip codes. Other questions were whether people normally drive using highways or mostly through the city. One of the questions that was a deciding factor for the team on whether or not ridesharing will attract people was to ask respondents to indicate on a scale of zero to ten what their interest in carpooling is.

The answers to these questions provided enough data for the team to analyze and estimate a number for the transportation carbon footprint of the entire WPI community. The results also showed that most people consider carpooling as a viable alternative to reducing the university's carbon footprint in this area; there was a favorable response to participating in a ridesharing program.

Another phase of the project was to educate the community members on the need for reducing the school's transportation footprint and the possible alternatives that members of the community could use to do that. A campaign was organized by the team to fulfill two purposes: to inform the community on the team's findings while promoting ridesharing as an alternative for reducing WPI's carbon footprint, and also to give general suggestions on responsible driving behaviors that could be taken by individuals to minimize one's carbon dioxide emissions. Information for this campaign was gathered from very trusted sources, including the website of the United States Environmental Protection Agency (EPA). The campaign promoted the idea of ridesharing and how that could be achieved.

The final phase of the project was to initiate a working carpool program for the community, since the team got positive feedback about the prospects of such a system if it were

made available at the university. At this point the team sought help from the President's Task Force on Sustainability to help establish a database where interested members could go on and sign up for carpool partners.

The team gave a presentation to the committee showing the results from the survey and making an argument that a ridesharing system would be of great benefit to the users, the university, and the environment; sighting examples such as: users will save money, there will be less CO_2 emissions into the atmosphere, and the school can save money that would have otherwise gone into the building of more parking spaces. With this appeal, the task force overwhelmingly endorsed the project and asked the team to look for outside vendors who can provide pre-packaged software to be used by the community.

Twelve vendors were contacted, of which four had detailed discussions with the project team, and their terms and conditions of service as well as costs were inquired. Three out of the four vendors provided the necessary documents in response to the inquiry, upon which a proposal was sent to the President's Task Force based on the information from vendors. The committee selected one of the vendors, "Carpoolworld," to be tried for at least one year.

The team proceeded by asking for a contract from "Carpoolworld" and submitted it to the committee's representative for all the necessary legal procedures and approval. The final outcome of the project was to launch a database on the school's sustainability website so that users could sign up for ridesharing partners. The project was done through three school terms and was completed in D-term 2009.

Introduction

The issue of Global Warming has become more of a reality than a myth to the world. Today, governments and scientists all over the world are finding ways of reducing carbon footprints that are a direct result of human activities. Burning of fossil fuels emits CO_2, the main greenhouse gas that causes global warming, and its reduction has become the main target in the fight to combat this phenomenon.

Global Warming is defined as the progressive increase in the Earth's atmospheric and oceanic temperature predicted to occur due to an increase in the greenhouse effect, and is responsible for changes in the global climatic patterns. Solar infra-red radiation that is received by the Earth is trapped by greenhouse gases (GHGs) namely, water vapor, carbon dioxide, methane, nitrous oxide and chlorofluoro carbons (CFCs), and part of it is re-emitted back to the atmosphere. This energy is required to keep the surface temperature of the Earth within a range that makes the Earth habitable for the species present. However, an increase in the concentration of these gases is causing the stratosphere to trap more energy than is required to sustain life and prevent the Earth from becoming uninhabitable.

Impacts of this rise in temperature may include rising sea levels resulting in floods and droughts, as well as influences on plant and animal life, thereby affecting human beings in a major way. "Predictions by the Intergovernmental Panel on Climate Change (IPCC), in its Third Assessment Report published in 2001, showed that the temperature will rise by an additional 1.4 to 5.8°C, shown in Figure 1.2, while the mean sea level will increase by 9 to 88 cm by the end of the 21st century, depending on the actual rate of emissions" (DEFRA, 2005 pp6).

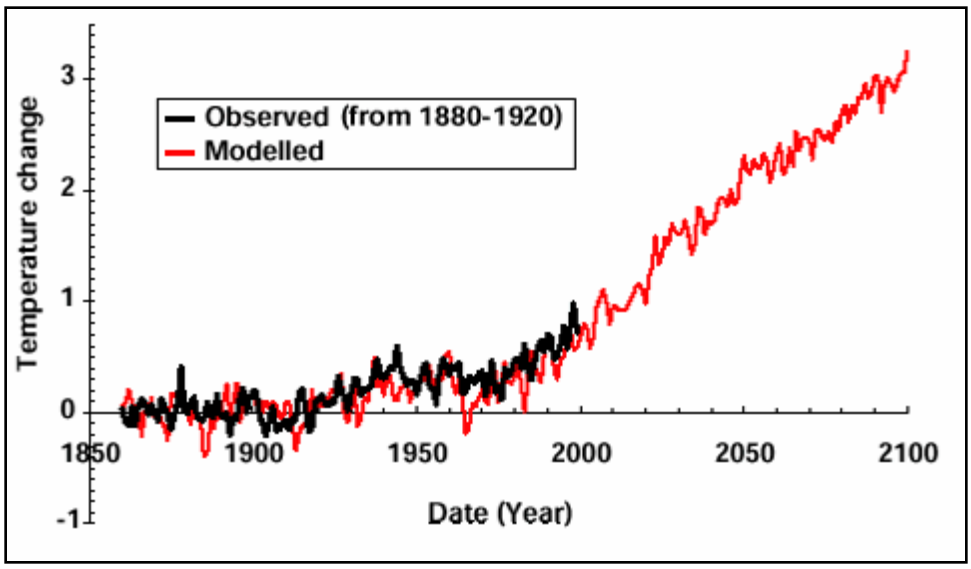

Figure 1.1 Global Temperature Change Trends (DEFRA, 2001)

This increase in the concentration of greenhouse gases is due to an increased usage of fossil fuels and other such sources that emit greenhouse gases. The constant rise in Earth's temperature since 1990, became a cause of concern all over the world and a detailed policy regarding the reduction of greenhouse gases was formulated in the Kyoto Protocol[1] of 1997(Siebenborn, 2000). As a result of this agreement, carbon dioxide emissions of countries will be monitored to evaluate and consequently reduce their carbon footprints on the planet.

"A carbon footprint is a measure of the greenhouse gas emissions associated with an activity, group of activities, or a product" (Abbott, 2008 pp4). It is an indirect measure of the impact that human activities have on the environment, and in particular climate change. It relates to the amount of greenhouse gases produced on a daily basis. Nearly every human activity contributes to carbon footprint, whether it be getting to work, watching TV, or buying lunch. However, there are certain activities that contribute more and leave a bigger footprint than

[1] Kyoto Protocol-The UN convention on Climate Change summit that was held at Kyoto, Japan from 1st -11th December, 1997. Around 10 countries of the world ratified this proposal and agreed to collect and share their greenhouse gas records and their policies at the national level. They also agreed to propose measures to achieve reduction in greenhouse gases to meet the targets set by the convention. The convention targets are currently set at 7% carbon dioxide reduction below the level of 1990 by the year 2012.

others. These include energy use, especially burning fossil fuels, transportation, and waste generation. Studies have shown that transportation is one of the major contributors to our carbon footprint (Abbott, 2008).

All means of transportation, apart from walking and cycling which are negligible, cause emissions. The worst transportation means are planes and cars where the gases emitted are calculated according to the number of passengers, the efficiency of the mode and the distance travelled (HEEPI, 2005).

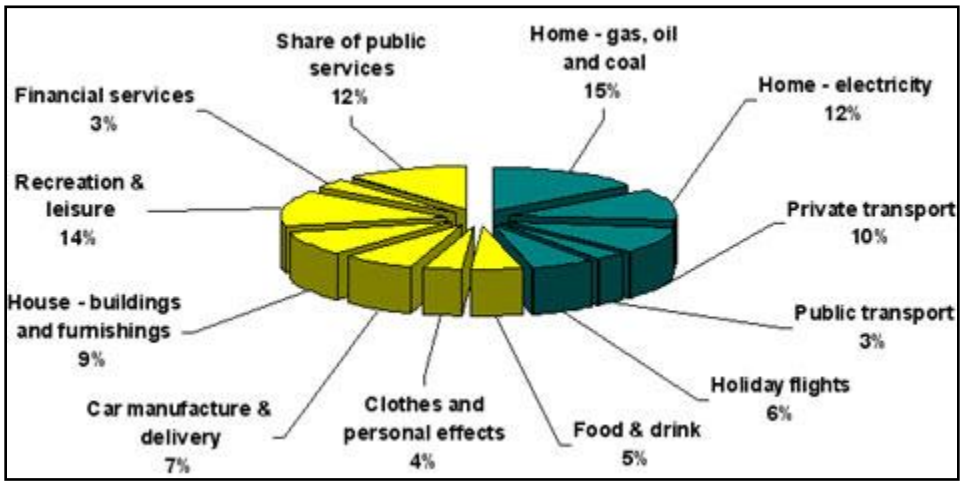

Figure 1.2 Main elements of an individual's carbon footprint

Transportation nearly constitutes 20% of a person's carbon footprint. Therefore one can estimate that the amount of carbon dioxide emitted by a large organization or group would be much larger, and a major cause of concern. Much research has been done on the issue of transportation related carbon footprint and how to reduce it, and various countries and organizations have already put these practices into use with successful results. These methods include using unleaded fuels, using vehicles with high fuel efficiency, and hybrid cars. As public transportation only makes up for 3% of an individual's carbon footprint, it brings forth an interesting premise that carbon footprint can be reduced if multiple people use the same vehicle for transportation. Therefore, public transportation is a very potent method of reducing one's

carbon footprint hence reducing the production of greenhouse gas emissions. This also gives rise to another ingenious idea, ridesharing. ("What is a Carbon Footprint")

Ridesharing or carpooling is becoming an increasingly popular alternative to daily driving, since it reduces transportation costs, decreases wear and tear on vehicles, reduces fuel consumption, and provides opportunities for social interaction. Carpooling also reduces carbon footprints as fewer vehicles are used to transport the same number of people. Ridesharing helps reduce mechanical stress on roads and freeways and also reduces infrastructural costs as fewer parking spaces have to be built to accommodate the reduced number of vehicles.

A ridesharing system can be extremely effective in places where a large number people travel to and from, such as industries, corporate offices, schools and colleges. Hence, carpooling is one of the easiest and most economically viable ways of reducing carbon footprint. As environmentally conscious and educated citizens of the 21st century, many people have realized the importance of sustainable living practices and taking care to reduce their carbon footprint on the Earth. This is indicated by the number of industries, corporate offices, and educational institutions that have ridesharing services in place and encourage carpooling by providing incentives such as discounted parking decals, green air miles, reserved parking spots, and much more.

Worcester Polytechnic Institute (WPI) is one of the leading institutions that have made sustainability and environmental consciousness a part of their daily culture. WPI is making all necessary efforts by constructing LEED certified buildings, conducting programs like 'Recyclemania,' organizing Earth day activities, holding various seminars and talks, and designing projects on sustainability and environmental issues.

This Interactive Qualifying Project takes the WPI culture of sustainability a step forward and studies the social and environmental impacts of energy consumption and carbon footprint. The purpose was to understand the scale of the problem, and try to gauge or calculate through various research methods the carbon footprint of the community attributed to transportation. Another goal of the project was to suggest practical and easy solutions such as carpooling to reduce the community's transportation related carbon footprint and ultimately contribute to cultivating the culture of sustainability and responsible living at the university.

Chapter 2: Literature Review

In the past, many researchers have studied global warming, its causes and how its effects could be reduced. Many methods for reducing carbon dioxide emissions including reducing the number of vehicles on roads have been suggested by different researchers. To achieve the latter, people are continuously being encouraged to use mass transportation or share a ride with others.

2.1 Carbon Footprinting

Scientists are in agreement that global warming is a problem that the earth is experiencing as a result of human actions, rather than of natural causes. The amount of scientific support and evidence surrounding it is great and cannot be overlooked. Scientists have been able to extensively study and understand the causes of global warming. ("Environmentally Friendly Carbon Footprint Calculator")

Many negative outcomes and changes in our environment are occurring as a result of this consequence. For example, some negative impacts are the increase in the amount of severe storms, droughts, and the melting of glaciers ("Environmentally Friendly Carbon Footprint Calculator"). Additionally, the number of category four and five hurricanes has doubled over the last thirty years (Emanuel, 2005). A minimum of 279 species of animals and plants have been impacted by global warming and are being forced to move closer to the poles ("Global warming science, climate change science, facts & evidence"). In Greenland, the flow of ice from glaciers has doubled over the past ten years (Krabil).

In addition to the present, negative consequences of global warming, scientists have been able to make predictions for its future ramifications ("Environmentally Friendly Carbon Footprint Calculator"). For instance, scientists predict that human and animal life will be at great threat. The amount of human loss will double to 300,000 people annually within a period of

twenty five years ("Global warming science, climate change science, facts & evidence"). Furthermore, by the year 2050, more than a million species worldwide will become extinct (Bjerklie). Droughts, wildfires, and heat waves will occur more frequently and powerfully ("Environmentally Friendly Carbon Footprint Calculator"). Coastal areas around the world will be endangered due to the rise of global sea levels by more than twenty feet resulting from the loss of shelf ice in Greenland and Antarctica (Eilperin).

Thus, with this scientifically supported problem at hand, every individual has a moral obligation to help solve this problem by making small modifications to one's daily routine. The problem of global warming can be at least partially addressed. ("Environmentally Friendly Carbon Footprint Calculator")

2.2 Sources

An individual's carbon footprint is the immediate impact his or her actions and lifestyle have upon the environment in terms of carbon dioxide emissions ("Information product"). An individual's emissions vary on the basis of location, habits, and personal choices; the amount of emissions an individual is responsible for can therefore be managed ("Climate change, greenhouse gas emissions"). Additionally, society releases greenhouse gases through various activities such as driving, electricity use, growing food, raising livestock, and garbage disposal. By taking environmentally friendly measures when carrying out such activities, one can reduce his or her carbon footprint ("Climate change, what you can do").

Greenhouse gas emissions can result directly from the burning of oil or gas to heat a home and indirectly through the use of electricity that is generated from the burning of fossil fuels. For example, the amount of greenhouse gases that are emitted per unit of electricity by a

power plant that runs on coal is greater than that of a natural gas based power plant ("Climate change, greenhouse gas emissions").

Simple steps such as the purchasing of green power or driving fuel efficient cars are some effective ways in which individuals can help improve the environment. Various aspects associated with driving and transportation greatly impact carbon dioxide emissions. Such factors include the amount of time spent idling on the road, the fuel efficiency of a vehicle, and how frequently an individual drives ("Green Power Partnership").

2.3 Transportation and Carbon Footprint

The EPA reports that transportation accounted for approximately twenty nine percent of the total greenhouse gas emissions in the United States, in 2006. Additionally, the greatest growing source of GHG emissions for the United States is attributed to transportation; it is responsible for forty seven percent of the net increase in the total emissions since 1990 ("Transportation and Climate").

The U.S EPA Office of Transportation and Air Quality reports GHG emissions related to transportation has increased more than any other contributing sector. The total U.S production of GHG's in 2003 increased by thirteen percent since 1990, while the transportation sector grew by twenty four percent ("Greenhouse Gas Emissions from the US Transportation Sector").

The Agency additionally reports that, in 2003, eighty one percent of transportation related GHG emissions in the United States were a result of on-road vehicles, which is comprised of light duty vehicles (passenger cars, sports utility vehicles, vans, motorcycles) and medium and heavy duty trucks and buses. Sixteen percent of GHG emission from transportation resulted from non-road transportation sources. Furthermore, two percent of total transportation GHG emissions

were attributed to automobile air conditioning and refrigerated transport, while the final one percent was due to lubricants ("Greenhouse Gas Emissions from the US Transportation Sector").

The amount of carbon dioxide emissions per capita and per GDP that various nations around the world were responsible for in 1996 are listed in the table below (Fay and Golomb, 2002).

Nation	Carbon Emissions Per Capita (kg/capita)	Carbon Emissions per GDP (kg/$ GDP)
United States	5270	0.26
Canada	4040	0.25
Russia	3340	2.01
Japan	2460	0.1
Germany	2790	0.15
France	1600	0.09
Italy	1960	0.13
India	270	0.65
Mexico	1070	0.63
World Total	1090	Not Applicable

Table 2.1 1996 Carbon Dioxide Emissions of Nations

The United States of America and China are responsible for the largest carbon dioxide emissions, followed by Russia[2]. In terms of per capita emissions, the United States and Canada have the greatest, with 5270 and 4040 kilogram per capita per year respectively. Russia follows behind the United States and Canada, with 3340 kg per capita per year. The emissions of the

[2] in terms of absolute quantities of carbon dioxide emissions

United States are approximately five times as much carbon per capita, in comparison to the rest of the world (Fay and Golomb, 2002).

The major sectors responsible for the consumption of energy in the United States are residential (commercial), industrial, and transportation. The distribution of these sectors includes 36.2% for the industrial sector, 36.6% for residential-commercial, and 27.2% for transportation.

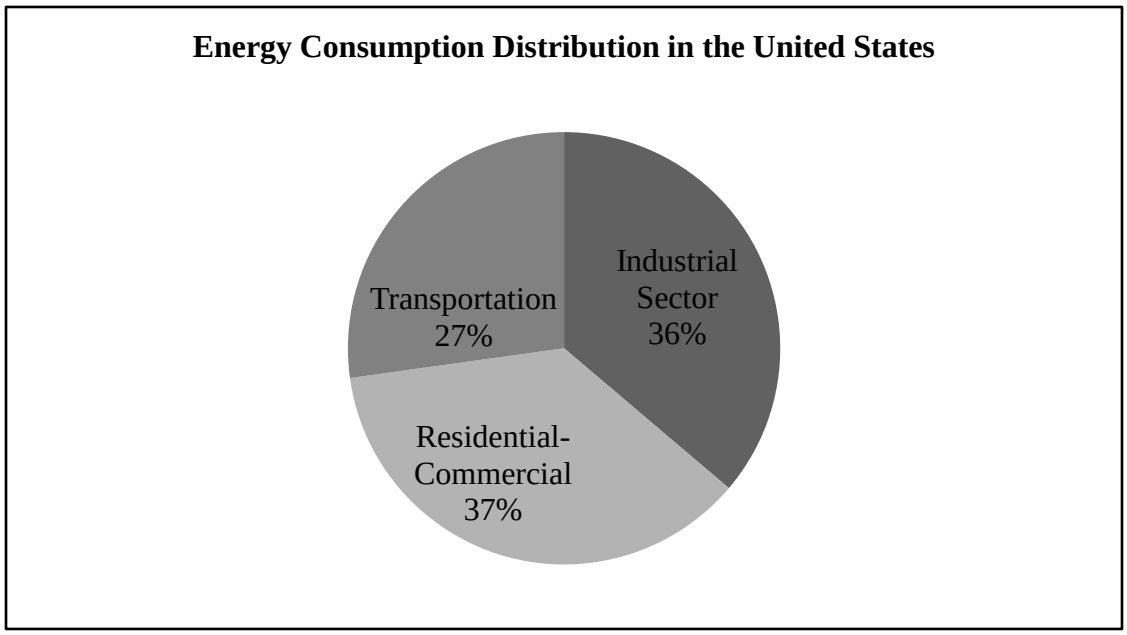

Figure 2.1Energy Consumption Distribution in the United States

Transportation of people and goods among homes, workplaces, to and from other locations, local and foreign is a key ingredient in any industrialized economy. The main forms of transportation used to perform this function are ground, air, and marine vehicles powered by fossil-fueled combustion engines. These three general forms of fossil fueled transportation are listed below:

- Heavy cars, light cars, and trains
- Airplanes
- Marine vessels

The largest transportation component of this sector that is responsible for energy use is due to personal automobiles, which makes up 42% of the total. Additionally, 20% is due to light trucks, 16% for heavy freight, 9% for air, 7% for water, 4% for pipe, and 2% for rail transport. This distribution within the transportation sector can be seen in the figure below (Fay and Golomb, 2002).

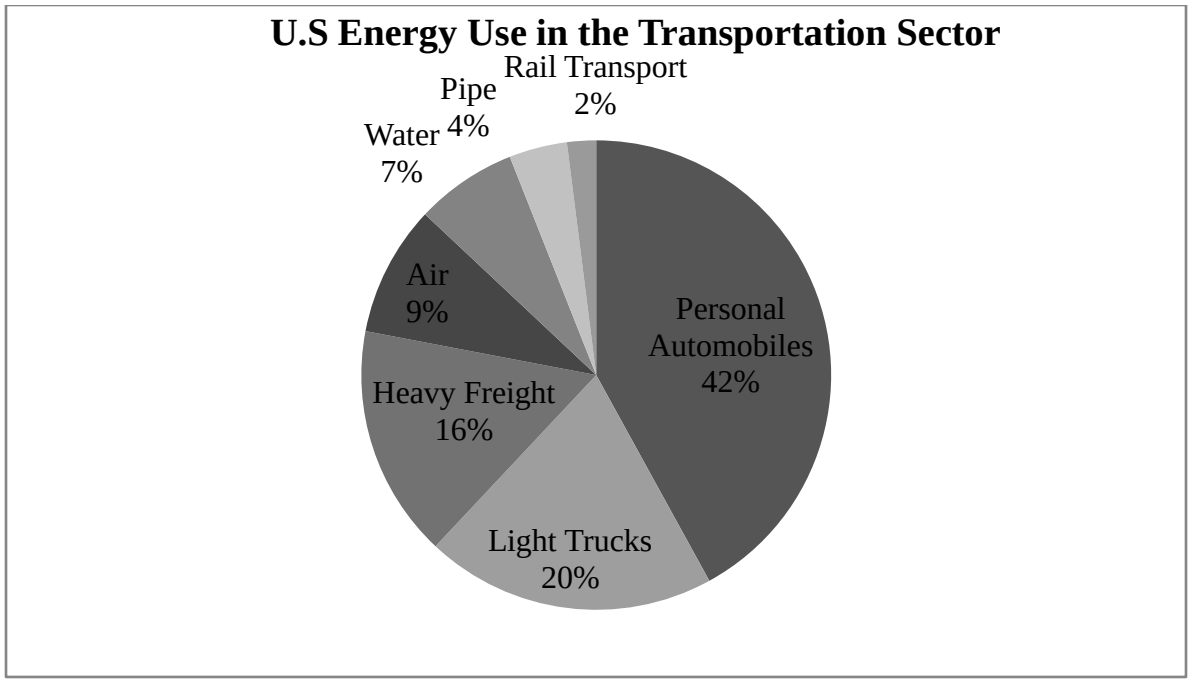

Figure 2.2 U.S Energy Use in the Transportation Sector

Great deals of energy consumption, air pollution, and carbon dioxide emissions could be decreased by reducing the weight of automobiles, raising the fuel efficiency of engines, using cars that are powered by fuel cell and electrically powered batteries, using "hybrid internal combustion engine-electric powered cars" (Fay and Golomb, 2002 pp22), and increasing the use of public transportation (Fay and Golomb, 2002).

2.4 Reducing Carbon Dioxide Emissions

The United States Environmental Protection Agency (EPA) reports various sources of greenhouse gas emissions along with suggestions for making reductions in carbon dioxide emissions. Small changes can translate to immense decreases in greenhouse gas emissions released into the earth's atmosphere ("Climate change, what you can do").

To make a reduction in carbon dioxide emissions, the EPA explains how the use of ENERGY STAR qualified products is not only beneficial to the environment but also saves money in energy bills. Furthermore, cleaning air filters on a regular basis and tuning heating and cooling equipment annually by a licensed contractor results in energy conservation and thus a reduction in greenhouse gas emissions ("At Home What You Can Do").

Reducing, reusing, and recycling are some methods through which greenhouse gas emissions can be minimized according to the EPA. In addition, increased insulation and sealing of one's home, prevents air drafts and thus reduces energy waste ("At Home What You Can Do").

2.5 Carpooling

Ridesharing, also referred to as carpooling, is increasingly becoming a popular alternative for people to reduce costs due to transportation, and at the same time reduce carbon dioxide emissions. All over the world, individuals and organizations are becoming more informed and convinced that carpooling is one of the easiest and most cost effective ways of not only saving the environment but also money.

In an article by Fiona McCann, a very good argument is made about the successes carpooling has achieved, citing programs in many countries, including France, Germany, United States and Canada. In North America, the provision of High Occupancy vehicle lanes (HOV) is a

positive way of making people park their cars and share a ride. Since its inception in the 1970's, carpooling has been gaining popularity over the years. It has even become a better alternative to driving by oneself in recent times due to rising cost of fuel prices, increasing traffic congestion on roads, public outcry, scientific evidence for the need to reduce global warming, and the general global rise in the cost of living (2008).

Stories about carpooling however have not always been pleasant, and some people have never been interested in riding with strangers. Reasons range from personal security to privacy. Other concerns include incompatibility with carpooling partners such as the use of cell phones, mood changes, conversational lines, radios and seating arrangements (Shea, 2007).

Although these concerns remain, the practice seems to have caught on well with many people and is still gaining more popularity.

All participants of car pooling programs do so because of numerous benefits that come with the practice. Benefits range from savings in cash and time to reducing carbon dioxide emissions and global warming. Some regular carpoolers measure their annual savings in dollar amounts. An article by Tess Kalinowski cites how two people have saved $ 3,000 each per year since they decided to carpool together to work (2007). These friends have made their carpooling a fun activity, and mention how they use their commute to relax if it is not their turn to drive. Carpoolers make schedules that work for all the participants, and make provisions for emergency rides in case any of the participants has to leave work or school before the scheduled time.

With growing world population and increasing urbanization, carpooling promises to be one major method of solving some complex problems that the world faces today. Global vehicle population is said have an annual growth of 4.1 percent. At this the total number of vehicles is expected to reach 92.7 million in the year 2015 from an estimated 72.2 million in 2008. Clearly,

current worldwide infrastructure cannot support this rate of growth. This means in the coming years, more roads, bridges, and parking lots must be built to support the increase. Increasing infrastructure will only worsen the problem of global warming because more cars will be on the road. Research has shown that one of the best solutions to reducing global warming is reducing the number of vehicles on the street. Road congestion keeps increasing and does not show any signs of decline, and although some major European countries are taking steps to reducing cars on their roads by charging higher fees and tolls, ridesharing seems to be the most cost saving and viable solution to ensuring this objective ("Carpooling and Car Sharing: Solutions to Complex Problems").

2.5.1 Carpooling at Other Colleges

As never before, institutions and colleges are taking the challenge of introducing carpool programs on their campuses as a way of helping solve both the environmental and economic problems that the world faces today. Across the United States, many campuses have already established ridesharing systems for their students, faculty and staff.

Trinity College in Connecticut has a ridesharing program which by default has the names of all students and staff of the college. This step is to encourage the majority of the community to take advantage of the program. Members who are not interested have the option to withdraw their names from the system ("Transportation").

In Massachusetts, Wellesley College, Babson College and Olin College have collaborated on a similar project. Together they offer what they call the "Green Line to campus" for both faculty and staff using the Massachusetts Bay Transportation Authority (MBTA). Those who do not want to use this service have the option of visiting a website and joining a carpooling conference. This was an initiative taken by the sustainability committee to reduce carbon

footprints. They have the shuttle stop at arranged stops, using a comprehensive schedule ("Transportation").

The University of Florida also has a comprehensive program for the entire campus community. Like the other schools, the system was put in place to help improve air quality and conserve energy, and also to reduce traffic and ease parking congestion. As part of their promotion of the program they encourage the community to use the opportunity to reduce wear and tear on their vehicles, as well as to save on gasoline and insurance costs. Members are reminded that other benefits of sharing a ride are to "make new friends, reduce the stress of commuting alone, and enjoy preferred parking at a nominal cost" ("Carpool Program"). Carpooling has become a culture in colleges, universities and other institutions all across the United States as well as other countries. It is a program worth promoting; it is good environmentally and economically.

2.5.2 Ride Sharing Database

As much as carpooling has become a very popular concept for people who want to cut costs and reduce carbon footprints, there are other concerns that have to be addressed if this concept is to work effectively and be embraced by many more in the community. One of the questions that people ask is how they will be able to find partners to carpool with. It is in this regard that one of the most convenient approaches has been setting up online databases, where people can sign up and find matches that suit their needs. There are many web sites that have been created to give people flexibility to sign up and choose when and from where they are willing to commute daily with other users.

However, it has been demonstrated that many schools and institutions feel more comfortable with such websites that have been customized to their specific needs. Most

employers and schools believe that a carpool program branded with their school or corporate logo and that meets their specific requirements will attract their people to participate and share their pertinent origination and destination points

Databases that are created to help fulfill the goal of ridesharing should meet some basic requirements. It should be easy for participants to sign up and provide information such as origination location, preferred origination time, and destination location. Also, participants should feel safe in sharing information about their daily commute. Privacy and security of information shared must be ensured for people to feel comfortable in using these services. All legal requirements must be met, such as receiving approval to obtain and manage participant's origination points and contact information, and enough disclaimers that will give prospective participants options to make responsible choices. All the above concerns, if addressed, give the ridesharing database some authenticity and participants will feel more comfortable providing their information (ALTRANS, 2004).

2.6 Research Methods

Scientific research is an important step in the development of new ideas; it can be used to prove or disprove existing theories or come up with completely new theories. In order to conduct research various techniques and instruments are used. These techniques or processes are collectively known as research methods. Research methods are a systematic set of approaches to gathering information that rely on established processes and procedures, particularly those developed in social or behavioral sciences. Research methods include procedures for studying a certain phenomenon (for example, study of how human behavior changes under authority), including ways of collecting, storing and analyzing empirical observations and data.

There are many ways of collecting data, including surveys, interviews, focus groups, discussions and observation. Generally, one or a combination of these techniques is used in order to collect data, especially in the study of social phenomena or problems. Surveys are the most commonly used research method to collect data for an experiment or simply to gauge public opinion about a product or facility. A survey is a method of gathering information from a sample population. This sample is just a fraction of the larger target population being studied. Surveys can be divided into two broad categories: interviews and questionnaires (NSS, 2008).

2.6.1 Interviews

An interview is a face-to-face interaction with the respondents where the interviewer notes down the answers provided by the respondent. Some of the advantages of using interviews as a survey method are:

- Interviews provide a more personal method of data collection unlike questionnaires.
- It gives the interviewer a chance of asking follow-up questions.
- They help increase the accuracy of responses.
- Interviews allow the interviewer to observe body language and such behavior that cannot be observed through a questionnaire.
- They provide first hand feedback, thereby enabling re-evaluation and modification of the line and method of inquiry.

Using interviews as a research instrument has its disadvantages too:

- Personal interviews can be very time consuming and expensive.
- They might have a limited response rate because it is difficult to get a big sample size.
- They provide information of a quality that is largely dependent on the interviewer and is subject to the interviewer being bias.

- They are subject to biases such as respondent bias or even discomfort, as there is no anonymity (NSS, 2008).

2.6.2 Questionnaires

A questionnaire is a paper based research instrument with a set of concise, pre-planned questions designed to yield specific information about a particular topic. Like interviews, questionnaires have various benefits and drawbacks as well; some of these are illustrated below.

Advantages:

- Questionnaires are very cost effective and save the researcher a lot of time.
- They can reach a larger sample of the target population.
- They aid collection of information in a standardized way thereby diminishing the possibility of respondent or researcher bias.
- Questionnaires increases respondent comfort level as they are anonymous, thereby increasing the chance of obtaining accurate and unbiased data.
- They make data entry and analysis very easy.

Disadvantages:

- Questionnaires might obtain low response rates.
- They do not allow the possibility of probing responses and asking follow up questions.
- Questionnaires might reduce the flexibility of a survey as they are structured and a pre-planned instrument.
- They might include questions that could be misunderstood due to ambiguous language or poor design ("How to evaluate EIS", 2006).

Comparing the above methods for data gathering, the benefits of using a questionnaire outweigh its drawbacks. These drawbacks can be easily fixed or reduced in order to make the

questionnaire a very effective research method. Drawbacks can be taken care of by conducting a pre-test or a pilot study. A pilot study provides valuable feedback to reduce the errors in questionnaires and also provides researchers with some familiarity with the quality of responses and data analysis that they might obtain from the main study.

A good questionnaire has the following stages:

1. Survey design
2. Sampling
3. Implementation
4. Analysis and reporting

Figure 2.6 shows a possible flow of activities for data gathering by a questionnaire.

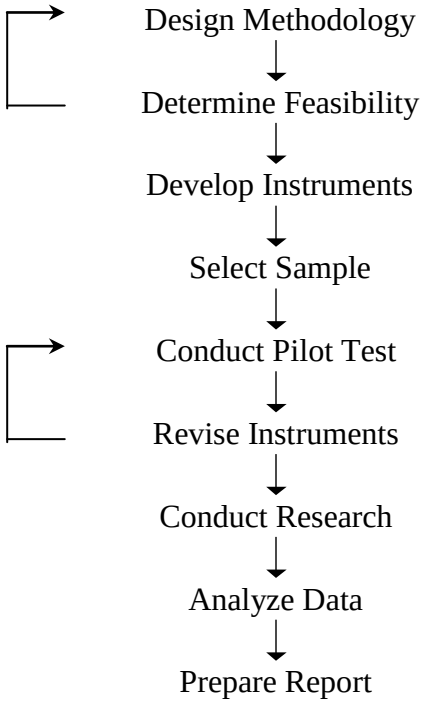

Figure 2.3 Questionnaire Design Flow Chart (Walonick, 1997)

Two feedback loops in the flowchart allow for considerable revisions and fine-tuning of the survey.

Survey Design

After considering different data collection methods and various distribution techniques, the next step in a research is to design the questionnaire that is going to be circulated to gather correct, concise and necessary data. Designing a questionnaire for a survey is not an easy task; a lot of things need to be kept in mind, and a lot of issues need to be considered for designing a user-friendly and successful survey questionnaire. For designing a survey the researchers need to consider the following questions:

a. Can the questions be easily understood?

b. Is the question too vague or precise?

c. Is the question open to bias?

d. Is the question necessary to the study?

e. Is the question applicable to all respondents?

f. Will the respondents be willing to provide an answer to the question ("How to evaluate EIS", 2006)?

The questionnaire should be short and as concise as possible. It should only ask for data that cannot be obtained from other sources. Therefore any unnecessary and redundant questions should be removed from the questionnaire. This ensures that the survey is short, relevant and not time consuming, which increases the chances of getting a higher response. The questions being asked should not be very complex, thereby ensuring that most of the target population can answer all the questions without difficulty. If the questions are simpler, more people will be inclined to respond, which will in turn make the data more reliable. The survey should be attractive, neat and well organized. The questions should be very objective with no leading

suggestions. The questions should be numbered such that they make chronological sense and the preceding question leads into the next one. Questions that seem to have a flow help the participants to organize their thoughts so that their answers are logical and objective. A good questionnaire can always stand alone without needing a person to describe it to the respondent. Therefore a good survey should have a brief introduction at the opening describing the purpose of the survey, introducing the surveyors and sponsors if any, and clarifying the terms and conditions of participation. The terms and conditions should include information such as if the survey is anonymous and confidential, will the results be published anywhere, and if it is mandatory to complete the survey once started. These questions clarify the purpose of the study and make the participants aware of their rights. This also makes them feel more comfortable and secure about giving out their information, as they know how and when it is going to be used. The way the questions are asked also impacts the comprehensibility, participant comfort level, and the flexibility of the survey.

There are three types of questions that can be asked on a survey. Open ended questions are questions that ask for unprompted opinions; there is no predetermined set of responses and the participants are free to respond in the manner they like. These questions allow for a greater depth of the response but are open to ambiguity and are harder to interpret and summarize. An example of this type of question would be "suggest a few methods that you think would be effective in reducing WPI's carbon footprint."

Close-ended questions are questions that have fixed options that the respondents have to choose from. In informative surveys, it is better to have close-ended questions, as they leave less ambiguity in the responses and give tangible results that can be analyzed statistically. An

example of this type of question would be, “in your opinion what is the best method to reduce WPI’s carbon footprint- a) carpooling b) recycling c) solar panels.”

Scaled questions are questions that give participants a range of values from which they can pick a number to indicate the quantity asked about. This scale generally consists of numbers that indicate some quantity. Each number or range of numbers, on the survey is explained in words to show what quantity they indicate. An example of a scale question would be, “on a scale of 1-10, rate the effectiveness of carpooling as a method to reduce WPI’s carbon footprint, where 1 is the least effective, 5 is somewhat effective and 10 being the most effective method.” These questions are easy to summarize and give reasonable data to quantify and statistically analyze.

In informational studies it is always better to gather data using close ended or scaled questions as they give more quantifiable data. Open-ended questions should only be used where individual opinions need to be studied in detail. However, since close ended and scaled questions can fail to get detailed individual input, they reduce the flexibility of the survey. Therefore it is advisable to provide a comment box at the end of the survey for participants to express their opinions, concerns or suggestions. This will increase the flexibility of the survey.

Sampling

Sampling (Kalton, 1987) is a statistical technique of selecting a suitable subset (people, objects) to study and draw statistical inferences when it is hard to study the entire population. Sampling is generally done in such a way that the sub-group selected is representative of the entire population that is being observed or studied. In order to ensure that the sample is representative of the entire population and is as unbiased as possible, there are various techniques that are employed.

Random Sampling (Walonick, 1997): This is the purest form of probability sampling, where each member of the target population has an equal chance of being selected as the sample. Generally this kind of sampling is done by random generation of subjects when target populations are very large, and it is difficult to obtain data the entire population. However, if there are certain specific groups that need to be represented in the sample, they might be overlooked due to random sampling.

Stratified Sampling (Walonick, 1997): Stratified sampling is the method of sampling where the target population is divided into groups, each of which needs to be represented in the sample. These groups are known as strata and examples of strata can be students, faculty and staff of an institution. Once the strata are chosen their actual representation is determined and then random sampling is used to select the sample according to the same ratio as in the original population. This method of sampling reduces sampling error as the important groups are all represented and no stratum is overlooked.

Convenience Sampling (Walonick, 1997): In this kind of sampling the sample is chosen because they are convenient; this method is generally used during the preliminary research. This sampling method is appropriate for experiments where no strata or crucial groups exist and is very cost and time effective.

Implementation: Distribution methods

Just as there are different techniques for gathering information, there are also many methods for distributing these research instruments in order to maximize response and make data gathering, storage, and analysis as convenient and error free as possible. The various ways of distributing a questionnaire include:

1) Paper Surveys

2) Telephone Surveys

3) Face to Face Surveys

4) Web-based Surveys

Paper surveys are well suited for target populations that are not very "tech savvy" and are unfamiliar with web based or telephone surveys. However, paper surveys run a high risk of low response as they are generally mailed, and the mail can be ignored by the participants, it can get lost or not reach participants in a timely fashion.

On the other hand telephone surveys introduce an instrument bias as the respondents might be reluctant in answering questions to a person they cannot personally see, and the answers might be affected by the demeanor or tone of voice of the surveyor. Telephone surveys are very time consuming as each respondent has to be questioned personally and they are very expensive to conduct, as telephone calls might need to be made over a large geographic region. Response rates are generally low keeping in mind the number of respondents that might answer the call.

Face-to-face surveys pose similar problems of instrument bias with surveyor tone and demeanor affecting responses and respondents being uncomfortable about talking to a stranger. Face-to-face surveys are also time- consuming and expensive to conduct, and people often don't have the time to stand and answer a survey.

Paper based surveys seem to have the least drawbacks of all the distribution methods. However, they can be further improved by converting them into web-based surveys. An on-line or web-based questionnaire is a form of a written questionnaire that is posted on-line or circulated via email to the sample population.

Some advantages of web-based surveys are:

- Web-based surveys can be sent out very swiftly to a large number of people.
- They have a very low cost of administration
- Online survey responses can be pre-coded to eliminate transcript errors
- On-line survey response frequency can be predetermined to remove multiple response bias
- On-line survey generated data is very simple and convenient to analyze

Disadvantages might include:

- Surveyors/respondents can experience technical problems
- Non-users might be overlooked (Herbert, 1996).

Criteria	Postal	Telephone	Electronic	Personally Administered
Low Cost	X		X	
High Speed		X	X	
Detailed Questions		X		X
Anonymity	X		X	
Rapport with Respondents		X		X
Little Staff Time Required	X		X	
High Response Rate		X		X

Table 2.2 Comparative Analysis of survey implementation methods ("How to evaluate EIS", 2006)

Analysis and reporting:

Since analysis and reporting is the most important part of the survey, it needs to be done accurately and reliably. To achieve this, the method of data storage and the preliminary way to analyze that data should be decided before implementing the survey. There are several methods of data storage, however electronic saving makes it easier and convenient, and in case of data mishaps, there is always back-up data that can be recalled and used.

In order to test the functionality of the survey and to gauge what survey administration methods would yield the highest response rate, it is advisable to conduct a pre-test or a pilot study before administering the real survey. A pre-test also helps to find and eliminate mistakes and limitations in the proposed study design.

2.7 Pilot Studies

A pilot survey is a small-scale version of the full-scale study and is useful for pre-testing a particular research instrument. Pilot studies can offer valuable insight into the study being planned. A pilot survey should be developed considering the following key elements (Kasunic, 2004)

(1) Purpose of the pilot study

(2) Sample size for the pilot study

(3) Plan for data entry and analysis

(4) Plan for achieving the desired survey return rate

A pilot study generally improves the internal validity of the questionnaire. A typical sample ranges from anywhere between six to forty five participants. A pilot test can be done to test various aspects of the survey and these tests can be conducted in phases. The first phase of a pilot might consist of in-depth interviews or focus groups to establish the issues to be addressed in a large-scale study. The questionnaire design can be tested by piloting different orders of the questions or asking for respondent feedback about the range of answers, order of the questions, and comprehensibility and wording of the questions. Finally, a pilot can be conducted with different survey distribution methods to gauge the most effective and user-friendly way of administering the survey. Some things should be kept in mind while conducting a pilot survey in order to reduce bias or inaccurate predictions:

- The pilot should be administered in exactly the same way, as it will be in the main study. For example, a face-to-face interview should be conducted in the same way and similar conditions as would be in the real study.
- The respondents should be asked for feedback about ambiguity, and difficult or redundant questions.
- The time taken to complete the survey should be recorded to gauge whether the survey length is reasonable.
- Pilot responses should be stored with the same method as would be used for the main study, and analysis should be done to see if all the information that is required is obtained through the survey.

Pilot studies have their limitations too, and they should be considered before making a final decision or interpretation of pilot test results. Limitations include the possibility of making inaccurate predictions or assumptions on the basis of pilot results. The response rate and general perception of the respondents might be totally different in the main study. The pilot results might contaminate the main study results and analysis.

2.8 Focus Groups

Another method of data gathering in qualitative research is focus groups. "A focus group is a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive non-threatening environment" (Krueger, 2000). This is achieved by asking a set of carefully pre-designed questions by a moderator who also moderates the discussion to keep it on track. Questions are asked in an interactive group setting where participants are free to give their opinions and also to talk to other group members. Focus groups are generally used when insights are needed into a new area of research, the purpose of the research is to investigate topics where

opinions or attitudes are conditional or the researcher needs additional information for a large-scale study. A focus group should be composed keeping the following points in mind:

- A focus group should be small enough to give everyone the chance to express their opinion and large enough to provide diversity of opinion.
- If possible, a focus group should have representatives of all the sub-groups or important strata that are being researched.
- The moderator should be a neutral person without any pre-existing bias about any person or the idea being discussed. They should not provide any leading suggestions, cut people off or express personal opinions about someone's point of view.
- The note taker should also be a neutral person who should transcribe opinions exactly as they are being expressed without adding their personal judgment or bias (Larson, Grudens-Schuk, Allen, 2004).[formatting]

Advantages of using a focus group include

- The focus group format allows the moderator to probe and ask follow up questions. It provides the flexibility to explore unanticipated issues.
- Focus groups are relatively low cost and yield fast results that can be easily interpreted.
- They allow surveyors to gauge opinions, apprehensions and ideas of their target group first hand.
- They provide opportunity for detailed individual input and explanations behind certain choices that is not possible in questionnaires.

Some disadvantages are:

- Focus groups have less experimental control.
- They require experienced moderators and transcribers.
- Groups may vary considerably and may be hard to assemble.
- Focus group discussions must be conducted in an environment that is conducive to conversation.
- Group discussions could become emotionally charged and get out of control.
- They result in loss of confidentiality (Morgan, 1997).

Some of these flaws can be fixed by getting a neutral and experienced moderator and transcriber. The questions should be pre-designed and practiced by the moderator and there should be a time limit set for discussing each topic. A good focus group program should include icebreakers, introductory questions, good transition questions and ending questions that summarize the discussion. Only participants who willingly agree to be a part of the discussion and have no qualms about the lack of anonymity and confidentiality should be selected to be a part of the focus group (Morgan, 1997).

2.9 Campaigns

A campaign is defined as a series of actions advancing a principle or tending towards a certain end. It is generally a collection of several related operations (generally promotional) for achieving a certain goal (Wordnet Web, 2006). Campaigns can be varied in their nature, purpose and method of conduction, such as political campaigns, environmental campaigns and human rights campaigns. Well planned, small scale educational campaigns are useful in raising awareness and education amongst the target population (Davis, McCallon, 1974).

Environmental Campaigns are a set of actions that are taken to promote environmental awareness and spread education about issues that either the masses are unaware of or are

neglecting to pay attention to in terms of their responsibility to the environment. These campaigns can include distributing pamphlets, information sessions, talks, and movie screenings in order to raise awareness among people. Campaigns can be conducted at different scales. They can be really large scale campaigns, such as the US presidential campaign, medium scale, such as the human rights protest campaigns, or small scale, such as conducting workshops to raise awareness about environmental issues.

Chapter 3: Methodology

This chapter discusses all the methods that were employed for the project. It talks about the different approaches that were considered, and elaborates on the ones that were used.

The major goal of this project was to investigate the carbon footprint of the WPI community due to transportation, and propose an efficient and cost effective alternative for the community to reduce its carbon footprint, by reducing the amount of greenhouse gasses that members emit into the atmosphere as a result of driving to and from campus. To achieve this goal, the team did extensive research on different related topics. Areas of research included:

- Greenhouse gas emissions, primarily $CO_{2,}$ and its impact on the environment.
- Ways in which CO_2 is emitted into the atmosphere and how such emissions can be reduced.
- What other colleges and institutions have done as efforts to reduce greenhouse gas emissions.

After a variety of information had been gathered from existing literature, the team settled on carpooling as the best alternative for the WPI community. The team then went ahead and considered the tasks as shown in figure 3.1 as a means of executing a successful project.

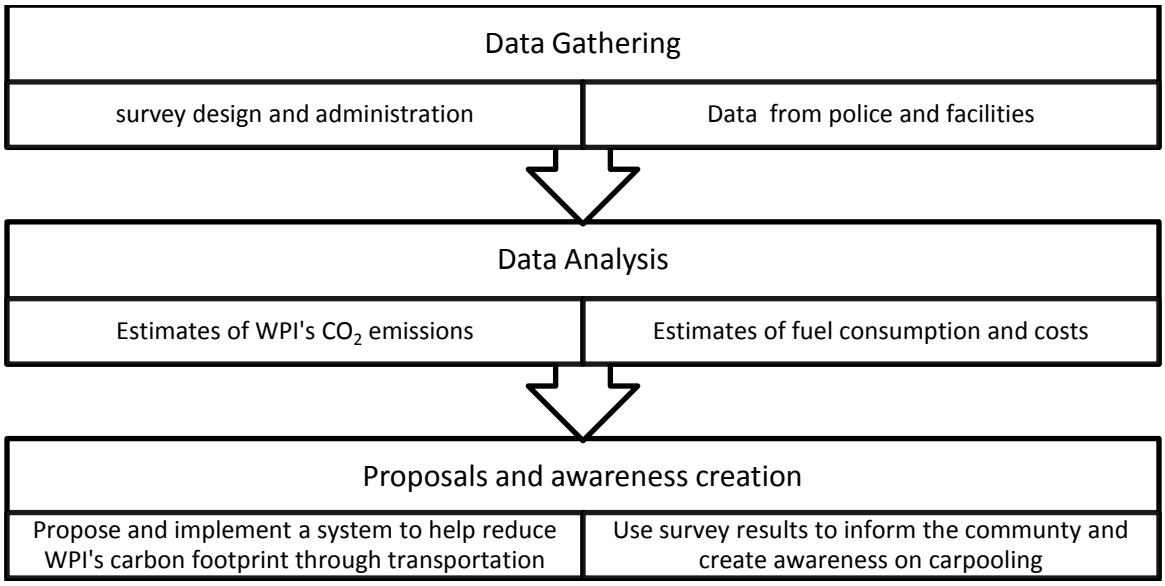

Figure 3.1 flow chart of tasks executed for project.

The average annual carbon dioxide emission of the WPI community in the area of transportation was estimated using the results from the survey. The results were also used to inform the community on the impact of the university's carbon footprints on the environment.

3.1 Carbon footprinting

The project was approached from various perspectives with the ultimate goal in mind. The group began by researching general published materials on carbon footprinting. The objective for research in this area was to find how greenhouse gas emissions and carbon footprints are interwoven. It was also necessary to identify the relationship between carbon footprints and global warming. Extensive literature was reviewed to establish a convincing argument that human activities were responsible for greenhouse gas emissions, and that green house gases were the main cause of global warming.

3.1.1 Sources of carbon dioxide emissions

There are several ways by which CO_2, which is the primary greenhouse gas, is let out into the atmosphere. This became a research point for the team to focus on, because to be able to reduce the emissions, the sources had to be identified. Different human activities, such as

industrial and institutional operations, domestic activities, and transportation were the main sources that were studied. Research showed that these three contributors constituted some of the primary sources by which the environment is polluted with carbon dioxide (Fay and Golomb, 2002).

Almost all industrial and institutional activities emit some amount of carbon dioxide into the atmosphere. The team looked into some detailed industrial and institutional activities and their levels of pollution of the environment. Most of these activities that were investigated are activities that industries and institutions perform on a daily basis and are necessary for their existence. Specifically the group touched on some pertinent issues such as power generation and consumption, and daily use of materials and products such as paper, plastics, water and chemicals.

For the WPI community, the group researched how the community utilizes energy and water. Also, the group considered how the community uses everyday products such as printing paper, plastic materials, writing materials and all other products that community members need for their daily activities. Since every joule of energy produced with fossil fuels emits some amount of carbon dioxide into the atmosphere, using energy wisely or reducing the amount of energy needed will help reduce carbon dioxide emissions.

General domestic activities, including eating and waste disposal, surprisingly also constitute a major component of greenhouse gas emissions. To narrow down on one economically viable approach for the university to take in reducing their carbon footprint, the team also researched how every day domestic activities by community members also contribute to daily carbon dioxide emissions into the environment. Some general patterns of behavior such

as eating habits, use of electrical gadgets and equipment, use of water, and driving habits were all examined.

The final source of carbon dioxide that the team researched was transportation. To begin with, the team studied how transportation plays a role in polluting the environment. Members of the team researched the impact that burning fossil fuels to power various means of transport has on the environment. It became quite obvious to the project group that transportation was one major component of carbon dioxide emissions into the atmosphere, and also it was one area that could be the focus of efforts to reduce greenhouse gas emissions.

3.1.2 Transportation and Carbon Footprinting

As the team investigated various sources of carbon footprints and the different alternatives to reducing them, one area that seemed to have a lot of impact on greenhouse gas emissions, yet is simple to reform, is transportation. As a result, more time was spent on researching this source of CO_2 than was spent investigating other sources. Research in this area was seen as a good starting point to help identify a viable alternative for WPI to reduce its carbon footprint. The team wanted to establish a point that transportation is one major component of carbon dioxide emissions, yet it is an easy way by which emissions can be reduced to save the environment. To make this point viable, some work had to be done to make a convincing argument. General data gathering regarding carbon dioxide emissions as a result of transportation was done. This data was gathered from published materials including peer reviewed journals, books and reliable web-based sources. Data gathered included all means of transportation and how these transports are powered. Also, the amount of carbon dioxide produced by each of these modes of power generation was investigated. Various modes of transportation were compared to find out which produced the most greenhouse gas emissions and

which modes were frequently used. In the global perspective, fossil fuel consumption by different nations was compared.

Relating all the data collected from published documents to WPI, the team then estimated WPI's annual carbon dioxide emissions as a result of transportation to and from the campus. This was meant to be a basis for an argument that it was significant enough to have an impact on the environment, and that reducing it could be as easy as ride sharing.

3.2 Reducing Carbon Dioxide Emissions

Having reviewed a fair amount of literature on carbon footprints and greenhouse gas emissions and how they are produced, it was time to investigate the available alternatives in reducing these emissions. Different means of reducing the listed sources were considered on an individual basis, and the best available alternatives, including best available technologies, were explored to ascertain their economic viability and feasibility of implementation.

