Towards Carbon Neutrality at Indiana University

Campus Greenhouse Gas Inventory and Emission Reduction Strategy Analysis

Jonathan Brooks Bell
IU Sustainability Intern

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Abbreviations and Notations

The following abbreviations and notations are used throughout this report:

GHG – Greenhouse Gas

GWP – Global Warming Potential

CO_2 – Carbon Dioxide

CH_4 – Methane

N_2O – Nitrous Oxide

eCO_2 – Carbon Dioxide Equivalence

IUB – Indiana University, Bloomington (main campus)

CHP – Central Heating Plant (at IUB)

CA-CPCCC – Clean Air-Cool Planet Campus Carbon Calculator

WRI – World Resources Institute

ACUPCC – American College and University Presidents Climate Commitment

EPA – Environmental Protection Agency

MMBtu – Million Btu (energy unit)

Kg – Kilogram (mass unit)

FY – Fiscal Year

Ton – Greenhouse gases measured in metric tons; coal/landfill waste measured in short tons

Executive Summary

Global climate change is one of the most important issues facing society. This phenomenon has been linked to the increase in the atmospheric concentration of greenhouse gases including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), as well as other gases. Furthermore, it has been shown that this increase in greenhouse gas concentrations is at least partially due to human activity. Without drastic intervention, the increase in greenhouse gases could produce irreversible consequences. Indiana University bears a particular responsibility to address this problem. The institution's commitment to research, outreach, and progress makes it a prime candidate for the implementation of emission reducing strategies.

The greenhouse gas emissions from Indiana University (Bloomington campus) were estimated using the Clean Air-Cool Planet Campus Carbon Calculator for the fiscal years 1990 through 2006. These emissions were calculated in Carbon Dioxide Equivalence (eCO_2). Emissions were highest in the fiscal year 2003 at 439,669 metric tons eCO_2. Emissions were also analyzed by source and scope. Scope 1 emissions (primarily on-campus stationary emissions from the IUB central heating plant) fluctuated often with no predictable pattern. Scope 2 emissions (emissions related to purchased electricity) increased at a predictable, linear rate. Scope 3 emissions (transportation emissions) decreased at a steady, linear rate. This decrease was attributed to increased fuel efficiencies in personal vehicles and campus buses.

In addition to a campus-wide greenhouse gas inventory, predictions were made of future emissions. These predictions were made under the assumption that emissions would increase at a steady, linear rate. The predictions show that, under current practices, emissions could reach nearly 500,000 metric tons of eCO_2 by 2020.

Several emission reduction goals were analyzed to determine the extent at which Indiana University must reduce its emissions each year to reach various levels of emission reduction. Particularly, the effect of a carbon tax was analyzed and it was determined that the carbon tax must be at least $887.9 per ton of carbon for Indiana University to be economically bound to reduce Scope 1 emissions by switching from coal to natural gas. For this reason, it was determined that any significant decrease in emissions at Indiana University will most likely be the result of voluntary action with little economic pressure.

If Indiana University hopes to maintain its reputation as a world-class research institution dedicated to societal progress, it must realize its responsibility to set an example for aggressive emission reduction strategies and goals. With this accomplished, the university will have made significant strides in the fight against global climate change.

1.0 Introduction – IU's Role in the Fight Against Climate Change

Greenhouse gases (GHGs) are responsible for the greenhouse effect which traps the sun's radiation and warms the earth. Venus, the second closest planet to the sun, is considerably warmer than Mercury, the closest planet to the sun, simply because Venus has a much denser atmosphere than Mercury. Earth may not be as warm as Venus, but it is clear that if current trends continue Earth may reach temperatures that will drastically upset ecosystems across the planet through rising sea levels, through increasing severity of natural disasters, etc.

Human activity has been linked to an increase in the atmospheric concentration of greenhouse gases. Without drastic intervention, these concentrations will continue to increase. For this reason it is necessary to monitor the concentration of greenhouse gases. This is difficult, if not impossible, to do through direct atmospheric measurements. Estimations must be made using data related to fuel usage, transportation methods, and other sources.

Indiana University, Bloomington, IN

<www.music.indiana.edu/.../SAMPLEGATES01.jpg>

As a public university, Indiana University bears a particular responsibility to further the progress of the local, state, and national communities. Global climate change is one of the most important issues facing society. Indiana University's expertise and resources make it a particularly relevant location for research into climate change. Also, Indiana University can serve as a model of sustainability for local, state, and national entities. If Indiana University can successfully identify emissions, reduce emissions, and set a reasonable goal for carbon neutrality, it will be a large step forward in the fight against global climate change.