Regarding industrial and institutional activities, reducing CO_2 emissions could range from

- Discarding an existing boiler and replacing it with a modern fuel efficient boiler
- Changing all heating and air conditioning units at an industrial or institutional facility
- Undertaking major renovation work on a facility to re-orient windows and roofing to make use of natural light during the day. These alternatives are much more expensive and less appealing to management, to practices as simple as turning off lights in places when light is not needed, or using just the right amount of materials and products for a manufacturing process. The team's responsibility in this area was to research how viable these steps are, and how likely it is that institutions and industries will ensure that they are followed.

Reducing emissions based on domestic practices and attitudes could also be as simple and inexpensive as opening the window in one's house to allow air flow during summer, instead

of turning on the air conditioner, to a more expensive alternative such as changing all the bulbs and electrical appliances in a house to energy efficient ones. The group looked at how likely it is for people to change their habits in this regard.

The third source of carbon dioxide emissions that had been listed was transportation. Therefore, the project team focused on all the possible ways that carbon footprints in this area could be reduced. As it was the team's goal to focus on this area, several alternatives were considered. The group narrowed their focus to the WPI community. The question of how the members of the university could reduce their carbon footprint was considered, and several alternatives were listed. These alternatives included encouraging people who lived a few miles away from the campus to walk to school, encouraging people to bike more often, promoting the use of Zip Cars on campus, and encouraging people to use alternative transports such as the bus or train. Also among the alternatives was to encourage the community members to share rides among each other. The goal was to have all the alternatives in the area of transportation available so that the team could brainstorm to select the best alternative. After some brainstorming sessions, the team settled on ridesharing as the best and most feasible alternative, which had a chance of winning approval from the community. At this point, further research was launched into carpooling.

3.2.1 Carpooling

Several questions about carpooling had to be answered in order for university members to buy into the initiative. Individuals from the team were tasked to look into different areas of carpooling. If the team proposed ridesharing to the WPI students, faculty, and staff, what would be the most convincing argument? Will it be economically feasible? Will it be safe for people to share a ride with someone else? What do carpooling participants stand to benefit? How can

people find interested carpool partners? Are there other colleges and universities who are using this alternative? These are questions that the team hoped to answer in their research in order to make a convincing conclusion that carpooling was a viable alternative. To answer the above questions, some colleges were researched to find out whether ridesharing was being used as a means of reducing their carbon footprint. Benefits of carpooling such as cost savings on gas, maintenance, reduction in pollution and CO_2 emissions, and networking were looked into.

As a next step the team compared its chosen alternative to the other transportation alternatives, and their differences and feasibility were analyzed; their practicality was also considered. Results from these considerations convinced the team that carpooling was the best alternative to be pursued. As part of the feasibility studies the team did a casual observational study to find out how people come to the university. The various parking lots around the campus were observed for about a week. The goal here was to confirm whether or not most people drive to the campus, and whether or not most of those who drive always come to campus alone. After observing the arrival and departure of community members to the campus over the period, it was concluded that at least 9 out of ten cars coming to or leaving the campus had only the driver as the passenger of the vehicle. This observation gave the team enough evidence to launch further inquiry into the commuting habits of the members of the community. The next step in the process was to proceed by collecting and analyzing data.

3.3 Data Gathering

This part of the project was one of the key assignments that the team needed to complete in order to progress. The data collected would be used to confirm the observations made by the team that most people in the community drive alone to the campus. Also, the data would be used to estimate the annual carbon footprint of the community. Finally, it was the goal of the team to

use the data gathered to predict whether a carpool program would be attractive to members of the community.

To be able to collect relevant data, the team had to decide on what information they hoped to get from the data. Several methods of data collection were considered, and the best option was chosen. Methods that were considered included:

- Experimental and quasi-experimental research
- Action Research
- Phenomenological Research
- Analytical Survey

Experimental and quasi-experimental research is a classical scientific research method where by subjects are assigned to an experimental or a control group, treatment is assigned to the experimental group, and the results are compared with the control group (Gray 2004). This method was not appropriate for the project need, so a second method, "Action Research," was considered. With this method, there is some form of collaboration between researchers and practitioners in a particular field, where researchers seek opinions and perspectives about the research subject from the practitioners in the field. Since the team's research did not involve any field of study, the Action Research Method was also ignored because it did not satisfy the needs of the project.

A third research method was "Phenomenological Research." This method is a more perspective seeking method that seeks the opinions and subjective accounts of participants. This method also relies on qualitative analysis, and it appealed to the team as one that could provide part of the needed information.

A fourth and final research method was "Analytical Survey." This method attempts to test a theory in a subject matter by exploring the association between variables. Analytical surveys tend to be very structured, and place emphasis on the selection of the sample so that the results could be generalized to other situations in the context. The downside however is that the restriction of analytical surveys tends to hinder participants from expressing their full opinions on the research topic. The analytical survey method was also one that appealed to the team as a possible research technique that would provide helpful feedback. After reviewing these methods the team decided to use a multiple method approach (Gray 2004).

The phenomenological and the analytical survey methods were the two that the team settled on. The reason for using this multiple method approach was so that participants, in addition to following a strictly structured method as found in the analytical survey, could also express their opinions and perspectives on the subject. With this approach, the team was attempting to cover the weaknesses of one method by the other.

3.3.1 Designing a Survey

Once the team had settled on a final data gathering method, it moved towards designing a survey questionnaire that would serve two purposes. The survey was supposed to ask all the questions that would bring the answers that the team needed to confirm their initial observations, as well as help the group make generalized statements about the subject. This part of the process would satisfy the analytical survey method. Secondly, the questionnaire was supposed to satisfy a phenomenological research approach, such that respondents were supposed to have the opportunity to express their opinions and perspectives about the subject.

Before the detail of the design was planned the team did some review on how effective surveys are designed in order to expedite the design process, and also produce the most

appropriate survey for the task. Having reviewed material on survey designs, the team decided to brainstorm to bring out relevant questions to be used in the design. An array of questions were presented by each member of the team, and questions ranged from the status of community members, which meant whether they were students, faculty members or staff members, to whether or not they would participate in a ridesharing program if one was available. The questions were carefully analyzed and debated for relevance, and a good number of them were dropped from the list. At this point a trial design was generated to be used on a pilot basis.
A pilot survey was designed from the list of final questions to be administered to a few people [See Appendix A-1]. The target was to obtain feedback from the participants regarding the questions and also the general approach that the team had taken. The team hoped to have about twenty participants answer the pilot survey.

As was the expectation of the team, the pilot survey revealed some weaknesses in the design which were corrected for the general design. There were still some irrelevant questions that needed to be removed. The length of the survey became a very critical topic for discussion, because the team acknowledged the fact that it was less likely for people to respond to longer surveys than they would a shorter one, thus the survey had to be concise. A fair amount of time and thoughts were put into the survey design until a final version that contained twelve questions was produced.

The final survey sought to obtain information about the participants regarding their status at the university, their driving habits, and their interest in ridesharing to campus. As a phenomenological approach, a comment box was provided for them to express their opinions and perspectives, and also make contributions and suggestions. Other questions on the survey were to

extract information about the cars that participants drive; questions such as the make, model, and age of their vehicles [See Appendix A-2].

This information would be used to estimate individual respondents' carbon footprint. While being careful to get the right questions to avoid any ambiguity, the confidentiality of the respondents was also a factor that was considered. On the final document, a statement of confidentiality was made by the team, to assure participants that any information obtained from the survey would be used only for research purposes, and would be kept confidential. The final survey was then submitted for approval by the Institutional Review Board so that it could be administered to the entire community.

3.3.2 Administering the Survey

Before the general survey could be administered, the team had to get permission from the Institutional Review Board of WPI. An IRB form was filled in by the group to explain the research methods that were being used, and also how the data obtained and information gathered would be stored [See Appendix A-3 to A-5]. Once this approval was obtained, the survey was ready to be given to community members.

A challenge for the team was to figure out a way to administer the survey in order to obtain the best results. Once again published literature was reviewed to help in choosing the best alternative. The team wanted to ensure a high return rate of answered questionnaires; therefore close attention was paid to the means of distribution. Several methods, such as mailing the surveys to respondents, interviewing people with the survey questions, using the internet, distributing the questionnaires to participants and collecting them at a later time, or allowing respondents to answer and hand them back on the spot were reviewed. Out of these methods, three were predicted to be most effective. The team therefore decided to combine all three

approaches. The first approach was to hand the surveys to people and have them answer and return the questionnaires on the spot. The main parking lots of the campus were targeted for this approach, such that team members would ask community members who were arriving from their homes or leaving the campus to fill out the questionnaires. This approach seemed reasonable because the main targets for the questionnaires were people who drive regularly to the campus. However, after trying out this method for about two days, a major flaw was identified. Community members were not willing to stop and answer the surveys, because they were either rushing to their various duties for the day, or they were rushing to go home from the campus. This demanded a change in plan; therefore the other two methods were employed to ensure that any anticipated problems were ironed out.

The paper questionnaire was converted to a web based survey using Microsoft Office SharePoint. As much as possible the online questionnaire was consistent with the paper questionnaire so that the results would be easy to compile. Also, the design was such that respondents could only answer the survey once, to prevent multiple responses. After the design was verified by staff from the Academic Technology Center of WPI, permission was obtained from the Computing and Communications Center of WPI to administer the online survey via the campus emailing list. The project team decided to make the online survey the primary method. Since all community members have e-mail addresses on the university's domain, reaching every member of WPI through this means was guaranteed. A mass email was sent to two general campus email lists, employees@wpi.edu, and students@wpi.edu. To ensure anonymity of the respondents, links to the SharePoint site that had the survey were provided in the emails and respondents who wanted to answer the survey could do so from their own SharePoint page. In this way their answers were kept confidential and the research team only had access to their

responses. However, respondents had the option of disclosing their usernames to be entered for a raffle drawing. These user names were kept separate from the survey responses so that it was impossible to match responses to a particular user name.

After about one week of sending out the mass email, a second email was sent to thank all those who responded to the survey the first time, and also to serve as a reminder to those who had not had the chance to respond. This email was necessary due to some emails from community members who had difficulty in accessing the link. These complaints were reported to the Academic Technology Center of WPI, and together with the team, solutions were found. The second email thus included a second link to a duplicate of the first survey, so that those who had issues could go back and finish their responses.

Once the online surveys were completed, the team moved to distribute the paper questionnaires to various departments of the campus. The main target population for this round was faculty and staff members. This is because results from the online survey were showing very low responses from these two groups. It was deduced that faculty and staff members are less likely to take online surveys, especially if they are not sure of what they are meant for. Therefore if paper surveys were sent to them in their departments, responses from them could be improved. The paper questionnaires had return campus mail box numbers on them, so that participants could drop them in any campus mail bin to be delivered.

3.3.3 Additional Data

As mentioned earlier, the data gathered from the community members would also give information about cars that were driven to and from WPI. This information would be used to estimate the annual carbon dioxide emissions by the WPI community. During the team's deliberations on how to make a good estimate, it came up that there are other cars that are driven

around the campus that equally emit a significant amount of carbon dioxide, and such emissions must also be accounted for. These were the WPI police vehicles, the WPI Snap and Shuttle vehicles, and the Facilities vehicles. Contacts were therefore made to these departments so that their weekly mileage on each vehicle could be obtained. Obtaining such information was not as easy as was anticipated. None of the departments mentioned kept daily or weekly logs of their mileage; therefore a request was made that for about two weeks, the drivers of those vehicles should track the mileage of their trips. The police department and the Snap and Shuttle services were able to provide this information, but the Facilities department was not able grant the team's request.

3.4 Focus Groups

One of the ways that the team hoped to gather diverse information and opinions was through focus groups; the target was to have two separate focus group sessions. On the questionnaires that were sent out, an option was provided for participants to take part in a focus group discussion by contacting the team at cfp@wpi.edu. Those who responded through the questionnaires were to be the first focus group to hold deliberations with the team on transportation issues at WPI, and also express their thoughts about having a carpool program on campus. The second focus group was to come from a general email that would be sent to the entire community asking anybody who wanted to have a discussion on the subject to attend a session on a suggested date and time at a particular location. These options would give the team the opportunity to solicit ideas from other members of the university who had some thoughts on how the program could be run effectively.

3.5 Campaigns

One presentation session and two campus wide campaigns were planned by the team. A presentation session was held for the President's Task Force on Sustainability at WPI for two reasons [See Appendix B-1]. The first was to introduce the IQP team and the project that was being worked on, and to request their endorsement and assistance to have a working database for a carpool program. A second reason was to inform them of the team's findings and convince them of the viability of the project. It was mentioned to them that the success of the project was a success of sustainability efforts at the university, and that it was worth the committee's support. The goal of the first campaign was twofold: informational and educational. The Informational part was for the team to share their findings from the data that was collected from the community through the survey. The educational part was to expose members to the effects that driving habits are having on the environment, and the need to reduce these destructive effects. Another goal of the campaign was to promote the team's vision of ensuring that the university signs on to a successful carpool program.

The organization of the first campaign was very strategic; it was organized at the Campus Center between peak hours, when most people visit the center. It was the team's goal to reach a minimum of about 400 people. Flyers were designed by the group with information from the data that was gathered from the campus wide survey, and also educational tidbits from several published materials and websites [See Appendix C-2]. On the day of the campaign, three large posters with information about the team and ridesharing were displayed at vantage points on campus [See Appendix C-1]. Also, a short video that was retrieved from the website of the U.S. department of Energy was shown at the center during the hours of the event ("Gas Mileage Tips"). The video talked about effective and ineffective driving, and also about advantages of

carpooling. To make the occasion more fun and interactive, a map of Massachusetts and its neighboring states was displayed at the campaign site so that people could indicate where they commute from daily. All this was geared toward making people aware that there are several others that commute from their zip codes, and therefore carpooling might be a good idea. To ensure that everybody who visited the campus center on that day was informed, team members approached them with flyers, and explained the purpose of the campaign and the goal of the project; they were treated to some candies as well.

A second campaign was scheduled for the last week of the project, and the goal was to advertise a complete carpooling database that would be accessible to the entire campus community through the sustainability website. It was the plan of team to invite the entire community to share in the success of the project and also have first-hand information on how to use the database through a demonstration. Although this campaign was planned, it was not done because the database had not been launched by the time this report was written.

3.6 Database

For the project to be a success, a carpool database needed to be constructed on the university's domain through the sustainability website. The final hurdle for the team was to have a system of some sort that would allow members to sign up and find ridesharing partners with little effort. It was this task that made the team seek help from the sustainability committee. In response, the sustainability committee agreed to purchase pre-packaged software for this purpose if the team was be able to come up with some proposals from outside vendors.

Vendors for ridesharing packages were contacted via emails and online subscriptions. It was the target of the team to get a minimum of three vendors that were willing to establish a contract

with the university. Upon confirmation of their authenticity, a proposal was sent to the President's Task Force on Sustainability for their consideration.

The vendors contacted had to meet some criteria before they could be approved. The first requirement was for them to prove their ability by providing the team with some of their past projects in the area of ridesharing software development. In particular the following were some of the criteria the team used for selection.

- Vendors were asked to tender evidence of a working system that they have developed for other universities or institutions.
- The package to be provided should be accessible only to the WPI community.
- It should ensure the privacy and security of any information provided by participants.

Other questions regarding the contract that were asked included pricing and how the package would be delivered. In addition, the team required the vendors to explain how their systems would be managed and maintained, whether they would be maintained and managed by WPI once the package is acquired, or the vendors would still be responsible for the management and maintenance of the websites. Once all these inquiries were satisfied, three out of about twelve vendors contacted met the team's criteria for selection and they were confirmed. A proposal containing the explanation and services provided by these vendors, as well as their prices was submitted to the sustainability committee for consideration [See Appendix B-2].

3.6.1 Database Implementation

The proposal that the team sent to the President's Task Force had information on three vendors who provided very similar services with little differences. The main difference was in their pricing; therefore the team recommended the one that had the lowest price yet offered the basic services that were necessary for the community's needs. "Carpoolworld" was the team's

first choice and "Zimride" was the second choice. The task force reviewed the proposal that was submitted and endorsed the team's first choice. The committee agreed to try this vendor for a year.

Following the approval of the proposal, the team contacted the operators of "Carpoolworld" and informed them of the development. They in turn moved quickly to develop a database for WPI using WPI's logo and making it only accessible to people with WPI email addresses. The team requested a contract from them, and when it was provided it was given to a representative from the President's Task Force assigned to work with the team [See Appendix D-2]. The contract was forwarded to the Legal Department of WPI for review and approval.

To set up the system, "Carpoolworld" provided the university with the link to the database, to be placed on the Sustainability website of WPI. The university had to arrange a payment plan with "Carpoolworld" on a monthly basis which was based on the number of users of the software. A campus-wide letter introducing the new carpool software had to be sent via email to all users at WPI to inform them of the system and encourage them to make use of it [See Appendix D-1]. Other means of advertisement were proposed by the team to be used as ongoing promotional platforms for the program. They included:

- Publicity in the university's major news paper, "The Towers,"
- New student and employee orientation brochures,
- Periodic news updates on students' "mywpi" pages, and
- Occasional campus wide reminders via emails.

These avenues were targeted so that the cross section of the whole community would receive information about the new program on occasional basis. It was agreed on by the team and the

Task Force representative that consistent announcement and advertisement of the program was necessary at the beginning to ensure that people would develop the interest in using it.

Chapter 4: Results

This chapter is a summary of all the results that the team came up with in the course of the project. It contains both successful and unsuccessful results. The chapter also tries to analyze the data and uses those analyses to make some inferences. Results are both qualitative and quantitative.

4.1 Pilot Survey

A pilot survey was administered to the four main groups that make up the community; undergraduate students, graduate students, faculty members, and staff members. This was meant to obtain a balanced feedback to be used in designing the general campus-wide survey. The team administered the survey by approaching people in the four categories and handing them paper questionnaires. They were then asked to take a few minutes to respond to the survey while the team member waited. After about one week the data gathering for the pilot survey was complete and the results were compiled and analyzed.

A total of 17 community members answered the pilot survey. Out of this number, 9 were undergraduate students, 3 graduate students, 2 faculty members and 3 staff members. Eight out of the 17 respondents drove to the campus always, 6 walked to school every day, 1 person shared a ride, and another person used a bicycle. The last of the 17 respondents was dropped off to the campus everyday by another person who worked somewhere in the city. A breakdown of the results is shown in figure 4.1.

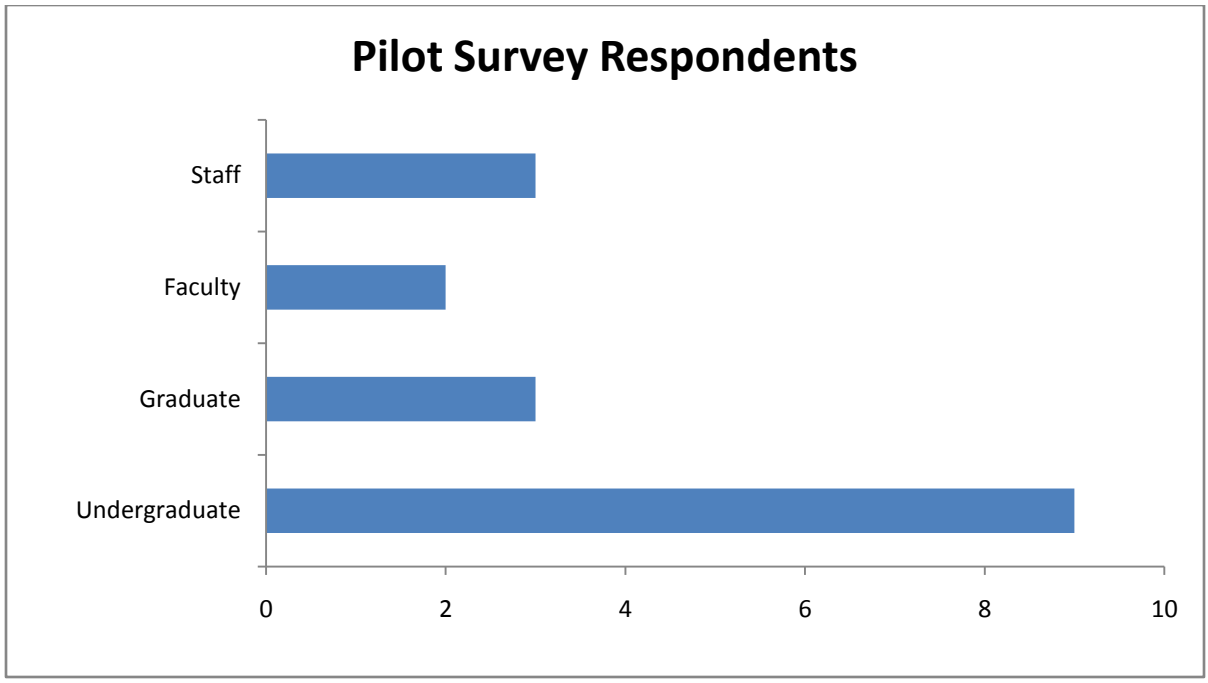

Figure 4.1 Pilot survey respondents

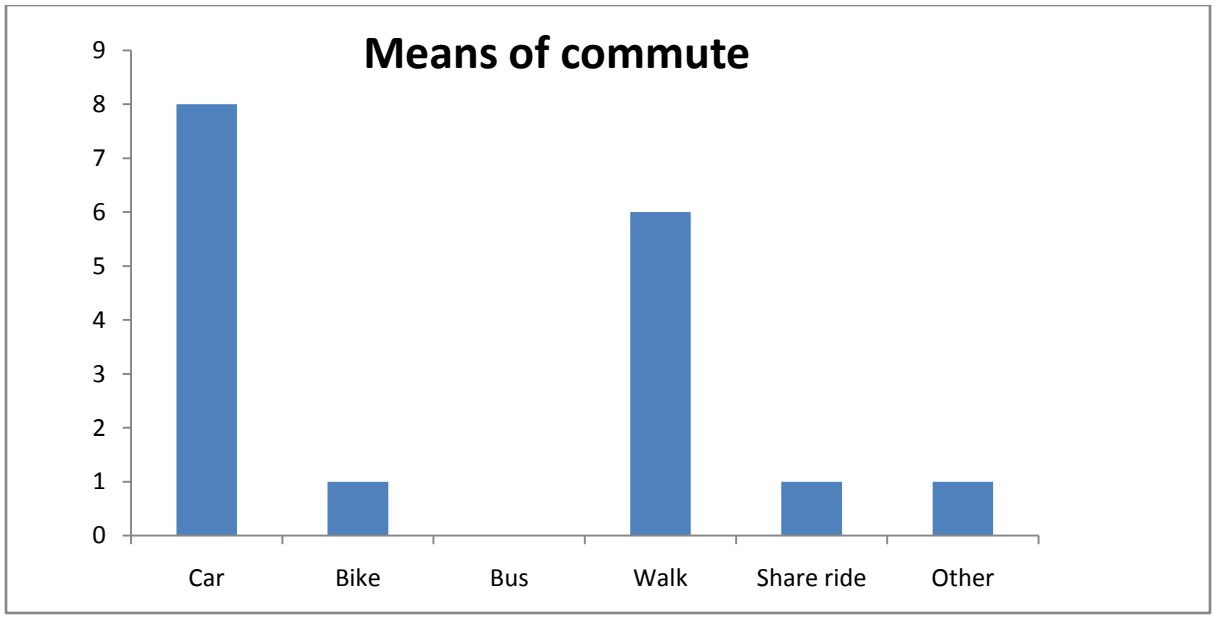

Figure 4.2 Primary means of commute of respondents

Other interesting results that came up in the pilot survey indicated that the idea of ridesharing was not new to many people, and many were willing to participate in such a program

if it was made available. One of the questions on the survey was for participants to indicate their interest in a carpooling system if one was available on the campus. They were to indicate their level of interest on a scale of 0-10; 10 being extremely interested and 0 being not interested at all. Seven people did not answer this question because it did not apply to them. Out of the 10 that answered 5 answered a level of 5 and above. The results showed that those who answered were the people that drove always, and those that shared a ride. These responses gave the team an indication of what the general survey results would look like.

In the pilot survey a comment box was provided so that individuals could share their thoughts on some of the questions that were being asked. Also, a grading scale was provided at the bottom of the survey so that participants could grade the quality of the survey. They were also encouraged to suggest better ways that the survey could be written. Some people had no comments and indicated total satisfaction with the survey. Others however gave very constructive criticisms of some of the questions, which were very helpful. On the pilot survey, one question was to ask participants how many miles their cars get per a gallon of gasoline. None of the respondents knew this and some of the comments indicated that such questions made them think too much. For that matter the team removed this question from the revised version of the survey [See Appendix A-1].

4.2 General Survey

Only one survey was administered for the data gathering process, however it was designed such that by a multiple method approach all the information needed was available. The survey was administered to the entire WPI community, which consists of about 5,400 members. Three methods were used to administer the survey questionnaires. The primary method was to use the

internet, and in the other two methods, hard copies of the survey were distributed to community members for them to fill in as stated in the methodology.

In all 634 questionnaires were returned completed with useful data. Out of this number, 587 were received via the internet and 47 were hard copies. The team anticipated that the first method would involve members who always drive to the university, which was the target population. However, this did not work out as expected. Some asked that they should be allowed to take the survey home and return them at a later time, and others opted to answer the questions online. As a result even though the team hoped to get most of the target group, only 10 responses were received. The second hard copy method however was more flexible; members were given the option of filling in the survey and returning them at a later time. A total of about two hundred paper questionnaires were passed out and 37 completed surveys were received.

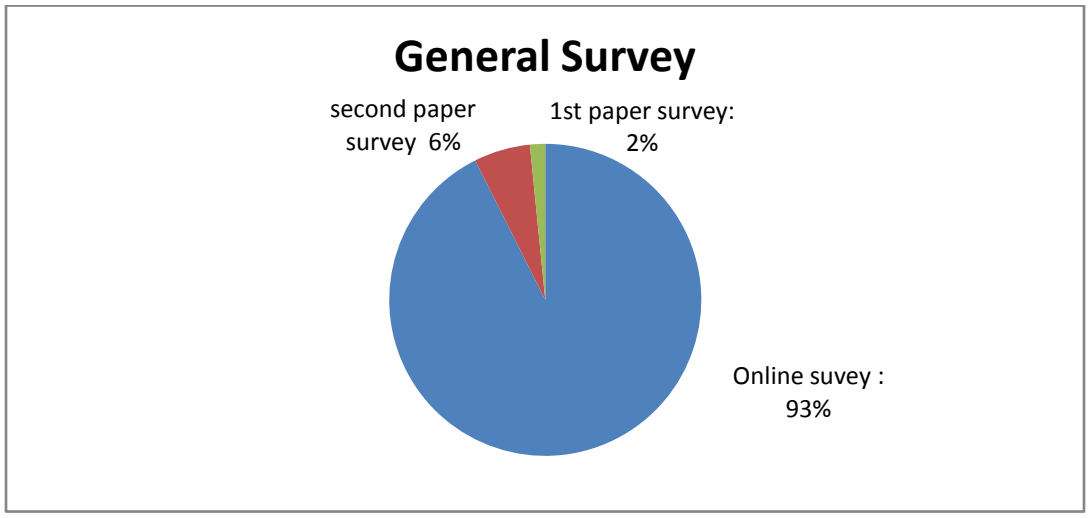

Figure 4.3 Pie chart of means of return of the general survey

4.2.1 General Survey Responses

The results from the general survey from all three methods were compiled and the distributions are as follows. Out of 5,403 members of the WPI community, 634 people who constitute about 12 percent of the entire university population participated in the survey. The

University has a total of 3,252 undergraduate students, 1,309 graduate students, 314 faculty members and 528 staff members. Table 4.1 shows how the survey was answered by the various categories.

Category	Total Number	Answered Survey	Percentage (%)
WPI community	5,403	634	12
Undergraduate Students	3,252	314	10
Graduate Students	1,309	68	5
Faculty Members	314	56	18
Staff Members	528	186	35

Table 4.1 Survey responses by categories

About 52 percent of the number that answered the survey said they always drive to campus. This made the results appreciable, because the team inferred that the majority of the survey respondents fell into the category of the target population; this gave the team some confidence about the data that was received. Most undergraduate students who answered the survey said they walk to campus on a regular basis, and the results showed that only few community members used alternative transportation. Figures 4.4 and 4.5 shows the commuting habits of the survey respondents.

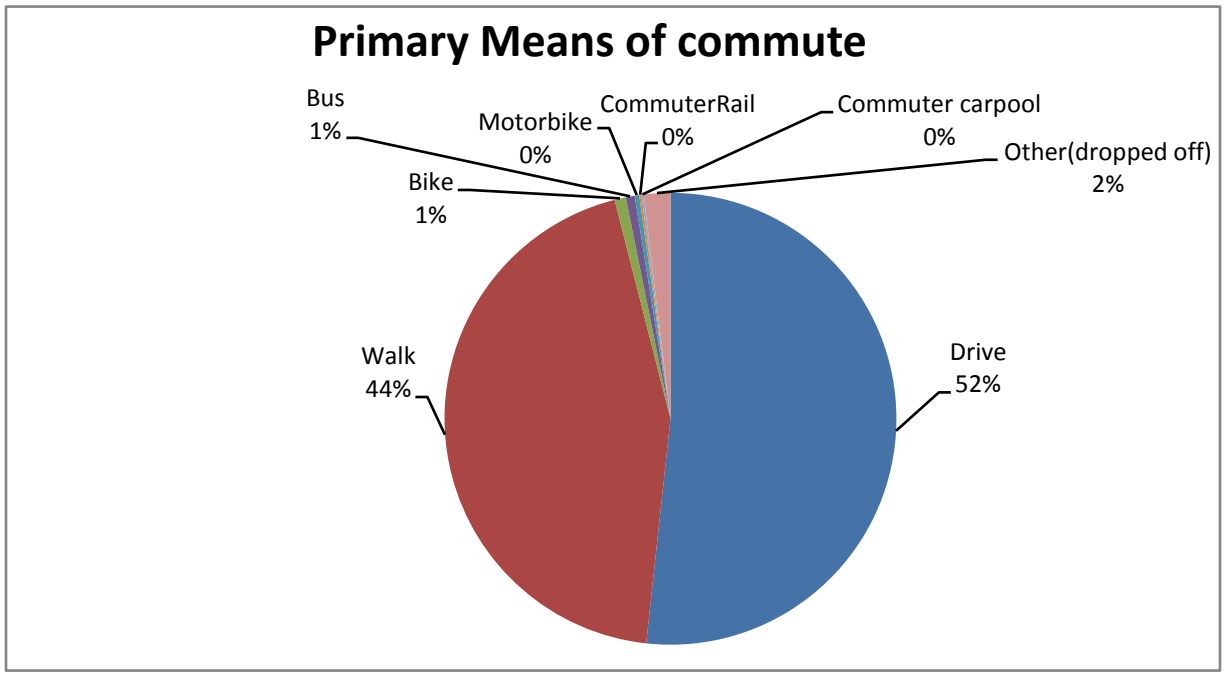

Figure 4.4: Pie chart of the means of commute for members who responded to survey

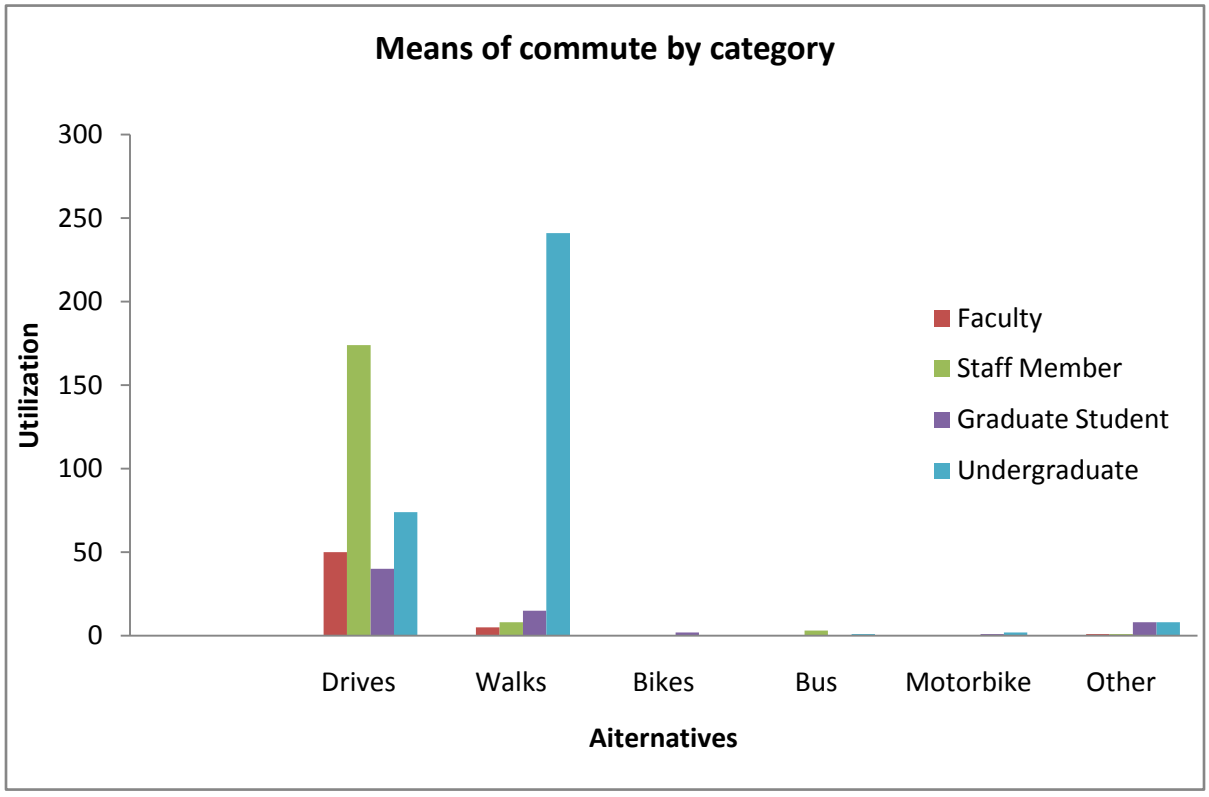

Figure 4.5: Bar chart comparing primary means of commute by category

One of the questions on the survey was to find out how many people already engage in some sort of carpooling. Participants were asked to indicate whether or not they share a ride to campus always, sometimes or never. The results indicated that ridesharing was not a new idea to the community; there were a sizable number of respondents who said they were already participating in some form of carpooling either with other members of the university or with other people who worked in areas in Worcester. Twenty percent of respondents that always or occasionally drive to the university said they always share a ride. Twenty two percent said they sometimes share a ride and 57 percent said they never share ride to school. This meant there is an appreciable number of people who have already gotten used to the carpooling idea, and there is still enough people who have not yet taken advantage of this gas saving alternative.

Interest in carpooling

During the design of the survey, the team's main objective was to find out how many community members would participate in a ridesharing program if one were made available. Therefore one question on the survey sought to find the level of interest of participants in carpooling. A Likert scale was used to determine the degree of interest. The question asked respondents to show on a scale of 0 – 10, to what extent they would be interested in carpooling at least once a week, 0 being not interested at all and 10 being extremely interested.

Initiating a ridesharing program for the university depended on the responses of this question. The results showed a favorable response to the idea. Although there were some people who absolutely said no to carpooling, the majority of drivers indicated some level of interest in such a program. Some people who do not drive also showed interest in a ride sharing system.

The survey was written such that all participants had to indicate their level of interest in ride sharing, because although the first target group was community members who drive daily or occasionally to the campus, there were others who would be willing to share a one-time ride between campus and their homes at the end or the beginning of each semester. Responses from such members were to be considered in the creation of a ridesharing database, such that provision would be made for one-time carpoolers. Table 4.2 shows the number of members who showed interest from a level of 5 and above on the Likert scale.

Level on scale	5	6	7	8	9	10
Respondents	44	19	29	22	17	94

Table 4.2 Members interested in carpooling

There were 225 people who said they were interested in carpooling at least once a week, about 35 percent of the total number of respondents. Out of this number 68 percent were people who always or occasionally drive to campus. Some participants who showed no interest in carpooling by selecting level four or lower on the scale gave various reasons why they wouldn't carpool. Reasons varied from the need for personal space to taking children to day care and picking them up [See Appendix A-6].

People with the same zip codes

In addition to participants indicating their level of interest in carpooling, they were asked to provide their zip codes as part of the survey questions. This question was included to collect data on the proximity of WPI community members' homes with one another. The team recognized that a successful carpool program would require the participation of members who live in the same area or whose homes are along the same path to the university campus. It was realized from the survey that out of the 634 people that responded, there are 67 zip codes where at least

two community members live, and there are 36 zip codes where at least four members live. Figure 4.8 shows a chart of the number of people living close to each other

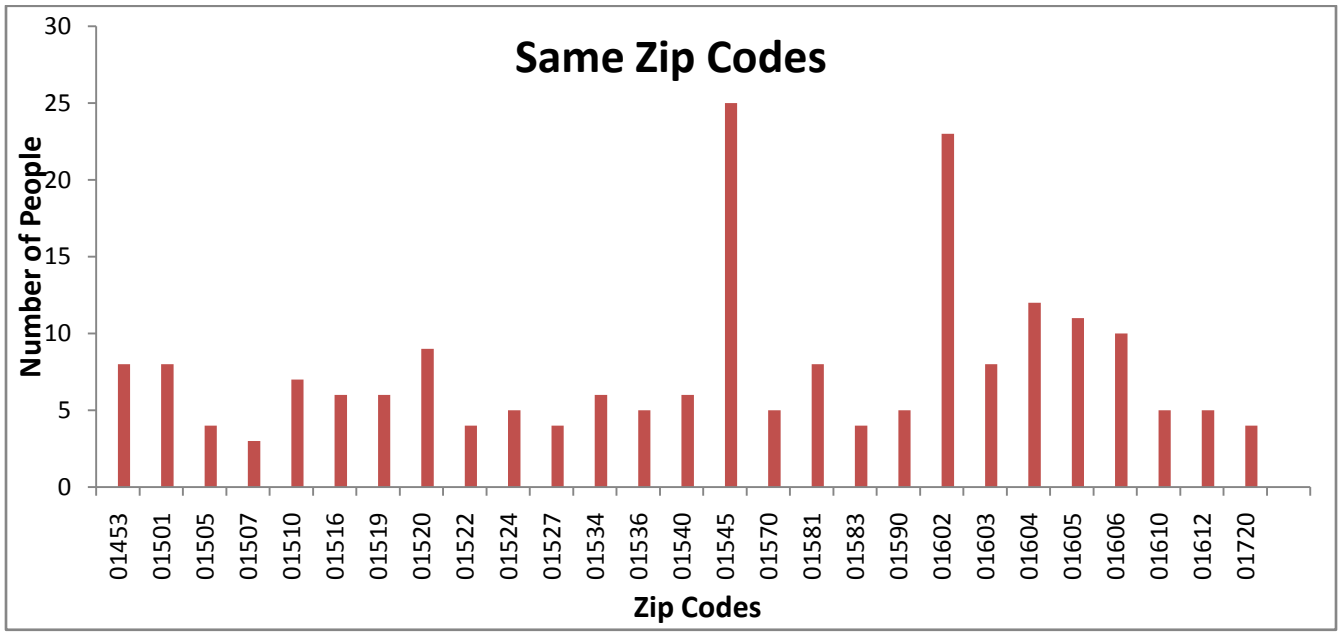

Figure 4.8 People living in the same zip code area

From the survey results it was surprising to discover that some people drive as far as 50 miles or more to and from campus every day. This observation caused the team to analyze the results further for some of the distances that participants travel. The results showed that the majority of commuters who answered the survey live within 20 miles of the university. However, up to about 9 percent of the respondents live more than 50 miles away. Such commuters are some of the main target groups that the team hopes to appeal to. Figure 4.9 below shows the distances that the survey respondents travel every morning.

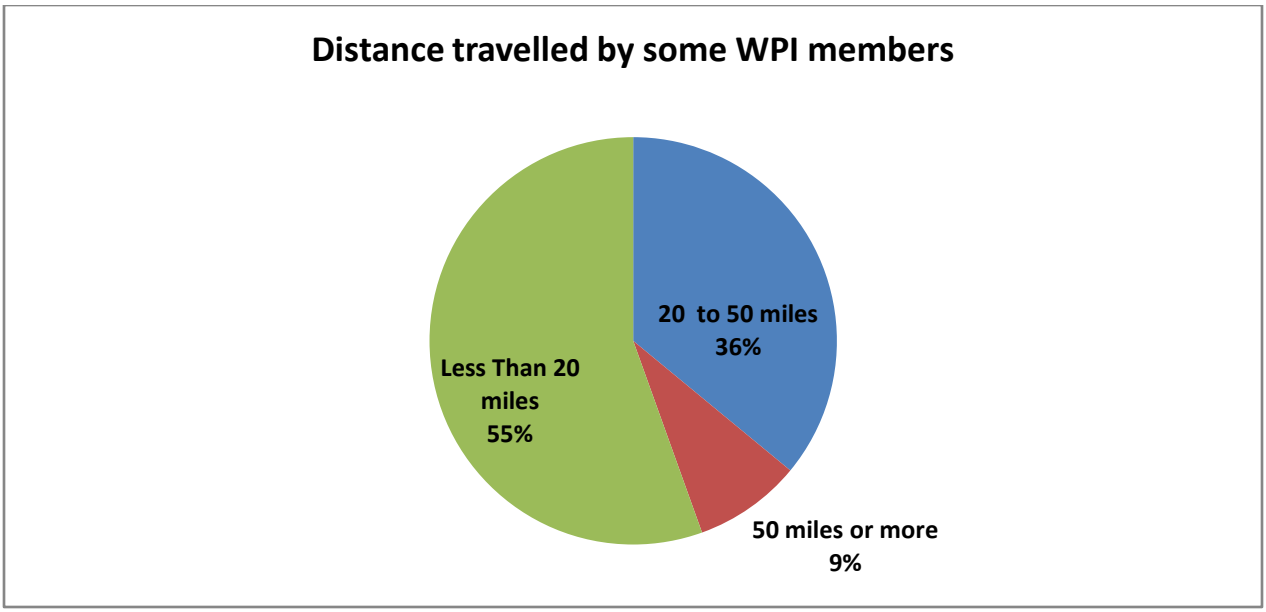

Figure 4.9 Pie chart of distance travelled by some WPI members

Although many people in the community might be living close to each other, it is not easy to identify such people and suggest ride sharing. The team hoped that the results of the survey will make a convincing appeal to the community to explore the possibility of reducing the university's carbon footprint through ride sharing.

Correlation of distance travelled with interest in carpool

After analyzing all the data that was collected from the survey, the team sought to find out whether people who said they were interested in carpooling were people who lived far from the campus. Data from the question that asked respondent's interest in carpooling was regressed on the distance that respondents travelled to campus daily, to find out if there was a correlation between the two.

It turned out from the analysis that people who answered level five or above to interest in carpooling were not necessarily those who lived at least 20 miles or more from the campus. Distance travelled did not play any major role in the way the question was answered. Figure 4.10 shows a regression analysis of the two variables.

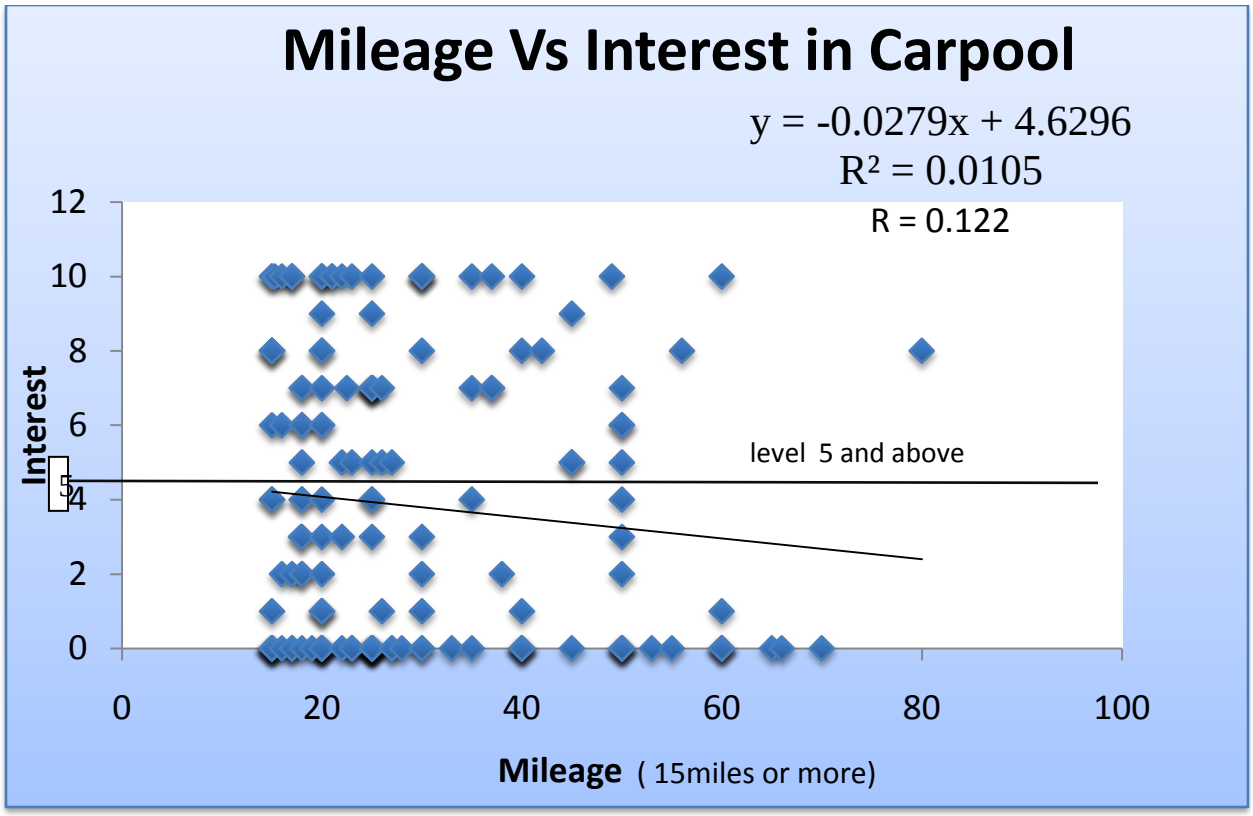

Figure 4.10 Mileage vs. interest in carpool

As shown in the chart above, there was no correlation between those who answered level 5 or above and those who live at least 15 miles or more away from the campus. However, all the people shown above the line between level 4 and 6 on the chart showed interest in making use of a ride sharing system if one was made available to the community.

Summary of survey results

The total number of the WPI community is about 5,400. 634 people answered the survey of whom 52% said they drive always to campus. Out of the 52%, 20 percent said they always share a ride and 22 percent said they sometimes share a ride. 57% of the 52% that drive said they never share a ride. About 45% of those who never share a ride drive at least 20 miles to campus daily.

There are 67 zip codes where at least 2 community members live and there are 36 zip codes where at least four members live. About 35% of all respondents and 68% of those who drive always or occasionally said were interested in carpooling at least once a week.

Other Results from survey

- About 72% of WPI members who drive said they have parking decals and 28% said they did not have decals.
- About 97% of cars surveyed are gasoline powered, and 2% are hybrid. There was one electric car and about 2 diesel powered cars.
- About 80% of the cars have automatic transmission, and the most popular make of car from the survey is Honda, followed by Toyota
- The oldest car from the survey was a 1990 Volvo 740, and the most fuel efficient car was the Toyota Prius (hybrid), which has 45 mpg highway and 48 mpg city.

Chapter 5: Analysis

5.1 Calculating the Carbon footprint

Survey takers who at least drive occasionally were asked to answer additional questions aimed at obtaining relevant information to be used in calculating the individual's carbon footprint [See Appendix A-2]. The main information needed to accurately calculate the carbon footprint was the year, make, and model of the vehicle they were driving. With this information the team estimated the average miles per gallon for their vehicles for highway and city driving, using a miles per gallon estimator from the United States Department of Energy website ("Find a Car").

Also, participants were asked on average how many miles their one-way commute to WPI was. Then the survey asked on average how many times in a week the individual commutes to campus. Next respondents were asked if their vehicle had standard or automatic transmission and also what type of fuel their vehicle consumed; regular or diesel. The survey takers were then asked to choose a range on a scale from 0-10, with 0 being equal to a commute that is all highway, 10 being a commute that is all city, and 5 being roughly half city and half highway. This scale was a key part of how accurate the CO_2 emission calculation would be. In the calculation, the team first multiplied the one-way distance travelled to the campus by two so that it would equal the distance to and from campus. Next the distance was multiplied by a factor that describes the amount of CO_2 emissions per gallon of gas. This factor for regular gasoline is 8.8 kg of CO_2 per gallon of gasoline and for diesel, 10.1 kg of CO_2 per gallon ("Emission Facts"). This number was then divided by the weighted average of the vehicles mileage per gallon which depends on the range of the individual's highway and city driving. This yielded the amount of CO_2 emitted per day for that individual's specific vehicle for the specific distance of their

commute, and for the U.S. Department of Energy estimated mileage per gallon for the individual's preferred route of commute, highway or city.

The next step was to multiply the daily carbon footprint by the average number of times the individuals drive to campus in a week to get the weekly amount of CO_2 emissions. To get the yearly CO_2 emissions the team had to look at whether the individual was an undergraduate, graduate, staff or faculty member, because each of these groups are on campus a different number of weeks a year. For undergraduates and graduates, the weekly CO_2 emissions was multiplied by 28 weeks because there are four terms with seven weeks in each term, and graduate students follow the same schedule except that they have semesters instead of terms. It was assumed that faculty members come to campus on an average of 45 weeks in a year, this assumption was made because most of them come to campus a few weeks before the term starts, and a lot of them do research on campus over the summer and on breaks. For staff members the team multiplied the weekly CO_2 emissions by 50 weeks because it was assumed that they have at least two weeks of vacation, and they work for the most part of the year. The final form of the equation looks like

$$CO2\ emitted\ per\ day = \frac{(8.8\ or\ 10.1) * 2(distance\ traveled)}{\left(\left(\frac{(10 - Scale)}{10}\right) * (HW\ MPG)\right) + \left(\left(\frac{Scale}{10}\right) * (City\ MPG)\right)}$$

$$CO2\ emitted\ per\ day\ (dimensional\ analysis) = \frac{\left(\frac{kg\ of\ CO2}{gallon}\right) * (mile)}{(mile/gallon)}$$

$$= \left(\frac{kg\ of\ CO2}{gallon}\right) * (mile) * \left(\frac{gallon}{mile}\right) = kg\ of\ CO2$$

The formula to calculate the amount of gas consumed was similar. The amount of gasoline consumed is

$$gallons\ of\ gas\ consumed\ per\ day = \frac{2(distance\ traveled)}{\left(\left(\frac{(10 - Scale)}{10}\right) * (HW\ MPG)\right) + \left(\left(\frac{Scale}{10}\right) * (City\ MPG)\right)}$$

$$gallons\ of\ gas\ consumed\ per\ day\ (dimensional\ analysis) = \frac{(mile)}{(mile/gallon)}$$

$$= (mile) * \left(\frac{gallon}{mile}\right) = gallon$$

Again to get the weekly amount of gas consumed or CO_2 emitted the gas consumed per day or CO_2 emitted per day was multiplied by the number of days the individual drives to campus on average.

$$gallons\ of\ gas\ consumed\ per\ week = (gallons\ of\ gas\ per\ day) * (\#\ of\ days\ on\ campus)$$

$$CO2\ emitted\ per\ week = (CO2\ emitted\ per\ day) * (\#\ of\ days\ on\ campus)$$

By multiplying the number of weeks individuals come to campus (28 for undergraduates and graduates, 45 for faculty members, and 50 for staff members) by the weekly numbers one will obtain the selected yearly numbers.

$$gallons\ of\ gas\ consumed\ per\ week = (gallons\ of\ gas\ per\ day) * (\#\ of\ days\ on\ campus)$$

$$CO2\ emitted\ per\ year = (CO2\ emitted\ per\ week) * (\#\ of\ weeks\ on\ campus)$$

Once all these numbers were obtained one could then multiply the daily, weekly, or yearly gallons consumed by an assumed certain dollars per gallon depending on the average price of gas ($2 was assumed) in the area to see how much the individual or all the individuals spend.

$$Cost\ of\ gas = (gas\ consumption - Time\ Scale : \{daily, weekly, yearly\}) * (Average\ cost\ of\ gas\ per\ gallon)$$

To obtain the tonnage of CO_2 emitted one could multiply the kilograms of CO_2 per day, week, or year by a conversion factor: 1 kilogram = 2.2 pounds and divide by 2000 pounds, because one ton equals two-thousand pounds.

$$\#\ of\ tons = (\#\ of\ kg) * \frac{(2.20462262\ lb)}{(1kg)} * \frac{(1\ ton)}{(2000\ lb)}$$

One could also obtain the number of barrels of crude oil consumed from the number of barrels consumed using the conversion factor 1 barrel of crude oil equals 42 gallons of gasoline.

$$1barrel\ of\ crude\ oil = 42\ gallons\ of\ gas$$

All of these formulas were placed into a spreadsheet to wait until the final survey was compiled and administered. After the raw data from the survey was gathered, the team manually placed the

data into the pre-made spreadsheets with all the formulas ready to calculate the carbon footprint, total gas consumed, and the total cost of the gas.

It should be noted that the most accurate estimates for the emissions, consumptions, and costs are for the weekly timetable because there were no assumptions made. For the yearly numbers an assumption was made about the number of weeks in the year. The daily numbers are as accurate as the weekly numbers except when one looks at the total daily numbers. This is because the total daily numbers assumes that everyone in that category would drive that day or the maximum amount that category could drive for any given day. For example, in reality the daily emissions, consumptions, and costs for undergraduates would be much lower than portrayed because not all undergraduates drive to school every day.

The team found that out of the 498 who at least drive occasionally there were only 351 respondents who provided enough information to accurately calculate their carbon footprint. There were 102 undergraduates, 33 graduates, 46 faculty members, 164 staff members, and 6 vehicles from police/SNAP/Gateway from which information was used.

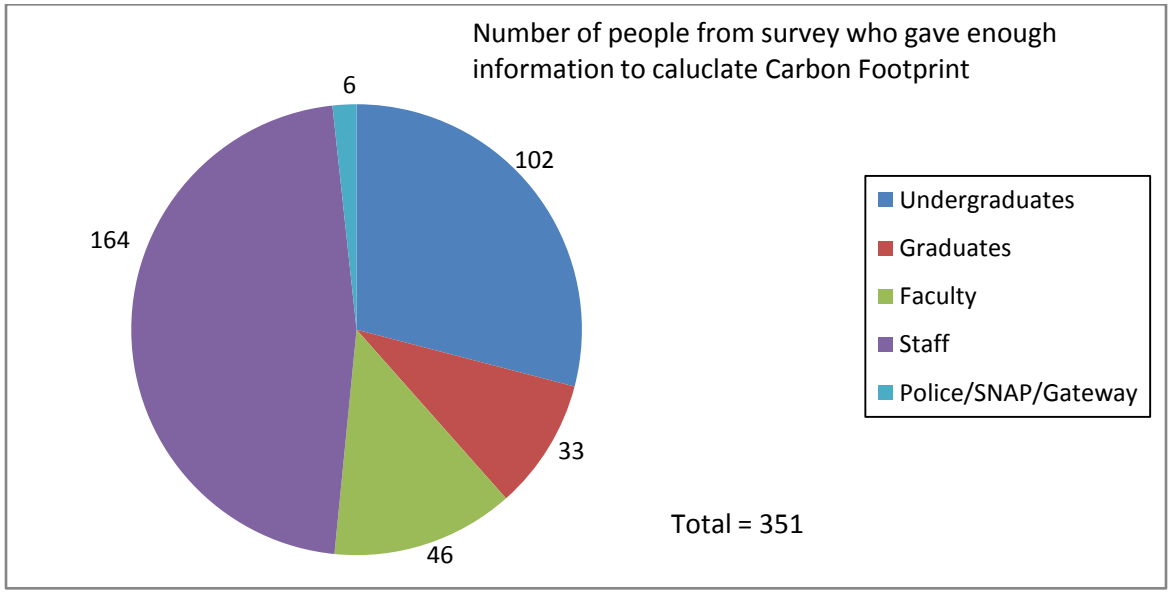

Figure 5.1 Breakdown of survey respondents

5.2. Undergraduate Emission, consumption, and costs

The CO_2 emission for the 102 undergraduates is 1263.59 kg or 1.39 tons daily, 3228.69 kg or 3.56 tons weekly, and 90403.23 kg or 99.65 tons yearly. The 102 undergraduate respondents consume 140.65 gallons or 3.35 barrels daily, 355.14 gallons or 8.46 barrels weekly, and 10190.37 gallons or 242.63 barrels yearly. They spend $281.30 daily, $710.28 weekly, and $20380.73 yearly on gasoline.

Number of Undergraduates (102)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	1263.596	1.393	140.652	3.349	281.304
Week	3228.687	3.559	355.142	8.456	710.283
Year (28 week)	90403.228	99.653	10190.367	242.628	20380.734

Table 5.1 Summary of the undergraduate figures

To see graphical representations of Table 5.1 [See Appendix F-1].

5.3. Graduates emissions, consumption, and costs

The CO_2 emission for the 33 graduates is 333.23 kg or 0.367 tons a day, 760.06 kg or 0.838 tons a week, and 21281.72 kg or 23.46 tons in a year. These 33 graduate respondents consume 37.87 gallons or 0.902 barrels a day, 86.37 gallons or 2.06 barrels a week, and 2418.38 gallons or 57.58 barrels a year. The graduate respondents spend $75.73 daily, $172.74 weekly, and $4836.75 yearly on gasoline.

Graduates (33)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	333.232	0.367	37.867	0.902	75.735
Week	760.061	0.838	86.371	2.056	172.741
Year (28 week)	21281.716	23.459	2418.377	57.580	4836.754

Table 5.2 Summary of graduate students' emissions, consumptions, and costs.

To see graphical representations of Table 5.2 [See Appendix F-2].

5.4 faculty emissions, consumptions, and costs

The calculated CO_2 emissions of the 46 faculty members is 553.98 kg or 0.611 tons daily, 2238.29 kg or 2.47 tons weekly, and 100723.02 kg or 111.03 tons yearly. The 46 faculty respondents consume 62.95 gallons or 1.49 barrels daily, 254.35 gallons or 6.06 barrels weekly, and 11445.79 gallons or 272.52 barrels yearly. They spend $125.90 daily, $508.70 weekly, and $22891.59 yearly on gasoline.

Faculty (46)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	553.981	0.611	62.952	1.499	125.905
Week	2238.289	2.467	254.351	6.056	508.702
Year (45 week)	100723.017	111.028	11445.797	272.519	22891.595

Table 5.3 Summary of faculty members' emissions, consumptions, and costs.

To see graphical representations of Table 5.3 [See Appendix F-3].

5.5 Staff Emission, Consumptions and Costs

The CO_2 emissions of the 164 staff members is 1724.57 kg or 1.90 tons daily, 8556.75 kg or 9.43 tons weekly, and 424543.96 kg or 467.97 tons yearly. The 164 staff members who

responded consume 195.97 gallons or 4.67 barrels daily, 972.36 gallons or 23.15 barrels weekly, and 48243.63 gallons or 1147.13 barrels yearly. All together the staff members who responded spend $391.95 daily, $1944.72 weekly, and $96487.26 yearly on gasoline.

Staff (164)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	1724.573	1.901	195.974	4.665	391.95
Week	8556.754	9.432	972.358	23.151	1944.72
Year (50 week)	424543.963	467.979	48243.632	1147.127	96487.26

Table 5.4 Summary of the 164 staff members' results.

To see graphical representations of Table 5.4 [See Appendix F-4].

5.6 Other vehicles' emissions, consumptions, costs

When calculating the estimated carbon footprint of the entire school the team wanted to account for the carbon dioxide emissions produced by the maintenance vehicles, police vehicles, snap vans and gateway shuttles. However, it was found that the maintenance vehicles would be very difficult to track because many maintenance vehicles are on temporarily lease to WPI, and there were so many such that it would be difficult to request all of those workers to track their mileage driven for any period. Thus the team abandoned the idea of incorporating data from the maintenance vehicles. This also explains why the actual carbon footprint of the entire university in reality would be much higher than what was calculated.

However, the police vehicles, snap vans, and the gateway shuttle's carbon emissions were estimated. For two consecutive weeks the team asked the police dispatcher to call in the three police vehicles, two snap vans, and one gateway shuttle, to record the weekly mileage. The dispatcher recorded it on a Monday at 3pm and then the next Monday at 3pm so it would be

exactly a week's worth of information. The team did that for two weeks to reduce the chances of anomalies. Also the team requested the year, make, and model of each vehicle so that the specific mileage per gallon for city driving could be looked up. The information about the average distances traveled can be seen below.

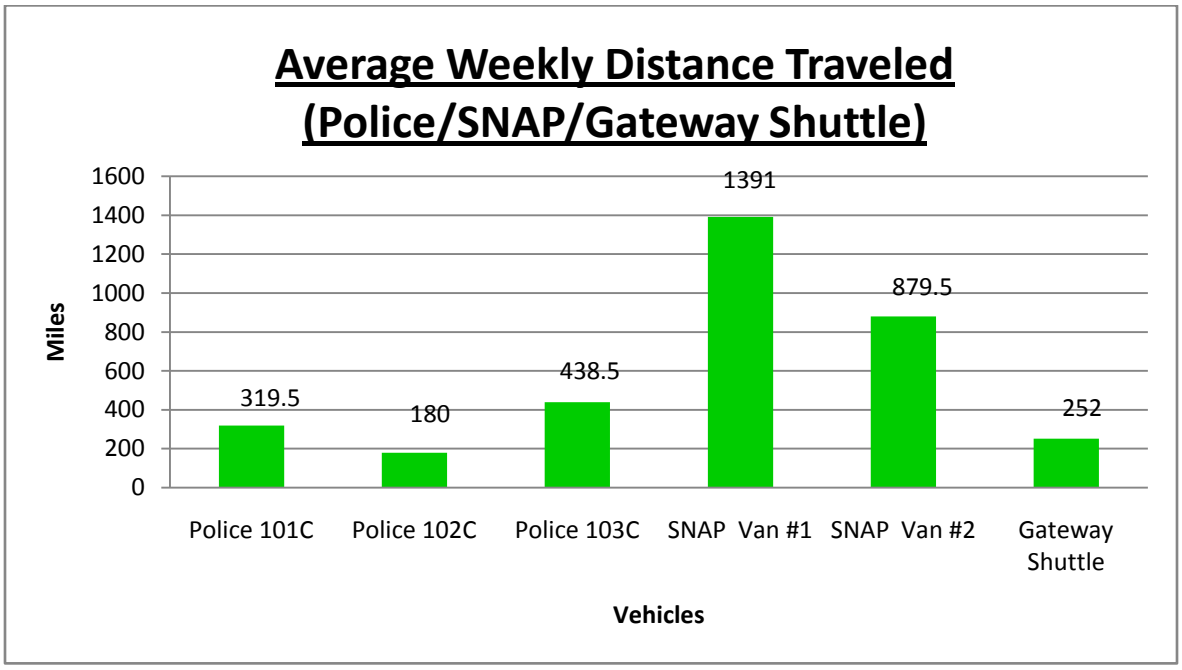

Figure 5.2 Average (Weekly) Distances Travelled (Police/SNAP/Gateway)

During the first week the three police vehicles traveled 681 miles, the snap vans traveled 1896 miles and the gateway shuttle 262 miles. During the second week of recording the police vehicles traveled 1195 miles, the snap vans 2645 miles, and the gateway shuttle 242 miles. This means the three police vehicles travel an average of 938 miles a week, the two snap vans travel an average of 2270.5 miles a week, and the gateway shuttle averages 252 miles a week. Using this information the team could calculate these vehicles' emissions, consumptions, and fuel cost per day, week, and year.

WPI Police (3)	Distance (mile)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	134	81.236	0.0895	9.231	0.2198	18.46
Week	938	568.651	0.6268	64.619	1.539	129.24
Year (52 week)	48776	29569.876	32.595	3360.213	80.005	6720.43

Table 5.5 Summary of Police Vehicle Operations

SNAP (2)	Distance (mile)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	324.36	167.90	0.185	19.08	0.454	38.16
Week	2270.5	1175.32	1.296	133.56	3.179	267.12
Year (30week)	68115	35259.53	38.867	4006.76	95.399	8013.53

Table 5.6 Summary of SNAP's Vehicle Operations

Gateway Shuttle	Distance (mile)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	36	19.8	0.0218	2.25	0.0536	4.5
Week	252	138.6	0.1528	15.75	0.375	31.5
year (30 week)	7560	4158	4.583	472.5	11.25	945

Table 5.7 Summary of Gateway Shuttle Carbon Footprint Data

To obtain the daily distances traveled, daily CO_2 emitted, daily gas consumed, and the daily costs the team divided the weekly numbers by seven days. To get the yearly numbers for the police vehicles the team multiplied the weekly numbers by 52 weeks because the police vehicles are always on campus. The team multiplied SNAP's weekly numbers by 30 weeks because SNAP is usually in service for the normal school terms plus a few days before and after

a term including some of the breaks. The group multiplied the Gateway shuttle's weekly numbers by 30 weeks for the same reason as SNAP

Police/SNAP/Gateway (6)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	268.938	0.2965	30.561	0.728	61.12
Week	1882.569	2.075	213.928	5.094	427.86
Year	68987.406	76.046	7839.478	186.654	15678.96

Table 5.8 Summary of Carbon Footprint Data of SNAP, WPI Police and Gateway Shuttle

To see Police/SNAP/Gateway comparison graphs [See Appendix F-5].

5.7 Total Survey

All together the CO_2 emissions from the surveyed vehicles is 4144.32 kg or 4.57 tons daily, 16666.36 kg or 18.37 tons weekly, and 705939.33 kg or 778.16 tons yearly. Together these 351 respondents consume 468.01 gallons or 11.14 barrels daily, 1882.15 gallons or 44.81 barrels weekly, and 80137.65 gallons or 1906.51 barrels yearly. For the entire survey the 351 individuals spend $936.01 daily, $3764.30 weekly, and $160275.30 yearly on gasoline.

Total Survey (351)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	4144.32	4.568	468.01	11.143	936.014
Week	16666.36	18.372	1882.15	44.813	3764.30
Year	705939.33	778.165	80137.65	1906.509	160275.34

Table 5.9 Summary of Survey Results (CO2 Emissions, Expenditure and Consumption)

These numbers are quite significant and that is only for 351 people (6.5 % of the entire 5403 members of the WPI community). The calculated numbers should actually be much higher

because of all the people who drive and didn't give enough information to calculate their numbers and because the team couldn't estimate all the facilities vehicles.

To see graphical representations of Table 5.9 [See Appendix F-6].

5.8 Summary and Comparison

Comparison of the CO_2 emissions of the 5 groups: undergraduates, graduates, staff, faculty, and police/SNAP/Gateway.

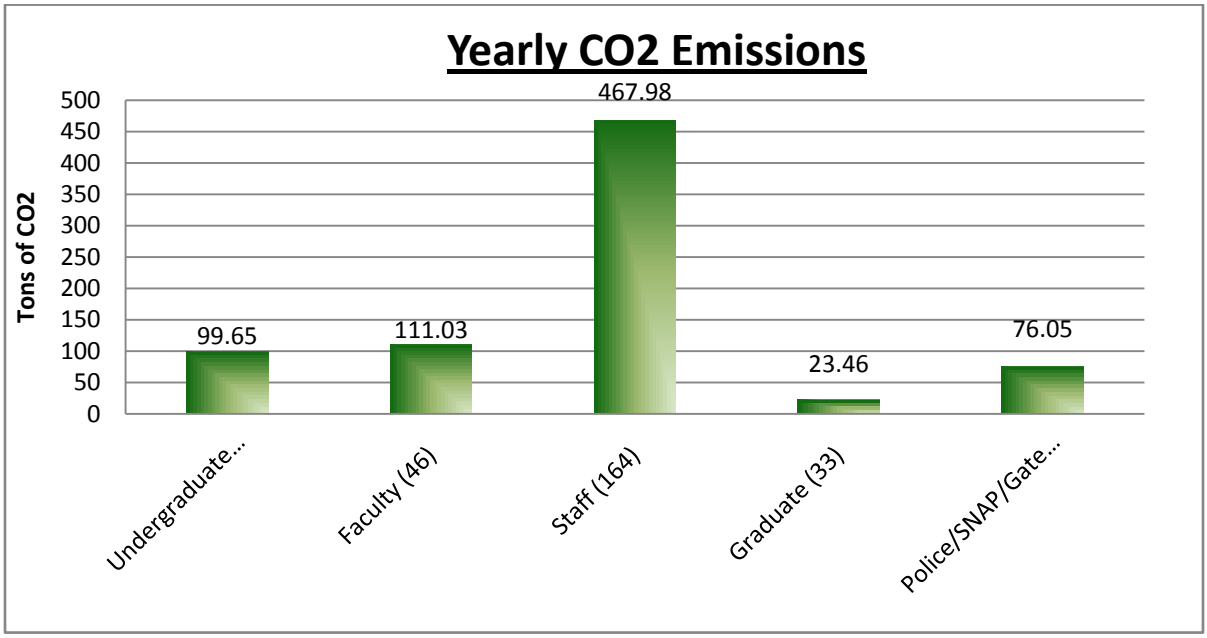

Figure 5.3 Comparison of Annual CO2 Emissions of all five strata

Comparison of the yearly gallons of gas consumed.

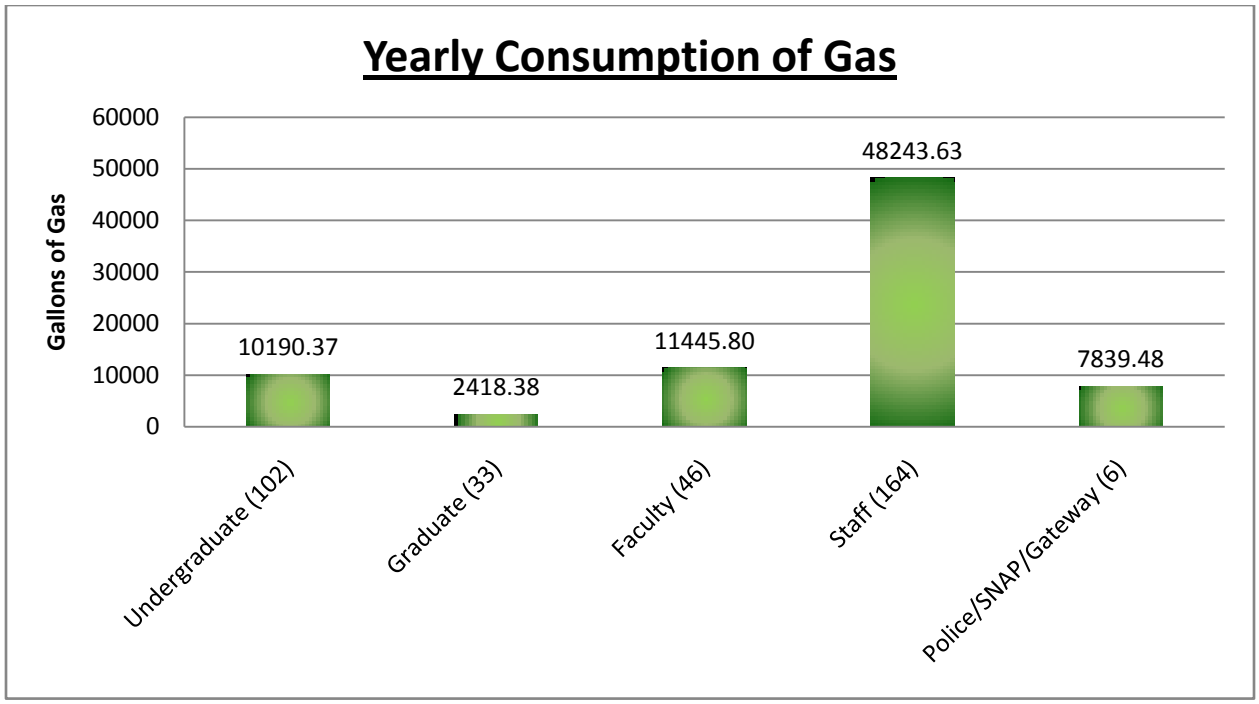

Figure 5.4 Comparison of Yearly Gasoline Consumption

Comparison of the money spent on gasoline yearly.

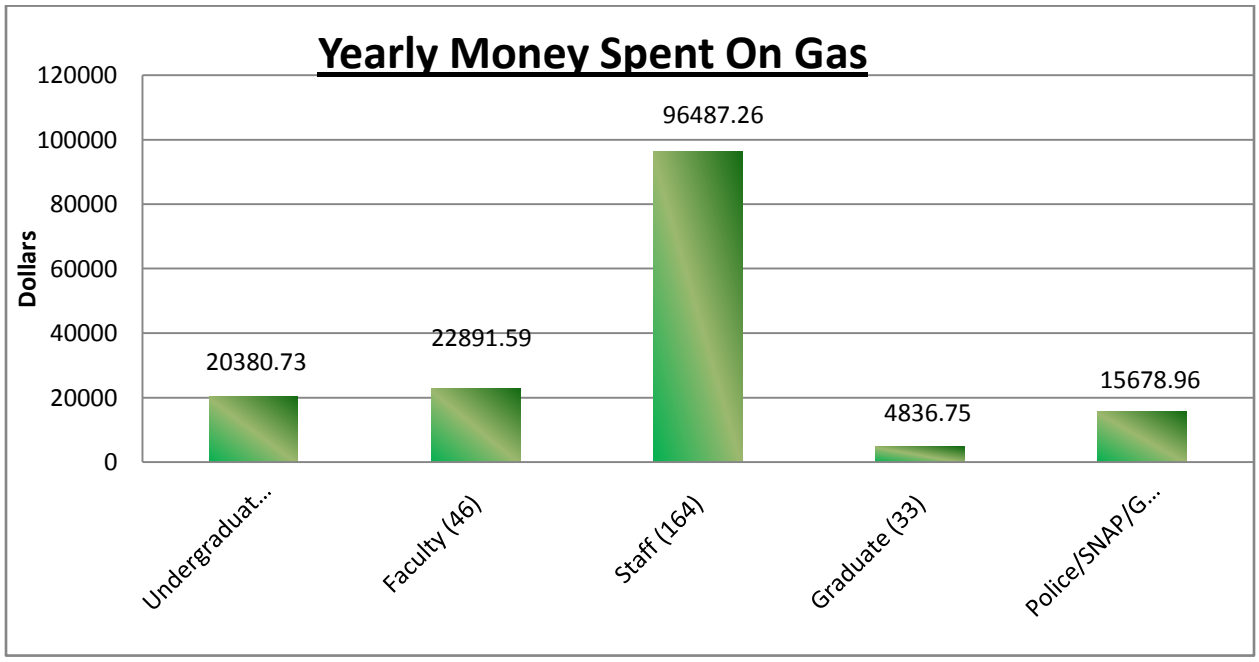

Figure 5.5 Annual Expenditure on Gasoline

When the yearly emissions, consumptions, and costs of the undergraduates, faculty, staff, and graduates are compared, there are three things that stand out. One may wonder why the undergraduates' numbers are so low even though they were such a large number of the survey respondents. The answer may be because most of the undergraduates walk to school, and a lot of the undergraduates who gave enough information to obtain accurate numbers only drive once or twice a week or even less and their commute is usually less than a mile. Also many only drive when there is bad weather conditions or at night. This type of information was provided to the team in the comment box on the survey [See Appendix A-6].

The second thing that stands out is why the staff members' numbers were so high. This could be because of a number of reasons. The team gave paper surveys to the head of the maintenance department and the staff members were encouraged to fill it out. Most staff members generally drive all the time at least 4 to 5 times a week with a fairly long commute, and the staff members were assumed to be on campus most of the year.

Lastly one may wonder why the police/SNAP/Gateway numbers are so high for only 6 vehicles. Again this could be caused by a number of reasons, such as the sheer amount of mileage put on the cars annually. The driving is also all city, the police vehicles constantly circle the campus all year long, and it might be that SNAP vehicles are driven more than necessary. The team believes that SNAP is frequently misused as a "free cab" not for safety reasons as was originally planned, and its overuse is contributing a large amount of the CO_2 emissions.
For more graphs comparing the different demographics [See Appendix F-7].

5.9 Total Community Estimated Emissions, Consumption, and costs

To make an accurate estimate of the total community's emissions, consumptions and costs, the team made some assumptions based on the general survey. The total community has a population of about 5400 people and the break downs of the different demographics can be seen in Table 4.1.

The team then looked at how many from each category responded to the survey and out of those who responded how many drive at least occasionally.

Demographics	# Responded to Survey	# who drive at least occasionally (survey)	Percent of group that drives	Estimate of # that drive
Undergraduate	314	151	0.481	1564
Graduate	68	41	0.603	789
Faculty	56	55	0.982	308
Staff	186	175	0.941	497

Table 5.10 Breakdown of survey demographics who drive

From these two pieces of information one can find the percentage of each group that drives

$$Percent\ of\ each\ group\ that\ drives = \frac{\#\ Respondents\ who\ drive}{Total\ \#\ Respondents\ to\ Survey}$$

and then multiply that percent factor by the total number of people in the group to estimate the total number that drive in that group.

$$Estimated\ \#\ of\ people\ who\ drive\ in\ a\ group = (percent\ of\ each\ group\ that\ drives) * (total\ number\ of\ people\ in\ the\ group)$$

After estimating the number of people who drive in each group, ratios of the daily, weekly and yearly emissions, as well as fuel consumptions and costs of the groups were made using the data from the survey that was provided by the 102 undergraduates, 33 graduates, 46 faculty, and 164 staff. The calculated results are assumed to be proportional to estimated annual numbers of the total number of people who drive in that group. Any such estimate can be obtained using the equation below.

$$\frac{x}{Estimated\ \ \#\ of\ \ peopl\ e\ who\ drive\ \ in\ group} = \frac{(Daily\ ,Weekly\ ,Yearly\ \rightarrow emissions\ ,consumptions\ \ ,costs\ )}{(undergrad\ \ (102),grad\ \ (33),faculy\ \ (46),staff\ (164))}$$

Using this ratio the estimated total undergraduates emissions, consumptions, and costs can be seen in Table 5.11 below.

Undergraduates (1564)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	19375.14	21.36	2156.66	51.35	4313.32
Week	49506.53	54.57	5445.51	129.65	10891.01
Year (28 week)	1386182.83	1528	156252.29	3720.29	312504.58

Table 5.11 Estimated Total Undergraduate's Emissions, Consumptions, and Costs

The estimated total graduate emissions, consumptions, and costs can be seen in Table 5.12.

Graduates (789)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	7967.28	8.78	905.37	21.56	1810.75
Week	18172.37	20.03	2065.04	49.17	4130.09
Year (28 week)	508826.49	560.89	57821.19	1376.7	115642.39

Table 5.12 Estimated Total Graduate's Emissions, Consumptions, and Costs

The estimated total faculty emissions, consumptions, and costs can be seen below in Table 5.13.

Faculty (308)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	3709.26	4.09	421.51	10.04	843.01
Week	14986.81	16.52	1703.05	40.55	3406.09
Year (45 week)	674406.29	743.41	76637.08	1824.69	153274.16

Table 5.13 Estimated Total Faculty member's Emissions, Consumptions, and Costs

The estimated total staff member emissions, consumptions, and costs can be seen in Table 5.14,

Staff (497)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	5226.3	5.76	593.9	14.14	1187.79
Week	25931.14	28.58	2946.72	70.16	5893.44
Year (50 week)	1286575.30	1418.21	146201.74	3476.36	292403.48

Table 5.14 Estimated Total Staff member's Emissions, Consumptions, and Costs

The figures can be added from the four demographics to yield the estimated numbers of the total community (3158) who at the least drives occasionally.

Total (3158)	CO2 Emitted (kg)	CO2 Emitted (ton)	Gas Consumed (gal)	Oil Consumed (barrel)	Cost of Gasoline ($)
Day	36277.98	39.99	4077.44	97.08	8154.88
Week	108596.85	119.71	12160.31	289.53	24320.63
Year	3855990.92	4250.50	436912.30	10398.04	873824.60

Table 5.15 Estimated Total Community's Emissions, Consumptions, and Costs

The police vehicles, SNAP vans, and Gateway shuttle were in the end not added to the community's total carbon footprint. The reason was because the savings were based on the total numbers of the community and how those numbers would be reduced by a carpool program. Since the police, SNAP, Gateway, and facilities cannot carpool, if their numbers were added to the whole community the savings would be skewed.

The total community is responsible for a significant amount of CO_2 released, gallons consumed, and money spent. A carpool program could greatly reduce the CO_2 released by the WPI community, reduce gas consumption, and ultimately save the community a lot of money not only from the gasoline but less oil changes and car maintenance because people would be driving less.

For graphs on total community estimates [See appendix F-8].

5.10 Assumed Reductions and Savings

After it was shown that there is a strong interest in carpooling, the team decided to see how much a carpool system would actually reduce carbon emissions and how much commuters would save. The entire community's estimated number of people who drive at least occasionally is about 3158 people. The team then took 68% of 3158 people, which is 2147, because 68% of the people who at least drove occasionally in the survey showed a high interest in carpooling, a level of 5 or higher on a Likert scale.

$$Estimated\ WPI\ commuters\ interested\ in\ carpooling = (.68) * (3158) = 2147$$

The team estimated the savings if 5%, 10%, 15%, 20%, 25% of those who drive and are highly interested in carpooling started to carpool, and their cars were taken off the road.

$$People\ who\ started\ carpooling = (x\%) * (2147)$$

$$= (.05) * (2147) = 107.35$$

$$= (.10) * (2147) = 214.7$$

$$= (.15) * (2147) = 322.05$$

$$= (.20) * (2147) = 429.4$$

$$= (.25) * (2147) = 536.75$$

The team looked at what was calculated for the daily CO_2 emissions, gas consumed, and money it costs for the entire community and ratios were made comparing the totals of those numbers over the entire community (3158) being proportional to the average amount of CO_2 emissions, consumptions, and cost of the people who started carpooling, (which would be solved for), over the number of vehicles that would be taken off the road.

$$\frac{Daily, Weekly, Yearly \rightarrow Emissions, Consumptions, Cost}{3158} = \frac{x}{(5,10,15,20,25\%) * (2147)}$$

$$\frac{Daily, Weekly, Yearly \rightarrow Emissions, Consumptions, Cost}{3158} = \frac{x}{(107.35,214.7,322.05,429.4,536.75)}$$

This yielded the amount saved if the percentage of the community that drive at least occasionally and have a high interest in carpooling (level 5 or higher on Likert Scale) started carpooling.

The reductions and savings if 5% or 107.35 people started to carpool are given in Table 5.16

Savings 5% (107.35)	Less CO2 Emitted (kg)	Less CO2 Emitted (ton)	Gas saved (gal)	Oil saved (barrel)	Monetary Savings ($)
Day	1185.25	1.31	133.79	3.19	267.58
Week	5097.25	5.62	575.64	13.71	1151.28
Year	215904.81	237.99	24509.34	583.09	49018.67

Table 5.16 Estimation of Savings by 5% of people Carpooling

The reductions and savings if 10% or 214.7 people started to carpool are given in Table 5.17

Savings 10% (214.7)	Less CO2 Emitted (kg)	Less CO2 Emitted (ton)	Gas saved (gal)	Oil saved (barrel)	Monetary Savings ($)
Day	2370.5	2.61	267.58	6.37	535.15
Week	10194.49	11.24	1151.28	27.41	2302.55
Year	431809.61	475.99	49018.67	1166.17	98037.34

Table 5.17 Estimation of Savings if 10% of the people at WPI start Carpooling

The reductions and savings if 15% or 322.05 people started to carpool are shown in Table 5.18

Savings 15% (322.05)	Less CO2 Emitted (kg)	Less CO2 Emitted (ton)	Gas saved (gal)	Oil saved (barrel)	Monetary Savings ($)
Day	3555.75	3.92	401.37	9.56	802.73
Week	15291.74	16.86	1726.91	41.12	3453.83
Year	647714.42	713.98	73528	1749.26	147056.01

Table 5.18 Estimation of Savings if 15% of the people at WPI start Carpooling

The reductions and savings if 20% or 429.4 people started to carpool are shown in Table 5.19

Savings 20% (429.4)	Less CO2 Emitted (kg)	Less CO2 Emitted (ton)	Gas saved (gal)	Oil saved (barrel)	Monetary Savings ($)
Day	4740.99	5.23	535.15	12.74	1070.31
Week	20388.99	22.48	2302.55	54.82	4605.10
Year	863619.23	951.98	98037.34	2332.35	196074.69

Table 5.19 Estimation of Savings if 20% of the people at WPI start Carpooling

The reductions and savings if 25% or 477.5 people started to carpool are given in Table 5.20

Savings 25% (536.75)	Less CO2 Emitted (kg)	Less CO2 Emitted (ton)	Gas saved (gal)	Oil saved (barrel)	Monetary Savings ($)
Day	5926.24	6.5	668.94	15.93	1337.89
Week	25486.24	28.09	2878.19	68.53	5756.38
Year	1079524.03	1189.97	122546.68	2915.44	245093.36

Table 5.20 Estimation of Savings if 25% of the people at WPI start Carpooling

For more graphs comparing the reductions and savings [See Appendix F-9].

5.11 Conclusions

These are significant savings and the price of a pre-packaged carpooling system would be dwarfed by the amount saved, even if there were only a 5% turnout, which is about $49,000 a year. At the other end of the spectrum, if 25% of the likely carpoolers started carpooling the savings would be enormous, about $245,000 a year. However, all these figures are estimates and are subject to error because of the assumptions made and the team's reliance on the survey respondents providing correct information. These savings are likely to be much higher in reality than the calculated savings because of the members who drive but did not provide enough information to accurately calculate their numbers.

Also, because the team could not take into account the monetary savings of driving one's car less, the team could not accurately calculate what would be saved from less frequent maintenance and "wear and tear" costs. One could estimate by assuming that if one carpooled one would be driving half as much which would cut maintenance costs in half annually and double the lifetime of the vehicle. However, based on the savings on gasoline alone, carpooling seems to be the best, easiest, most efficient, and most popular choice of mechanism to provide a more sustainable campus through the medium of transportation. Though these monetary savings are significant they do not compare to the reductions in CO_2 that such a program would yield, and the positive impact it would have on the environment.

The numbers are staggering, 5% would reduce the community's carbon dioxide emissions by about 474,000 pounds a year and 25% would reduce the carbon footprint by over 2,378,000 pounds a year. The numbers would probably be considerably higher if the facilities vehicles were counted.

Chapter 6: Conclusions & Recommendations

After careful consideration of the results and findings of this project, the team has come up with the following recommendations about some systems and services that can be put into practice. If successfully implemented, these will go a long way in reducing WPI's carbon footprint and building a more sustainable, greener campus.

Ridesharing

There are many options available for individuals, groups, and organizations of the WPI community to successfully reduce their transportation attributed carbon footprint. On individual levels, members of the community can make conscious efforts to make non-driving transportation choices whenever possible. Simple alternatives to driving an automobile such as walking or riding a bicycle do not produce any carbon dioxide emissions into the atmosphere and are thus some of the best ways of directly reducing the carbon footprint of the campus. Additionally, utilizing public transportation also decreases carbon dioxide emissions.

Whenever possible, members of the WPI community can consider utilizing other means of commuting to and from the campus rather than driving by themselves. Such systems include taking a bus, using the train or sharing a ride with other people. It will be of great benefit to individuals, the community and the environment if daily commuters to the university make use of the ride sharing system that this project has put in place with the help of the President's Task Force on Sustainability.

Effective use of the carpool program can be encouraged by consistent promotion and advertisement, and the provision of incentives. All sustainability related groups and activities at WPI can use their programs and meetings as platforms to talk about some of the benefits that using a ridesharing system will give. Several benefits including individual cost savings on

gasoline usage and savings on maintenance costs can be addressed. In addition to these benefits, sharing a ride provides stress relieving options such as chatting with carpool partners, relaxing while being driven and doing other desired activities during the commute.

Incentives

A well coordinated carpool incentives system can be a motivating factor for more people to participate in the ridesharing program. If people feel rewarded for making responsible choices in their transportation habits they will be more inclined to making more environmentally friendly decisions. Such people may also take it upon themselves to encourage others to make similar choices. As a way of promoting the system, they can be a voice by telling friends on how easy it is to reduce their carbon footprints by carpooling with others.

Incentives that WPI may want to consider as a way of encouraging ridesharing can be:

- Providing special parking spaces for carpoolers as there are for hybrid cars.
- Reducing parking decal fees for carpool participants.
- Occasional prize winning draws to create awareness of the program
- Provision of emergency ride home programs, such that if people need to go home before their scheduled departure times due to emergencies, they can do that.

These incentives can be incorporated in the school's policies regarding transportation on campus, so that potential carpoolers would feel encouraged that their decision to reduce their carbon footprints will be recognized by the university's authorities.

Other incentives that can be directed towards WPI staff members will be, for heads of departments to ensure that people who provide enough evidence that they carpool will be relieved of their duties on time in order for them to join their carpool partners. Also, they should be assured that if for some reason they show up late to their posts because their carpool team was

late, they would not be penalized. These staff targeted incentives will encourage more staff members to participate in the program ("Carpool Incentive Programs”).

To ensure continuous success of the program, it is essential that any incentive program is monitored and maintained following its implementation. Members of the community participating in the carpool program should be required to re-register on an annual basis in order to prevent fraud. By re-registering, the continuous attendance of students or employment of staff and faculty members at the university can be confirmed. The preferred parking for those who utilize the carpool program should be enforced.

Promotions

It is essential that the new program be integrated into the campus culture in order to enable increased success and maximum use by the community. The university can promote the system through its internal publications such as advertising the program in student and employee orientation materials, having brochures about the program placed at vantage places such as the campus center, the library, department lobbies, and all places that are regularly visited by community members. The program can also be advertised on a continuous basis in the schools major news paper, “The Towers.” Occasional campus-wide emails can also be sent out to remind the community of the existence of the program and encourage its use.

Promotion and advertisement for the program should be ongoing in order to have maximum participation. Creative promotional campaigns and competitions between campus buildings, departments, and majors can be launched in order to enhance program membership.

General Recommendations

Security Night Assistance Patrol (SNAP) services at WPI can take many small but significant steps to reduce their carbon footprint by enforcing their service policies. As the name

indicates, SNAP should only be used by members of the WPI community for security reasons, as a means of transportation from campus to residential areas and vice-versa. SNAP should only operate at hours when it is dark and unsafe for a single student to walk to their destination and should not provide services to large groups of students. Transportation to and from commercial places should not be provided. It should be ensured that the SNAP vehicles are not running while parked and there should be regular monitoring of the daily miles travelled, and fuel consumption to prevent misuse of the system.

WPI Police vehicles that are used by officers for regular patrolling of the campus, and the facilities vehicles that are used for maintenance related transportation cannot be a part of the carpool system. However, there are other measures that they can take to reduce their carbon dioxide emissions. WPI Police Personnel use multiple types of vehicles for patrolling at various times of the day. It is recommended that if possible they should use more fuel efficient vehicles or perhaps hybrid cars while patrolling. It was observed that SUV's are used to patrol campus even when a single officer is on duty. It is recommended that these driving habits be modified such that SUV's may only be used in case of inclement weather conditions.

The WPI facilities department owns various vehicles most of which are large sized trucks. It is recommended that they use smaller fuel efficient cars when possible and use the large trucks only when absolutely necessary. It has been observed that facilities vehicles are left running even when they are parked, and there are no drivers in them; this should be avoided as much as possible. If possible, the facilities department should impose a limit on the distance travelled by each vehicle on a daily basis.

WPI should encourage alternative modes of transportation; additional bike racks should be added at multiple spots on campus to encourage people to ride bikes. Additional racks will

also be convenient for people who already ride bikes. General promotions and additional incentive programs should be set up to encourage more people to ride or walk to campus.

Moreover, the city of Worcester has very good public transportation systems such as the Worcester Public Transit Authority (WRTA) and the MBTA. WPI should encourage its community members to make use of these public transportation services. There are various shuttles that run from the WPI campus to different important locations in the city, such as the consortium shuttle that stops at all colleges that are part of the Worcester College Consortium, and the "Woobus" that runs from the WPI campus to the Blackstone Valley Shops. WPI should encourage all its community members to use these shuttles instead of driving or taking a cab. In order to do so, links to the public transportation websites and shuttles should be provided, possibly under the WPI sustainability website. Schedules of these shuttles, buses and trains should be made easily available as online links on the WPI website. Paper copies of these could also be made available at various spots on campus.

WPI has already formed an alliance with Zipcar; an organization that provides hybrid, fuel efficient vehicles on rent. This system should be promoted more aggressively and the fleet of Zipcars should be expanded to encourage more people to utilize the service.

To ensure that on-going sustainability initiatives at WPI continue to run successfully, campus-wide awareness through more rigorous campaigns promoting responsible environmental practices will be necessary. This will only happen if all members of the community decide to make very small changes towards a more sustainable campus

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Appendices

A-1 Pilot Survey

Interactive Qualifying Project

As a component of WPI's commitment to sustainability, we are conducting research to find ways of reducing WPI's carbon footprint, primarily in the area of transportation. We would appreciate it if you could take a few minutes and respond to these questions. Your participation in this survey is voluntary, of course, and you may opt out at any time.

1. Are you a student, faculty or staff?
    a) Student
    b) Faculty
    c) Staff

2. How do you get to campus daily?
    a) Car
    b) Bike
    c) Bus
    d) Walk
    e) Share a ride (e.g., Carpool)
    f) Other (please specify): _____

Questions 3-11 only need to be filled out by those who drive a car.

3. Do you have a WPI parking sticker?
    A) Yes B) No

4. Please indicate the year, make, and model of your car.

Year: _____ Make: _____ Model: _____

5. How is your vehicle powered?
    a) Gasoline
    b) Diesel
    c) Hybrid
    d) Electric
    e) Other (please specify): _____

6. On average, how many times do you commute to campus in a week? _____

7. About how many miles is your commute to WPI? (one way) _____

8. About how many miles does your car get to the gallon? _____

9. On a scale from 1-10 is your commute,

1	2	3	4	5	6	7	8	9	10
All Highway			Half Highway, Half City						All City

10. What is your zip code? _____

11. On a scale of 1-10, to what extent would you be interested in carpooling at least one day per week (1=not at all, 10=extremely interested) _____

12. How would you rate this survey on a scale of 1-10? (1=Poor, 10=Excellent) _____

This is an anonymous and confidential survey and will only be used for research purposes. Thank you for your time.

Project Team Members:

Neda S. Zahid: Chemical Engineering 2010

Shubhneet Sandhu: Chemical Engineering 2010

Emmanuel K. Akese: Industrial Engineering 2010

Steven Ellis: Physics 2010

A-2 Final Survey

IQP: Transportation and Carbon Foot printing

As a component of WPI's commitment to sustainability, we are conducting research to find ways of reducing WPI's carbon footprint, primarily in the area of transportation. We would appreciate it if you could take a few minutes and respond to these questions. Your participation in this survey is voluntary, of course, and you may opt out at any time.

1. Are you a student, faculty or staff member?

    d) Undergraduate Student
    e) Graduate Student
    f) Faculty
    g) Staff member

2. How do you **PRIMARILY** get to campus?

    g) Car
    h) Motorcycle
    i) Bike
    j) Bus
    k) Walk
    l) Other (please specify): _____

3. What is your zip code? _____

4. On a scale of 0-10, to what extent would you be interested in carpooling at least one day per week?

0	1	2	3	4	5	6	7	8	9	10
Not interested at all										extremely interested

Please Note: ***Questions 5-12 should only be filled by those who drive always or occasionally to campus.***

5. Do you have a WPI parking sticker?

    a) Yes b) No

6. Please indicate the year, make, and model of your vehicle.

Year: _____ Make: _____ Model: _____

7. Is your car

    a) Automatic
    b) Manual

8. How is your vehicle powered?

    f) Gasoline
    g) Diesel

h) Hybrid
i) Electric
j) Other (please specify): _____

9. On average, how many times do you drive to campus in a week? _____

10. About how many miles is your drive to WPI? (one way) _____

11. On a scale from 0-10 is your commute,

0	1	2	3	4	5	6	7	8	9	10
All Highway					Half Highway, Half City					All City

12. Do you share a ride to campus? a) Always b) Sometimes c) Never

Optional

Please use the box below for any questions, comments, or concerns

This is an anonymous and confidential survey and will only be used for research purposes. Thank you for your time. If you are interested in participating in a focus group discussion on transportation issues, please e-mail us at cfp@wpi.edu.

Advisor: Prof. Matthew Ward, Computer Science**.**
Neda S. Zahid: Chemical Engineering 2010
Shubhneet Sandhu: Chemical Engineering 2010
Emmanuel K. Akese: Industrial Engineering 2010
Steven Ellis: Physics 2010

A-3 IRB Form

WORCESTER POLYTECHNIC INSTITUTE
Institutional Review Board
Application for Exemption from IRB Review for
Survey or Interview Research Involving Minimal or No Risk

WPI IRB use only
IRB #
Date:

Use of this application is recommended for most student project research involving minimal risk. Proposed research meets the definition of "minimal risk" when the risks to research subjects are not greater than those ordinarily encountered in daily life. This application is specifically intended for projects in which students are expected to conduct interviews, surveys or focus groups. If student projects are sponsored by US federal agencies, students and advisors should contact the IRB for assistance in filing a full application with the New England IRB.

Project Faculty Advisor(s):

Name: Matthew Ward Tel No: x5671 E-Mail Address: matt@wpi.edu

Department: CS

Name: _____ Tel No: _____ E-Mail Address: _____

Department: _____

Student Investigator(s):

Name: Steve Ellis Tel No: _____ E-Mail Address: sellis8600@wpi.edu

Name: Emmanuel Akese Tel No: _____ E-Mail Address: eakese@wpi.edu

Name: Shubneet Sandhu Tel No: _____ E-Mail Address: ssandhu@wpi.edu

Name: Neda Zahid Tel No: _____ E-Mail Address: nzahid@wpi.edu

Project Title: Transportation Carbon Footprinting

Project Location and Time Frame: WPI : b,c,d term

Expected Research Subjects: (e.g. museum visitors under the age of 12)

All students, faculty, and staff.

NOTE: This application must be accompanied by written research methods and a reasonably complete set of survey or interview questions.

1. Is the proposed research sponsored or supported by a US federal agency or by US government funding? No ☑ Yes ☐
2. Is the proposed research funded by a corporation or foundation? If so, please identify sources. No ☑ Yes ☐
3. Does the proposed research involve vulnerable research subjects? (e.g. children, prisoners, students, persons with mental or physical disabilities, pregnant women) No ☑ Yes ☐

WPI IRB Application for Exemption from IRB Review for Survey or Interview Research Involving Minimal or No Risk

4. Is the research confined to obtaining verbal or written information from subjects and/or publicly available documentary information? No ☐ Yes ☑

5. Could the disclosure of a human subject's identity and responses place the subject at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation? No ☑ Yes ☐

6. Will the researchers collect information that can be used to identify the subjects? No ☑ Yes ☐

7. If the researchers do know the subjects' identity, will individual responses be kept confidential? (e.g. only summaries of all data will be published) No ☐ Yes ☑

8. Will researchers be interviewing people chosen because of their expertise or experience? (See 4, below.) No ☑ Yes ☐

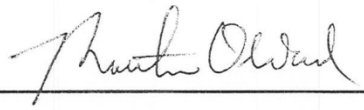
By signing below, all participants in this research project are agreeing to follow the following instructions:

1. You agree to inform subjects orally or in writing that:
   - Participation in the research is voluntary.
   - Participants may end their participation at any time.
   - Participants need not answer every question in an interview or survey.

2. If your research is **anonymous**, you also inform subjects that you are not collecting names or any identifying information from them.

3. If your research is **confidential**, you inform subjects that no identifying information will be disclosed with individual responses.

4. If your research subjects are chosen and interviewed for their expertise or experience, you seek and obtain each subject's permission to identify him or her in your report, and obtain each subject's permission to disclose his or her views and statements in your report. The subject must be offered the opportunity to pre-approve the publication of any quoted material. If a subject does not wish to appear in your report, you respect his or her wishes for confidentiality.

Signature of Faculty Advisor  Date 12/11/2008

Print Full Name and Title Matthew O. Ward, Professor of Computer Science

Please return a signed hard or electronic copy of this application to the WPI IRB c/o Office of Sponsored Programs or irb@wpi.edu.
If you have any questions, please call (508) 831-6716.

A-4 IRB Statement

IQP Research methods

Our objective is to calculate the carbon footprint of the WPI community and suggest methods to reduce it; hence our target population is the entire WPI community. The team for the Carbon Foot printing IQP is planning to use various methods for data collection in order to reach as many people as possible in our target population and get back as many responses from the target population. To achieve that, we are planning to use the following data collection methods.

1) **Email and Internet Surveys-** The team plans on using e-mail and internet surveys as a data collection method. A campus wide email containing the link to our Survey will be sent. Anonymity and confidentiality will be maintained and respondents will be given the option of opting out at any moment if they feel uncomfortable with any of the survey questions. The data gathered will be stored on the SharePoint site and will only be accessible to the team and our advisor.

2) **Questionnaires-** We also plan to hand out surveys to people to fill out in order to gather data. This is to make sure we reach the people who have not responded to the internet survey. The questionnaire is also anonymous and will give people the option of opting out at any time. The data gathered will be entered into an excel sheet and analyzed later. This data will not be displayed anywhere or made public and will only be accessible to the team members

Data Storage and analysis: After all the data has been obtained, it will be gathered into one document and process and analyzed to calculate the carbon footprint caused by different methods of transportation used by members of the WPI community . We will also try to find co-relations between different variables like distance from campus and carbon emissions etc. Only the generalized co-relations of this data will be made available on our website. We will not publish the personal information of any participant. Using these data and co-relations we will come up with suggestions of reducing WPI's carbon footprint.

3) **Focus Groups-** After the all the data has been obtained and processed, we will form a focus group of all the people who have voluntarily shown interest in being a part of such a group. We will use the input provided by this group as an indication of the ideas and attitude's of the larger community to the various suggestions to reduce carbon foot printing. The participants will be given a consent form to sign and indicate their voluntary participation and given the option of leaving whenever they want. We will have a moderator for this discussion who will keep the discussion focused on our area of interest and will debrief the participants at the end of the discussion. This data will be made available only to the team members and only the general trend will be made public. Anonymity will also be maintained here and we will just use the general ideas provided by the focus group to tune our suggestions to the attitude and needs of the WPI community.

A-5 IRB Approval

Department of
Social Science
and Policy Studies

100 Institute Road
Worcester, MA 01609-2280, USA
508-831-5296, Fax 508-831-5896
www.wpi.edu

17 December 2008
File: 2008-055

Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609

Re: IRB Application 2008-055: "Transportation Carbon Footprinting"

Dear Professor Ward,

The WPI Institutional Review Committee (IRB) has reviewed the materials submitted in regards to the above mentioned study and has determined that this research is exempt from further IRB review and supervision under 45 CFR 46.101(b)(2): "Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation."

This exemption covers any research and data collected under your protocol from 17 December 2008 until 16 December 2010, unless terminated sooner (in writing) by yourself or the WPI IRB. This approval becomes immediately null and void if this project receives any federal sponsorship and work on this study must cease until review and approval by New England IRB. Amendments or changes to the research that might alter this specific exemption must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue.

Please contact the undersigned if you have any questions about the terms of this exemption.

Thank you for your cooperation with the WPI IRB.