2.0 Statement of Purpose

The purpose of this project is to improve environmental sustainability at IUB by:

1. Developing a greenhouse gas inventory
2. Using the inventory to predict future emissions
3. Identifying methods to significantly reduce emissions

3.0 Background Research

Before an accurate greenhouse gas inventory could be compiled, research was performed on greenhouse gases, carbon calculators, and the greenhouse gas inventory previously compiled at IUB in 2007. This research was done in an effort to come to a better understanding of the challenges presented by compiling a greenhouse gas inventory.

3.1 Greenhouse Gases and the Greenhouse Effect

Greenhouse gases are responsible for the greenhouse effect, a process that traps ultraviolet light from the sun in the earth's atmosphere. This process is necessary to keep the earth warm enough for sustainable life to exist. However, if there is a drastic increase in the concentration of greenhouse gases, the earth can become overheated.

The earth is, undoubtedly, getting warmer. According to the IPCC's Climate Change 2007: Synthesis Report, "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Bernstein et al 30). Furthermore, the warming of the earth is at least partially due to human behavior that has increased atmospheric concentrations of greenhouse gases: "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations" (39).

There are numerous greenhouse gases present but only a few of these have a substantial effect on the atmosphere. These are the "long-lived greenhouse gases" and include Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and halocarbons (37). Any greenhouse gas inventory should include these important gases.

3.2 Carbon Calculators

Since it is nearly impossible to measure directly the greenhouse gas emissions from an institution as large as IUB, a carbon calculator must be used to estimate greenhouse gas emissions. Six types of carbon calculators were considered.

Method	Pros	Cons
Clean Air-Cool Planet Campus Carbon Calculator	- Recommended by ACUP - Recommended by EPA - Extensive inventory - Designed for universities - Used by ACUPCC signatories	- Requires extensive data - Used before
WRI Protocol	- Recommended by ACUP - Used by Harvard after CACP	- Not ACUP's first choice - Designed for businesses - Less user-friendly
Climate Action Registry Reporting Online Tool	- Recommended by ACUP - Allows for certification - Easy-to-use online interface	- Not ACUP's first choice - Not designed for universities

Harvard Template	- Very simple data input	- Not very extensive
City of Bloomington's Tool	- Simple data interface	- Requires modifications to apply to IU
Develop In-House Estimator	- Would be most accurate - Designed specifically for IU - Contacts could assist	- Could be very difficult - Most time consuming - Might not be feasible

Table 1: Pros and Cons of Inventory Methods

After reviewing the current methods of greenhouse gas estimation used by colleges, universities, and businesses throughout the U.S., it became evident that the Clean Air Cool Planet Inventory Calculator would provide the most comprehensive and feasible estimation for Indiana University. The calculator is recommended specifically by the ACUPCC team:

> The ACUPCC team has recommended the Clean Air Cool Planet Inventory Calculator because it is based on GHG Protocol methodology, but adapted for campus use. It has been designed to be used by an undergraduate or graduate level student, intern, or employee in a semester or less […] It is our belief that the Campus Carbon Calculator is the most user-friendly and appropriate tool currently available for application in the higher education context. (American College and University Presidents Climate Commitment 5)

Numerous signatories of the ACUPCC including Duke University, Middlebury College, University of New Hampshire, University of Pennsylvania, and Connecticut College as well as schools that have not signed the ACUPCC such as Harvard University, Colby College and University of Connecticut have used Clean Air-Cool Planet successfully. By using Clean Air-Cool Planet, IUB could easily compare its greenhouse gas emissions to peer universities.

Other than Clean Air-Cool Planet, the most popular method colleges and universities use to estimate greenhouse gas emissions is the construction of an individualized algorithm. This allows for a calculation that is specific to the college or university. The calculation is usually performed by a team of students and faculty. A calculation of this type would be difficult to perform given the current limitations of the IUB Summer Program in Sustainability.

In conclusion, it is apparent that the Clean Air-Cool Planet Campus Carbon Calculator is the best tool for IUB. The tool is highly recommended by ACUP, easy to use, and specifically designed for colleges and universities. Also, using the tool would allow ample time for scenario modeling of possible future greenhouse emissions.