Sincerely,

Kent Rissmiller
WPI IRB Chair

A-6 Survey Comments

Please use the box below for any questions, comments, or concerns:
I usually walk to campus but drive to the gym.
Not interested because I don't drive to campus
I'd ride my bike if it, was working, during the warm weather and even in cold weather, if I thought the sidewalks along park ave would be cleared of snow and ice (they never are).
For half the year I commute by bicycle. Carpooling is difficult since I ordinarily teach on Monday and Wednesday evenings until 8:30 or 9:00pm.
I wouldn't be interested in carpooling once per week because I primarily drive home during breaks only. When I do go home I often give rides to my friends who liver nearby though.
I live on campus in Morgan Hall, but I get here from home by car, which is what my responses represent.
I don't give out my zip code, sorry
I live on campus, but I go home once every couple of weekends
Well ... I live on campus, so I never need to get here ... but when I leave for breaks and stuff, I usually use snap, or get a ride from my friends.
I imagine this survey is more for commuting students, not ones in off-campus apartments.
If someone lived my way, I'd be willing to carpool, but it's rare to find someone out there. When I'm here, I rarely drive, except to church sometimes, and then I always carpool.
My car is messed up and gets 10mpg and burns oil.
If the Worcester bus system was good believe me I would take it at least some of the time ...
I'm in a carpool, and I get dropped off first,
I work for WPI, not a student.
Not sure if I would be interested in carpooling because I don't know anyone to carpool with

Since I don't have a parking sticker, I must get to campus before 8:30 am to insure I get parking during the winter ban. This isn't compatible with carpooling. Prior to June, I walked every day, but in June I moved to my present apartment. I expect to complete my studies by the end of December, after which I will not regularly travel to WPI.
I am going to school part-time, so I drive in from work for classess once or twice a week.
I only drive to campus because I stay very late and do not want to walk home in the dark.
carpooling is a great idea, but a big challenge is when time is of the essence. most graduate students who are also working full time need to rush to their 6 pm classes which leaves practically no time to meet for ride shares. if I live/worked any closer, biking to campus would be ideal. I've been biking in the Boston area when I went to undergraduate school and am currently commuting by bike to work 3/5 days per week. the other 2 days being class nights.
I'd walk but I live off Rt 9, not conducive to safe walking or bike riding.
Another faculty member lives nearby, but we have trouble coordinating our schedules.
Carpooling to a university job or to classes is unfortunately very confining and probably even counterproductive in terms of all the waiting around after that last class or lost flexibility that lets me get over to the DMV during the day when they are open, etc. It is ironic that a community that is so green-thinking is not very well-placed to get very green on its transportation issues.
My schedule is very crazy and erratic so although I used to carpool years ago, it would be difficult now.

It would be difficult to align my schedule with someone else's in order to carpool. The truth is, I hate driving and am terrified of driving in bad weather (winter), but family circumstances dictate that I live where I do. I have made a conscious decision to purchase a low emissions, gas efficient vehicle to counterract all the driving I have to do.
My schedule is erratic, and I often come in very early (6:30 am sometimes), so I can't depend on ride sharing. Even though I live close, the neighborhood is too dangerous for walking in the dark mornings and when I leave after dark (which is frequently).
Carpooling is a great idea for those who live further from campus. My commute is about 10 minutes (traffic included) so making a stop to pick someone up on the way would probably take longer than the commute itself. Also - work schedules do not always work well together so it may become inconvenient to wait for someone to finish with work at the end of the day, or visa versa.
My commute is pretty much all country roads until I get to Worcester, which is the last 10 minutes of my commute.
I would try to carpool but I have to bring my child to school every weekday.
I've thought about it alot, and am happy to drive people to & from work. However, my hours are from 8:30 to 5:00, and I really really really don't want to extend that at either end (except for picking up/ dropping off). So if someone wants to join me they are welcome to if they don't mind being here those hours. Also, my commute is really 1/2 country road (45 mph w/ no traffic lights), 1/4 highway, and 1/4 city by time. By miles, it's a little more highway and a little less country.
I am unable to carpool because I visit my husband in a nursing home after work every day.
Great to hear we are gathering data about commuters to campus and making the possibility of people carpooling a reality.

This survey doesn't adequately cover the case for a regular schedule of driving to/from different destinations. Not everyone drives directly from home to work/school and vice versa. I provided an average one-way distance over 10 one-way trips in an average week. You could change the survey to ask how many miles are driven in a normal work/school week.
I think an organized WPI carpool would be a great idea.
I do carpool on occasion
I work very long hours and cannot leave work at the same time others do
While interested in carpooling, my schedule is not typical and my children whould also have to be transported.
I work a second job that begins immediately after my full-time job. Also, I have a third job that requires me to remain in Worcester on a moments' notice.
I'm in at 6:46am I'm out at 3:00pm (most of the time)
I often have to leave campus for doctor's appointments so it's kind of hard to plan to carpool as I only know 1 other person from Leicester (who works in my department) but he gets here for 6am and I don't start until 8. He leaves at 2:30pm and I leave at 5. I also don't like being dependent on others for rides and vice versa. Something always winds up happening. It's Murphy's Law!
Currently have young children that I am getting off to different schools, carpooling would not work well at this time. In future years when they are older I would consider it.

I live in a rural area. I do not have neighbors that commute to WPI with the same schedule as mine. While my sole driving commuting is negative for the carbon footprint, I live on an environmentally friendly farm where my family grows most of our food. My house is extremely well insulated and uses both geothermal and wood for heating and consumes no oil. Driving is enjoyable for me and I look forward to my commute and the time by myself in my car. When I am not commuting I spend much of my time at home engaging in sustainable agriculture.

Although I would enjoy carpooling, it would be tough since I have to drop off my children at daycare on the way in to work.

I would welcome an opportunity to carpool, but from a logistical standpoint, carpooling can be tough for people who have flexible schedules or have family commitments.

For example if one of my kids was sick during the day (or school was released early due to bad weather) and I didn't have my own car with me - how would I get to the school to pick them up?

A better option to carpooling would be more opportunities to work from home. 70-85% of my job can be done remotely - using technology tools. Work-at-home options eliminate the need to use a car at all. It would be great to see WPI offer more work-at-home options for staff whose jobs don't require on-campus attendance all the time.

On a related note, improvements to the parking situation would help a great deal. I often see faculty, staff and students drive around campus for 20 minutes looking for a parking spot. That is 20 minutes worth of emissions that could be prevented simply by elimanting the need for the driving around.

If just 30 staff worked from home just 3-4 days per month (or even better, one day a week), that could open up more parking for those people who need to be on-campus. :)

This is a great idea for an IQP!

I currently carpool with my husband, who works down the road at QCC, every day.

I already do carpool with a colleague and would do it more often if our schedules allowed. He drives Mondays and I drive Wednesdays.

Unfortunatelty, carpooling to work is difficult. I have kids that may need to be picked up from school.

I live in leicester, my son goes to school in Shrewsbury and we car pool with another kid. When I drive him to school, I take the highway, but if I do not drive him it is city miles.

Not interested as i already do carpool and wouldn't be interested in having to work out more logisitics with someone else.

I would like to take issue with the "Hybrid Only" parking places on campus. This will not do anything at all to make our campus a greener campus. I either see no one parking in those spaces at all, or I see the occasional Lexus Hybrid SUV parked in one, a vehicle which gets far fewer mpg than my Corolla. If the idea behind having these spaces is to encourage people to buy hybrid vehicles, it won't do much at all to enable or encourage people to purchase them--it just isn't that much of an incentive. My paycheck won't stretch to purchase a brand new hybrid car, parking space or no parking space. I can barely afford the used Corolla I have now.

I see the net result of these spaces as 1) showing a fraudulant face of a greener campus to the public, and 2) forcing cars that use gasoline power to circle around looking for parking while these spaces are empty.

Parking is already an issue on this campus. Why make it more difficult for questionable reasons such as "Hybrid Only" parking that will do nothing to reduce WPI's carbon footprint?

Also transport my kids to school, so carpooling would be impractical.

I would love to carpool, but I can't because I have a carseat in my car to drop my daughter at daycare. I used to carpool before she was born.
love this idea wish there was mass transit-- bus system - that could used
I already carpool with my husband who also works in Worcester. If someone from the Dudley area ever needed a ride, we could help out.
I drive to campus if I need my car for off campus visits. I typically have meetings off campus in Boston and other regions in NE. Otherwise, I prefer to walk to campus.
I car pool about 8 out of 10 times.
The hybrid-only parking spaces are an affront to folks that drive other high fuel mileage vehicles (eg TDI diesels, sub-compacts, etc).
I wish I could have purchased a standard shift 4WD (on demand) car with good gas mileage...but no such models were available at the time I bought this one (Winter of 2005). I think Ford had one in production (the Encore), but the dealers I visited did not have any on the lot, nor did they have any interest in following up in helping me find one.

I already transport a second person to their workplace elsewhere in the city, doubling the number of person-miled per gallon on my trip. But many-many people drive alone to campus. I imagine that for most people, the prceived inconvenience of accomodating another rider (or more) will completely flatten the perceived bennies attached to increasing their commute's person-mpg. In Paxton, there is no public transportation into Worcester, either, which is troublesome. However people traveling from Rutland, MA and points west almost all would have to travel through Paxton Ctr (intersection of 122 and 31) in order to reach Worcester, making it a potential hub for carpoolers in the area.
very tough to carpool when I have to go to/from day care every morning and/or afternoon
I travel for my job so there are days when I do not travel to campus and there are times that I leave campus and return at a later time; my job requires this flexibility.
I carpool to WPI generally 3 days a week or more.
Living in Hackfeld Road
The e-mail states that this is an anonymous survey, yet it requires me to log in. The survey didn't ask where I lived in relation to campus, which greatly determines how one get to campus. I have an off-campus apartment and walk to campus, but periodically drive home on the weekend. Best of luck with your project.
I live on campus so there is no need for a system of carpooling, etc. As for going to and from home at the beginning and end of breaks, a carpooling service may be a wise idea, but on a daily basis, it is not probably as necessary.
I walk to school 1 block
Freshman living on campus... would be different if I was older...

I bike to campus when the weather permits. There is decent bike parking on campus. (Hi Emmanuel!)
No reason to carpool, I walk to campus.
I live so close to campus that it would be impractical to drive
I don't see why so many people flip out about burning gas for a car when the majority of pollution comes from other sources such as coal burning for electricity, which could easily be replaced by Nuclear power, especially when you consider the French of all people get the majority of their electricity from nuclear power. Also, many American's believe that we are the main contributor to world wide pollution while China does not have anywhere near the pollution controls in place on their industries as we, which is part of the reason why their industry is growing so rapidly. They don't have to afford the expensive filters or disposal processes that we do in the US.
No need to.
This might not be an accurate number, especially for the number of times I drive to campus in a week as I am currently working on my IQP in Gardner, MA, which is also my home town. Usually I walk to campus from my apartment, which is like 5 minutes from the quad.
I live right off of campus, so walking is not really a hassle.
I don't drive to school and am not interested in a carpool for the same reasons. I live on campus, just to clarify.

I live on campus, so I have no need for carpooling, or, at least, I won't have any interest in carpooling for the next few years. It's too easy to walk or (worst case scenario) biking wherever I need to go, so I don't have any interest in carpooling. With that said, if the carpooling was to a place downtown, I would be interested around an 11, because carpooling, although maybe not the most environmentally friendly, is significantly better for the environment than 4 individual cars driving around everywhere.
I prefer public transportation and walking (as of right now, my primary form of exercise), so any carpooling would have to involve a minimum of six people.
03051 is my home zipcode but I live on campus and do not have a car therefore I walk just about everywhere.
Would not want to carpool with people I don't know.
I live one block from campus to carpooling isn't necesary
I have an on campus apartment so this survey kind of isnt relevant to me.
I live on campus in a dormitory.
I live on campus so i walk almost everywhere, carpool isn't even neccessary for me.
I live 5 minutes from campus, so I walk. If I was commuting I'd consider it though.
Foot-printing should be hyphenated.
I live on campus in a WPI owned apt. I sometimes visit home (once or twice a month) and I drive friends sometimes as well.
This survey should ask about distance from campus, or if the participant lives on campus.
If i drove to campus i would definitely be interested in carpooling, but there is never a need for me because i live so close
If I did drive, I would be much more interested, but the fact that I don't drive to campus forces me to answer the way I did.

Your survey doesnt take into account students that live ON CAMPUS. why would I want to carpool up the hill everyday?
I live in a fraternity house offcampus and therefore only drive up to the hill when I have sports practice
good luck
I walk from my dorm to classes, but drive home on the less frequent occasion that I go there. I wasn't sure if this would be easily interpreted from the first several questions.
I generally just drive up the hill when it is late at night and I will be coming and/or going home alone. Since I am a woman, I dont feel safe walking back to my apartment.
I live on campus, currently. It would be silly for me to carpool every day from my home in Pennsylvania. :)
i don't mind getting a ride to campus daily :D it would be unfair for the driver though
I would not be interested in carpooling because I am perfectly happy walking.
I live so close that I walk to campus, but some days I need to drive up to campus (bad weather), so I'll drive myself or my roomates will drive up with me.
You should have had options for people who live on campus
i live on campus, but i go home or to work a couple times a week.
My lack of interest in carpooling is due simply to the fact that I already live on campus. Even though I don't need it, I think it's a pro idea.
I never usually drive to campus, since I live down the street. Sometimes I do drive though, with extenuating circumstances. Liek if I need to go somewhere right after class, or need to bring something (heavy) to campus.
I live on campus.
I live within 1 block of campus,;there's no need for me to drive.
I would be interested in a carpool if I needed to drive to class.

I am a Class of 2009 undergraduate student from New York City and I do not have a car with me on campus. I use the Greyhound bus to travel to/from Worcester and NYC. I live on Highland Street near Bonardi's so I am fortunate to live right outside campus. When I need to go to places that are outside of WPI (for student organizations and such) I hitch a ride with someone who does have a car.
you guys didnt give the option of on campus people. I may have my car here but i only drive it when im goin home for a weekend or for the vacation.
I'm not interested at all in carpooling because driving from my home to the campus would probably take longer than walking, considering the time to get a parking space on campus.
I dont drive to campus
I live about 15 minutes walking from WPI. Right now I am doing my off campus IQP in the downtown, which is 20 minutes away walking. I walk everywhere, and if i have to drive, i usually carpool with at least one more person.
If I drove to school, I would be interested in carpooling, but seeing how I live less than 5 minutes from campus, driving to class is just silly.
I only drive to campus if its late and i know snap is going to be busy. Usually i take snap several times a week.
get rid of those hybrid car spots on the quad, they are discriminatory and useless and reward people that can afford 30 tho cars
I live in a dorm, so most commute questions are moot. I do go home (My family lives near Hartford CT) every couple of weeks, for that i usually do drive.
I already carpool to school with my boyfriend's car (the one listed above). We only drive to after-class events, such as music rehearsals or meetings. We also only drive in bad weather or at night (dark and slightly dangerous).
none
I live about 100 feet from campus. :P Good luck with your survey, though.
I would not be interested in carpooling, because I live so close to campus, I generally only drive when it is dark or raining.

Clarification: Drive once a month to and from home to campus area, onto campus 2-3 times a month if going to be on campus late
I'd carpool w/ friends and roommates.
What is someone supposed to enter for zip code? The survey gives no clarification despite the fact that many people spend roughly half the time at WPI and half the time at home. I entered my home zip code, which is generally meaningless if you're using the survey to find distances people are traveling since I live on campus during the school year. Regarding the carpooling question, 11 grades with only 2 of them labeled, lol overkill. Remember that someone like me who walks everywhere will never need to carpool, but that isn't a negative when considering environmental impact. Finally, Microsoft Sharepoint, eww. (Linux User)
No need for carpooling
I only drive to campus when Im coming back from going home for vacation so I would not be interested in carpooling.
These answers are based on the fact that I am driving from my apartment.
I am practically on-campus. I have no need of carpooling to walk up the hill, no matter how cold it gets outside ;)
Please be aware, I am living on campus, and plan to live on campus as long as I possibly can.
"The Magical Number Seven, Plus or Minus Two" by George Miller This is an absolute judgement - you're giving a finer resolution than is useful.
I think that most students walk to classes
As a freshman, I live practically on campus, so I feel. as though this doesn't really apply. If I lived off campus, though, I would love to carpool or something to that effect.
I would definitely be interested in carpooling if I lived far enough to justify it.

I don't ever drive up the hill, so not interested.
I live near the school so i walk
I do not commute to campus every day or even every week and therefore am not interested in carpooling.
I live near to the school. Ans that almost voids any need to use of car. I use zipcar over weekends to go around Worcester and use train to go to Boston. Good luck to all you guys in this. I really find topics like carbon foot print very helpful in quantifying the unstoppable harm we do to the eco-system. And, in a way, making our selves aware of such irreversible damage that we do everyday. Thank you.
I currently live very locally in WPI-owned housing, but the residential service's turnover policy will force me out in two years. After that point, I probably will need to start driving to campus.
More options would probably help a lot of people for the question about how often (for example: daily, a few times a week, once a week, a couple times a month, a couple times a year...). I would have specified a couple times a year rather than never because there are rare occasions when I need to carry things that I can't carry home on foot.
it would be hard to time the carpool rides between individual class times
Make SNAP efficient
I think the carpooling idea is a good one, although I will not be using it.
Carpooling is a great idea, but doesn't make sense for me for many reasons, not the least of which is that I work 10-11 hour days!

If I lived farther, I would be interested in carpooling, but I live just a few blocks away.

I'm extremely glad that you are doing this kind of research.

I'm afraid, though, that those who have a long commute might not fill out a survey called carbon footprint.

I am not interested only because I live so close to campus and walk to work 95% of the time that it would not be practical to carpool.

Organizing carpool would be best done with a calendar system where users could add/extend times they need to be on campus/home (Outlook, google, etc).

Primary transport is bicycle, but also motorcycle ~1 day week

Would suggest enforced motorcycle parking, similar to the enforcement of the "hybrid only"; even better, covered motorcycle parking.

If carbon footprint is the main worry, I suggest requirement of backing into parking spaces on campus, and orientating parking lines in the correct manner: see http://www.iam.org.uk/fleetirelandabout/News/Driving+Tips/Driving+Tip+Number+16+Reverse+your+fuel+bills.htm for more info.
This will also make campus safer! As a cyclist, I have never once had a near-miss with a car pulling forward out of a parking spot or street, whereas I have had countless near misses with individuals backing out.

I would love to be a part of any continued work stemming from this project, whether it be lobbying for change or assistance in research: contact ptrimby@wpi.edu.

I would walk, except I work in the lab till late, and walking back home would put me next to bad section, even though where I live is very nice and I trust around campus.

I work for WPI at Gateway Park, and when needed to go to campus, I take the shuttle
I'm in the ADLN program, so I'm reducing my carbon footprint already:)
I live on campus so I have no idea why I would be interested in car pooling of driving
I live on campus.....
if i could use it late at night. Being a grad student, you work late hours.
The problem is that during the season I am here until very late at night so it would be difficult to carpool.
Please use the box below for any questions, comments, or concerns:
My commute varies with weather conditions. I bike to school most of the year, taking cabs when it is raining. However this winter I have been riding with my husband early in the morning.
I find it very difficult to carpool because I have to drop off my son at daycare every morning.
I have carpooled in the past. Different schedules and the need to visit off campus project locations confound carpooling
Please share this data with the faculty/staff as I would be curious to see if any car pool activity based on zip-code could be promoted throughout campus and how many may participate.
I work part time so it is hard to car pool
I tried to get a carr poll started awhile back. I'm not sure why people are not that keen on the idea. Personally. I would have a dificult time working this out with others due to my odd schedule. In the Athletic Dept. we do not work 8-5 hours
nop
If someone in my area needed a ride my husband and I could drive them occassionaly
It is very difficult for part-time students to commute with other people. The shuttles are not very convenient, and besides my job is just a mile away.
My concern would be for the nights that I have to work late or arrive early.
If it were easy to find someone on a similar schedule to mine, i would carpool. But I do not know of any other faculty member in Holden on the same schedule. And my schedule changes every term and sometimes every week!! As such, it would be very difficult to make something work.

Shared ride has been problem in the past for hours of start 7:15 and varying end of 5-9 (most common 6)
My schedule at certain times of the year (fall) would prevent me from carpooling all the time, but I'd certainly consider joining a carpool at other times of the year.
I already do carpool, and we do not have room for any other individuals if this survey is going to try to get me and my brother to carpool others.
I guess the big isssue would be coordinating pick-ups and returns, but I would think this could be easily done. One simply needs a system.
it is not practical for carpooling for me because i am so close and only take my car to work when i have an off-site meeting or trip to attend to. i am hoping to move a couple of towns away next year and then would be very interested in carpooling 1 or 2 days per week.
I already carpool from time to time, but if I had a set day to carpool, I would be more apt to do it on a regular basis.
With a young child, my schedule is too unpredictable to carpool - although I recognize the value in it.
I have a different schedule than most of my co-workers. I leave earlier than most WPI full-time staff. I also sometimes have to do errands on my way home if my husband has car problems and needs to take my car to work. (he works nights). My car is very fuel efficient. I fill it up once every two weeks and I get very good gas mileage. It only costs about $25.00 to fill it, even at today's prices.
Need to drop off at day care - carpooling would be difficult
I wish I could carpool but I need to drop off my son at Day Care so I arrive late every day.
Carpooling is not possible with my work schedule
I'm a PT student, mostly ADLN. I come to campus rarely, ~1/month.
I live very close and usually walk or ride my bike unless the weather is really bad.
I drop off my son at daycare, so at this time in my life it really wouldn't work out for me (or others in the car!). :)
On average, how many times do you drive to campus in a week? 0, used to be 1 (currently taking an online class) FYI
Already have my own car pool

I have switched to taking my courses 100% on-line. A comment for survey development/distribution: Next time make it clear in your email that the survey is extrememly short. People will be much more likely to participate and on a timely basis.
Walking to work is great, good exercise, and if you want to drop some weight it's the best way, so I walk 4 miles a day. I sometimes Join other people to campus if they offer to pick me

B-1 Sustainability Presentation

Reducing WPI's Carbon Footprint: Transportation

Advisor, Professor Matthew Ward

Steve Ellis
Neda Zahid
Emmanuel Akese
Shubneet Sandhu

Project Purpose

- To contribute to sustainability initiatives on the WPI campus, by introducing a carpooling program and helping reduce carbon dioxide emissions.
- To approximate the amount of carbon dioxide emissions that is caused by the WPI community as a result of transportation.
- Create awareness about the benefits of carpooling.

Team Progress

- Researched CO_2 Emissions and carpools
- Surveyed the Wpi Community
- Compiled and analyzed data
- Have necessary information to start a carpooling program at WPI

Results of Survey

Total WPI community is 5403, 634 answered; about 12%

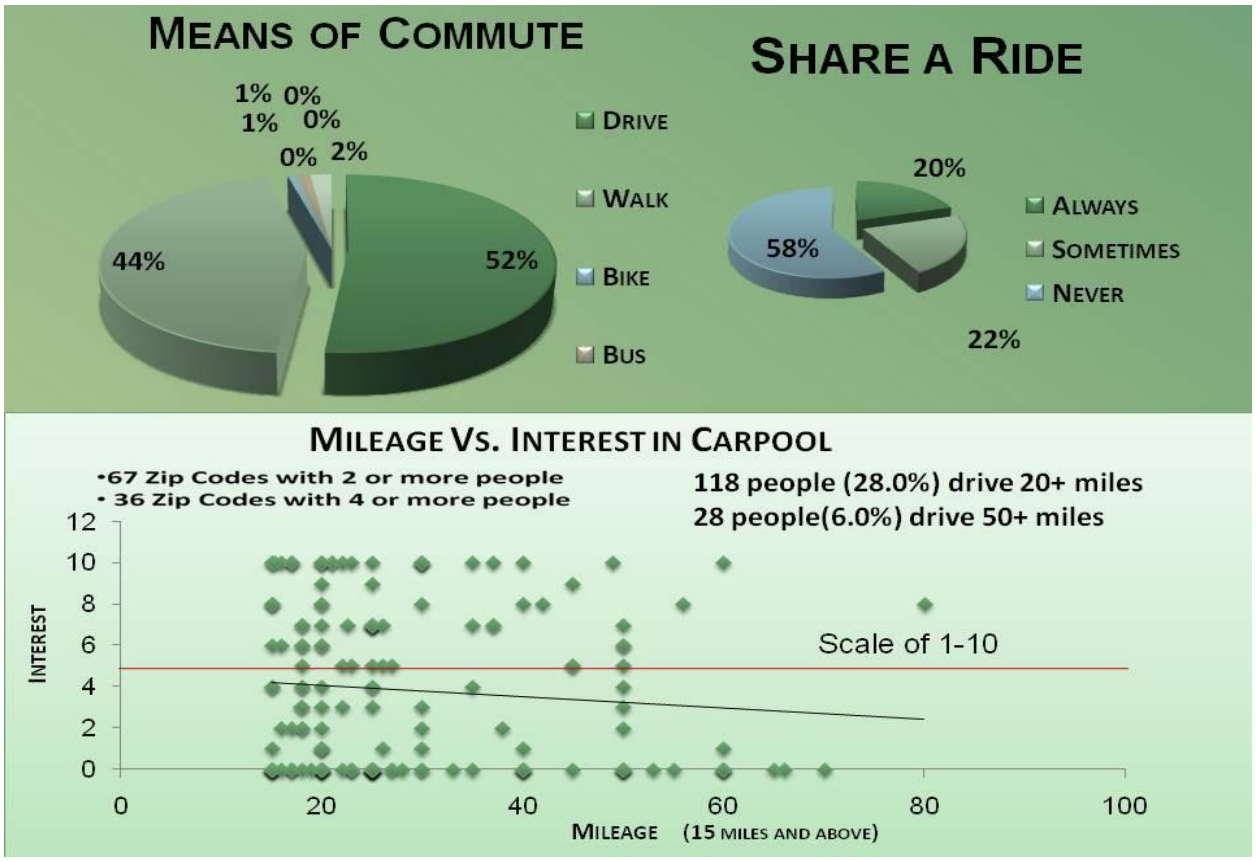
Total faculty is 314, 56 answered; about 18%

Total staff is 528; 186 Answered; about 35%

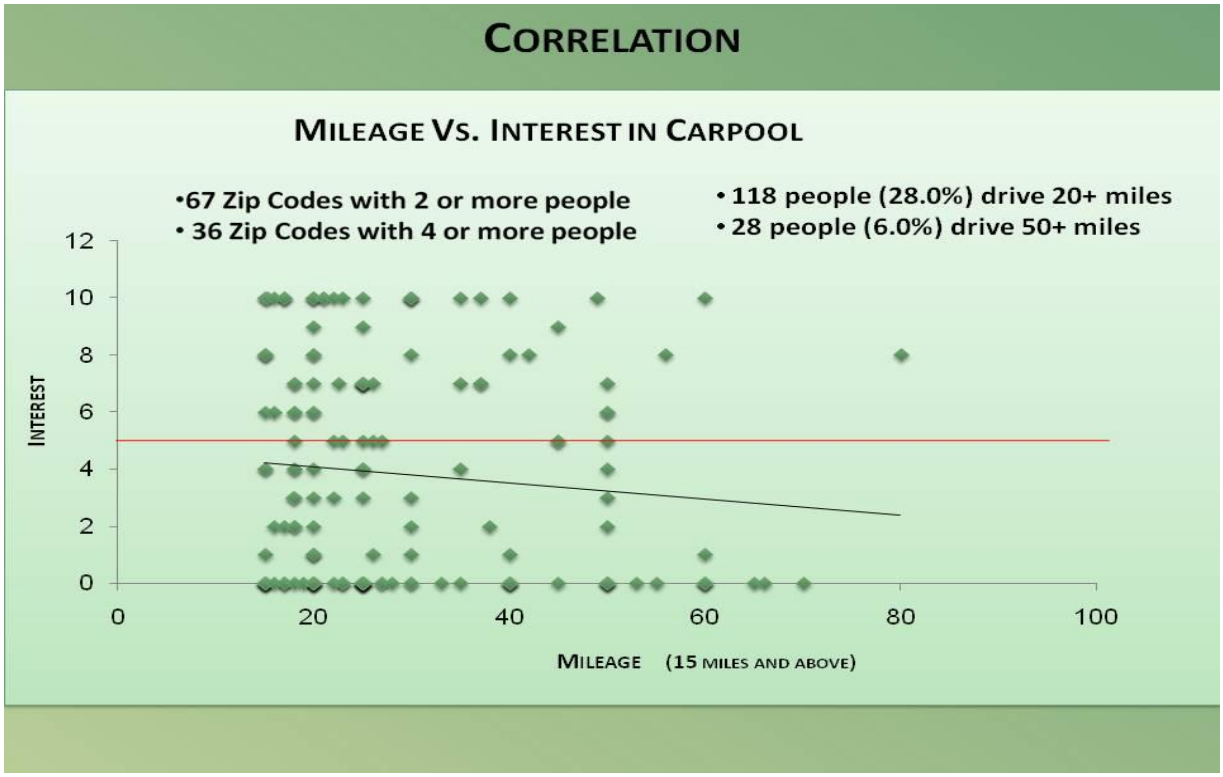
Total grad students is 1309, 68 answered; about 5%

Undergrad students is 3252, 314 answered; about 10%

Data source: www.wpi.edu/+ir



CORRELATION



WPI'S CALCULATED FOOTPRINT

	Survey	Whole WPI Community	Savings if 10% started carpooling
# of people	out of 498 who drive, 363 was used	(52% of 5403)= 2809 was used	52% of 5403=2809 68% of 2809=1910 10% of 1910=191
Co2 emissions per year	777 Tons	6010 Tons	409 Tons
Gas/year	80, 137 Gallons	620,253 Gallons	42,183 Gallons
Barrels/year	1,908 Barrels	14,767 Barrels	1004 Barrels
Cost/year	$148,255	$1,147,467	$78,040

CARPOOL PROGRAM PROTOCOL

WHAT DOES A GOOD CARPOOLING SYSTEM CONSIST OF?

- PRIVATE AND SECURED
- TERMS & CONDITIONS
- ACCESSIBILITY
- MAINTENANCE
- MARKETING & ADVERTISING
  (VISUAL APPEAL, PROGRAM PROFESSIONALISM – LOGO, NAME)
- INCENTIVES

Preliminary Design: Sample Match List Page

RIDE SHARE
www.SRVpooltoSchool.org

Your information is added to our database.

Welcome John Doe

There are 2 users matched from Alamo school.

Users 1 - 2 of 2

Full Name	Phone	Email	Zip	Cross street(s)	Commute Preference	Date
John Doe	opt out	JohnDoe@altrans.net	95117	First St & Main Rd	Ride & Drive	2002-09-05
Fee Ton	(120)898-8989	anytoo@altrans.net	95117	Andy Av & Cre Hwy	Ride	2002-07-30

Edit your profile

log out

Tips on forming a carpool

Disclaimer: The City of San Ramon, ALTRANS and participating school districts provide referral services. They do not certify the character of ridesharing participants. Participants are advised to screen referrals to their personal satisfaction. The City of San Ramon does, however, within the lawful limits of Title VI of the Civil Rights Act of 1964, as amended, reserve the right to refuse service to anyone.

Question/comments: email customer care or call: (925)973-2650

Source: http://www.altrans.net/B1.pdf

Team Goals

- Introduce a working, effective carpool program to the WPI community
- Launch 2 campaigns for carpool program
  1. Program advertisement and awareness
  2. Large scale event to present the program to the community and additionally serve as a platform for interested carpoolers to meet
- Potential logo design contest
- Completion of project by D term 2009

Current Team Status

- We have all of the necessary information required to set up a carpooling system.

What do we need?

- Assistance with the web development of a carpooling program database.
- Potential endorsements or support by the Wpi Sustainability committee.

Acknowledgements

Professor Ward
Erin De Silva
Liz Tomaszewski
Eva Parzych
Members of the Sustainability Committee

Questions & Suggestions

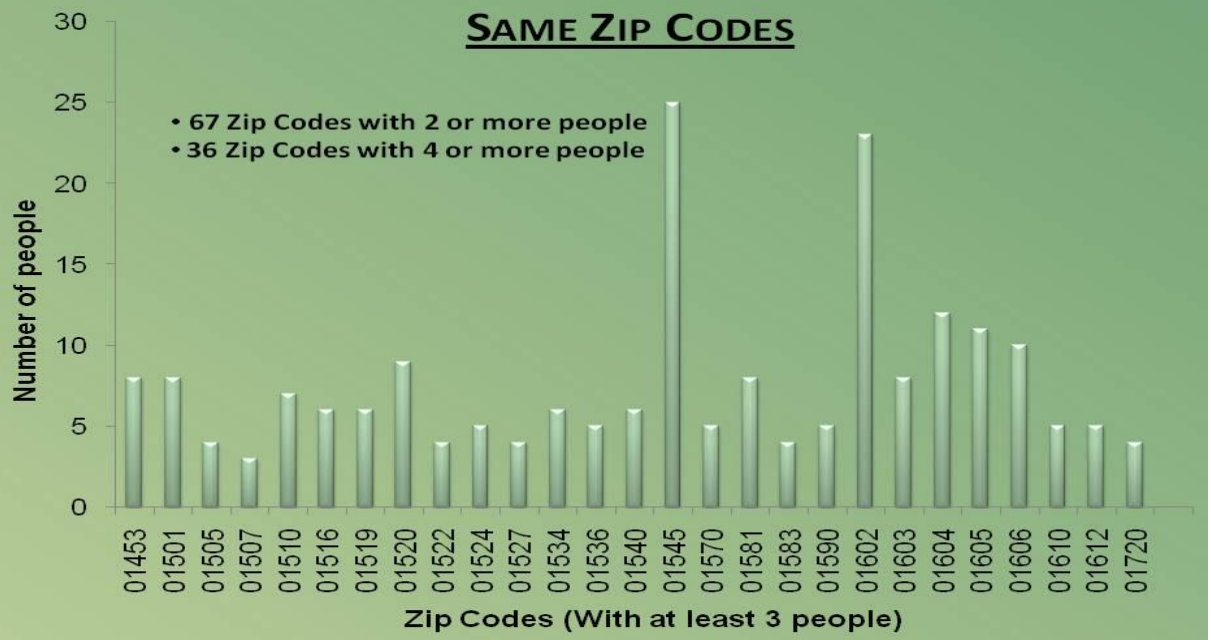
Community Members' Comments

"Great to hear we are gathering data about commuters to campus and making the possibility of people carpooling a reality."

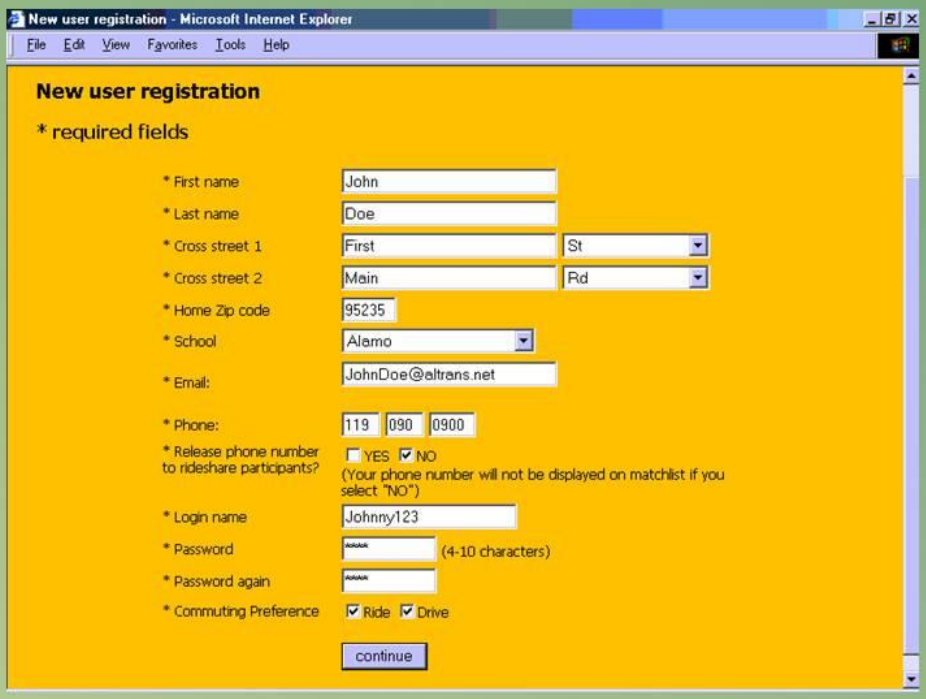
"I think an organized WPI carpool would be a great idea."

"What a great idea! I'm thrilled someone is looking into this. If we could get an automated car pool-matching service together, that would be wonderful."

SAME ZIP CODES



PRELIMINARY DESIGN: NEW USER REGISTRATION PAGE



SOURCE: HTTP://WWW.ALTRANS.NET/B1.PDF

B-2 proposal

IQP: Sustainability and Transportation
At WPI
Shubhneet Sandhu
Neda Zahid
Steve Ellis
Emmanuel Akese
cfp@wpi.edu
March 25, 2009

Sustainability Committee
Worcester Polytechnic Institute

Dear Sustainability Committee:

On 10th February 2009, our IQP team came to your meeting where we introduced our project goals and progress. One of our goals for this project is to have a working carpool system for the WPI community by its completion. This task made us ask for the committee's endorsement and assistance in getting a database set up for this purpose. We also proposed that such a database be made accessible through the sustainability website.
In response, the committee unanimously endorsed the project and agreed that if a website is made available it can be put on the WPI Sustainability webpage. For the database, members of the committee asked the team to look for vendors who have such packages ready for use. Based on this response our team conducted research for outside vendors and have come up with this proposal for the committee's consideration.
The attached proposal contains the information of three vendors; it has their services and prices. Please review and contact us for further questions or clarification.
Thank you.
Sincerely,
WPI IQP Sustainability and Transportation Team

List of Vendors Contacted:

- **www.icarpool.com**
- **www.greenride.com**
- **www.AlterNetRides.com**
- **www.erideshare.com**
- **www.nuride.com**
- **www.goloco.org**
- **www.ecommuter.com**
- **www.rideshark.com**
- **www.zimride.com**
- **www.ridetoo.com**
- **www.goosenetworks.com**

- **www.commute.com**
- **www.carpoolworld.com**

Criteria for Vendor Selection:

The following characteristics were used to assess prospective vendors.

- Terms of Contract (Service Agreement)
- Cost associated with services
- Security and Privacy of user information
- Can database be customized according to WPI needs (is customization done by vendor or customer)
- System maintenance (Does the vendor provide warranty /technical support, is system self maintained)
- Is there a trial version/demo?
- Mode of delivery(Downloadable, Available on a CD)
- Timeline for product delivery
- What schools or companies they have worked for?

Based on the above criteria the team settled on the following vendors.

1) Zimride
2) Carpoolworld
3) AlterNetRides

Common features:

- Ride sharing database
- Require User Registration
- Private and Secure (access limited to specific groups)
- One time trip capability
- Institutional customization
- Technical Support by vendor
- Privacy options
- Multiple modes of notification (optional email, text message, phone call)
- Display detailed maps showing user trip requirements and trips of potential matches.
- Allow users to choose whether they want to be driver, passenger, or both. Ask users for other information to find best matches.

The following are the selected vendors with their unique features:

Vendor 1: Zimride

http://www.zimride.com/demo.php

Zimride is a leading developer for users interested in online social ride-sharing and transportation software solutions. It provides its clients with the ride-sharing software products necessary to enable carpooling.

Features:

- Optional Facebook functionality for increased user interaction
- Flexibility for system administrators to edit database content
- Tracks your savings in gas and money and tracks CO2 reduction in real time

Other Users:

- USBC
- UCLA
- Stanford
- Cornell
- Eastern Kentucky University
- MVCC
- Wal-Mart

Payment for Services:

1. A professional service fee of seven hundred and ninety ($790) for each month of service, paid annually.
2. Add-on modules may be purchased for Zimride Premium Service. Modules will be priced according to the development time required to build them. There is no requirement to purchase any add-on modules.

Provider will invoice Organization annually upon commencement of the Term. Payments shall be made no later than thirty (30) days after Organization's receipt of Provider's invoice.

Vendor 2: Carpoolworld

https://www.carpoolworld.com/wpi.html

Carpoolworld.com is an Internet website that provides a free public on-line trip-matching service. It also offers an enhanced group service, for a fee, that lets employers, institutions and municipalities brand and administer their own virtual carpool matching web site.

Profile

- Flexibility for system administrators to edit database content http://www.carpoolworld.com/admins_guide.html
- Provides multiple options to new users and more options can be added to suit the specific needs of WPI.

Other users:

- City of Albuquerque
- UCLA
- University of Florida
- Endicott Interconnect

Payments for Services:

- $10.00 USD per month for up to 500 trips (*) in the group.
- $2.00 USD per month for each additional 100 users in the group or fraction thereof.

- (*) A trip is a registered entry in our system, which specifies a geographic origin, and geographic destination, time parameters, and contact information for the traveler. Basically, if you have 100 commuters in your organization, you have 100 trips.

Vendor 3: AlterNet Rides

www.parking.uci.edu

AlterNet Rides is a robust, innovative ride share service that is fast, simple to use, easy to install and inexpensive to implement.

Profile:

- It has a "blind" e-mail feature for users who do not wish to give out their personal e-mails to send e-mails out under aliases provided by the system.
- Shows thumbs up icon next to people who have already carpooled with someone else have recommended them as good carpool partners.
- Has a service called "Commuter Challenges". (http://CommuterChallenges.com). This service conducts "challenges" for organizations wanting to encourage alternative modes of transportation. They conduct challenges for other organizations but also run their own, specifically for universities and colleges.

Other Users:

- University of California Irvine
- University of Texas
- University of South Carolina
- University of Kentucky
- University of Washington
- University of Oregon
- University of Nevada
- Lockheed Martin Corporation
- Rhode Island Public Transit Authority

Payments for Services:

- Initial setup cost of $250 and a yearly service fee of $500 per campus.
- Additional campuses, if applicable are $100 each per year.
- Their service can be used for events - concerts, festivals, conferences, etc. A "package" of 10 events is $100.

Conclusions

Using the criteria determined by the IQP team, twelve vendors were contacted via e-mail and five vendors responded. Team members had further interactions with these vendors to ensure that they satisfied the team's requirements.

To do this, some vendors were contacted by phone and the rest communicated through emails. Upon contacting them, vendors were asked to explain how their system worked and all the questions that the team posed in their criteria were asked. Once these conversations took place, the team gave vendors the assurance that their services would be reviewed and they would be contacted.

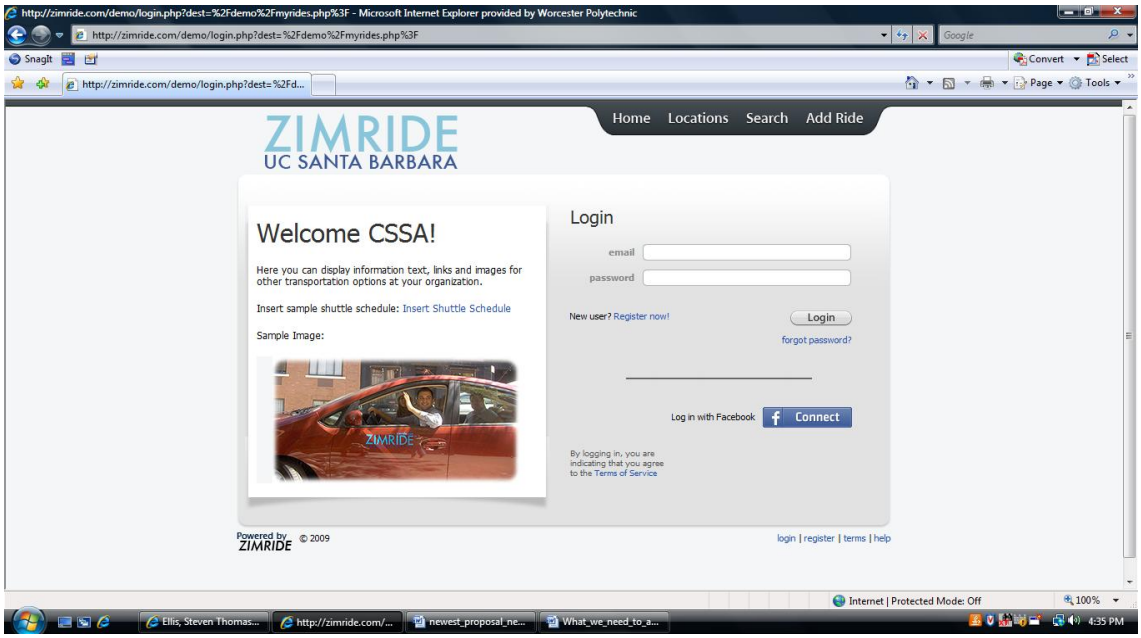
Each member of the team was assigned to individually evaluate a different vendor by visiting their webpage and confirming all the services that they claim to provide. Following this, the team met and collectively compared various opinions about the vendors.

“icarpool,” which is one of the five vendors, did not provide the costs of their services even after several follow up emails. “RideToo”, also a potential vendor, was not able to provide any previous services provided to other institutions. For these reasons the two companies were eliminated from the list.

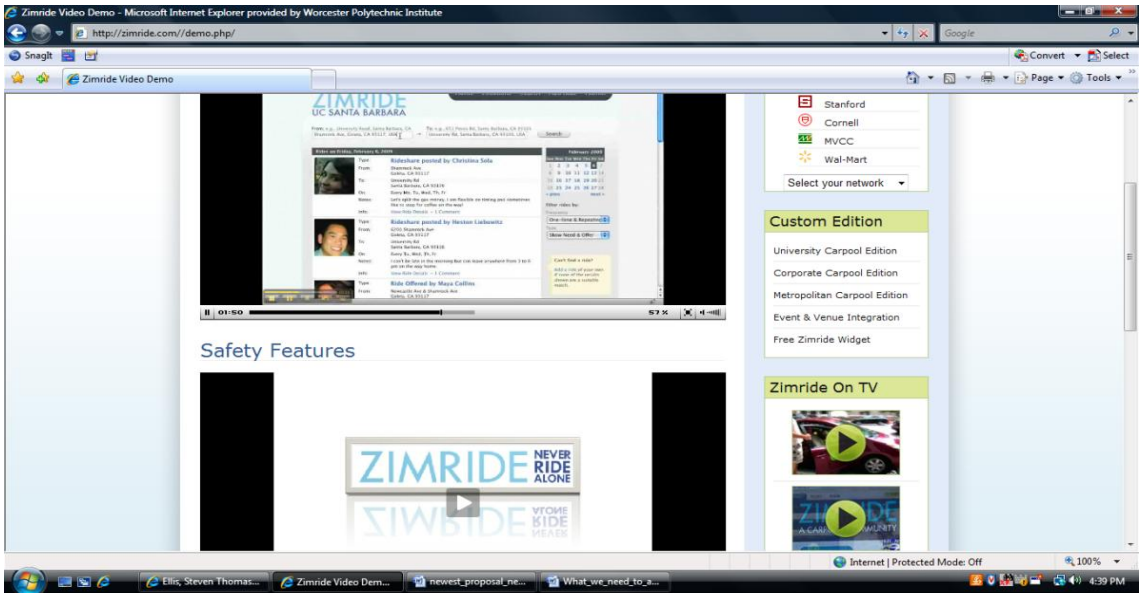
After further examinations of the various profiles of the three selected vendors, it is the team’s opinion that Zimride is by far the best option because they have the most features, contains the easiest user interface, and appears to have the most professional website; however their price is the highest. Some snap shots of their database are shown below.

Zimride User Interface

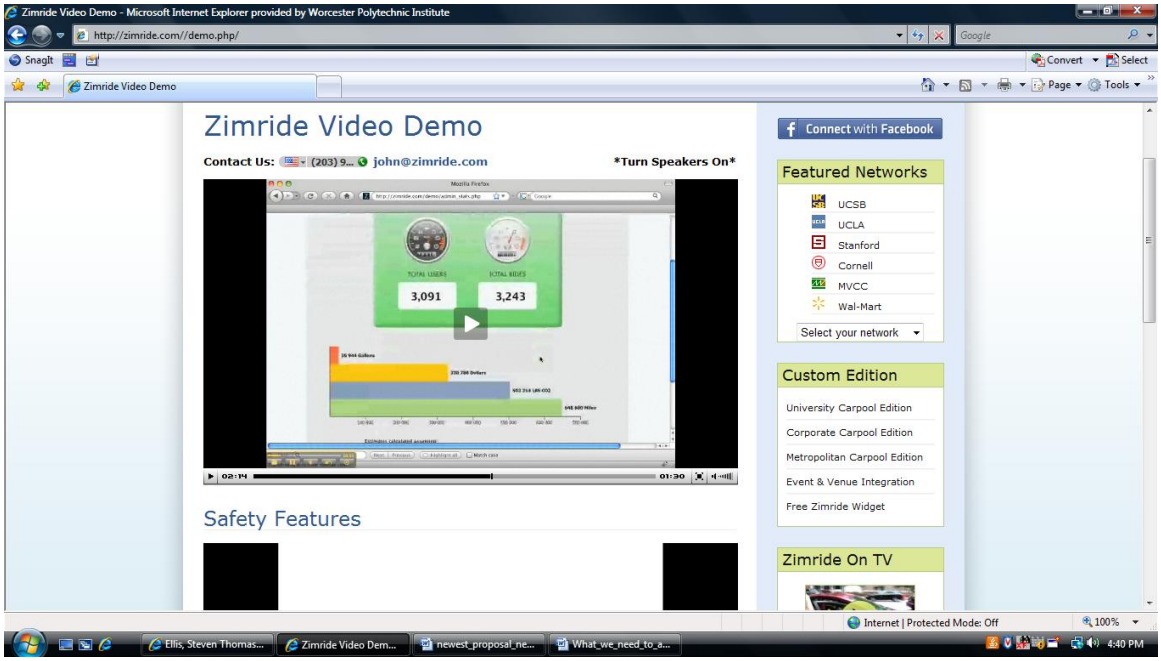
Log In Page:



User Profile Page:



Real-time CO_2 Reductions and Cost Savings Calculator:



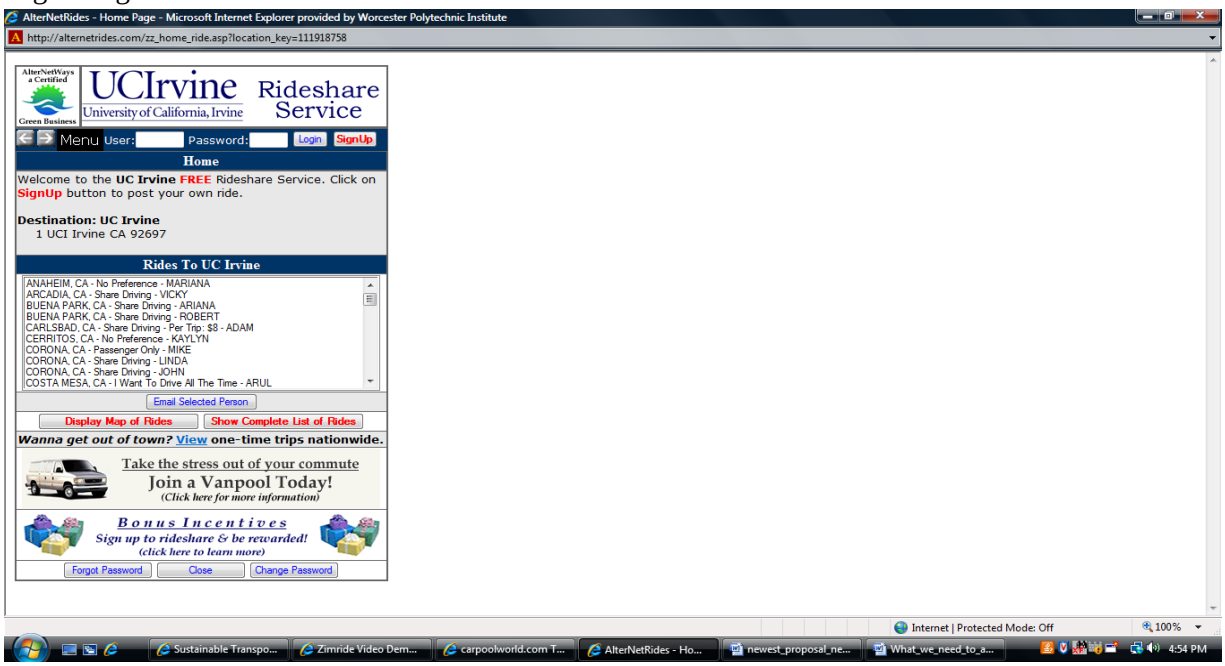
CarpoolWorld is a step down from Zimride, although It doesn't look as professional, it has mostly all the capabilities for a very reasonable price. The team came to the conclusion that it will be a better trial package for the campus. It is very inexpensive, and testing it for a year will not be a very big investment. Even if half the WPI community were to use it, the annual cost will be less than $750. The vendor was very quick in responding to emails and questions and even went ahead to design a sample page for WPI as shown below.

Log In Page:

Trip Registration:

AlterNet Rides, in the team's opinion does not offer much to be desired. Their product does not appear as user friendly as the other vendors, and navigating through their system was a little bit complicated. Snap shots are shown below.

Log In Page:



Among the three vendors, CarpoolWorld seems to be the most appropriate to start with for a campus like ours, because it is simpler and cheaper. For a second choice the committee AlterNet Rides might be worth a try, because their price is reasonable.

C-1 Campaign poster

WPI's Transportaion

Have wondered how we can reduce it?

Guess What! it is simple

Let's carpool!

Visit our IQP team at the campus center today, and learn some facts from our campus wide survey.

10:00am- 2:00pm

Do your part and save the earth, it couldn't be much easier; share a ride today, reduce daily CO_2 emissions, enjoy parking privileges and discounts, reduce road traffic, and above all save

Send comments and suggestions to cfp@wpi.edu

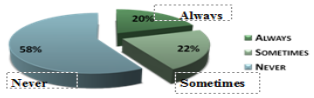
C-2 Campaign Brochure (outside)

Can you imagine the amount of energy and money we would save if those of us living within 15 miles or more of campus began ride sharing?

- If 10% of drivers interested in carpooling began to share a ride, our yearly CO_2 emissions will be reduced by 409 tons
- Our yearly oil consumption will be reduced by 1,010 barrels
- $78,000 dollars will be saved annually, and will be direct savings in our pockets

[Based on a 2009 WPI community survey[1]]

DO YOU SHARE A RIDE? [1]



DO YOU DRIVE SMART? LEARN HOW.

- The faster and more aggressive you drive, the more gasoline your car uses.
- You can assume that each 5 mph you drive over 60 mph, is like paying an additional $0.24 per gallon of gas. Assume $ 1.85/gallon of gas
- The air resistance generated while traveling @ 65 mph is about twice as much as that generated traveling @ 45 mph.
- CO_2 Emissions from a gallon of gas = 8.8 Kg (19.4 pounds)
- CO_2 Emissions from a gallon of diesel = 10.1 Kg (22.2 pounds)
- On average, your car consumes between 12 and 18 barrels of fuel a year

www.fueleconomy.gov/feg/driveHabits.shtml

Drive smart! share a ride!

NOTES:
1: 2009 IQP WPI survey included 634 total respondents.
2: www.wpi.edu/+IR
3: www.nfib.com
4: www.epa.gov

What are your opinions about carpooling? Send us your feedback via cfp@wpi.edu

REDUCING WPI'S CARBON FOOTPRINT: TRANSPORTATION

INTERACTIVE QUALIFYING PROJECT

WHO THOUGHT SAVING

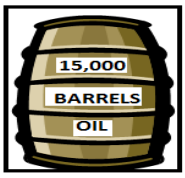
THE ENVIRONMENT COULD BE AS SIMPLE

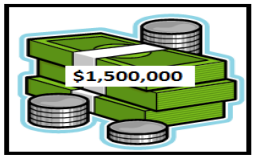
AS SHARING A RIDE?

(inside)

FACTS YOU SHOULD KNOW! [1]

- The WPI community consists of approximately 5403 people[2].
- About 52% drive daily to campus[1].
- Approximately 58% of drivers always drive alone to campus.
- The community emits an estimated 24 tons of CO_2 daily, and 6010 tons yearly, as a result of transportation to and from campus.
- Together our cars annually consume at least:



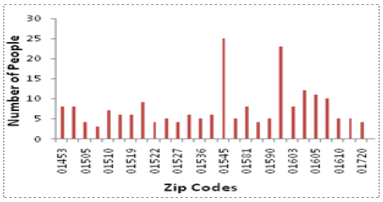


(Assuming $1.85/gallon gasoline)

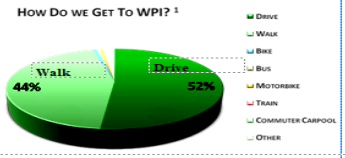
MORE FACTS YOU SHOULD KNOW![1]

- Based on our survey about 68% of people who always drive to campus are interested in carpooling at least once a week
- Many community members who commute to WPI live close to each other.

See detailed statistics below:



HOW DO WE GET TO WPI? [1]



WWW.WPI.EDU/+SUSTAINABILITY

BENEFITS OF CARPOOLING[3]

THERE ARE SEVERAL REASONS WHY YOU MAY WANT TO SHARE A RIDE.

- INCREASED PRODUCTIVITY: When individuals carpool stress levels are reduced. Travel time is also reduced since they have the option to use high occupancy vehicle lanes.
- GAS SAVINGS $$$: Carpoolers save good sums of money on gas, since gas costs are split or cars are rotated. This also helps the environment, because less gasoline will be burned limiting green house gas emissions into the atmosphere.
- INCREASED CAR LIFE SPAN: Since carpooling results in less use of a single car, wear and tear on participant cars are reduced. This translates into less car maintenance, and ultimately savings on maintenance costs.
- DECREASE IN NEEDED PARKING: If more people carpool, available parking space on campus will be increased, and People will not spend a lot of time finding parking spots.
- ENERGY CONSERVATION, CLEANER ENVIRONMENT: Energy is conserved, green house gas emissions and air pollution is reduced as a result of ride sharing.
- PARKING PRIVILEGES AND DISCOUNTS: carpoolers will enjoy privileges such as reserved parking and discounts on decals.
- RELAX WHILE OTHERS DRIVE YOU: It is relaxing to

Text Box

Worried about running errands without your car?
Rent a ZIP CAR!
http://www.zipcar.com/wpi

D-1 Sample carpoolworld intro letter

Dear Worcester Polytechnic Institute students, staff/faculty members, employees,

In lieu of rising gas prices and a general concern for the well being of our community, the school's Sustainability committee department has initiated a virtual carpool matching system that will benefit students, staff/faculty members, employees of Worcester Polytechnic Institute. The HR department has created a secured webpage through a site called, "Carpoolworld.com," that will connect students, staff/faculty members, employees of Worcester Polytechnic Institute with other students, staff/faculty members, employees within the university who live nearby or have similar schedules.

How does this program work?

Students, staff/faculty members, employees of Worcester Polytechnic Institute will go to http://www.carpoolworld.com/wpi.html and set up a personal account. There is no fee for individual users. Worcester Polytechnic Institute will absorb any fees associated with this process. All members of the Worcester Polytechnic Institute carpool group must have a valid e-mail address to access the group's information.

Group members will be asked to enter the location of their "origination location," namely where they lives or where they wish to meet people in order to carpool to school. All members in the group will select their default location from the list of locations displayed.

After your account is initiated, you are able to view your matches and contact other travelers by phone or e-mail.

How do I know my privacy is being protected?

When initiating your account, you are only required to enter the name of the city which you live in. Though you and other commuters will receive more accurate feedback regarding the mileage and proximity of your locations if you enter the street address of your house, it is up to you to offer that information. Only Worcester Polytechnic Institute students, staff/faculty members, employees will have access to this information.

Users are not required to list their phone numbers. Users within the Worcester Polytechnic Institute group can simply communicate with their @wpi.edu email addresses.

How easy is this system to use?

Once you have created your account, you are free to search the site for other students, staff/faculty members, employees who want to carpool.

CarPoolWorld offers various search options. You may search for those who live close to you, who have similar schedules, or who have similar driving preferences.

If you are interested in carpooling with someone, simply send them an e-mail and begin to devise a schedule that is convenient for both students, staff/faculty members, employees. You both may decide to designate one day of the week to stop at the grocery store or run an errand. You are certainly not required to carpool everyday of the week either!

Many students, staff/faculty members, employees are alarmed by rising gas prices and are willing to make their commuting routines more flexible to combat these extra expenses. Imagine the benefits of cutting that cost in half by carpooling! Carpooling will not only save you money, it will also promote a healthier environment for the community.

D-2 CarpoolWorld Service Agreement

Datasphere Corporation
d/b/a carpoolworld.com
366 N. Broadway, Suite 410
Jericho, NY 11753
Carpool Group Service Agreement
Client Site www.carpoolworld.com/

This Agreement between Datasphere Corporation ("CPW") and Client sets forth the terms and conditions under which CPW will provide a carpool matching group web site for Client. Client's users can use the Site to find other users with whom they may choose to carpool.

Client shall pay CPW according to the following pricing: $10 USD per month for up to 500 User Trip Records, plus $2 USD per month for each 100 additional User Trip Records or portion thereof.

A User Trip Record is an individual transportation definition in the Site containing a geographical origin and destination with associated descriptive and contact information. Normally, each user should have a single User Trip Record for their daily commute, but users may create additional User Trip Records for other journeys. Client can control whether or not to restrict e-mail addresses to a specific domain, and can also control whether or not individual e-mail addresses may be used more than once in their group, thereby controlling whether or not each individual user may create more than a single User Trip Record. Client can view and report User Trip Record details, including downloading those details electronically in standard spreadsheet format, and can delete individual User Trip Record if/as needed. User Trip Records that are created and deleted within the same month will be billed once only for that month. CPW will count the number of User Trip Records at the end of the calendar month as the basis for monthly invoicing.

Payment terms are net due 30 days after Client's receipt of the invoice. Payment may be made by check or credit card. Client may provide a purchase order number to be shown on the invoice. Invoices are provided to the client electronically via e-mail. Paper invoices may be mailed upon request. The IRS W-9 form for Datasphere Corporation is available at www.carpoolworld.com/w9.

Client may terminate the group at any time. CPW will immediately disable the Site upon request and process the final bill at the end of the month. Existing users will see a message that the Site has been deactivated and will be invited to join the public area of the system, at their own discretion. Alternatively, at the time of termination, Client may request that their users be transferred into the public area of the system automatically, which will be done at no charge. If such a request is made, then CPW will send a message to the users notifying them that they are no longer part of the Client's group but rather are part of the public area.

Client can control whether or not their users may match outside the Client's group, with the general public. Even if Client permits users to match outside the Client's group, users may still individually elect to match only within the Client's group.

Publication of the use of CPW by the client may bring additional public users or other groups to CPW, and may therefore increase the likelihood that Client's users will find optimal carpool matches. Client can control whether or not Client's use of CPW is published by CPW. If the Client chooses not to publish their use of CPW, then CPW will not disclose that Client has a group at CPW.

Client can control whether or not certain geographic, descriptive, or contact data elements are required, optional, or prohibited for their users, and whether or not each required or optional data element is shown or not shown to other users. Certain data elements however are always required, and certain data elements must be shown to other users, to operate the Site. The geographical origin and destination of each User Trip Record must be provided by the user and made available to other users, but Client can control the degree of precision used to provide and display these locations. User e-mail addresses are not shown on the site, but when a user initiates contact with another user, the user who receives the contact will be provided with the e-mail address of the user initiating the contact. The user who receives the contact may or may not respond. If the user who receives the contact chooses to respond, then at that point both users will have each other's e-mail address.

CPW will use the information stored in the site solely pursuant to fulfilling its obligations, including but not limited to allowing users to find potential carpool partners. CPW will not use or divulge the user's information – except in aggregated form to provide regional volumes - for any other purpose without prior written consent unless compelled to do so by a legal authority. CPW will remove user information from the

system at any time upon request from the user or the Client. CPW reserves the right to remove user information from the system if that information does not conform to CPW's standards for acceptable use as judged by CPW. CPW will be liable to Client for any claims or losses which arise out of CPW's grossly negligent or intentional misuse of user information.

Users are responsible for their own personal safety. CPW uses standard Internet practices to ensure the availability of the Site and the privacy of the user information in the Site. Neither Client nor CPW shall have any liability to any third party, including users, which arises out of this Agreement.

Terms of use and safety information are published at www.carpoolworld.com/legal.html. Users must accept these terms of use to use the Site.

CPW shall defend, indemnify and hold harmless Client, and its employees, officers, agents, affiliates, and representatives, from and against all losses, damages, costs, and expenses of every kind (including attorneys fees, court costs and disbursements) that arise from or related to (i) CPW's breach of any of its representation, warranties, or obligations under this Agreement, or its acts or omissions or (ii) any third party claim that the Site as provided to Client and Client's users infringes or violates the third party's intellectual property or proprietary rights.

CPW will provide at least 30 days notification of any changes to the pricing or any of the terms described above. If Client wishes to terminate the group, then the final billing will be at the current prices. CPW provides unlimited no-obligation free trials. Client will advise CPW once they determine that they will use the Site live. Billing will commence at the end of the next full month of use.

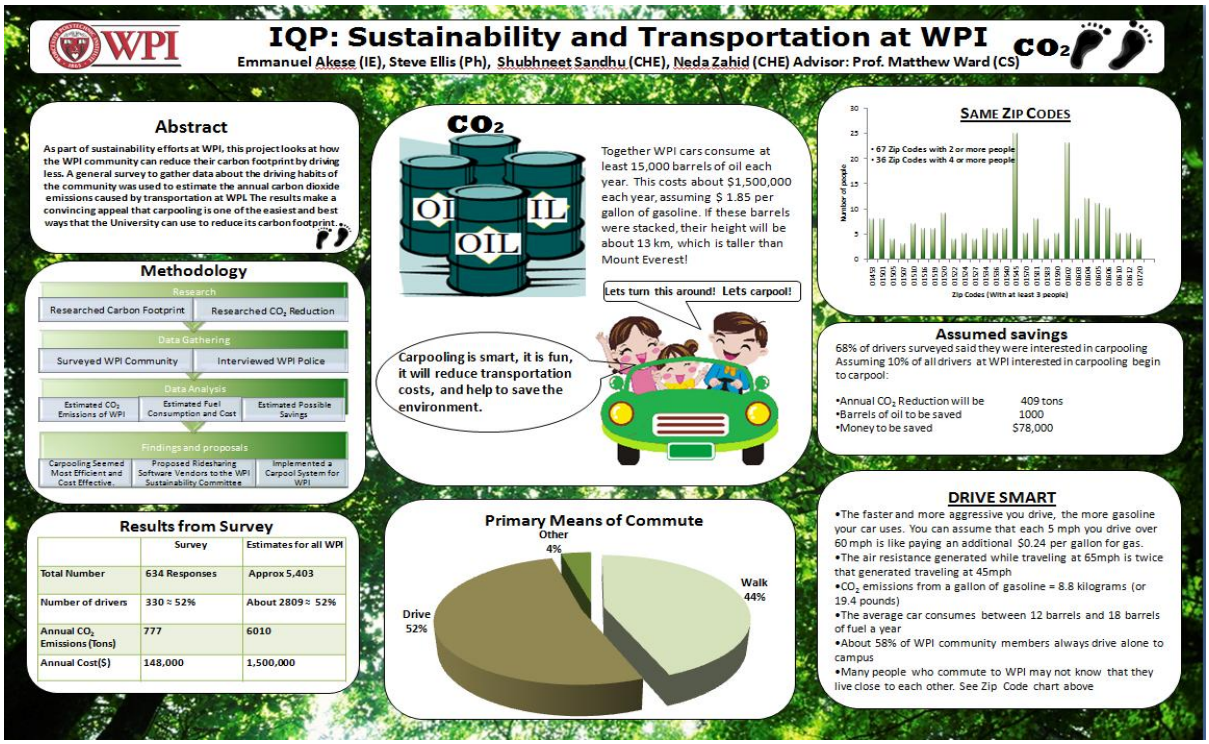
_____

Max Fox, President
Datasphere Corporation

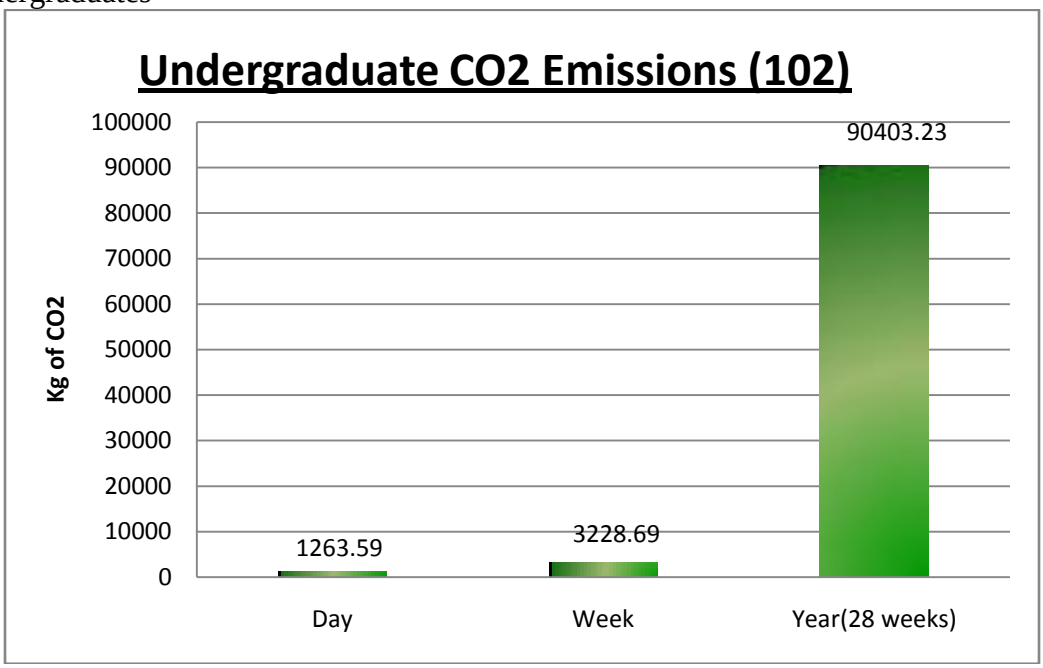
_____

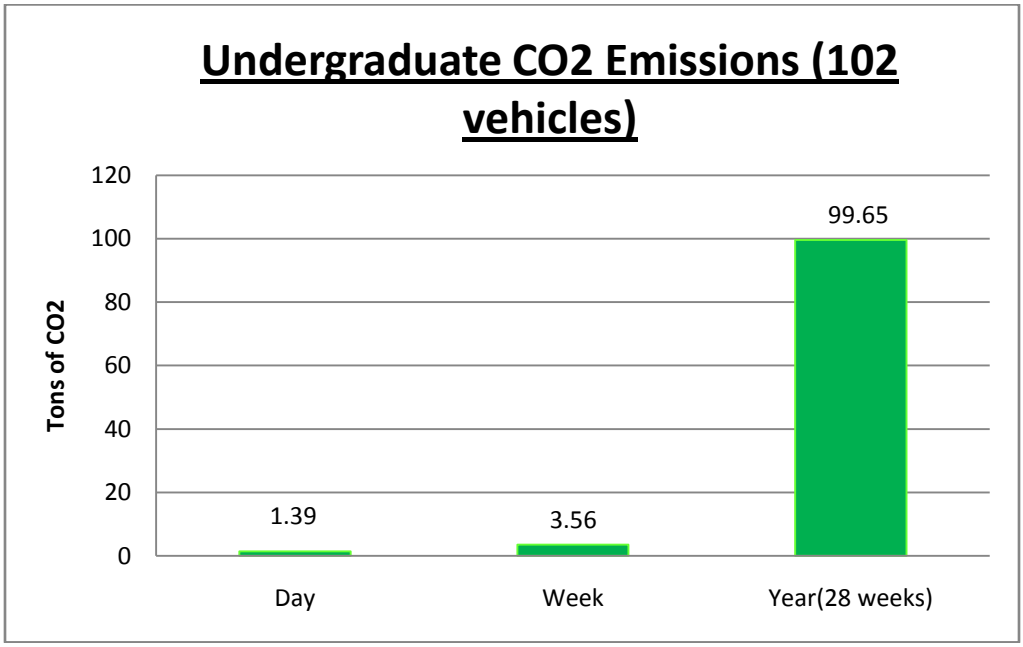
Client
Please sign and date
Please provide name, title, and company name and address

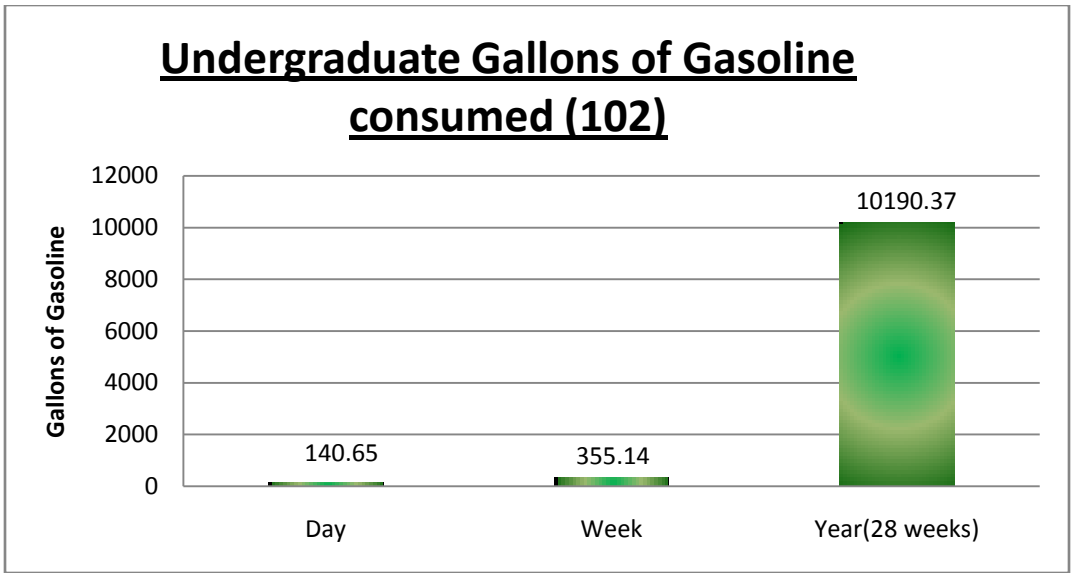
E-1 Poster Competition

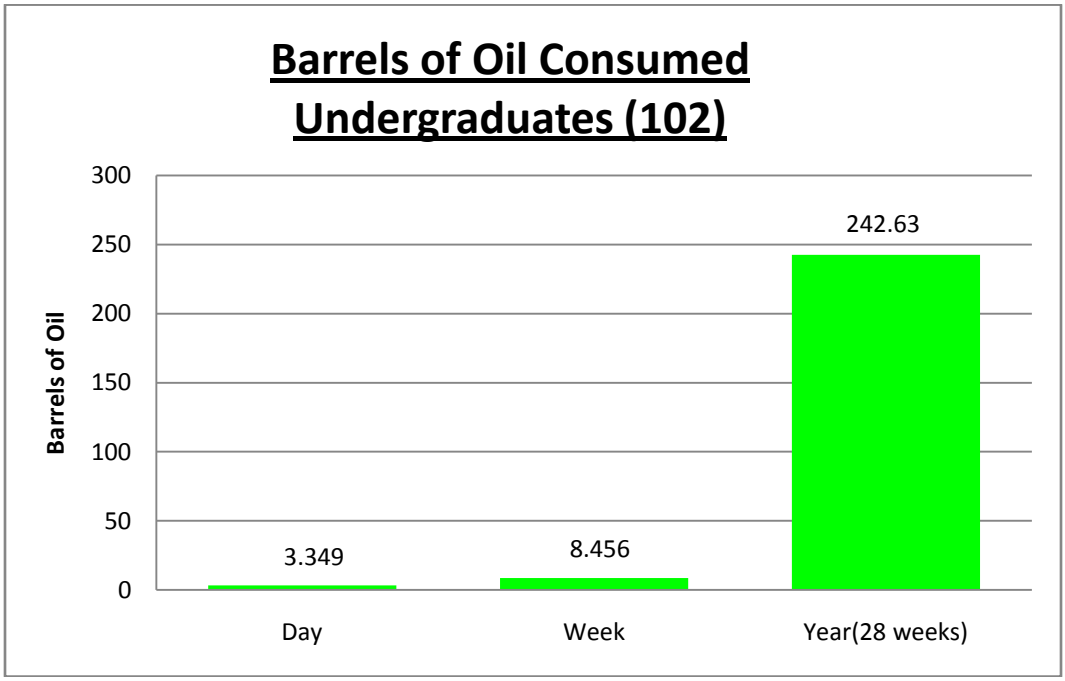


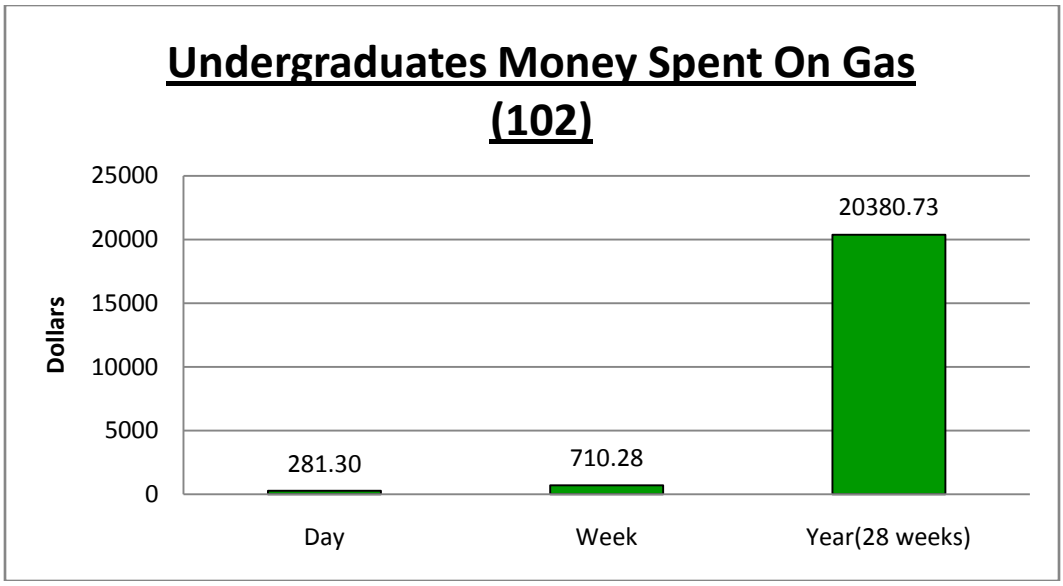
F-1 Undergraduates



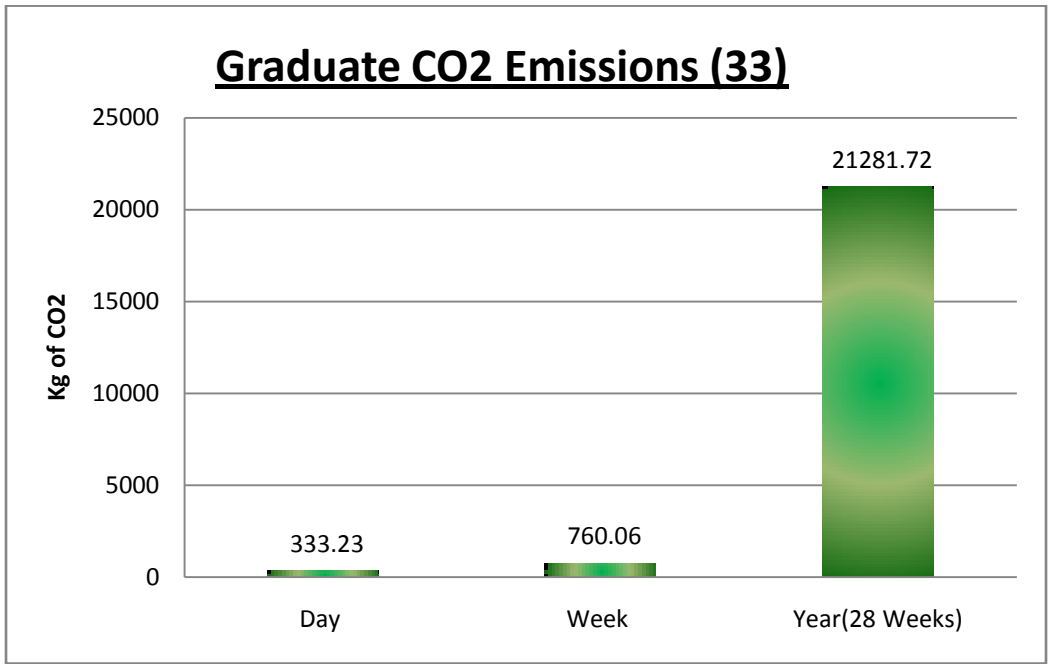


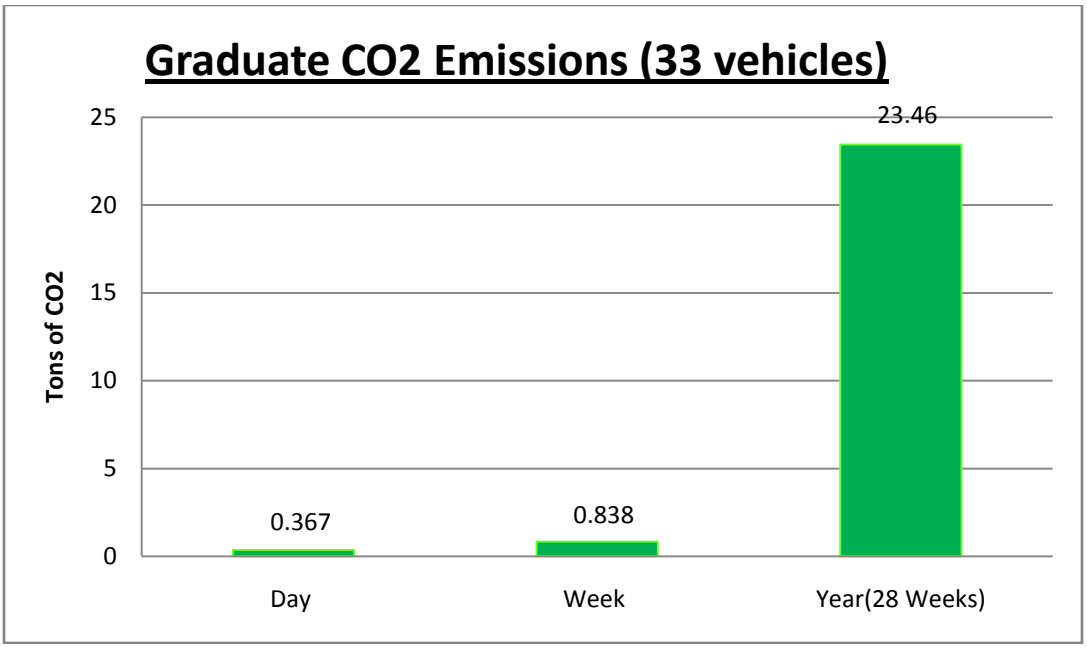

Undergraduate Gallons of Gasoline consumed (102)
Gallons of Gasoline
12000
10000
8000
6000
4000
2000
0
140.65
355.14
10190.37
Day
Week
Year(28 weeks)

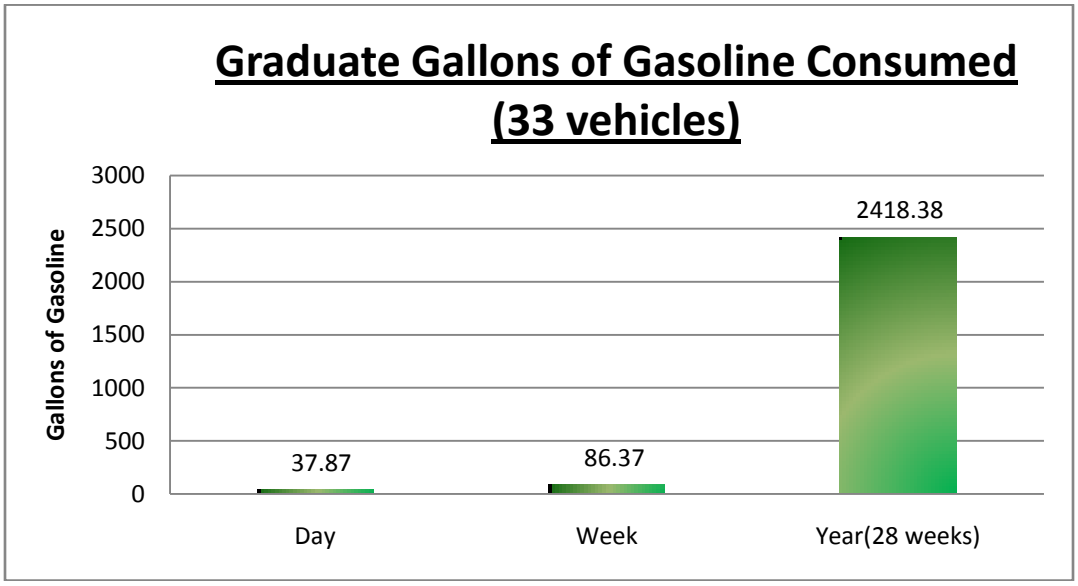

Barrels of Oil Consumed Undergraduates (102)
Barrels of Oil
300
250
200
150
100
50
0
3.349
8.456
242.63
Day
Week
Year(28 weeks)

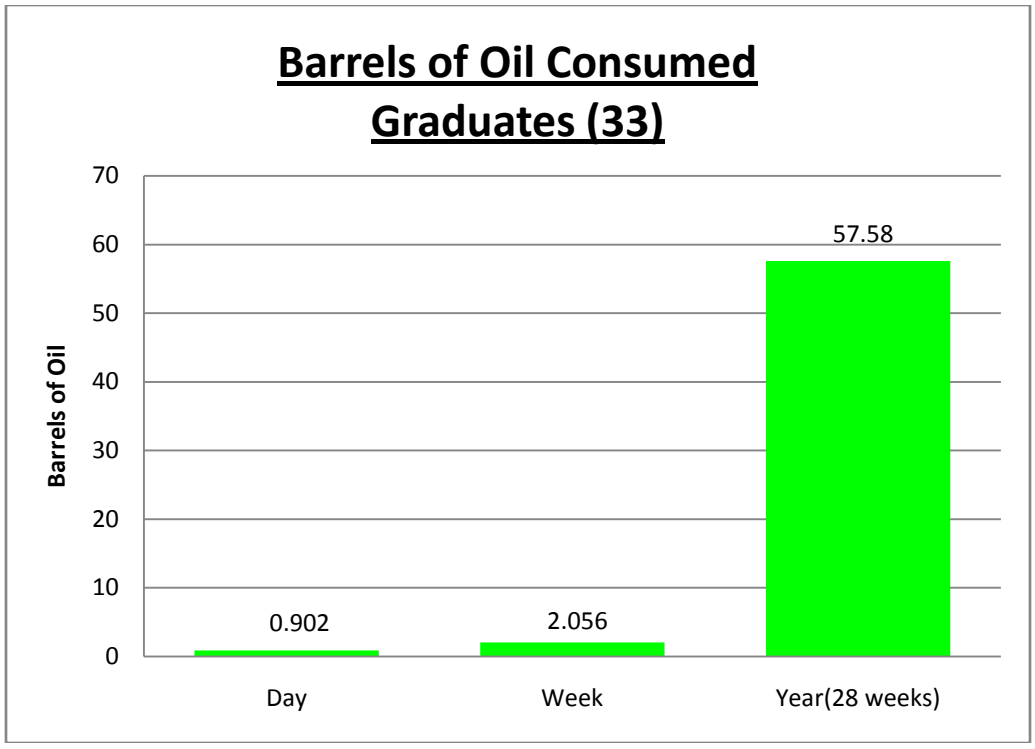


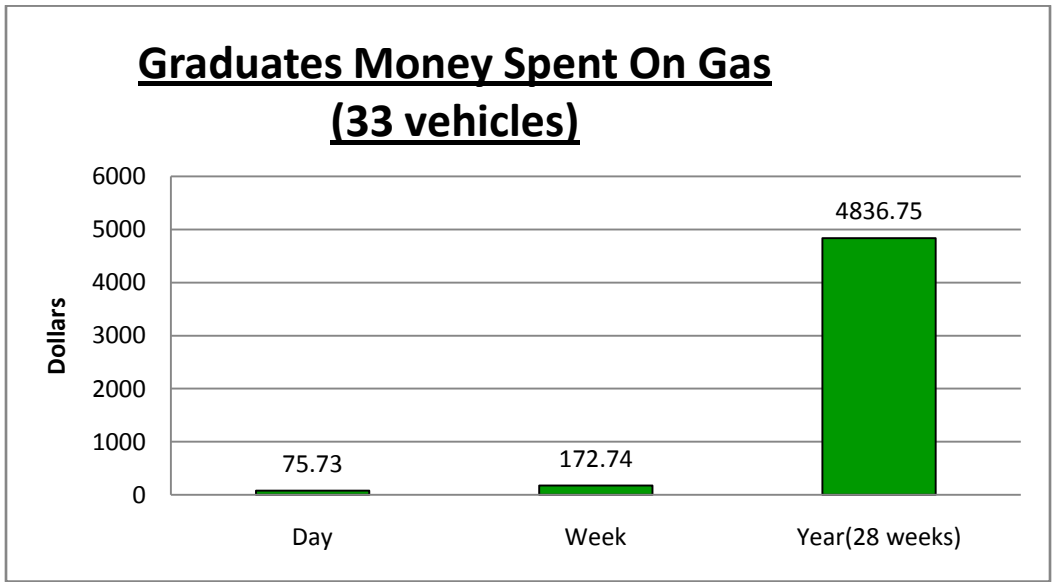
F-2 Graduates



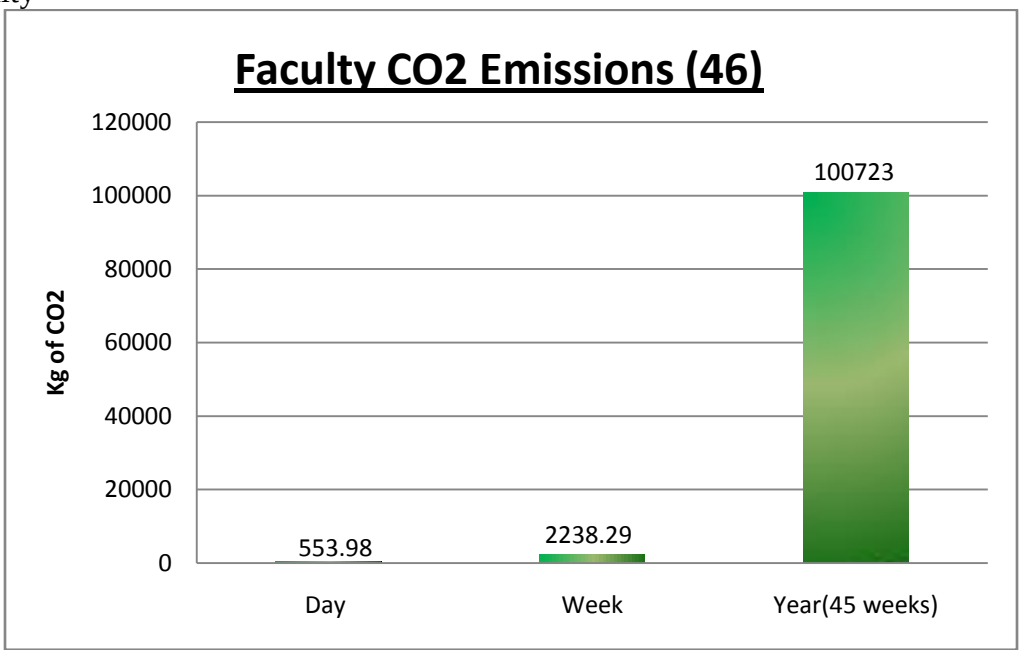

Graduate CO2 Emissions (33 vehicles)
Tons of CO2
25
20
15
10
5
0
0.367
0.838
23.46
Day
Week
Year(28 Weeks)

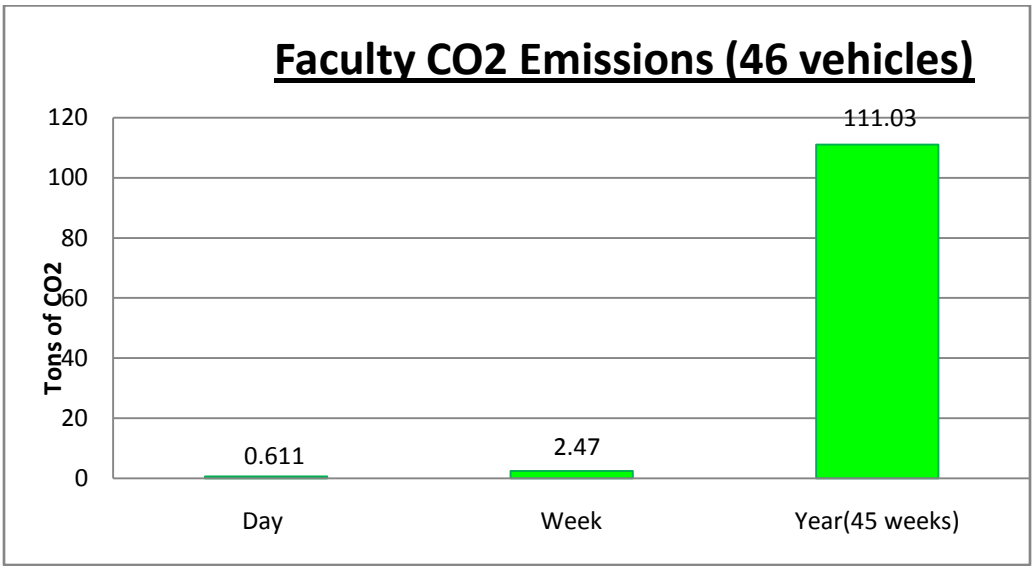

Graduate Gallons of Gasoline Consumed (33 vehicles)
Gallons of Gasoline
3000
2500
2000
1500
1000
500
0
37.87
86.37
2418.38
Day
Week
Year(28 weeks)

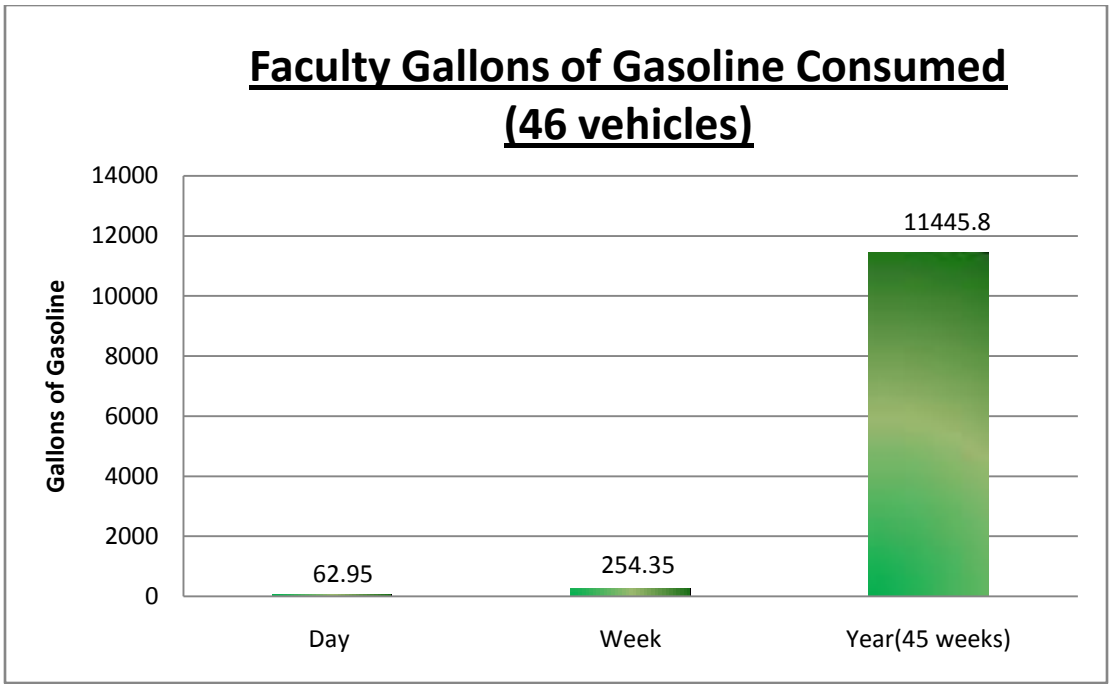

Barrels of Oil Consumed
Graduates (33)
Barrels of Oil
70
60
50
40
30
20
10
0
0.902
2.056
57.58
Day
Week
Year(28 weeks)

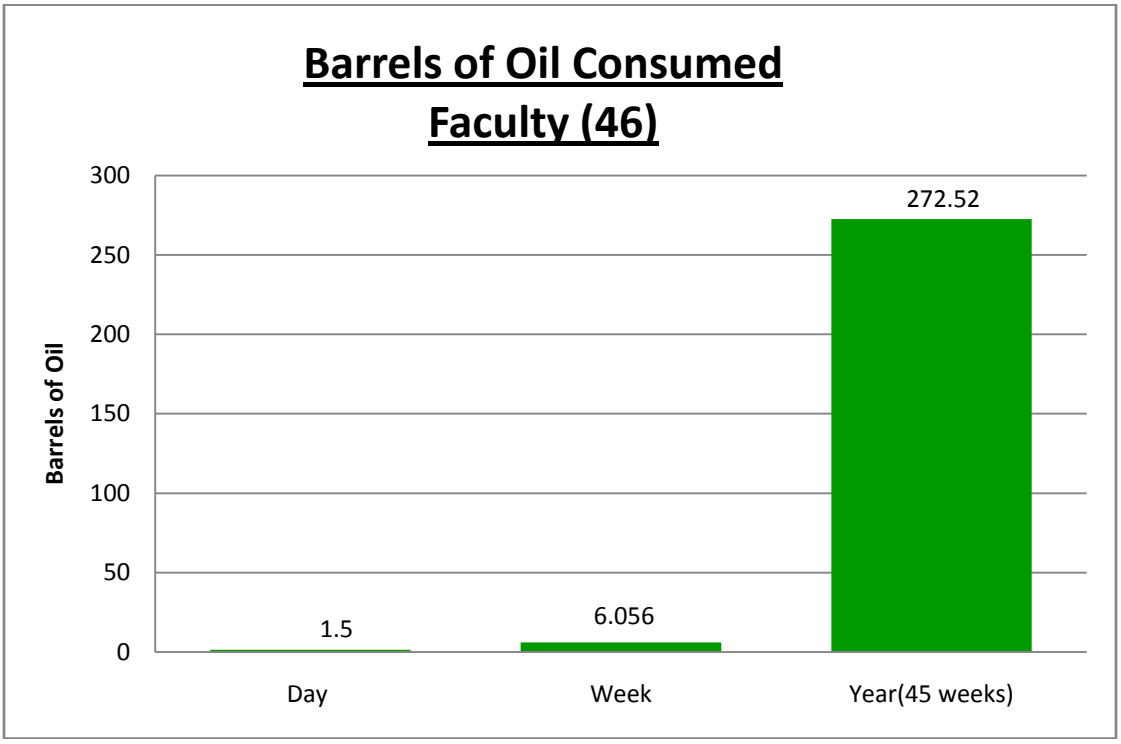

Graduates Money Spent On Gas
(33 vehicles)
Dollars
6000
5000
4000
3000
2000
1000
0
75.73
172.74
4836.75
Day
Week
Year(28 weeks)

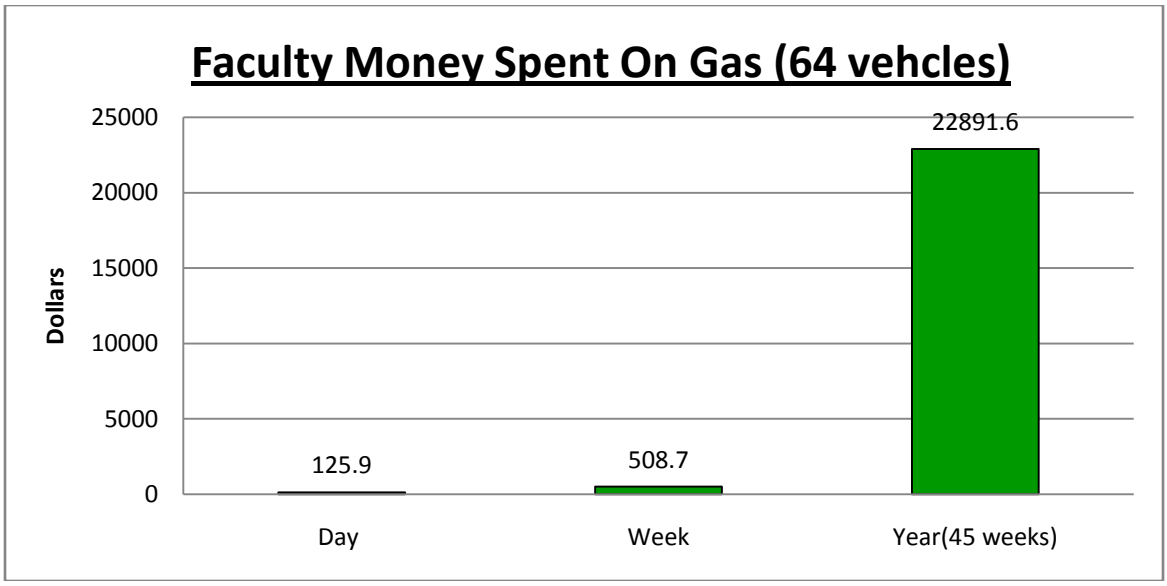
F-3 Faculty


Faculty CO2 Emissions (46)
120000
100000
80000
60000
40000
20000
0
Kg of CO2
553.98
2238.29
100723
Day
Week
Year(45 weeks)

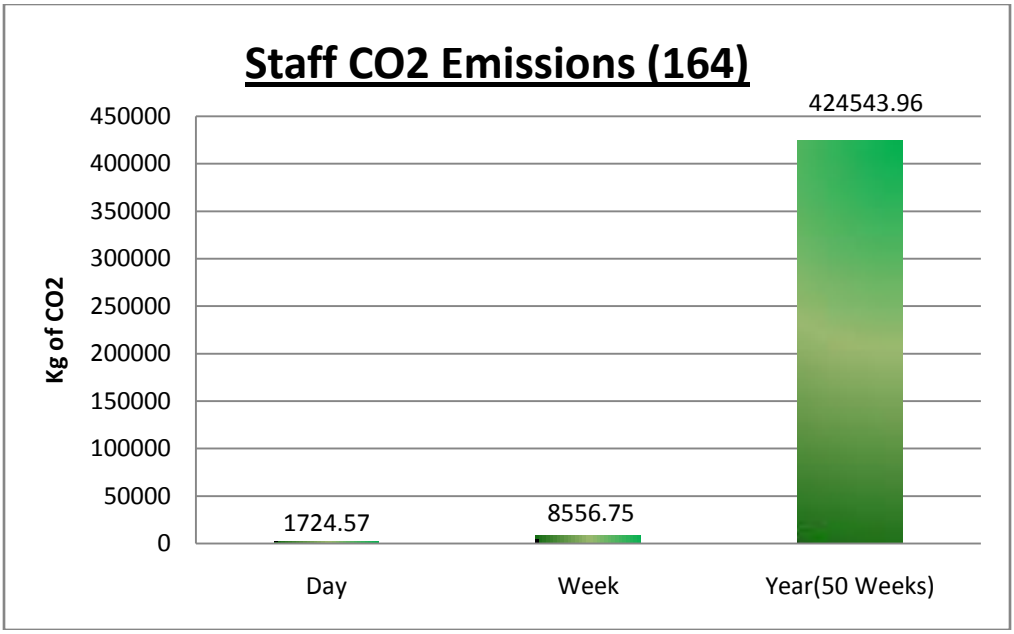

Faculty CO2 Emissions (46 vehicles)
120
100
80
60
40
20
0
Tons of CO2
0.611
2.47
111.03
Day
Week
Year(45 weeks)

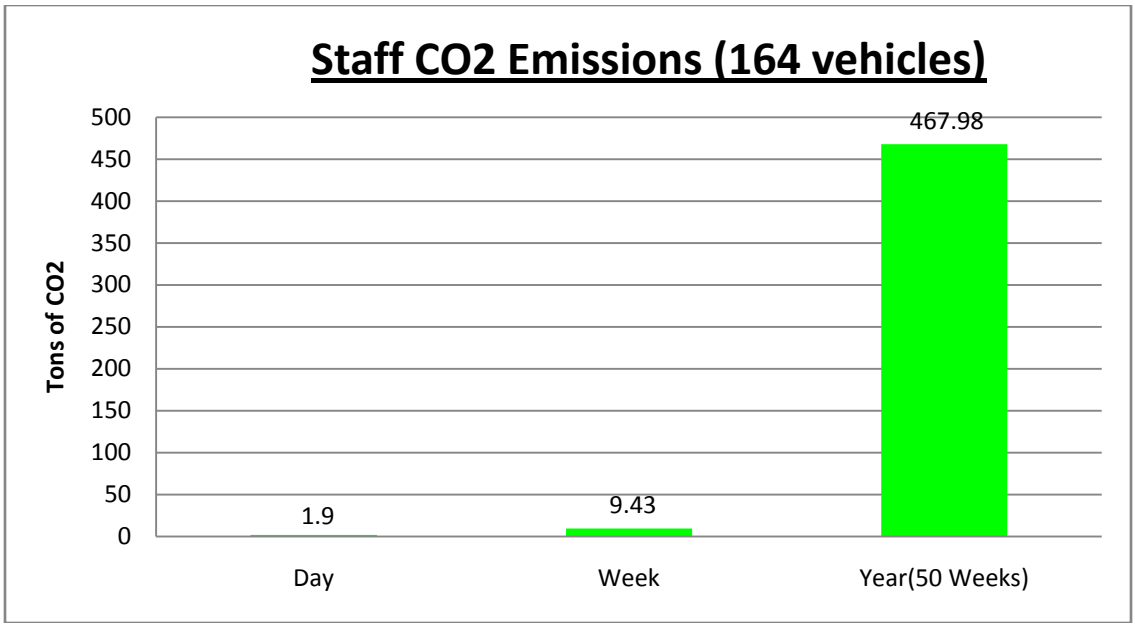

Faculty Gallons of Gasoline Consumed
(46 vehicles)
Gallons of Gasoline
14000
12000
10000
8000
6000
4000
2000
0
62.95
254.35
11445.8
Day
Week
Year(45 weeks)

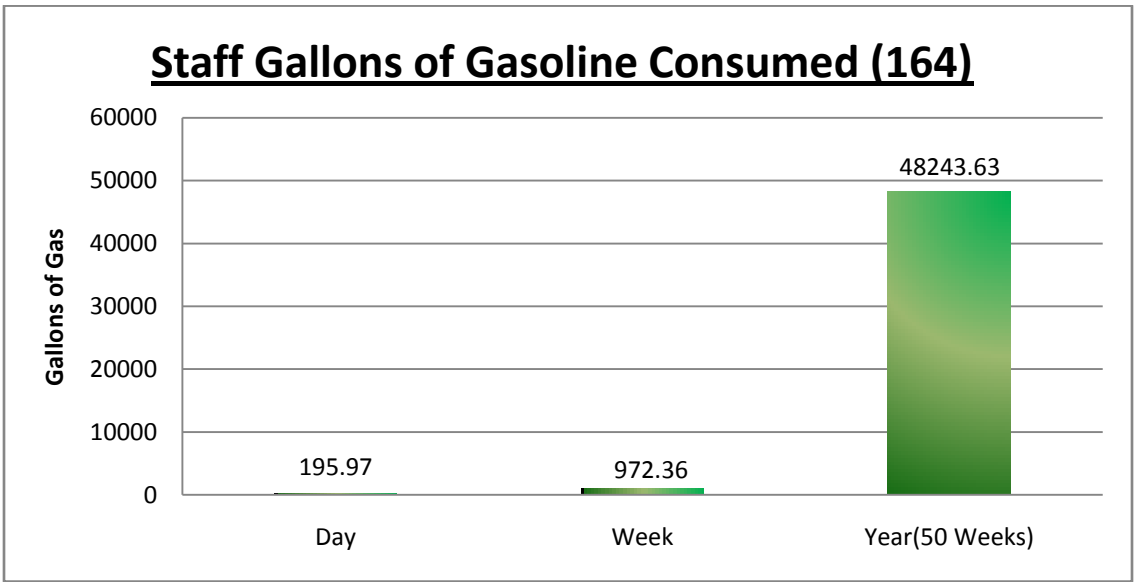

Barrels of Oil Consumed
Faculty (46)
Barrels of Oil
300
250
200
150
100
50
0
1.5
6.056
272.52
Day
Week
Year(45 weeks)

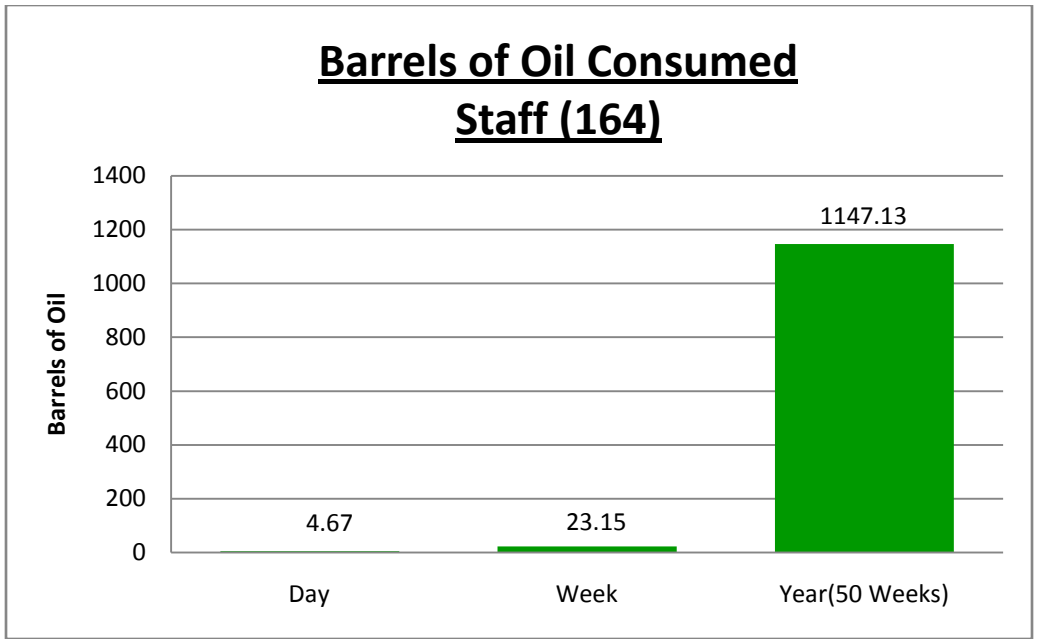

Faculty Money Spent On Gas (64 vehcles)
Dollars
25000
20000
15000
10000
5000
0
125.9
508.7
22891.6
Day
Week
Year(45 weeks)

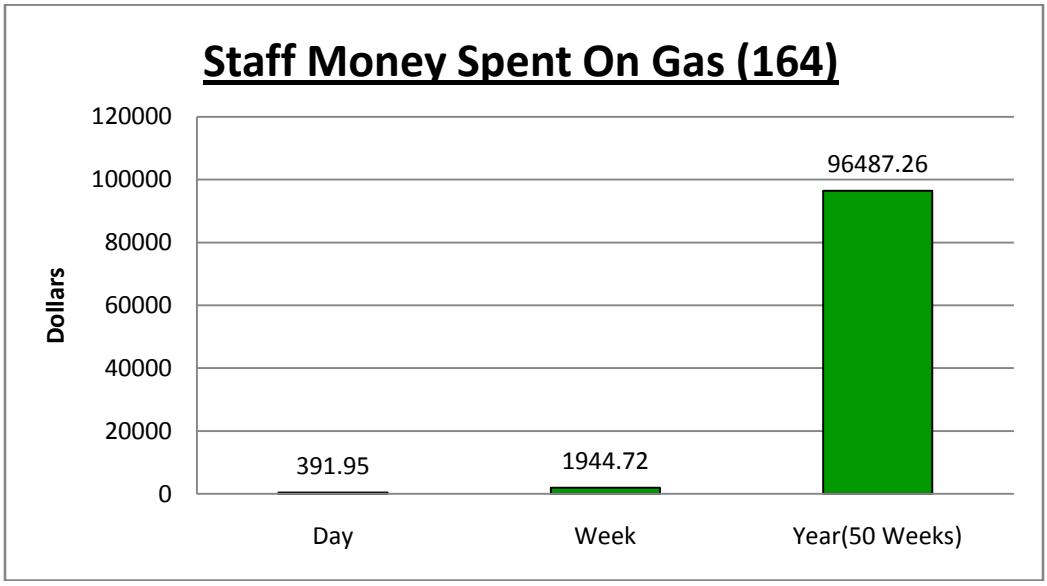
F-4 Staff


Staff CO2 Emissions (164)
Kg of CO2
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1724.57
8556.75
424543.96
Day
Week
Year(50 Weeks)

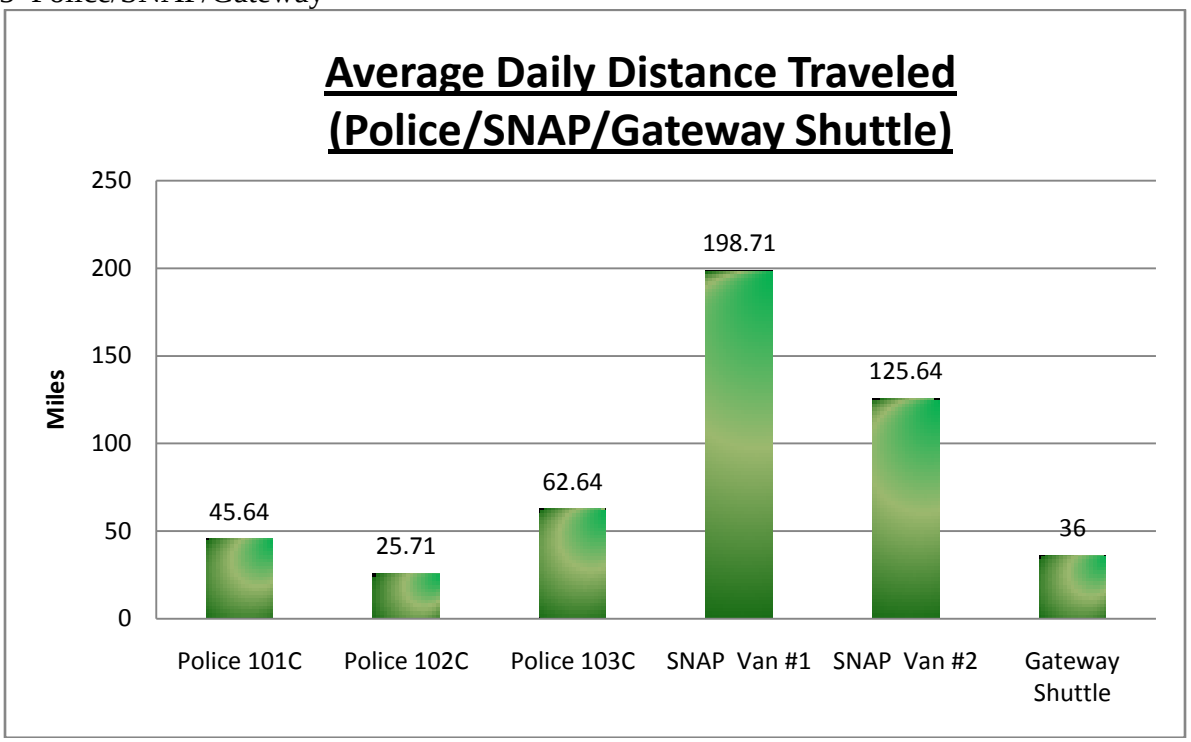

Staff CO2 Emissions (164 vehicles)
Tons of CO2
500
450
400
350
300
250
200
150
100
50
0
1.9
9.43
467.98
Day
Week
Year(50 Weeks)

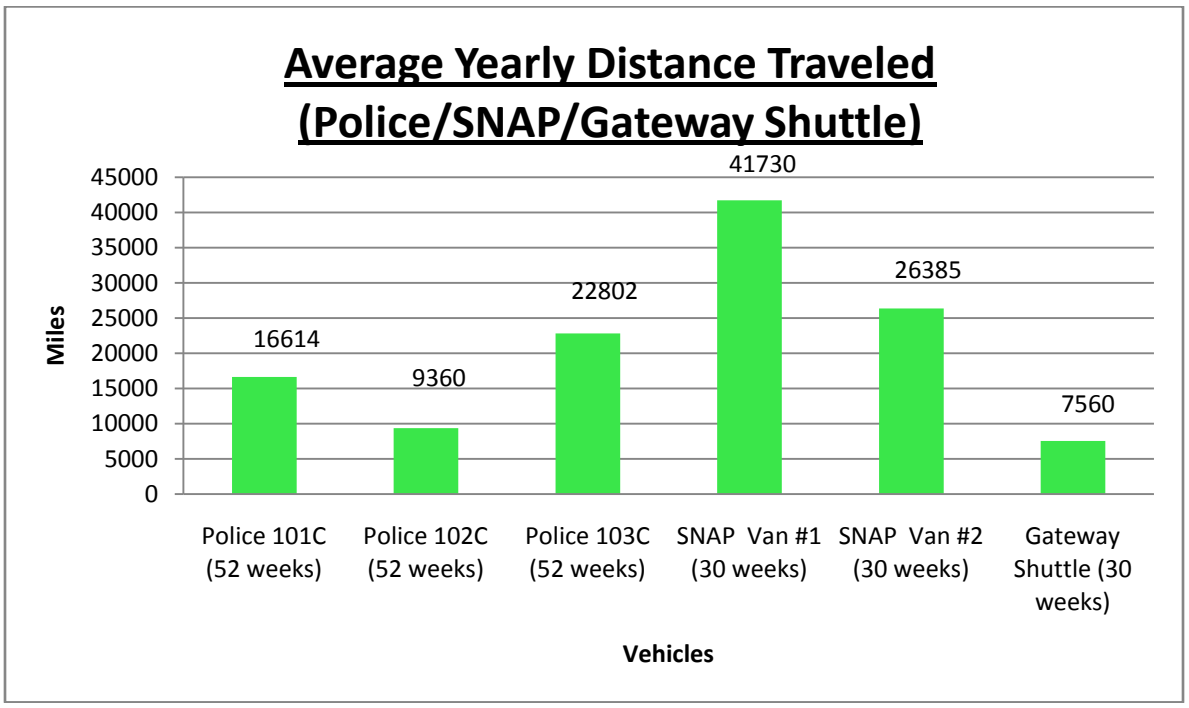

Staff Gallons of Gasoline Consumed (164)
Gallons of Gas
60000
50000
40000
30000
20000
10000
0
195.97
972.36
48243.63
Day
Week
Year(50 Weeks)

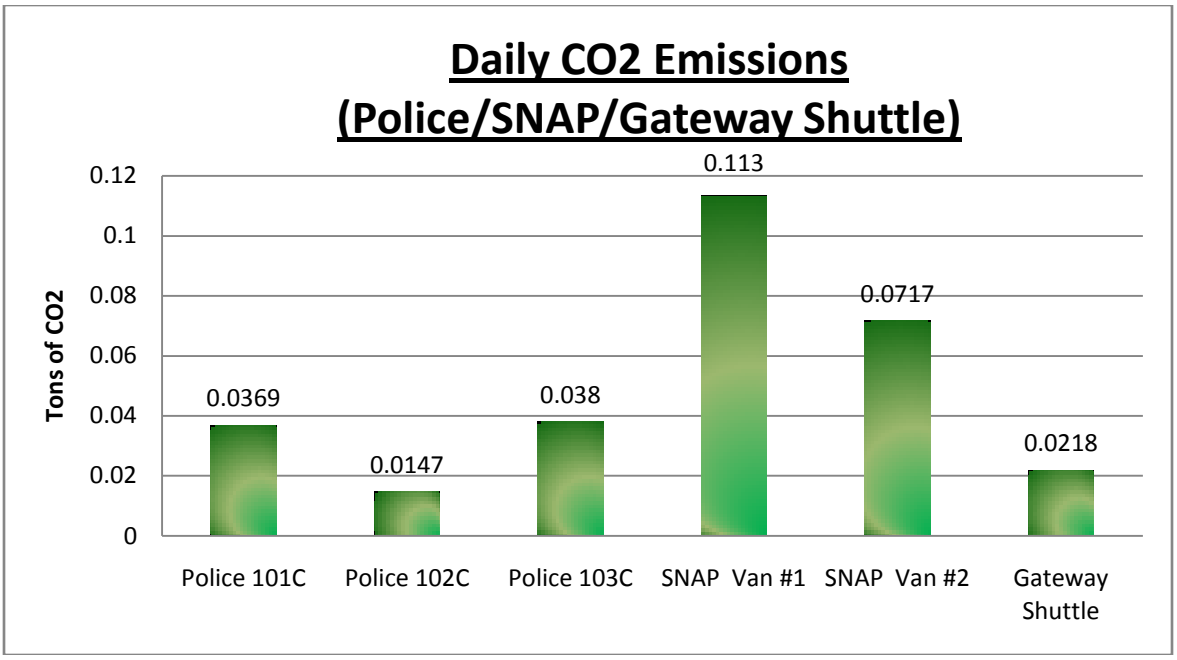

Barrels of Oil Consumed
Staff (164)
Barrels of Oil
1400
1200
1000
800
600
400
200
0
4.67
23.15
1147.13
Day
Week
Year(50 Weeks)

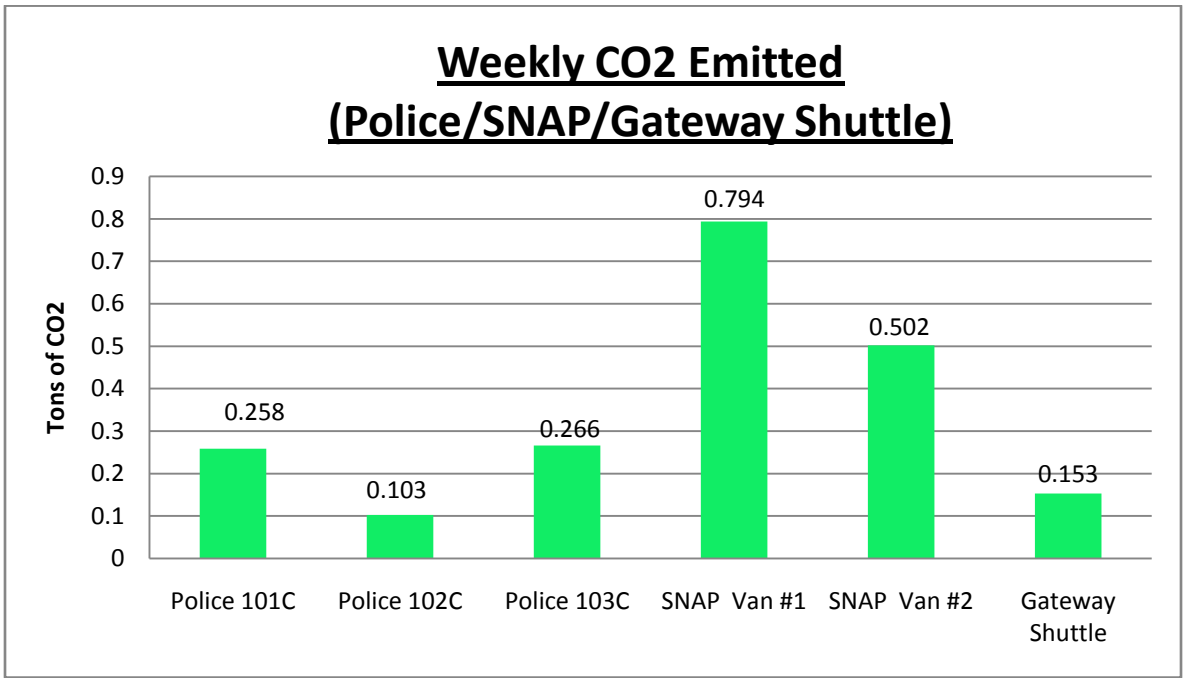

Staff Money Spent On Gas (164)
Dollars
120000
100000
80000
60000
40000
20000
0
391.95
1944.72
96487.26
Day
Week
Year(50 Weeks)

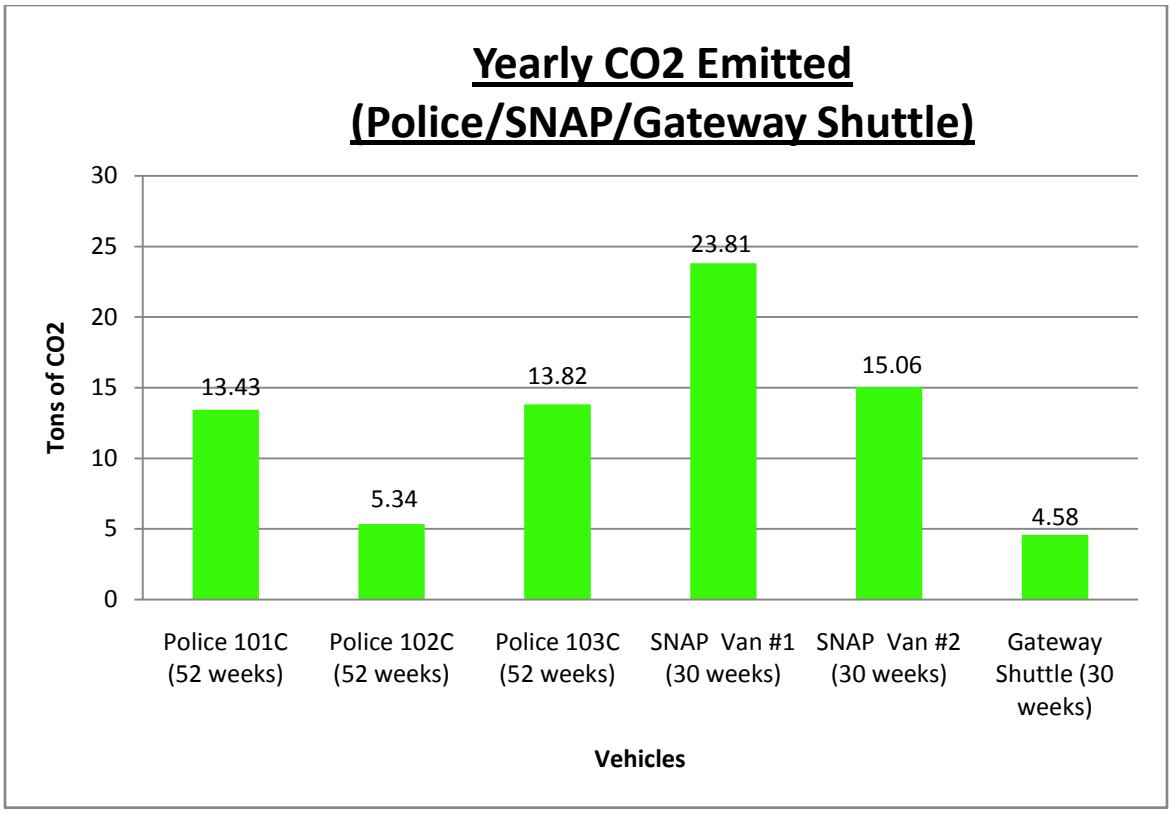
F-5 Police/SNAP/Gateway

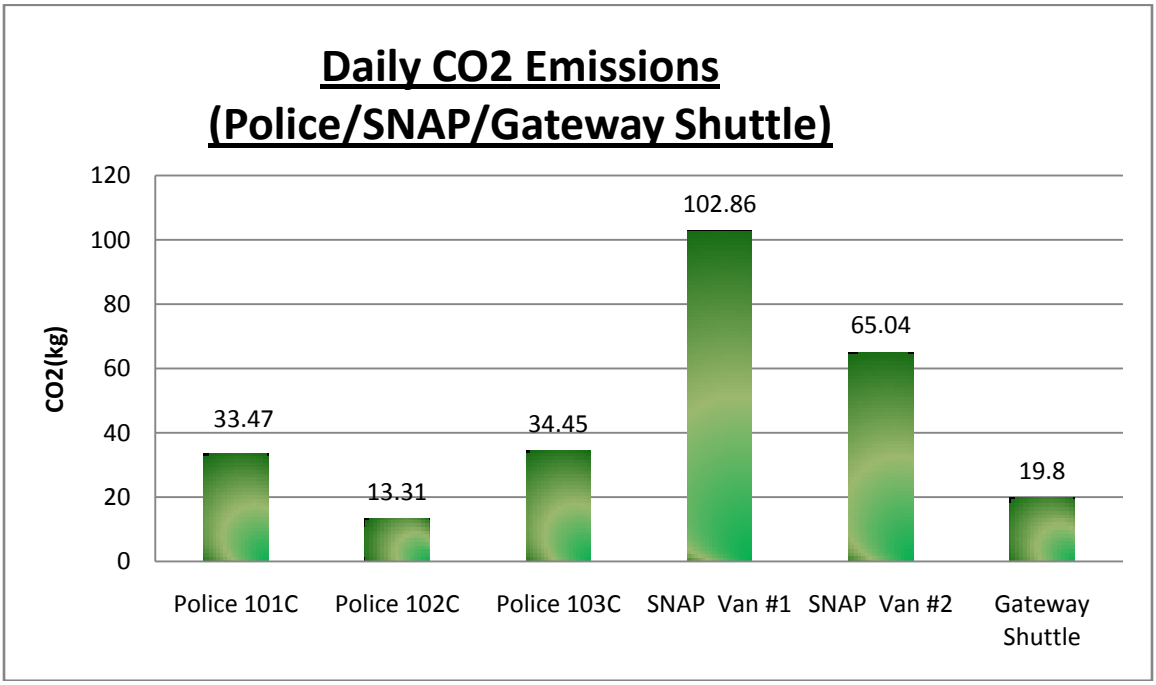


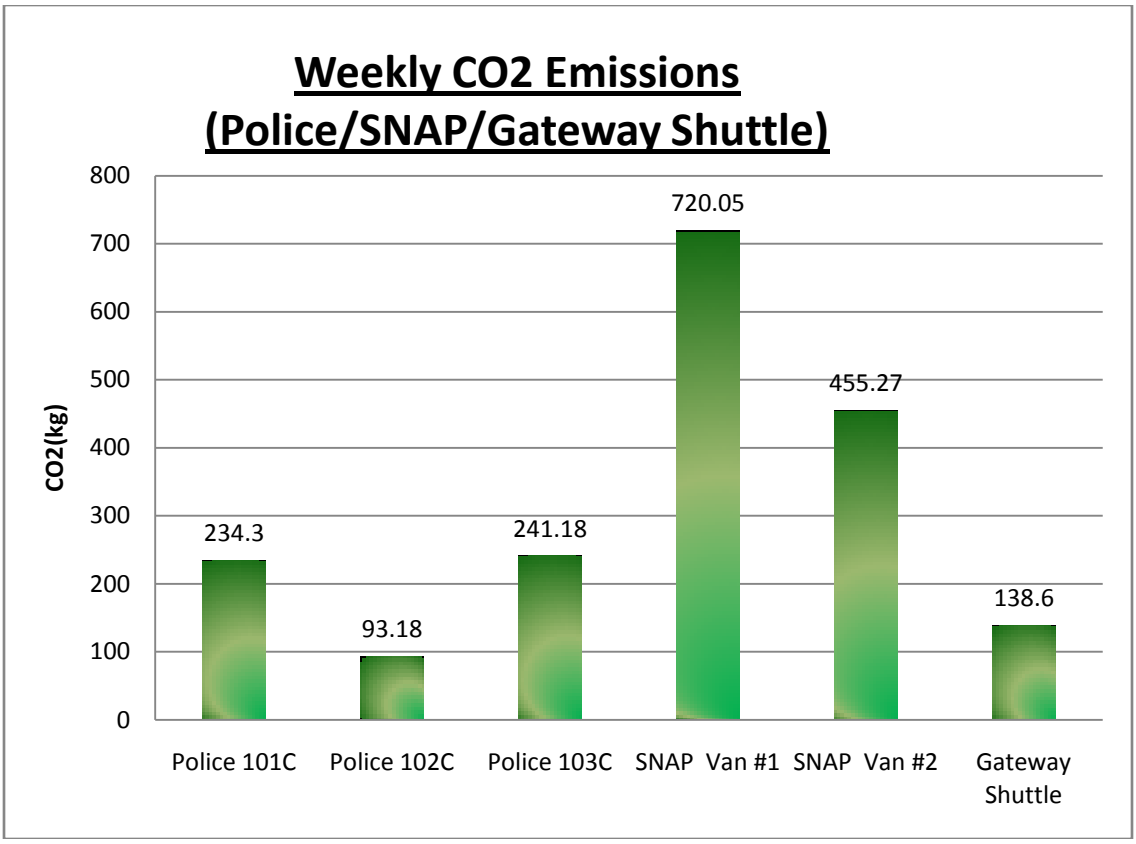


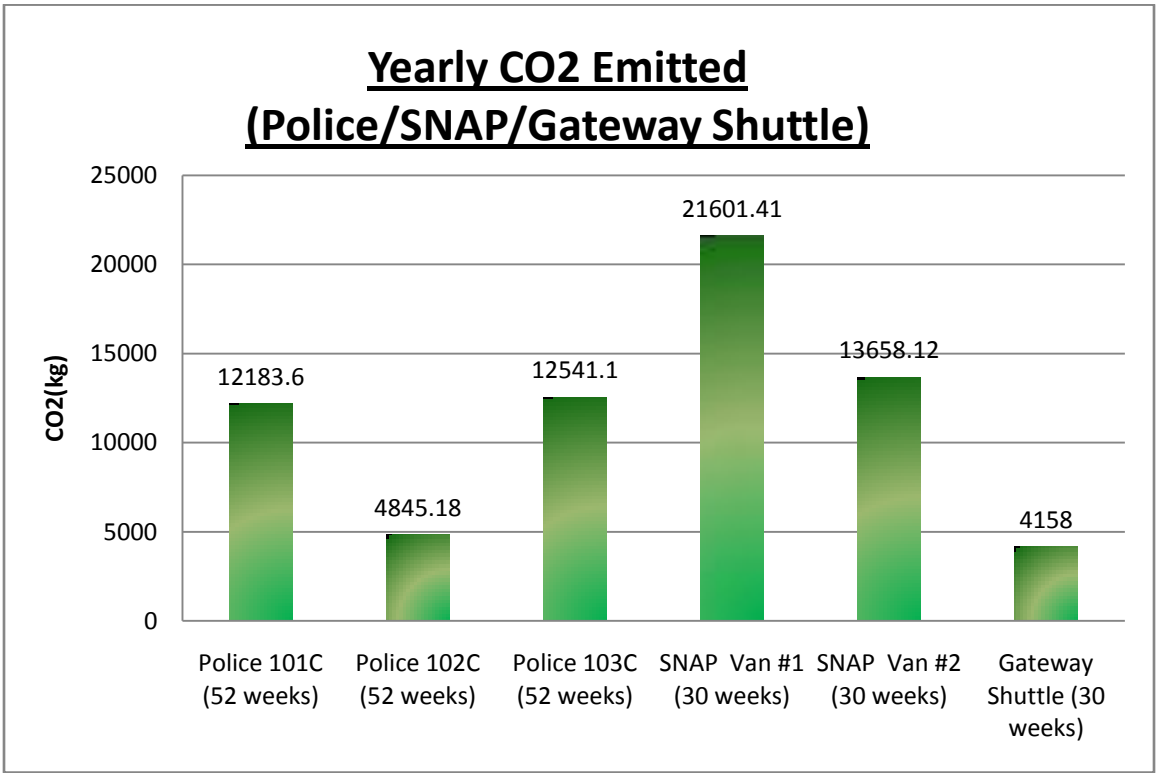

Daily CO2 Emissions
(Police/SNAP/Gateway Shuttle)
Tons of CO2
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0369
0.0147
0.038
0.113
0.0717
0.0218
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

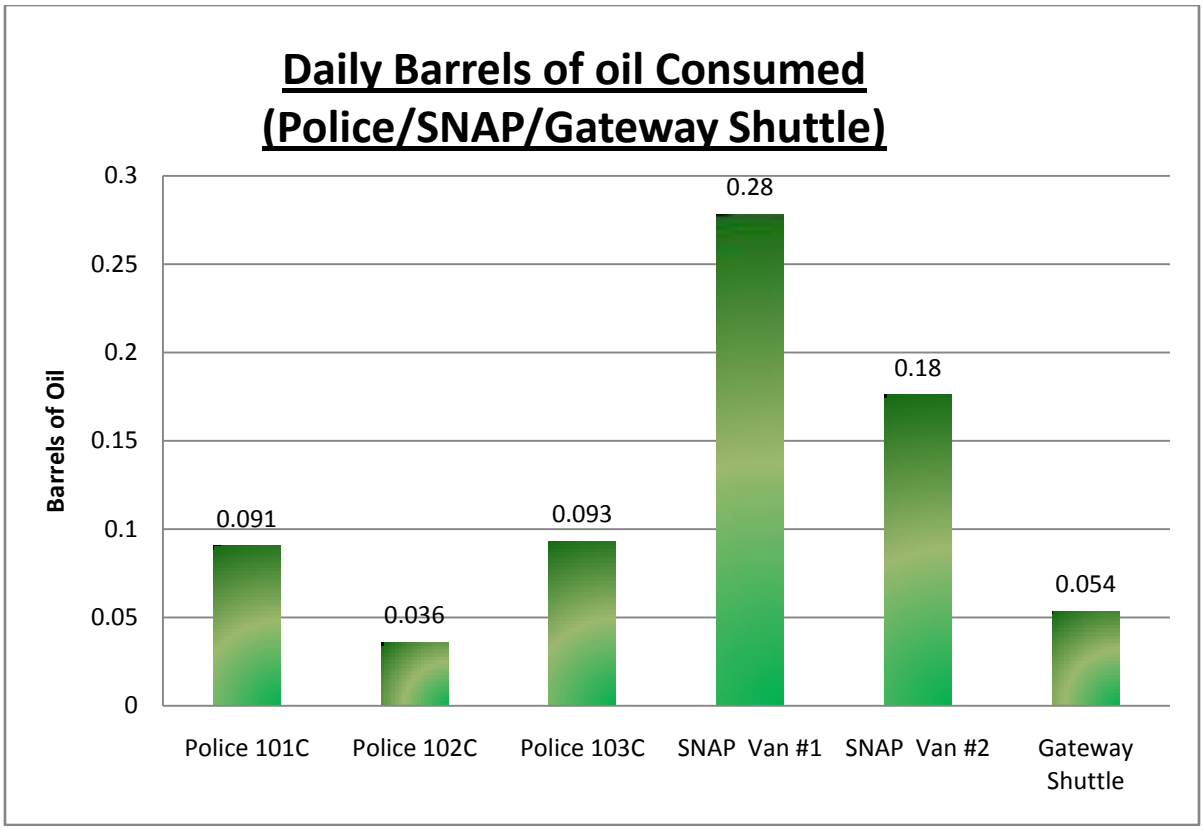

Weekly CO2 Emitted
(Police/SNAP/Gateway Shuttle)
Tons of CO2
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.258
0.103
0.266
0.794
0.502
0.153
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

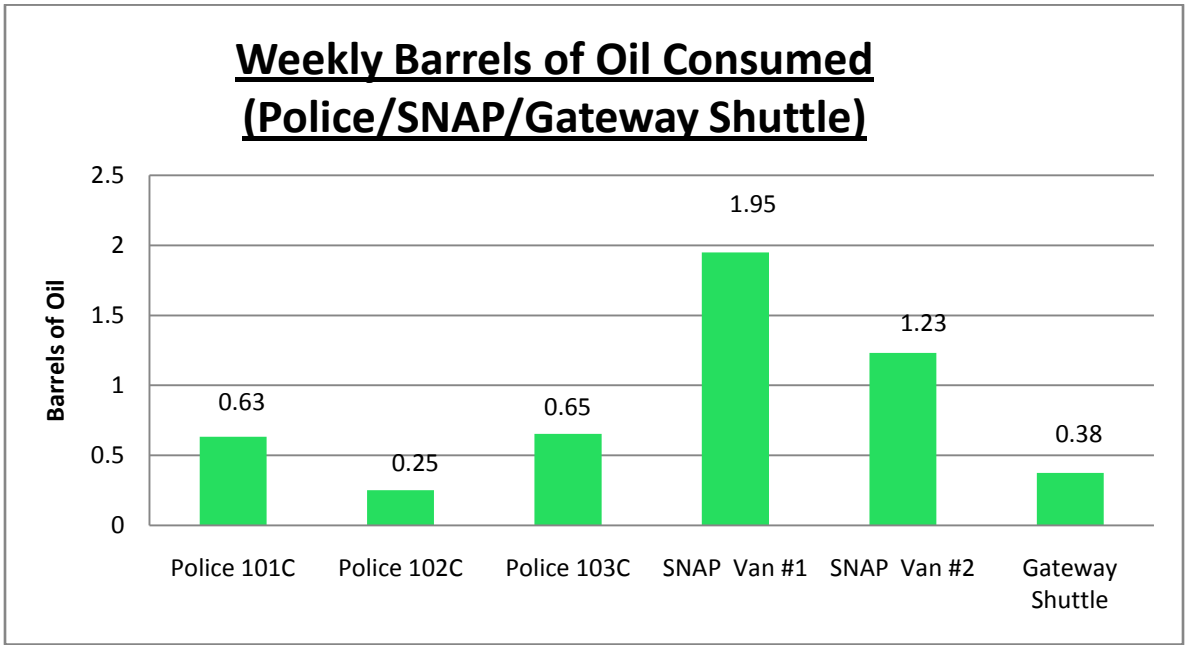

Yearly CO2 Emitted
(Police/SNAP/Gateway Shuttle)
Tons of CO2
30
25
20
15
10
5
0
13.43
5.34
13.82
23.81
15.06
4.58
Police 101C (52 weeks)
Police 102C (52 weeks)
Police 103C (52 weeks)
SNAP Van #1 (30 weeks)
SNAP Van #2 (30 weeks)
Gateway Shuttle (30 weeks)
Vehicles

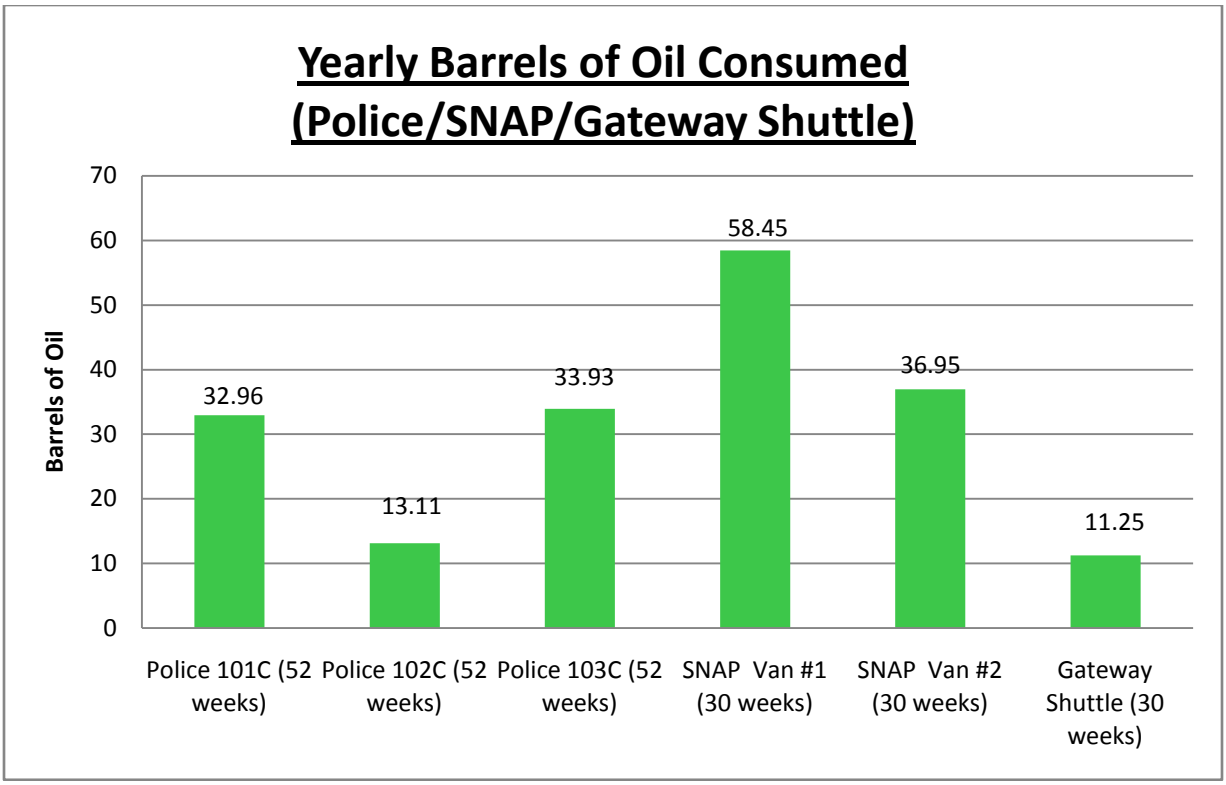

Daily CO2 Emissions
(Police/SNAP/Gateway Shuttle)
CO2(kg)
120
100
80
60
40
20
0
33.47
13.31
34.45
102.86
65.04
19.8
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

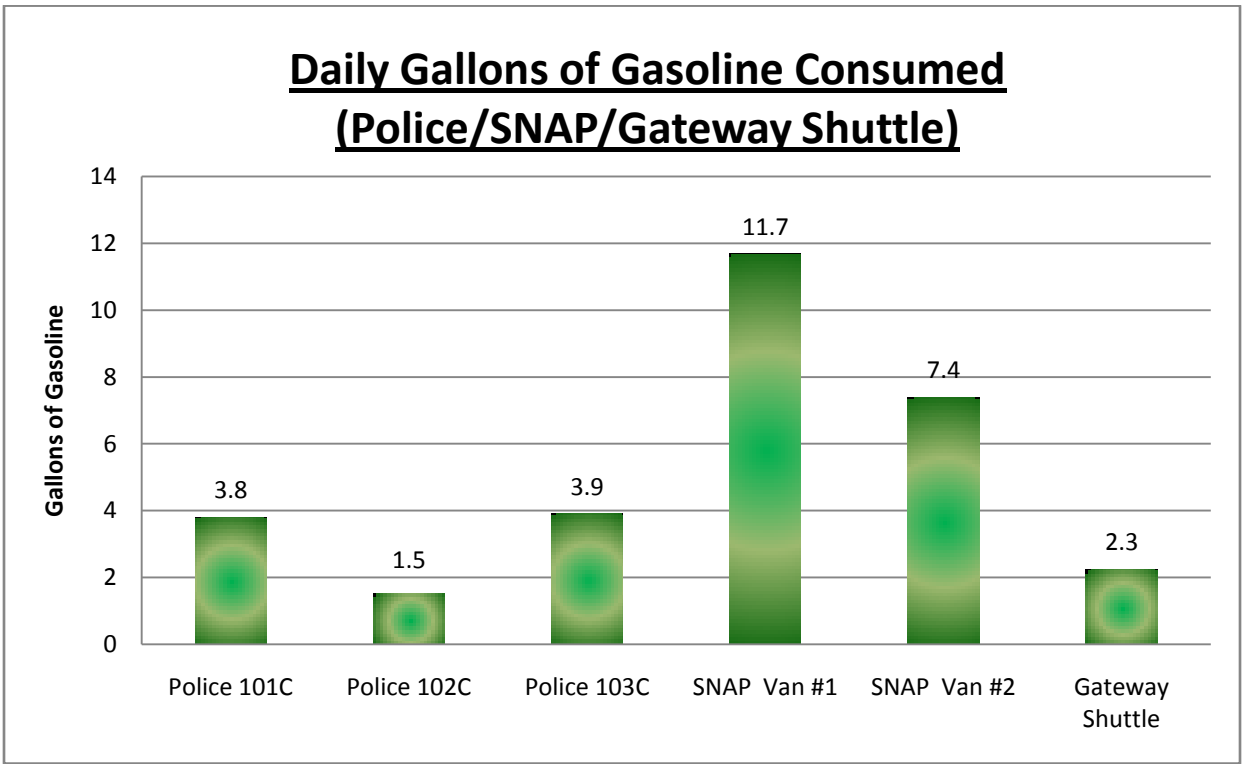

Weekly CO2 Emissions
(Police/SNAP/Gateway Shuttle)
CO2(kg)
800
700
600
500
400
300
200
100
0
234.3
93.18
241.18
720.05
455.27
138.6
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

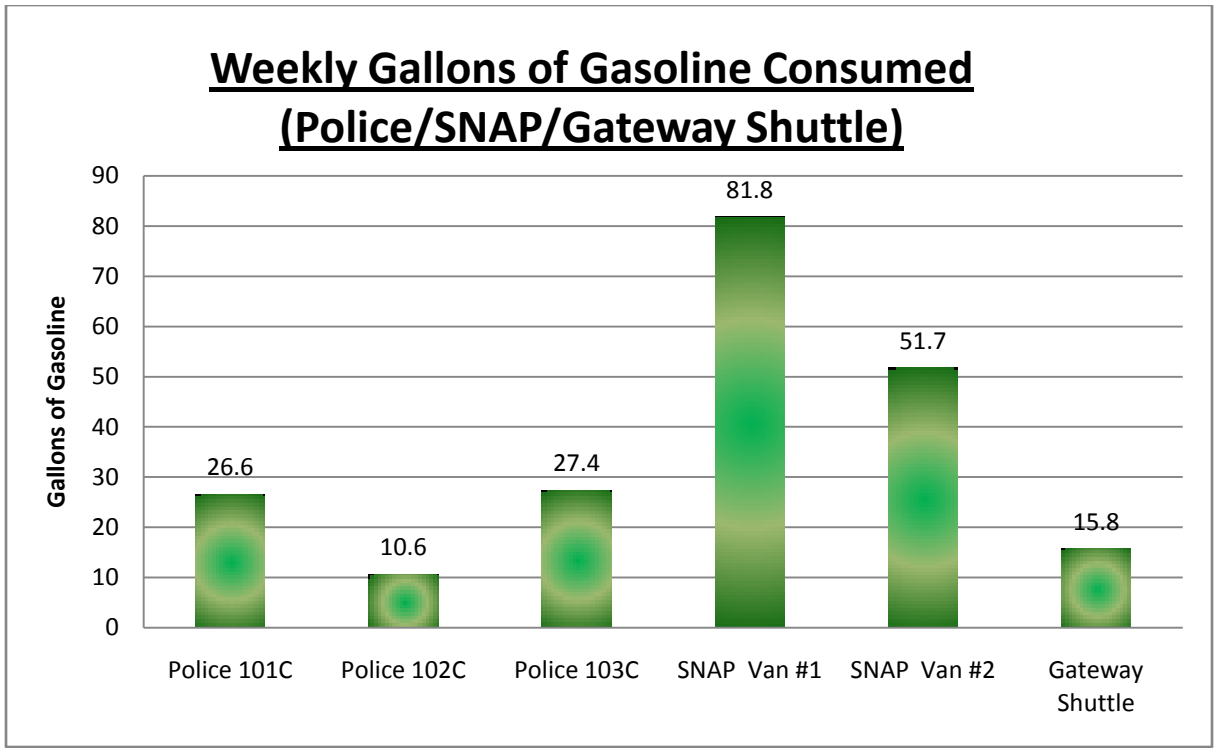

Yearly CO2 Emitted
(Police/SNAP/Gateway Shuttle)
CO2(kg)
25000
20000
15000
10000
5000
0
12183.6
4845.18
12541.1
21601.41
13658.12
4158
Police 101C (52 weeks)
Police 102C (52 weeks)
Police 103C (52 weeks)
SNAP Van #1 (30 weeks)
SNAP Van #2 (30 weeks)
Gateway Shuttle (30 weeks)

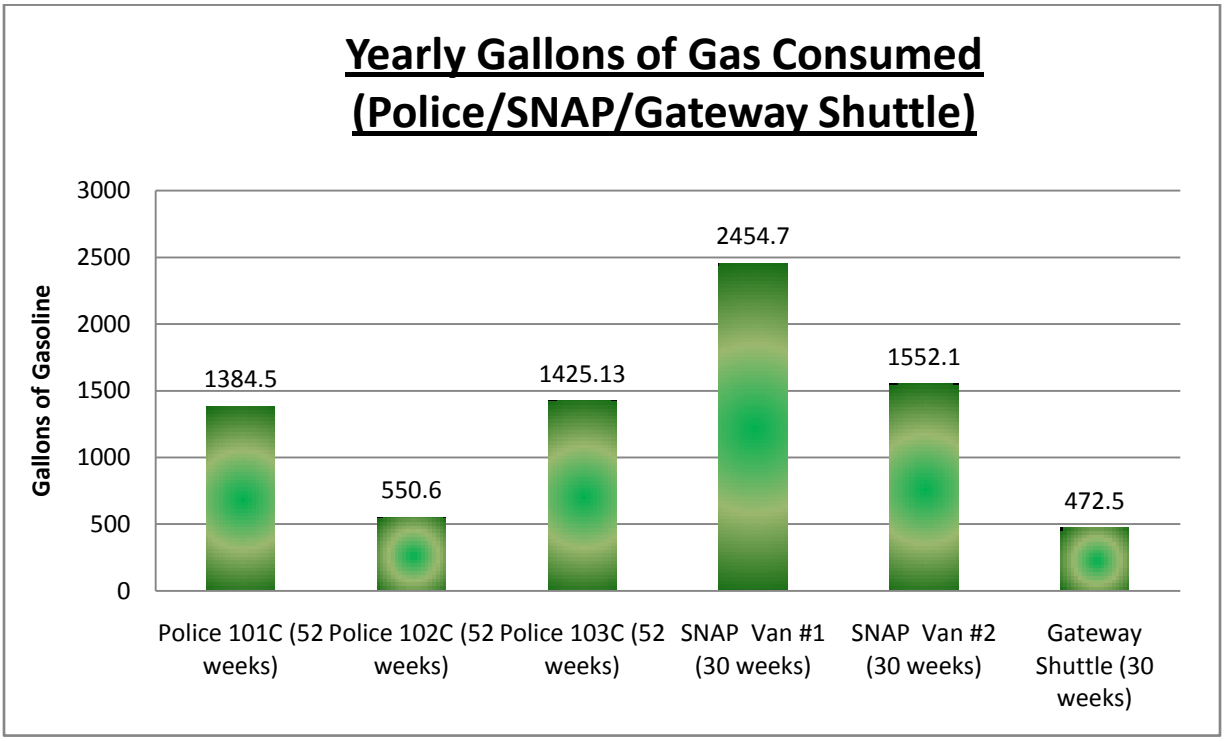

Daily Barrels of oil Consumed
(Police/SNAP/Gateway Shuttle)
Barrels of Oil
0.3
0.25
0.2
0.15
0.1
0.05
0
0.091
0.036
0.093
0.28
0.18
0.054
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

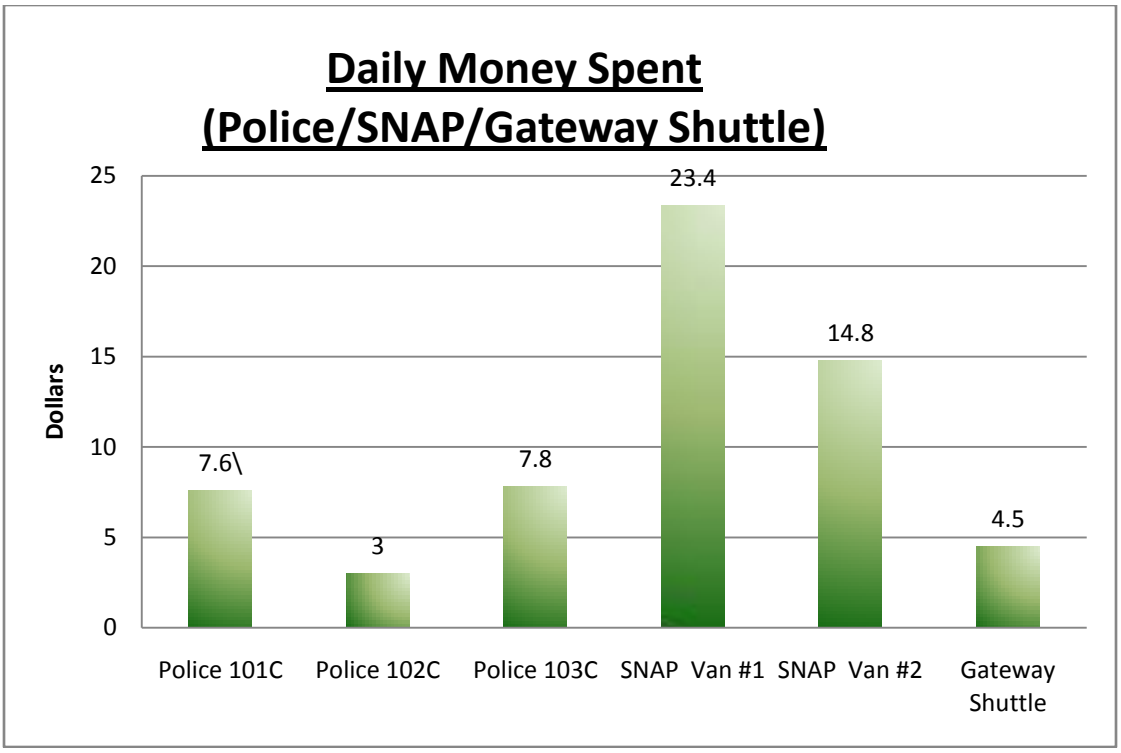

Weekly Barrels of Oil Consumed
(Police/SNAP/Gateway Shuttle)
Barrels of Oil
2.5
2
1.5
1
0.5
0
0.63
0.25
0.65
1.95
1.23
0.38
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

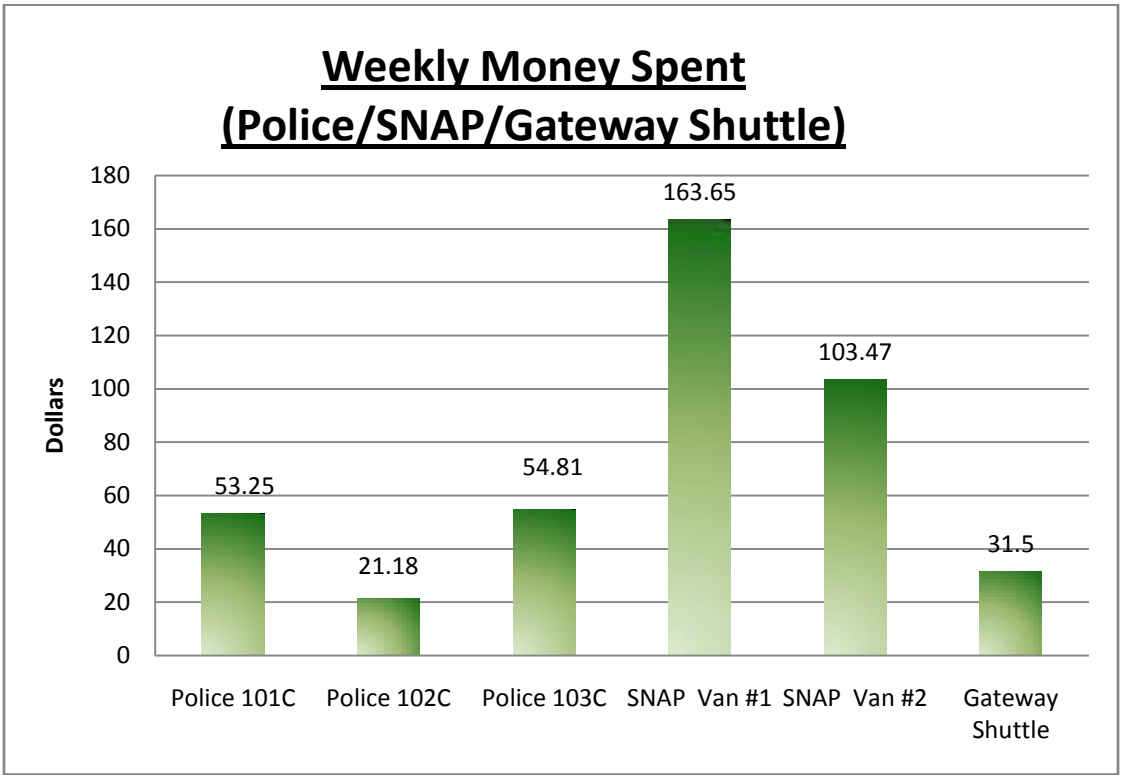

Yearly Barrels of Oil Consumed
(Police/SNAP/Gateway Shuttle)
Barrels of Oil
70
60
50
40
30
20
10
0
32.96
13.11
33.93
58.45
36.95
11.25
Police 101C (52 weeks)
Police 102C (52 weeks)
Police 103C (52 weeks)
SNAP Van #1 (30 weeks)
SNAP Van #2 (30 weeks)
Gateway Shuttle (30 weeks)

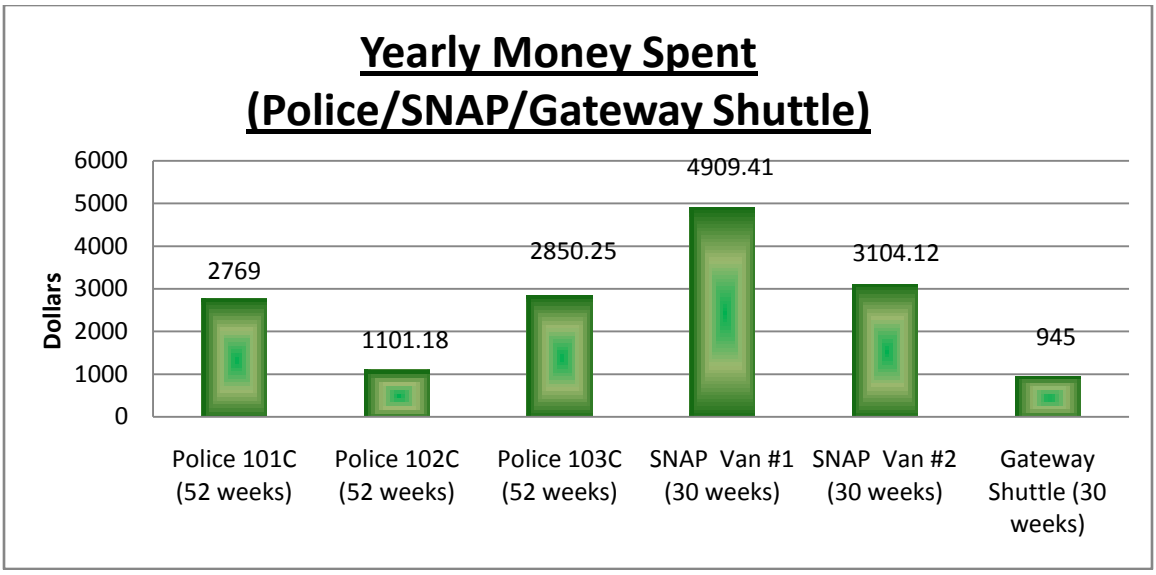

Daily Gallons of Gasoline Consumed
(Police/SNAP/Gateway Shuttle)
Gallons of Gasoline
14
12
10
8
6
4
2
0
3.8
1.5
3.9
11.7
7.4
2.3
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle


Weekly Gallons of Gasoline Consumed
(Police/SNAP/Gateway Shuttle)
Gallons of Gasoline
90
80
70
60
50
40
30
20
10
0
26.6
10.6
27.4
81.8
51.7
15.8
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

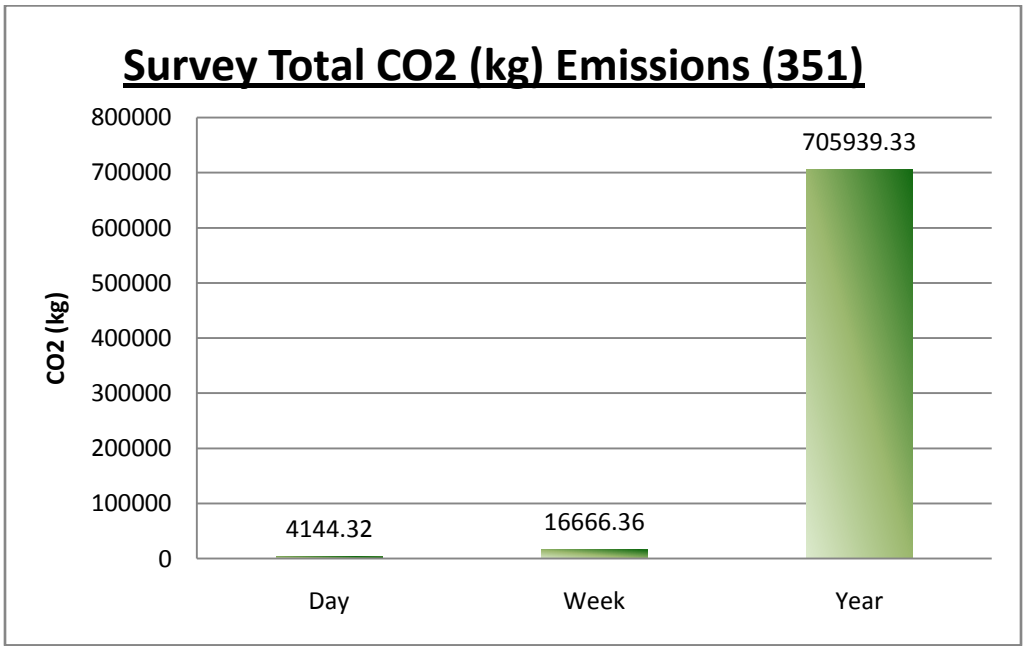

Yearly Gallons of Gas Consumed
(Police/SNAP/Gateway Shuttle)
Gallons of Gasoline
3000
2500
2000
1500
1000
500
0
1384.5
550.6
1425.13
2454.7
1552.1
472.5
Police 101C (52 weeks)
Police 102C (52 weeks)
Police 103C (52 weeks)
SNAP Van #1 (30 weeks)
SNAP Van #2 (30 weeks)
Gateway Shuttle (30 weeks)

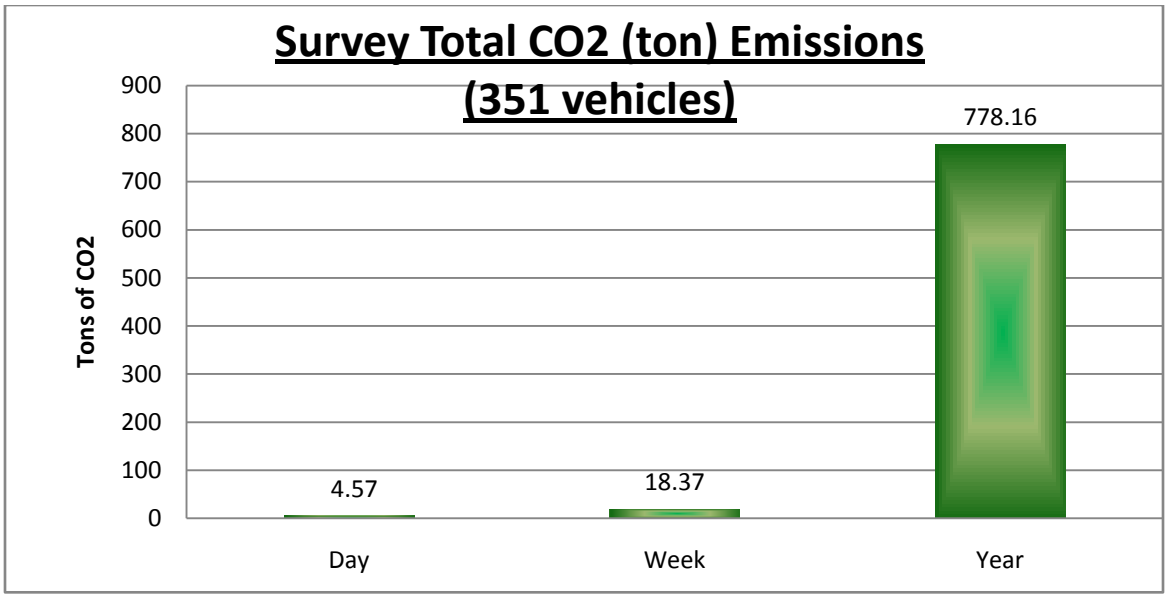

Daily Money Spent
(Police/SNAP/Gateway Shuttle)
Dollars
25
20
15
10
5
0
7.6\
3
7.8
23.4
14.8
4.5
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

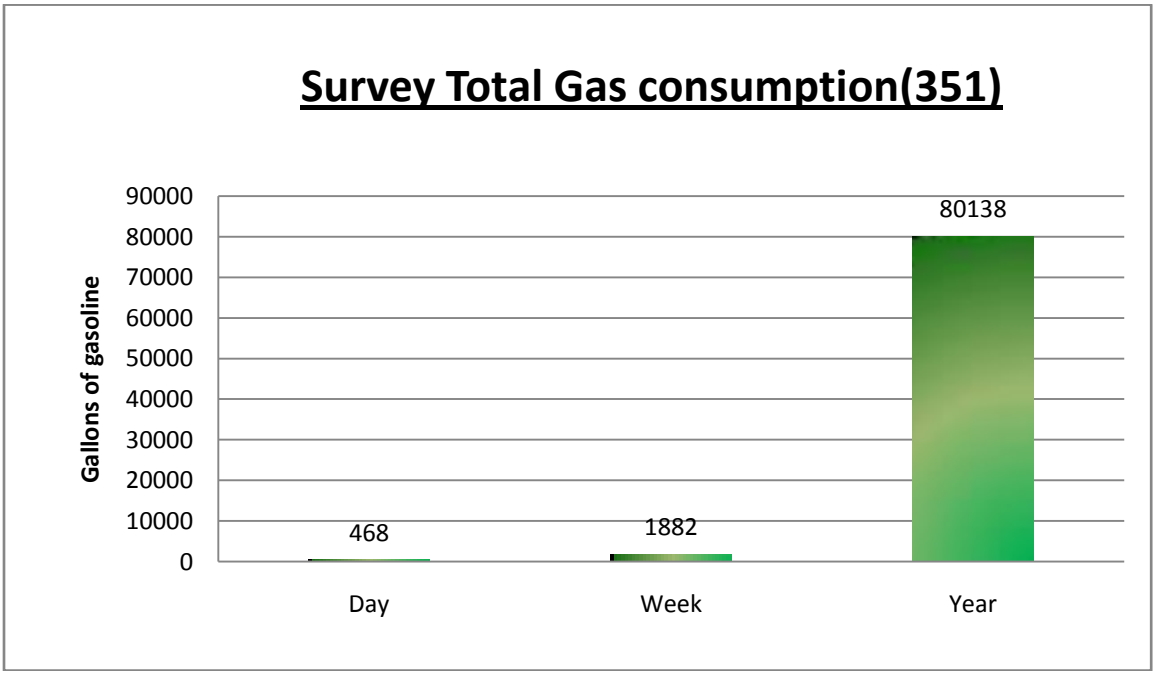

Weekly Money Spent
(Police/SNAP/Gateway Shuttle)
Dollars
180
160
140
120
100
80
60
40
20
0
53.25
21.18
54.81
163.65
103.47
31.5
Police 101C
Police 102C
Police 103C
SNAP Van #1
SNAP Van #2
Gateway Shuttle

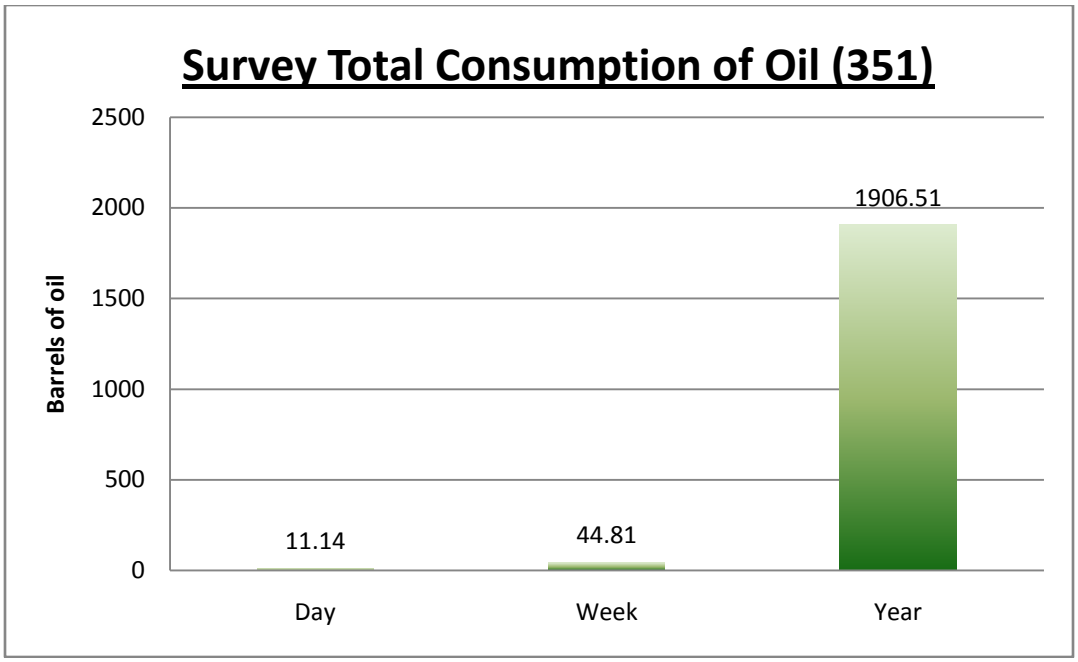


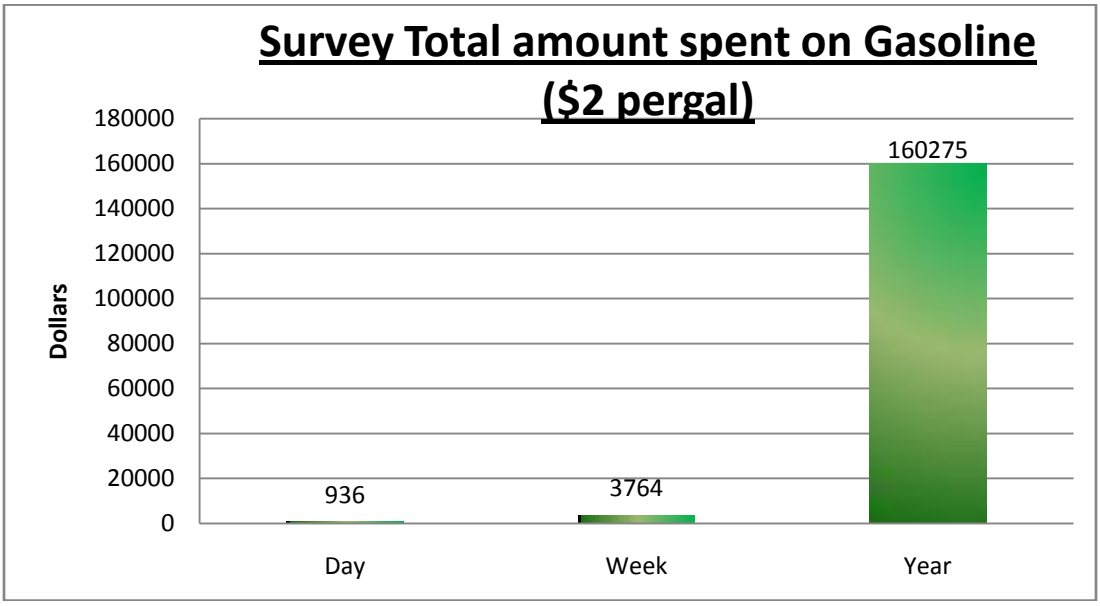
F-6 Total Survey (351)



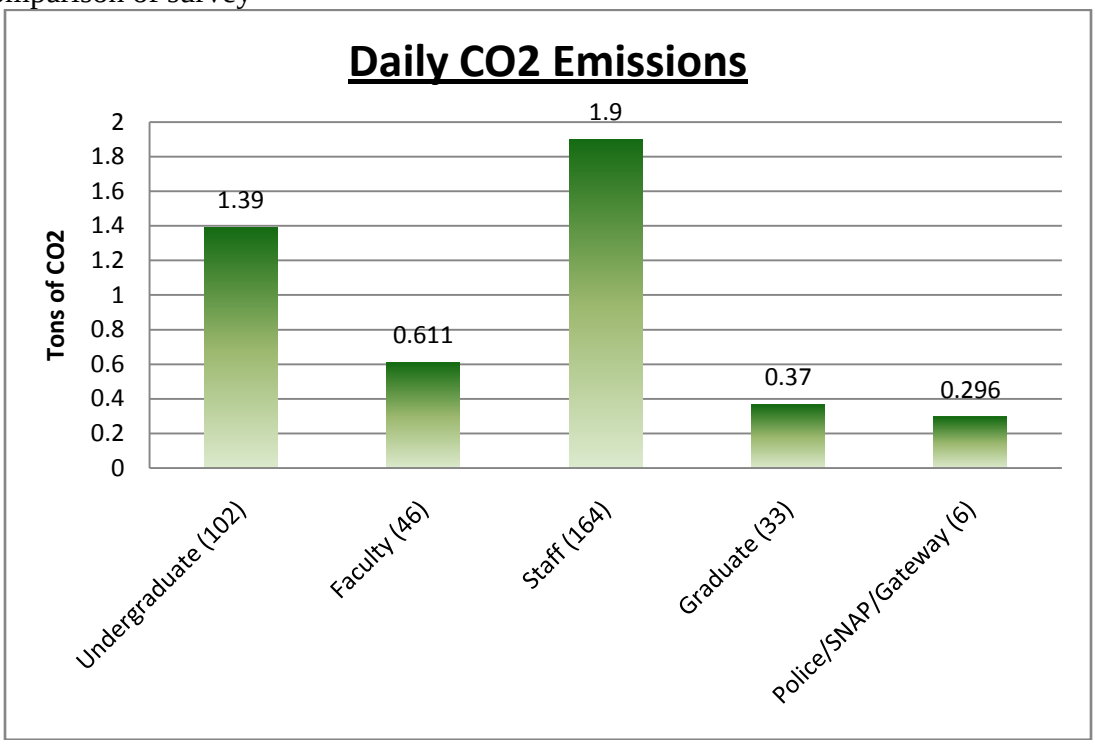

Survey Total CO2 (ton) Emissions (351 vehicles)
Tons of CO2
900
800
700
600
500
400
300
200
100
0
4.57
18.37
778.16
Day
Week
Year

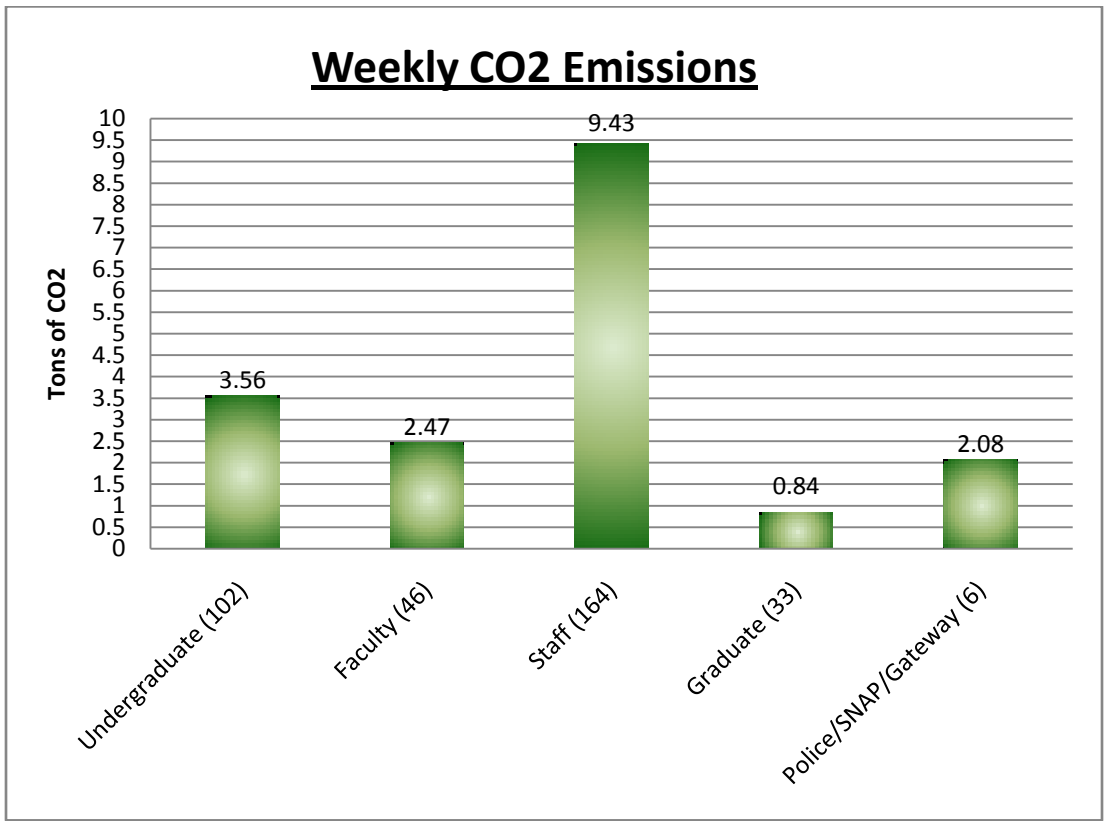

Survey Total Gas consumption(351)
Gallons of gasoline
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
468
1882
80138
Day
Week
Year

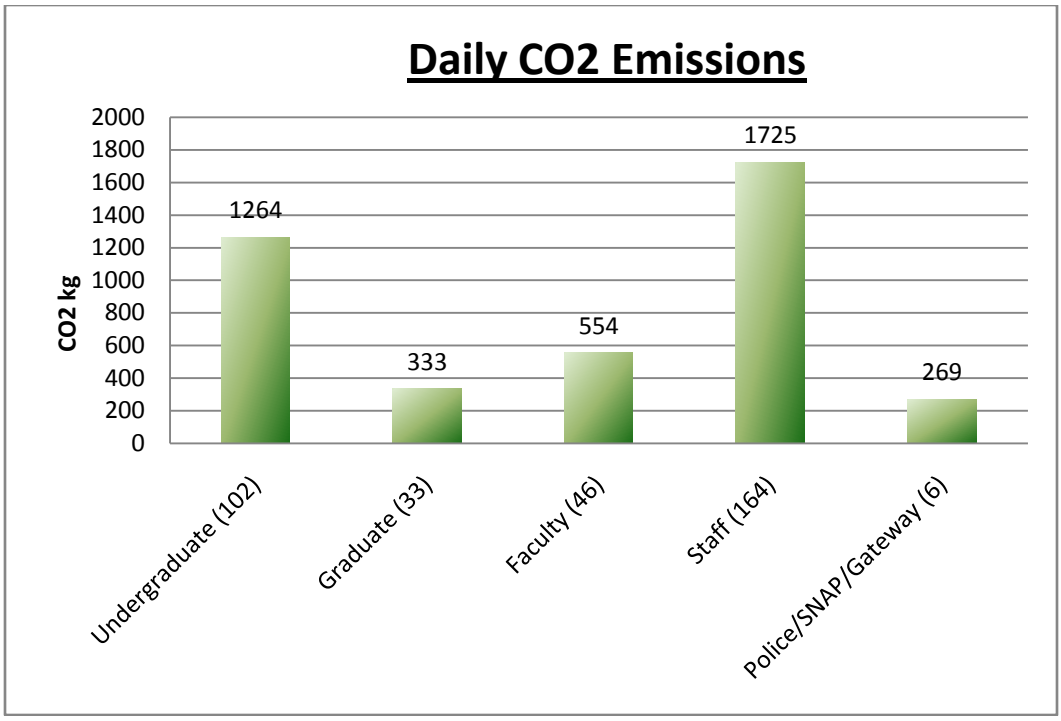

Survey Total Consumption of Oil (351)
Barrels of oil
2500
2000
1500
1000
500
0
11.14
44.81
1906.51
Day
Week
Year

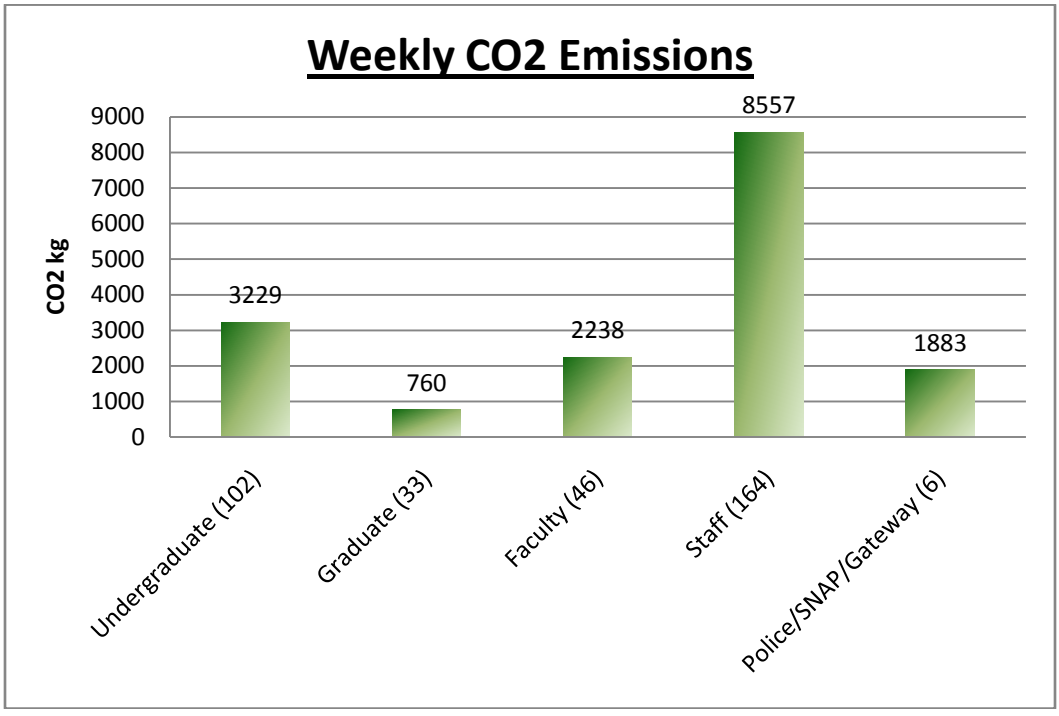

Survey Total amount spent on Gasoline ($2 pergal)
Dollars
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
936
3764
160275
Day
Week
Year

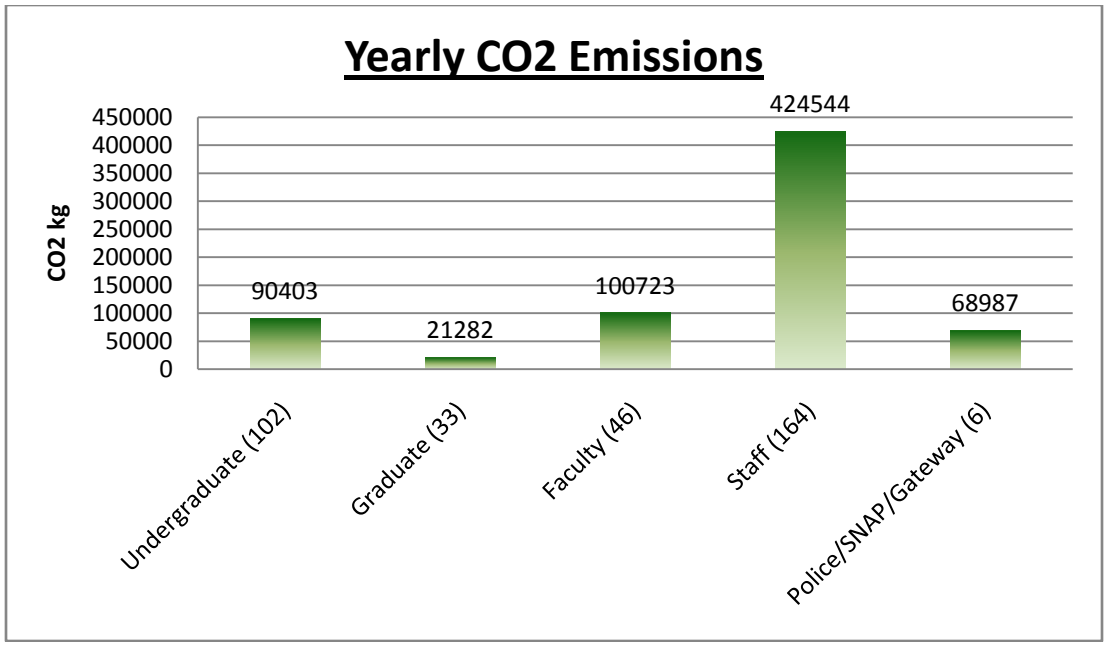
F-7 comparison of survey

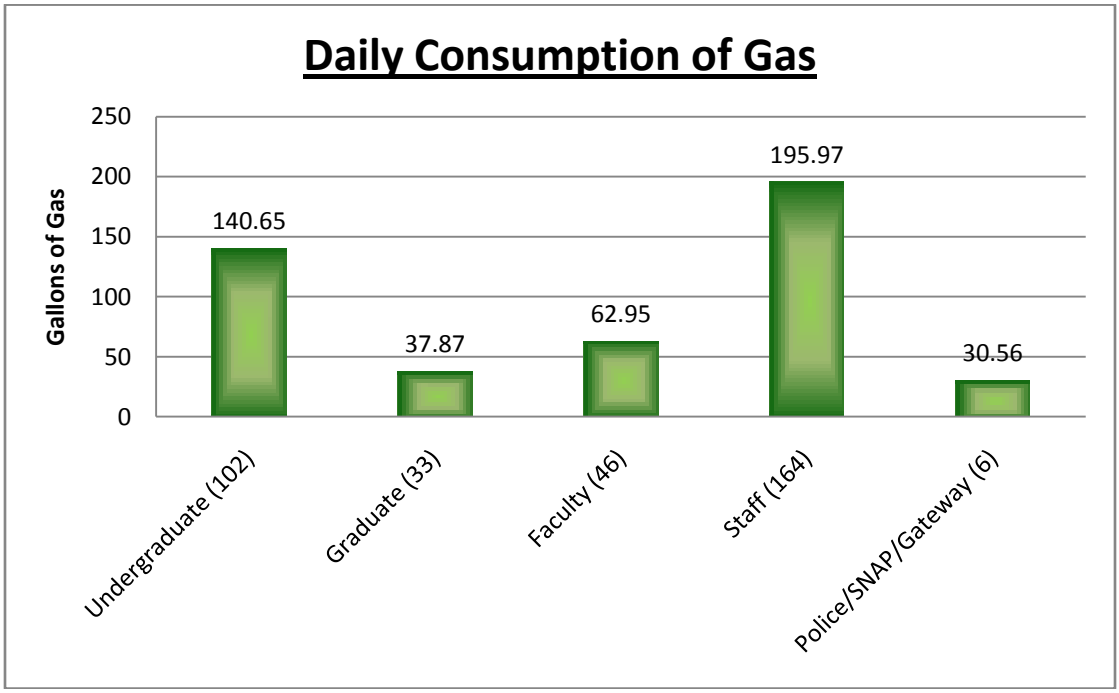


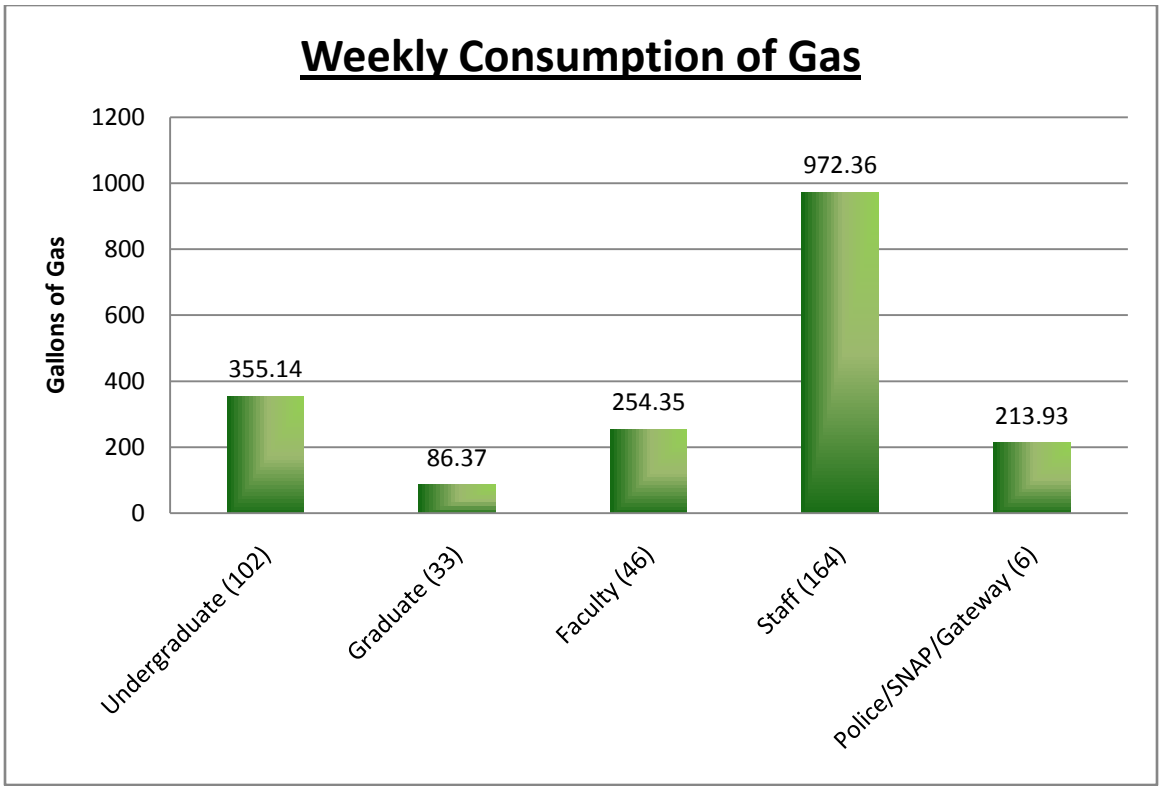


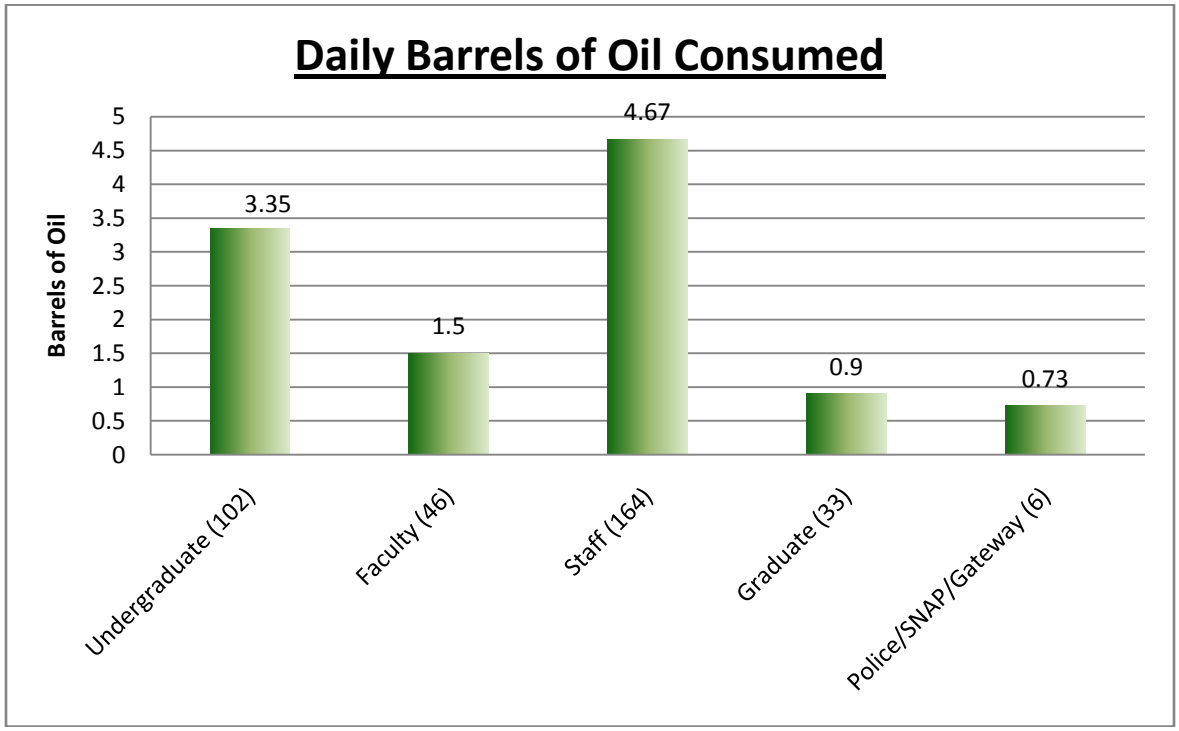

Daily CO2 Emissions
CO2 kg
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1264
333
554
1725
269
Undergraduate (102)
Graduate (33)
Faculty (46)
Staff (164)
Police/SNAP/Gateway (6)

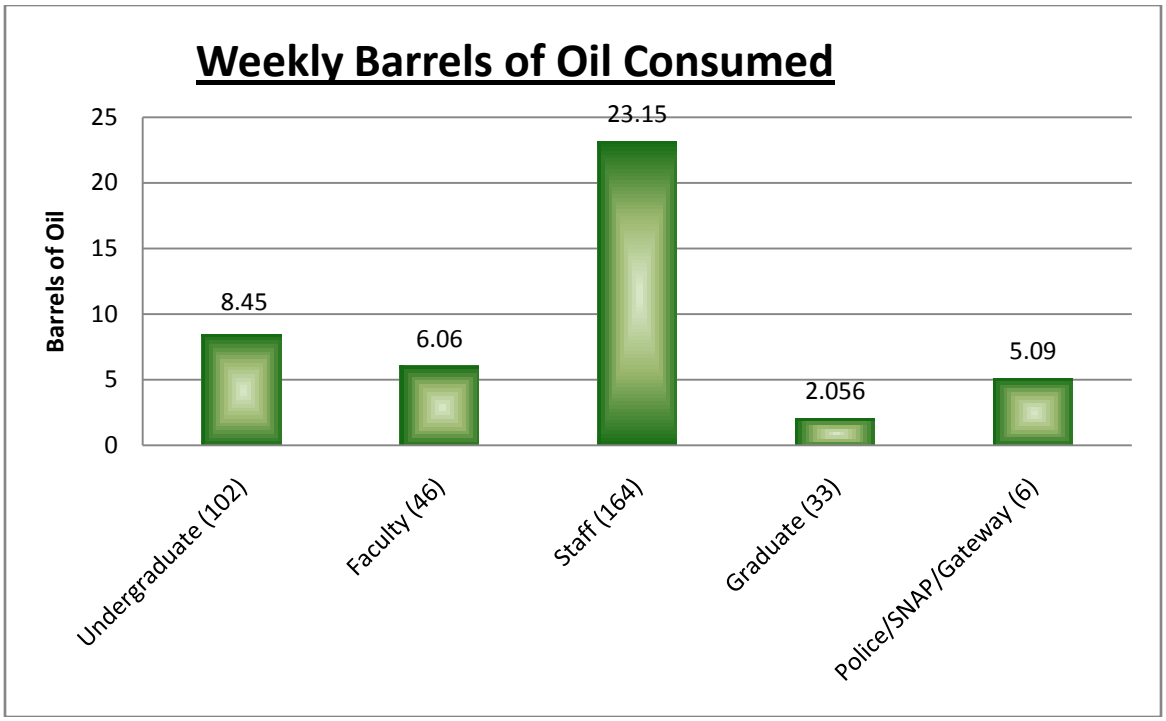

Weekly CO2 Emissions
CO2 kg
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
3229
760
2238
8557
1883
Undergraduate (102)
Graduate (33)
Faculty (46)
Staff (164)
Police/SNAP/Gateway (6)

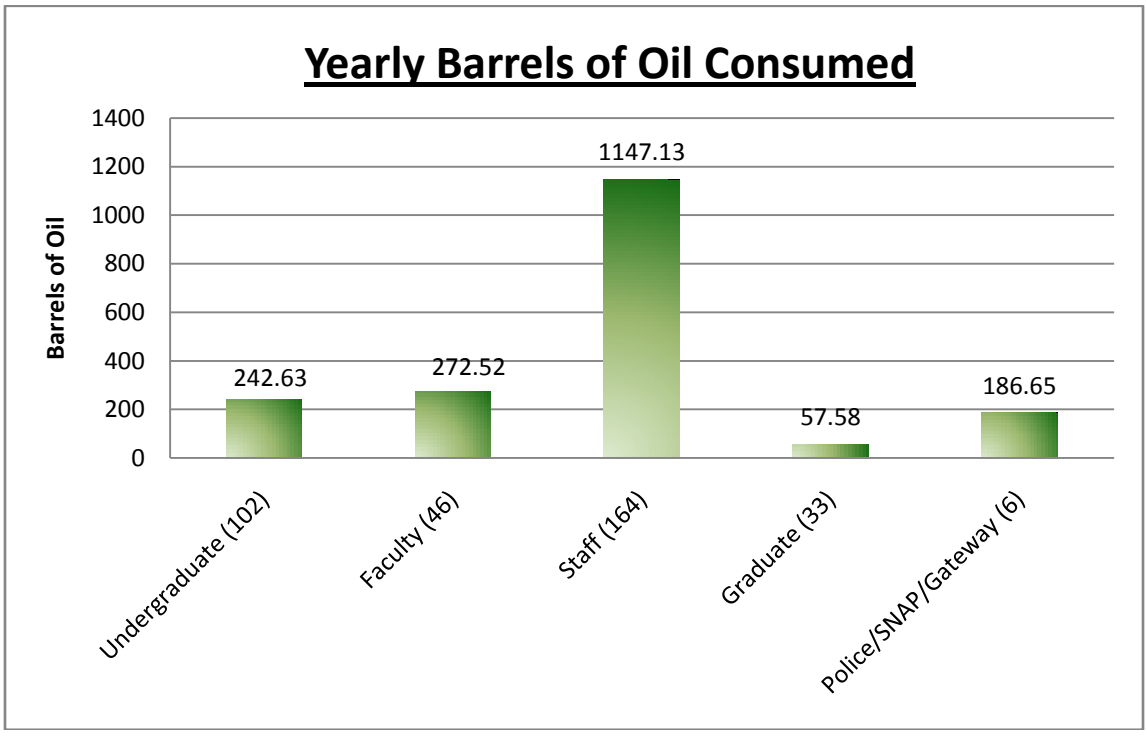

Yearly CO2 Emissions
CO2 kg
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
90403
21282
100723
424544
68987
Undergraduate (102)
Graduate (33)
Faculty (46)
Staff (164)
Police/SNAP/Gateway (6)

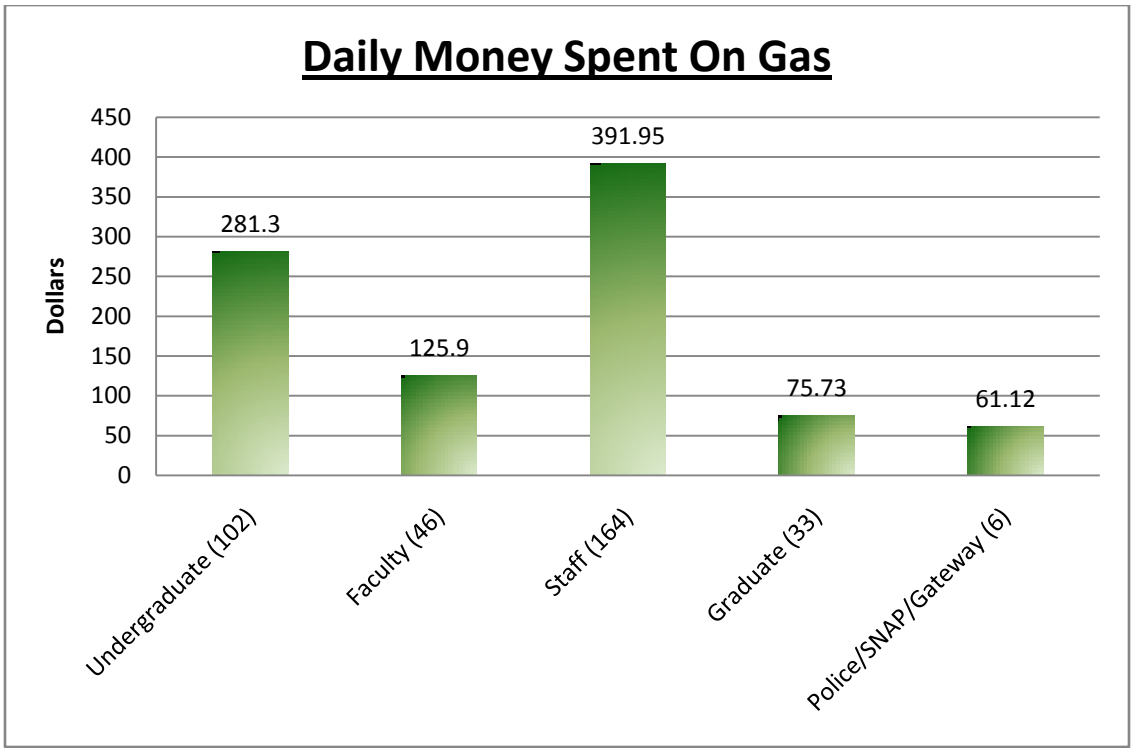

Daily Consumption of Gas
Gallons of Gas
250
200
150
100
50
0
140.65
37.87
62.95
195.97
30.56
Undergraduate (102)
Graduate (33)
Faculty (46)
Staff (164)
Police/SNAP/Gateway (6)

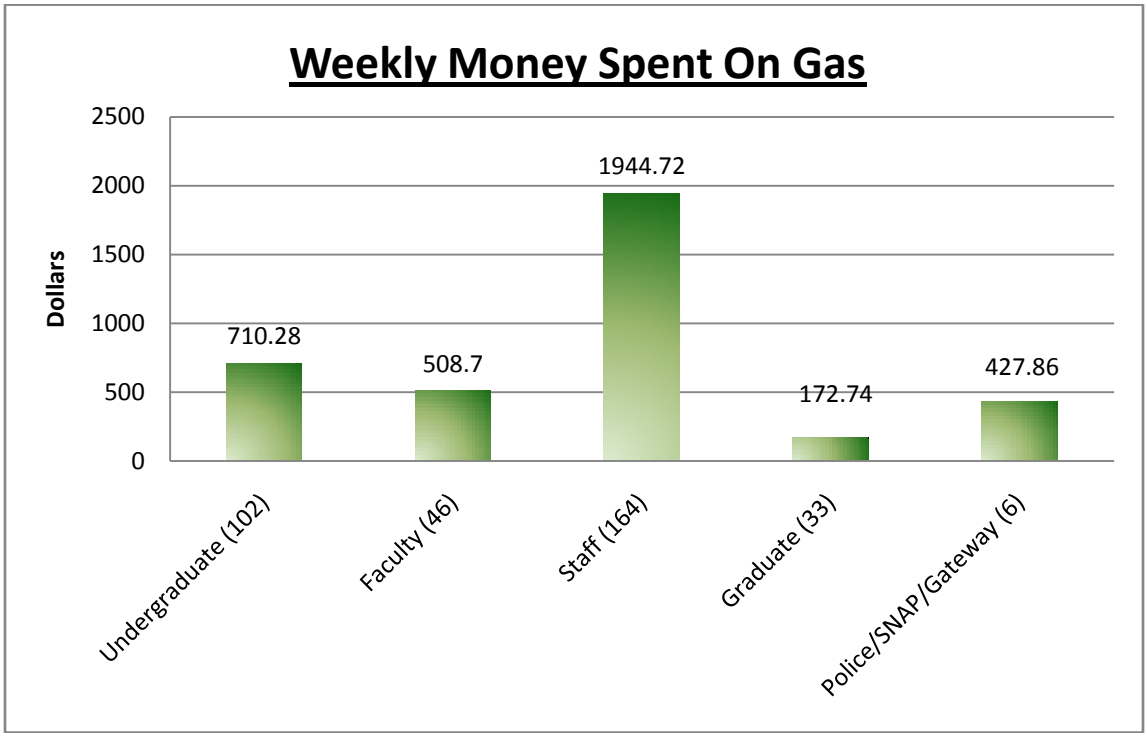

Weekly Consumption of Gas
Gallons of Gas
1200
1000
800
600
400
200
0
355.14
86.37
254.35
972.36
213.93
Undergraduate (102)
Graduate (33)
Faculty (46)
Staff (164)
Police/SNAP/Gateway (6)


Daily Barrels of Oil Consumed
Barrels of Oil
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
3.35
1.5
4.67
0.9
0.73
Undergraduate (102)
Faculty (46)
Staff (164)
Graduate (33)
Police/SNAP/Gateway (6)

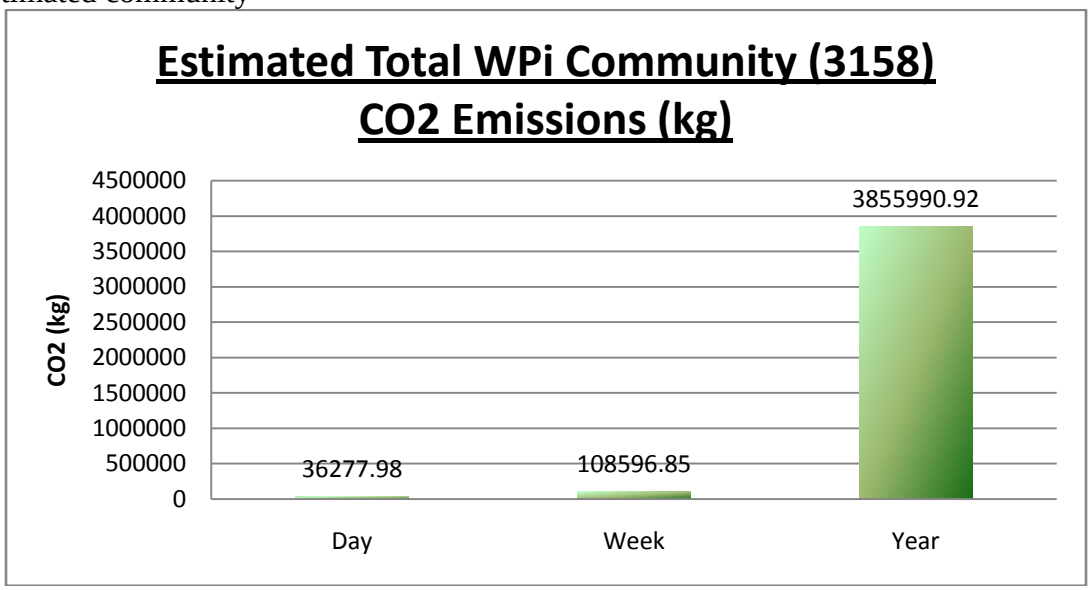

Weekly Barrels of Oil Consumed
Barrels of Oil
25
20
15
10
5
0
8.45
6.06
23.15
2.056
5.09
Undergraduate (102)
Faculty (46)
Staff (164)
Graduate (33)
Police/SNAP/Gateway (6)

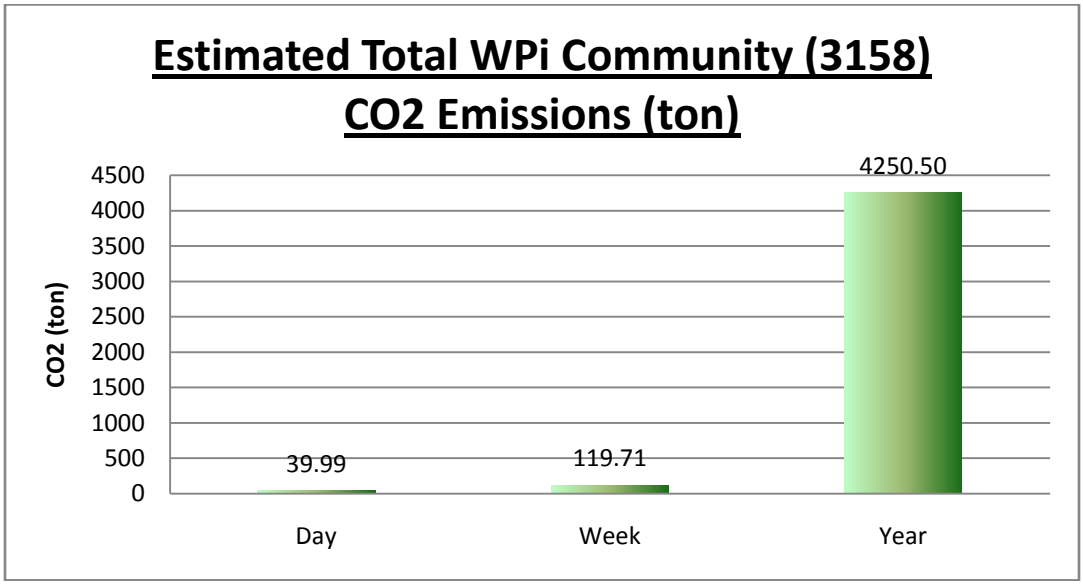

Yearly Barrels of Oil Consumed
Barrels of Oil
1400
1200
1000
800
600
400
200
0
242.63
272.52
1147.13
57.58
186.65
Undergraduate (102)
Faculty (46)
Staff (164)
Graduate (33)
Police/SNAP/Gateway (6)

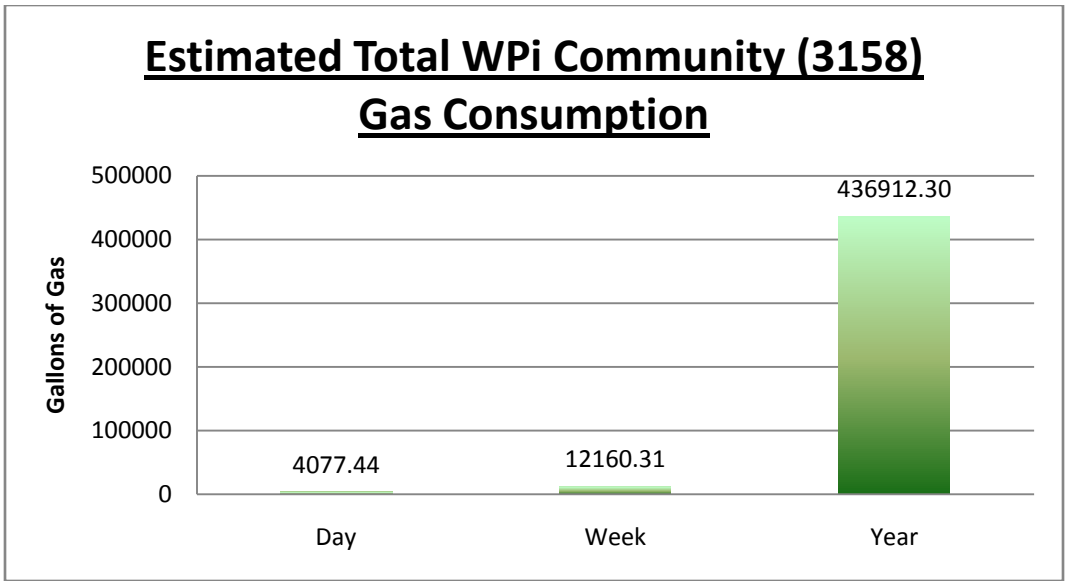

Daily Money Spent On Gas
Dollars
450
400
350
300
250
200
150
100
50
0
281.3
125.9
391.95
75.73
61.12
Undergraduate (102)
Faculty (46)
Staff (164)
Graduate (33)
Police/SNAP/Gateway (6)

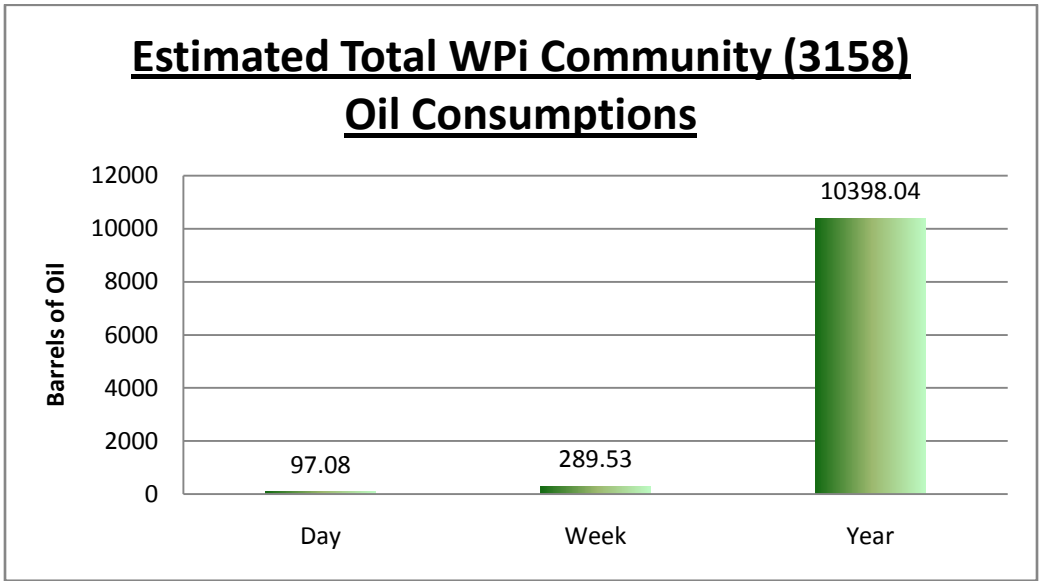

Weekly Money Spent On Gas
Dollars
2500
2000
1500
1000
500
0
710.28
508.7
1944.72
172.74
427.86
Undergraduate (102)
Faculty (46)
Staff (164)
Graduate (33)
Police/SNAP/Gateway (6)

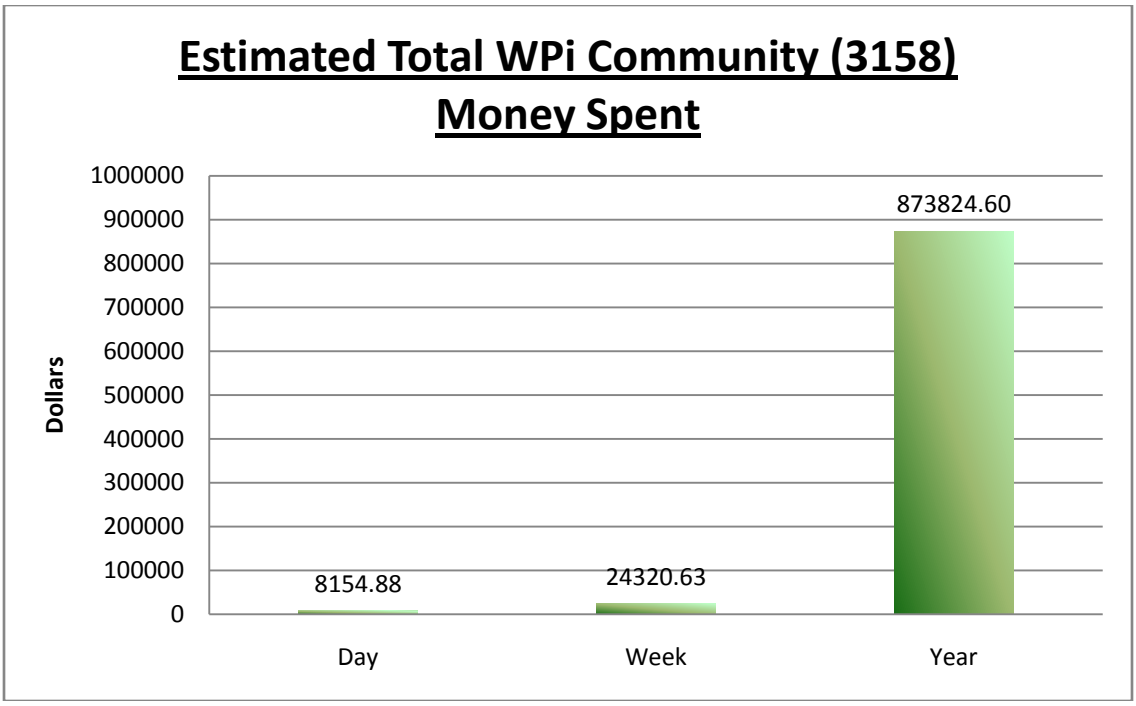
F-8 estimated community



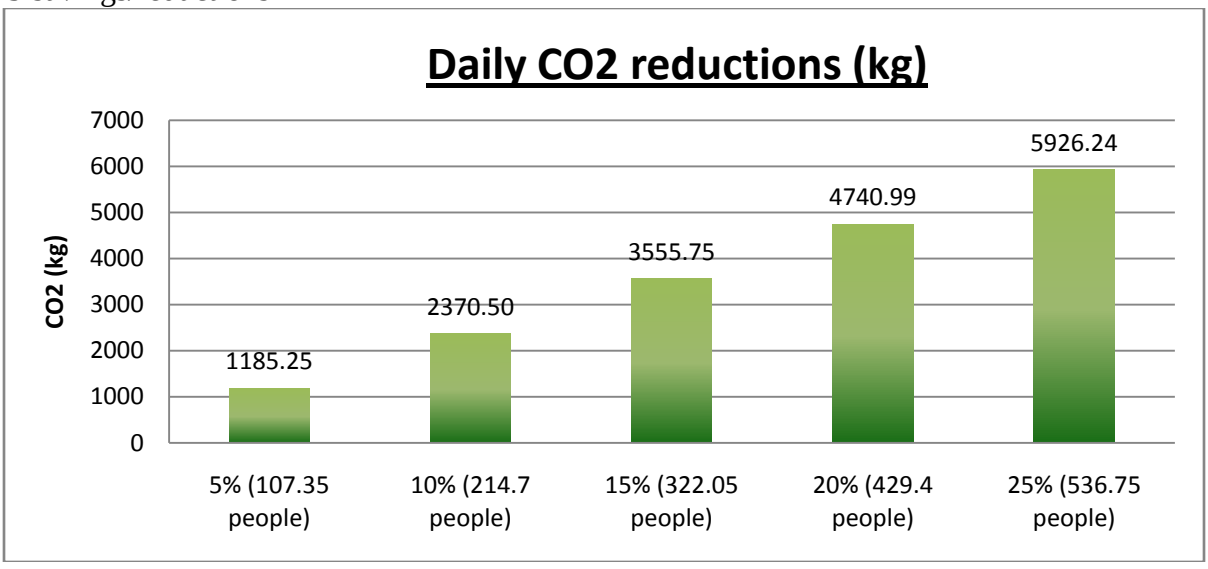


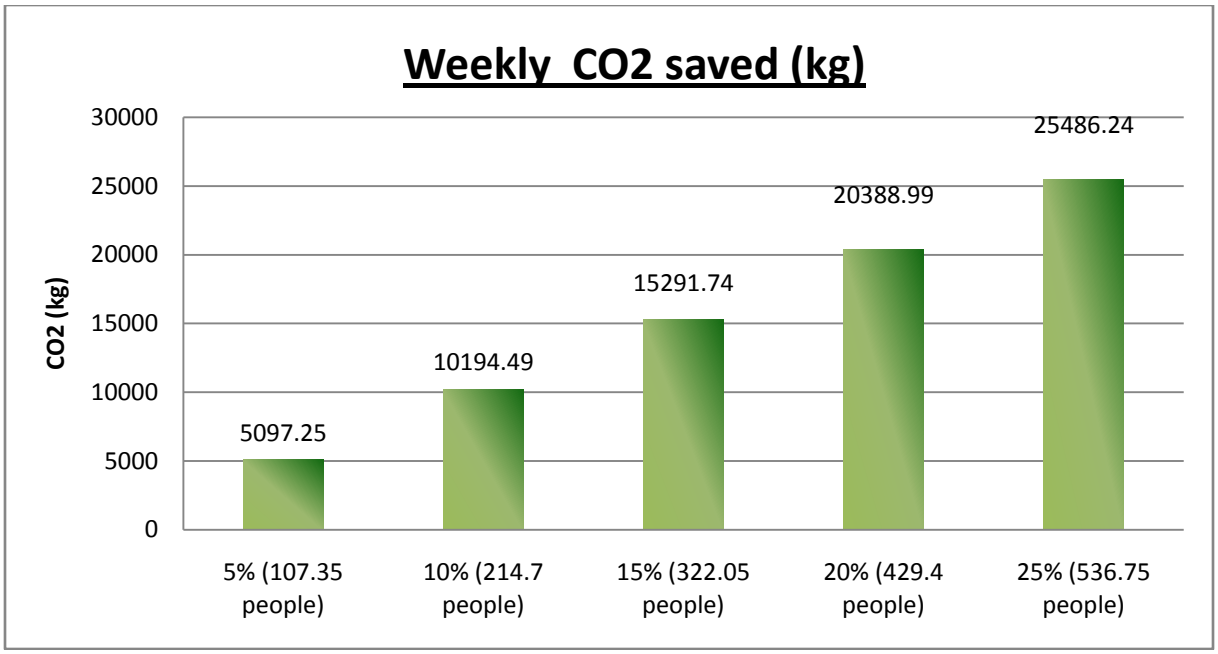

Estimated Total WPi Community (3158)
Gas Consumption
Gallons of Gas
500000
400000
300000
200000
100000
0
4077.44
12160.31
436912.30
Day
Week
Year

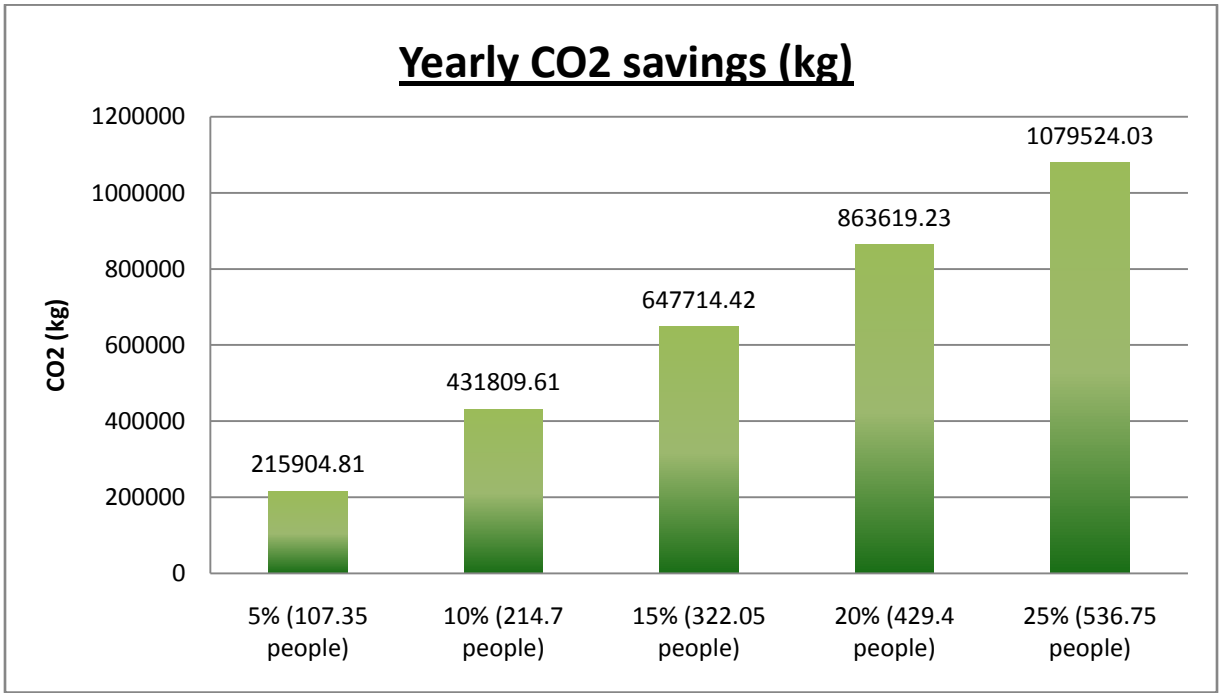

Estimated Total WPi Community (3158)
Oil Consumptions
Barrels of Oil
12000
10000
8000
6000
4000
2000
0
97.08
289.53
10398.04
Day
Week
Year

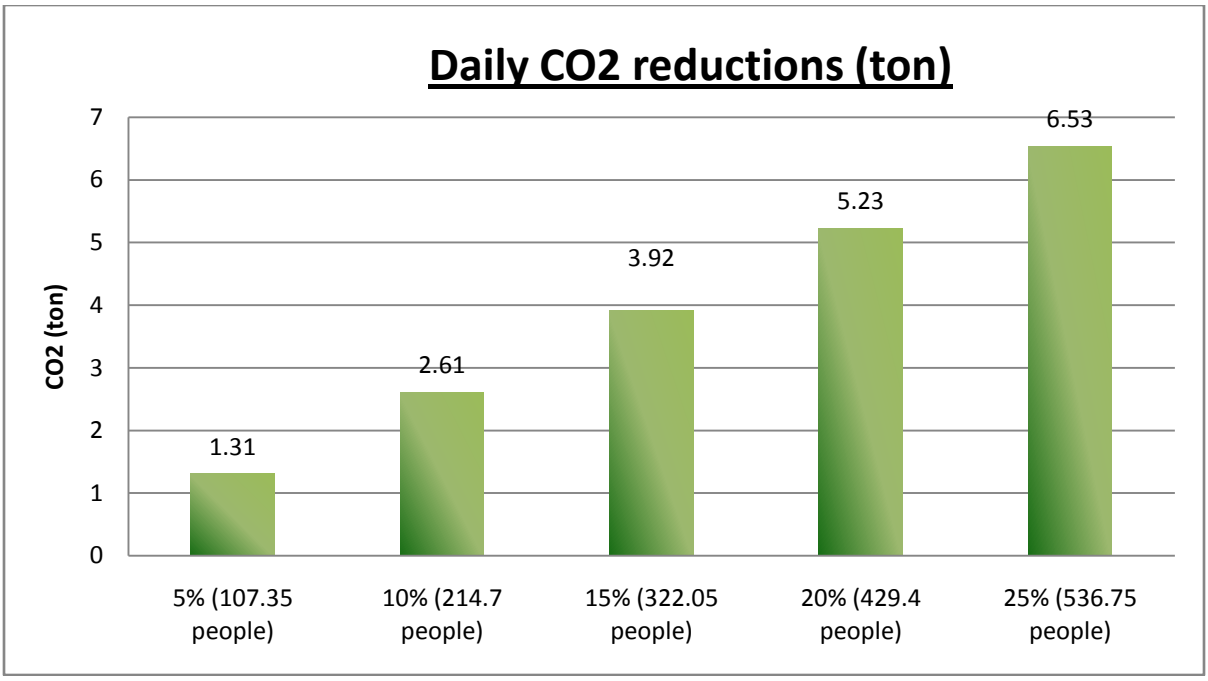


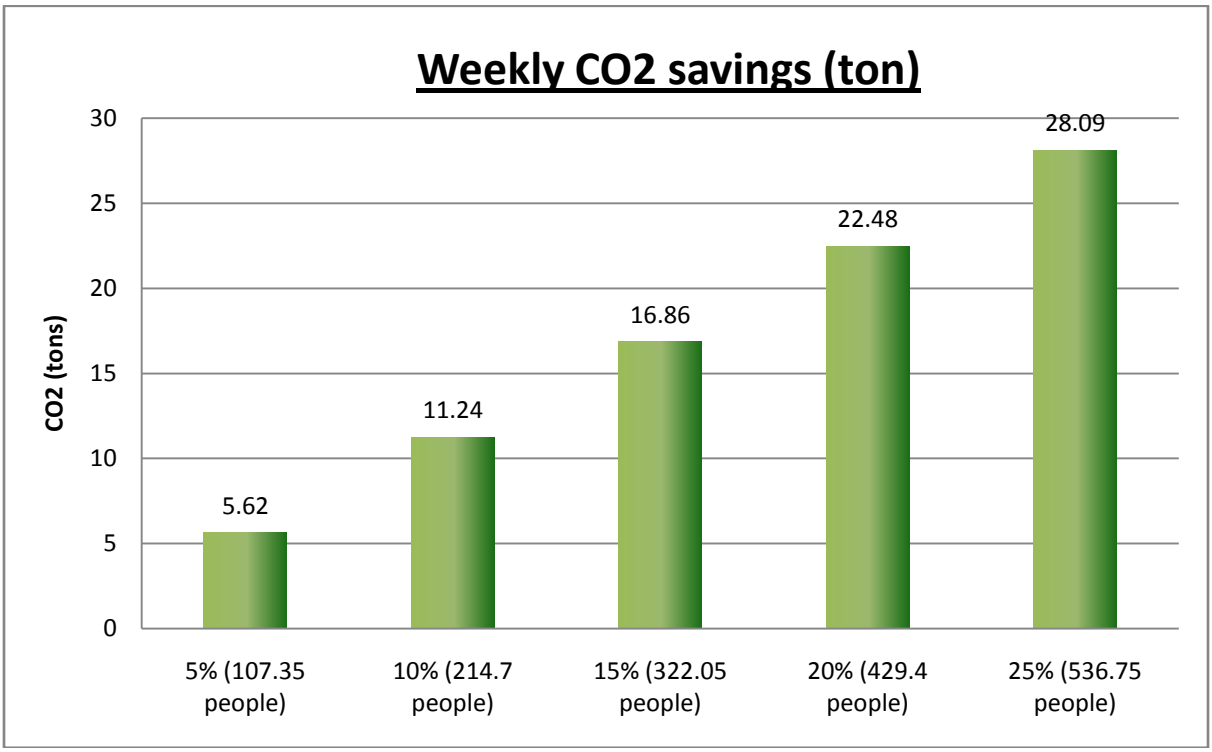
F-9 savings/reductions

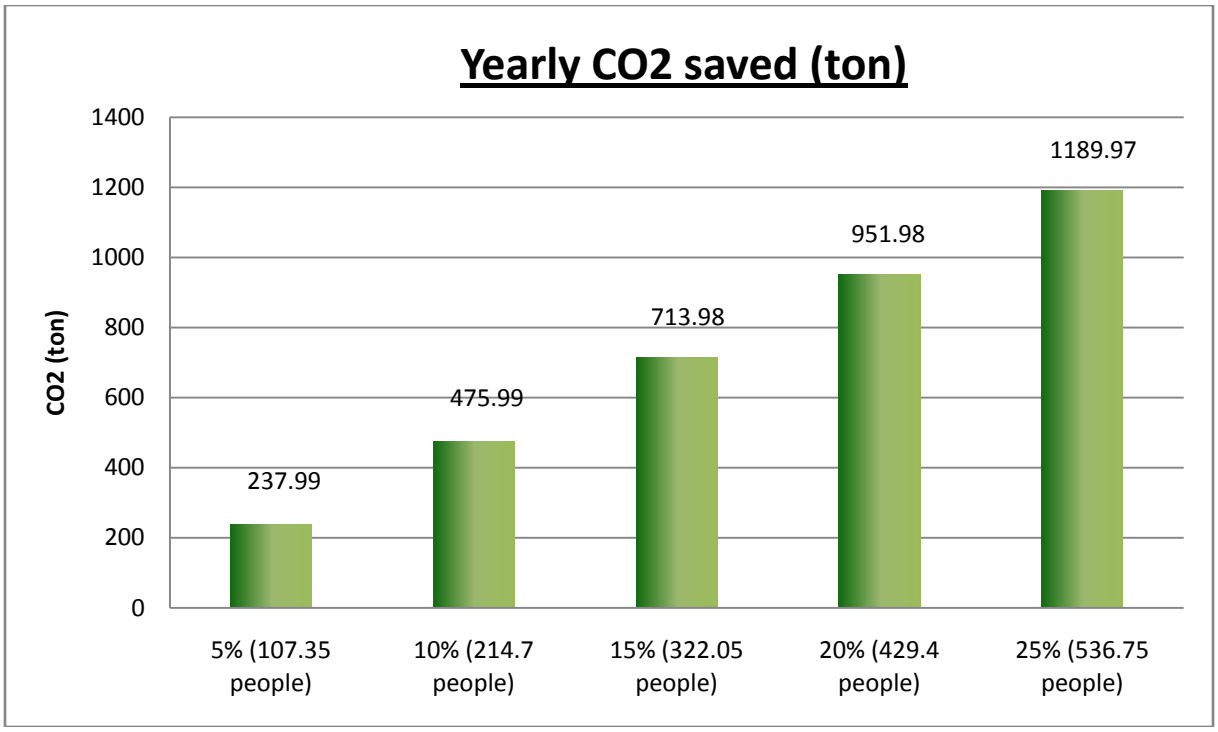


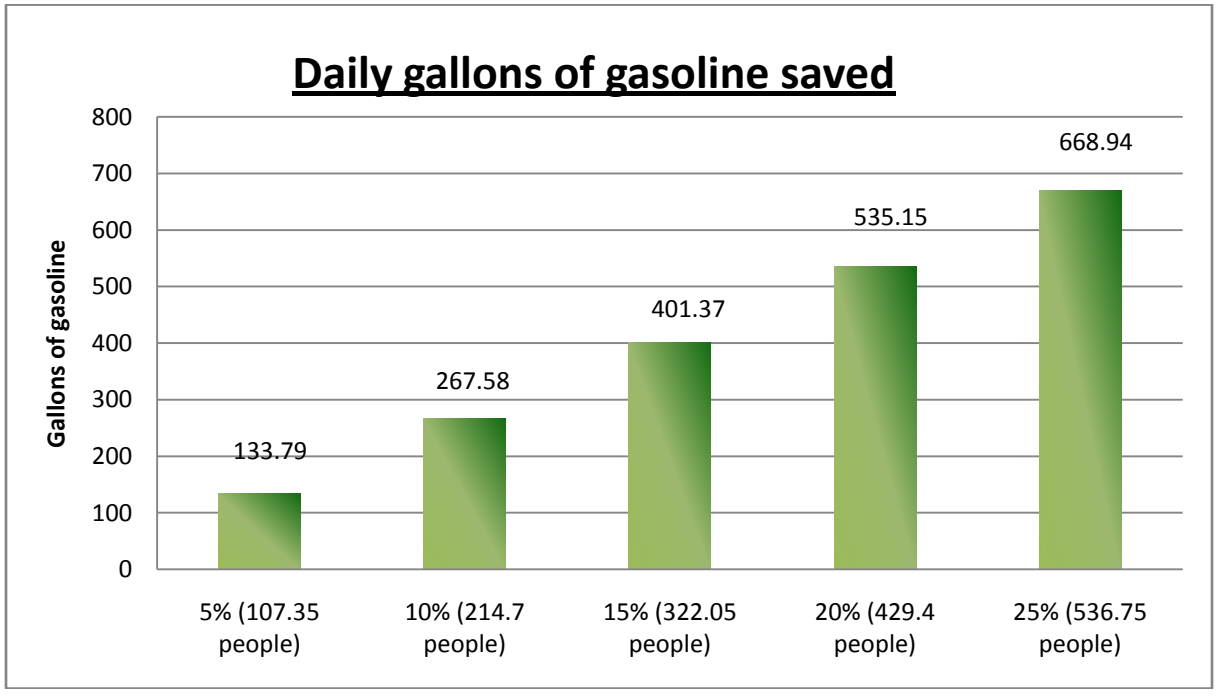

Weekly CO2 saved (kg)
CO2 (kg)
30000
25000
20000
15000
10000
5000
0
5097.25
10194.49
15291.74
20388.99
25486.24
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

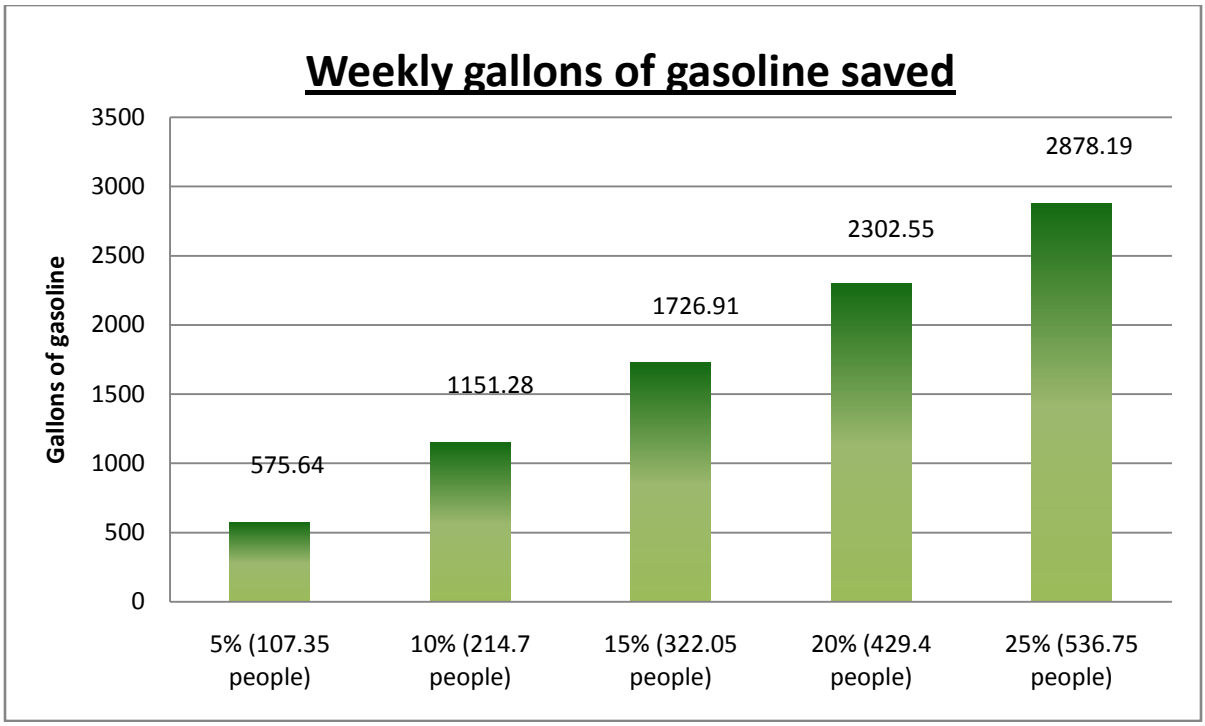

Yearly CO2 savings (kg)
CO2 (kg)
1200000
1000000
800000
600000
400000
200000
0
215904.81
431809.61
647714.42
863619.23
1079524.03
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

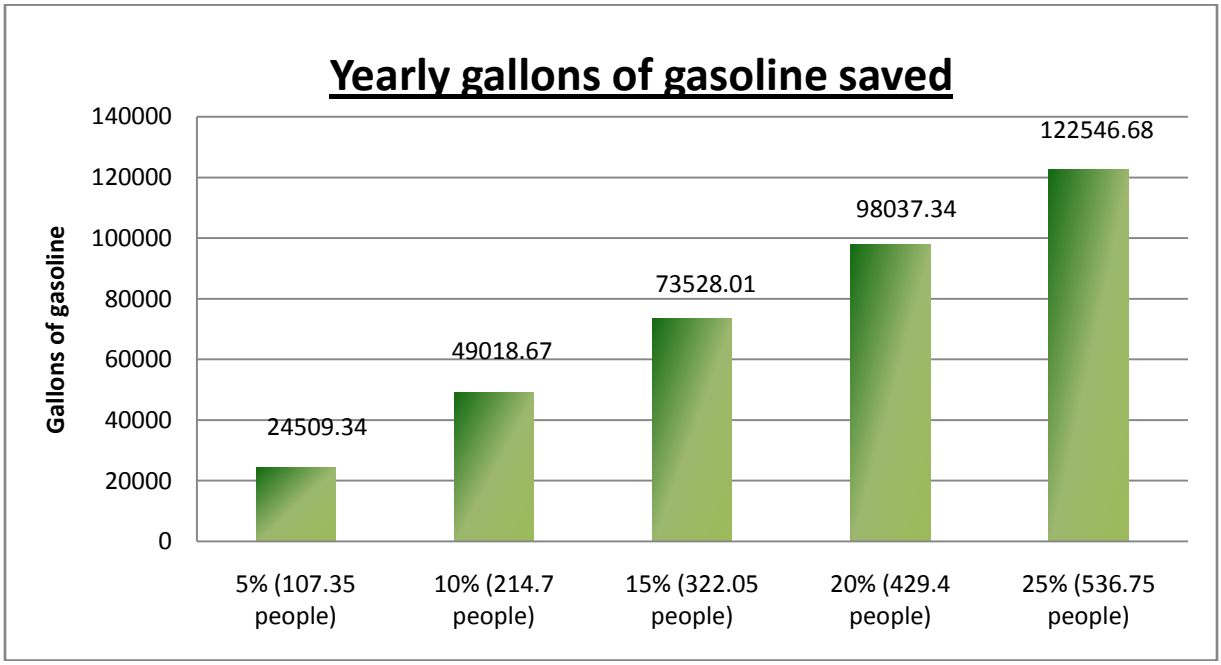

Daily CO2 reductions (ton)
CO2 (ton)
7
6
5
4
3
2
1
0
1.31
2.61
3.92
5.23
6.53
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

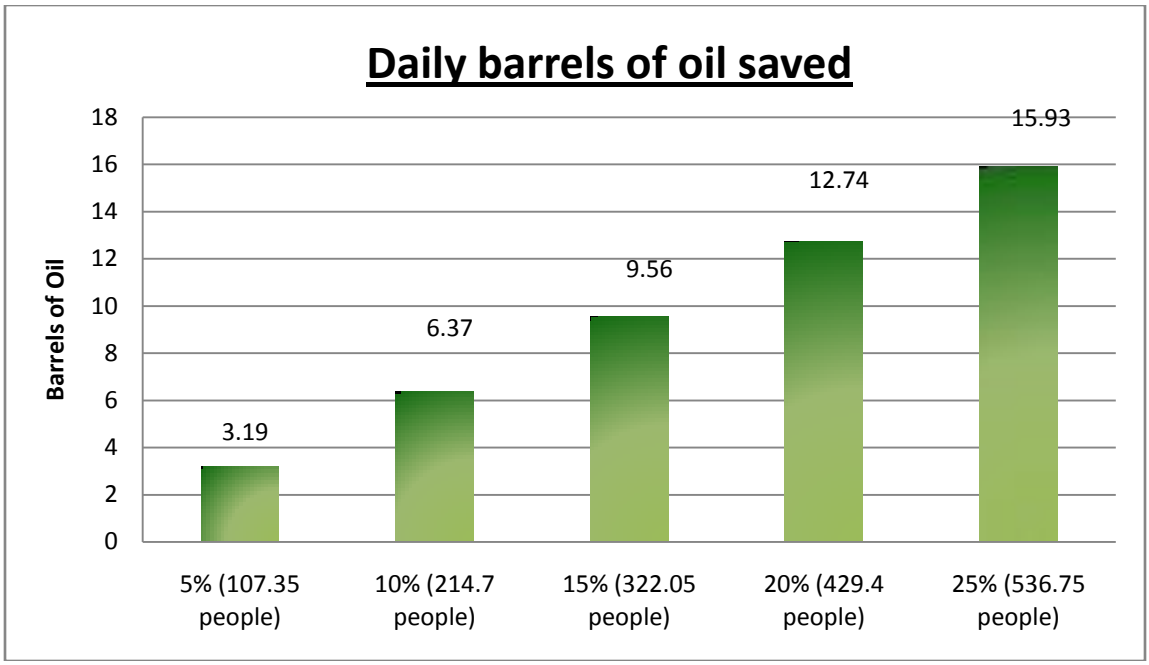

Weekly CO2 savings (ton)
CO2 (tons)
30
25
20
15
10
5
0
5.62
11.24
16.86
22.48
28.09
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

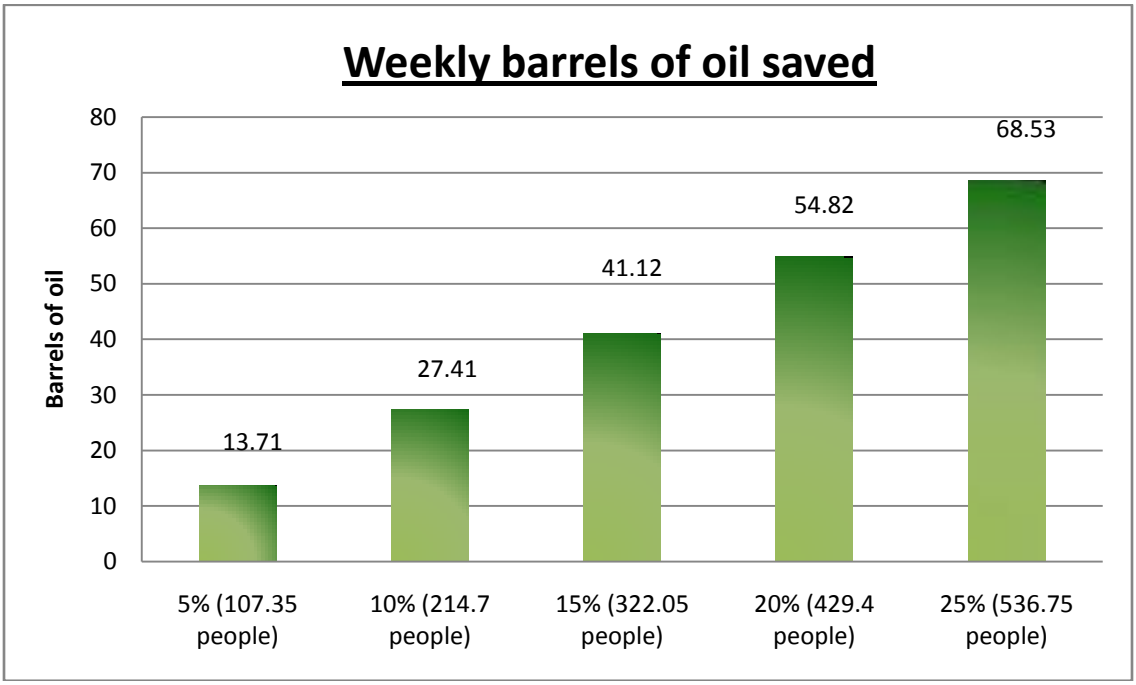

Yearly CO2 saved (ton)
CO2 (ton)
1400
1200
1000
800
600
400
200
0
237.99
475.99
713.98
951.98
1189.97
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

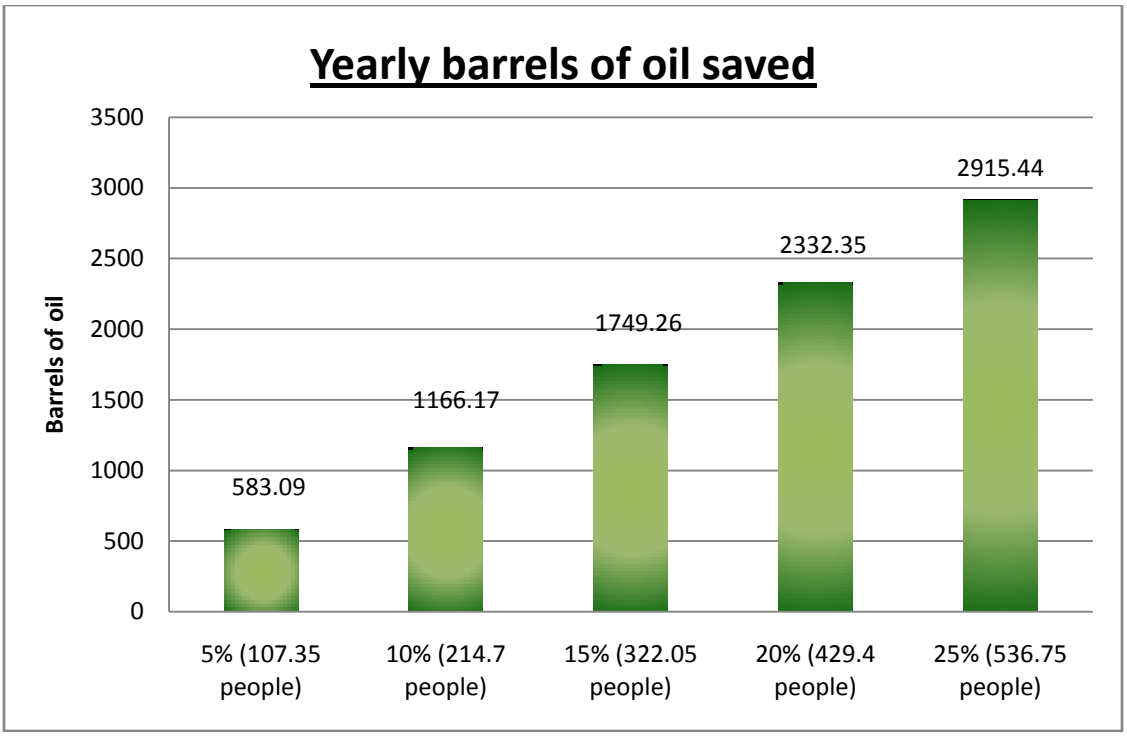

Daily gallons of gasoline saved
Gallons of gasoline
800
700
600
500
400
300
200
100
0
133.79
267.58
401.37
535.15
668.94
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

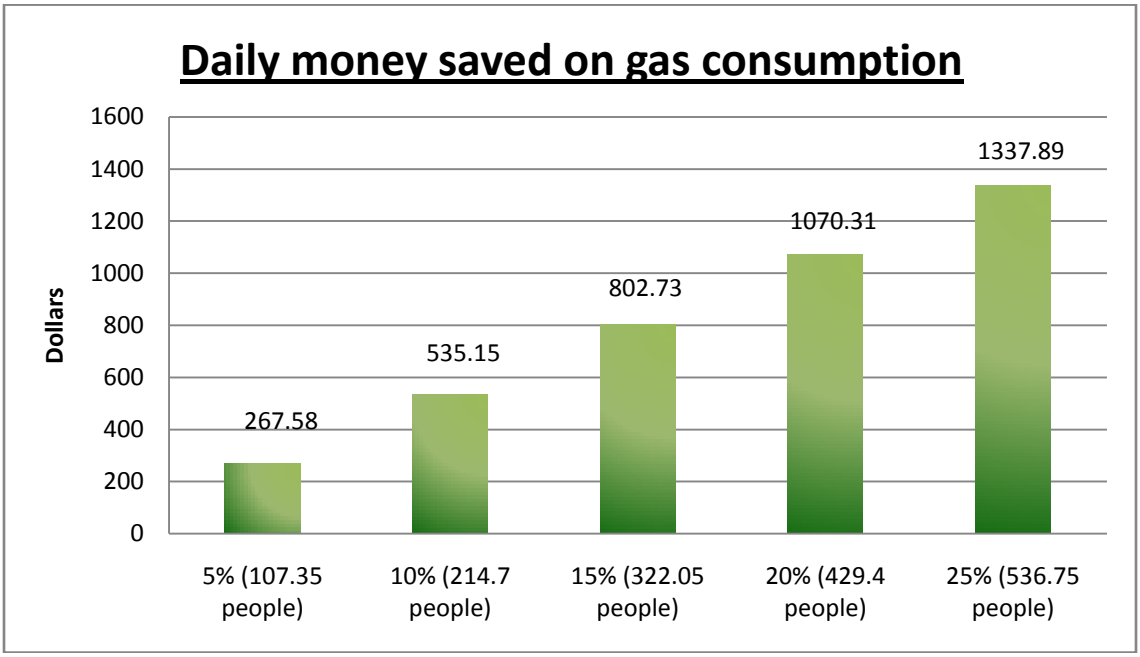

Weekly gallons of gasoline saved
Gallons of gasoline
3500
3000
2500
2000
1500
1000
500
0
575.64
1151.28
1726.91
2302.55
2878.19
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

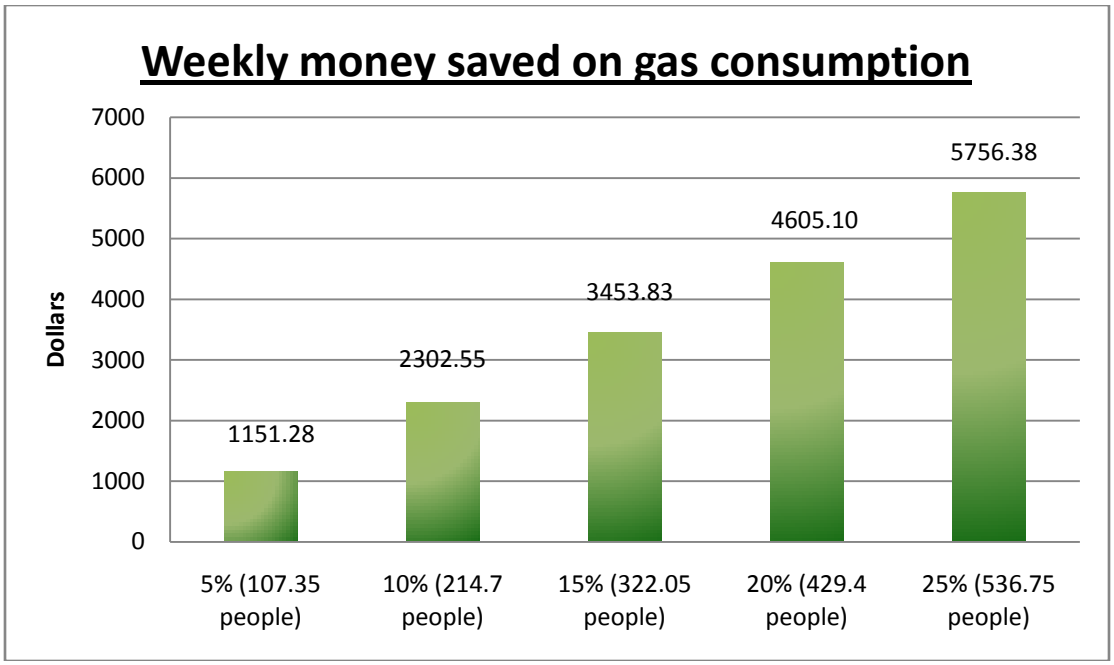

Yearly gallons of gasoline saved
Gallons of gasoline
140000
120000
100000
80000
60000
40000
20000
0
24509.34
49018.67
73528.01
98037.34
122546.68
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)

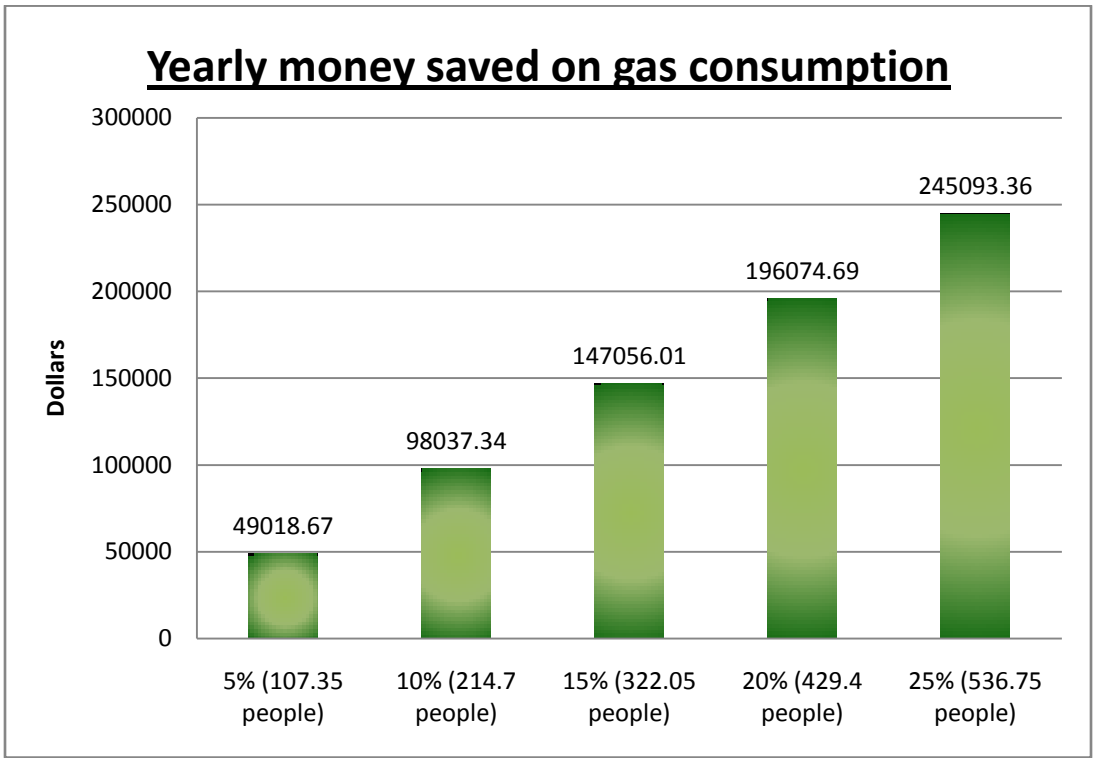

Daily barrels of oil saved
Barrels of Oil
18
16
14
12
10
8
6
4
2
0
3.19
6.37
9.56
12.74
15.93
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)


Weekly barrels of oil saved
Barrels of oil
80
70
60
50
40
30
20
10
0
13.71
27.41
41.12
54.82
68.53
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)


Yearly barrels of oil saved
Barrels of oil
3500
3000
2500
2000
1500
1000
500
0
583.09
1166.17
1749.26
2332.35
2915.44
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)


Daily money saved on gas consumption
Dollars
1600
1400
1200
1000
800
600
400
200
0
267.58
535.15
802.73
1070.31
1337.89
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)


Weekly money saved on gas consumption
Dollars
7000
6000
5000
4000
3000
2000
1000
0
1151.28
2302.55
3453.83
4605.10
5756.38
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)


Yearly money saved on gas consumption
Dollars
300000
250000
200000
150000
100000
50000
0
49018.67
98037.34
147056.01
196074.69
245093.36
5% (107.35 people)
10% (214.7 people)
15% (322.05 people)
20% (429.4 people)
25% (536.75 people)