3.3 Analysis of the Greenhouse Gas Inventory from 2007

The greenhouse gas inventory compiled previously at IUB used the Clean Air-Cool Planet Campus Carbon Calculator. The inventory produced results of questionable accuracy. Significant data were absent from the calculations. Figure 1 shows the calculated emissions by sector.

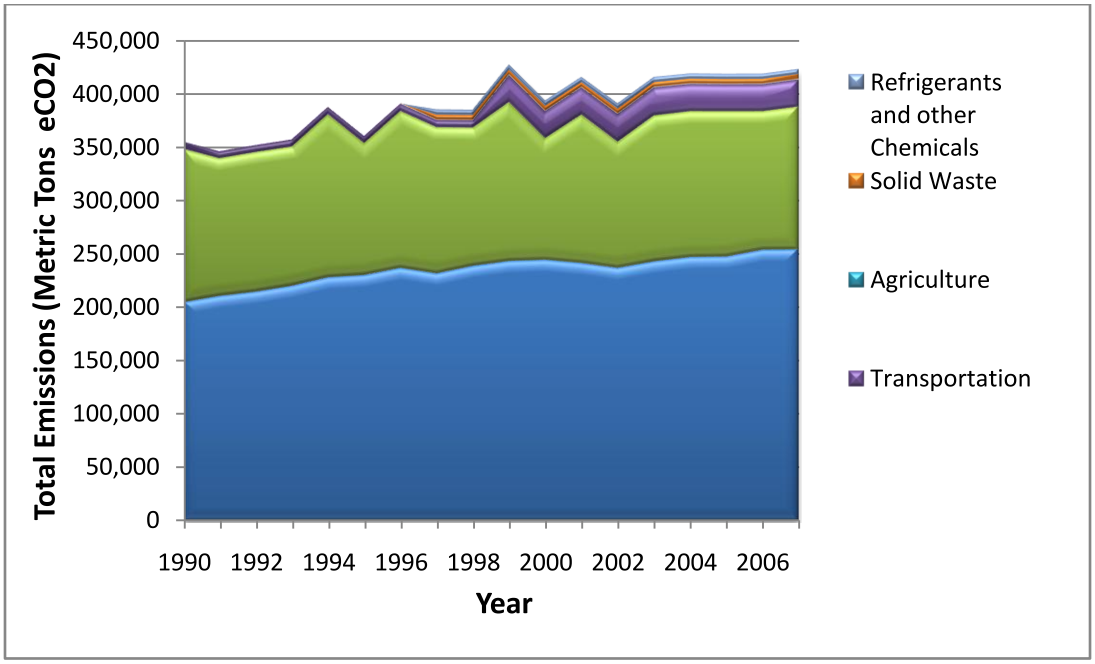

Figure 1: Emissions by Sector for 2007 GHG Inventory

There were several problems with the 2007 inventory. One of the major problems with the inventory was the lack of sufficient data. Much of the data was obtained through rough estimation. This was particularly true for the transportation data. The transportation data is perhaps the most difficult section of the inventory because it requires information that is not easy to obtain. The modal split is difficult to determine for a university as large as IUB. This problem was addressed extensively in the 2008 greenhouse gas inventory.

Another problem with the 2007 inventory was the timeframe of the data. Most of the data was off by one year. This is most likely because the Clean Air-Cool Planet calculator requires fiscal year data. This problem was easily corrected. However, this correction creates the illusion that the updated greenhouse inventory is not completely up to date. In fact, the updated greenhouse gas inventory uses the most recent data provided through the IU Fact Books, Physical Plant Reports, as well as other sources.

4.0 Updated Greenhouse Gas Inventory

The 2008 Greenhouse Gas Inventory was calculated using the Clean Air-Cool Planet Campus Carbon Calculator. The inventory was compiled using data from numerous sources. This was done in an effort to demonstrate current emissions, predict future emissions, and present opportunities for emission reductions. The following sections will overview the methodology and findings of the greenhouse gas inventory and present possible explanations for the current and future emissions at IUB.

4.1 Methodology and Data Sources

The greenhouse gas inventory calculated using CA-CPCCC required the input of numerous pieces of data. In the following section, the origin of this data is explained. Some of the data was obtained through simple calculations.

4.1.1 "Input" Tab

The majority of the data was entered into the "Input" tab. The following table outlines the origin of data entered into this tab. All of the sources were chosen in the belief that these sources would provide the most accurate data.

"Input" Tab	
1. "Operating Budget" Column	Data used from 2007 GHG inventory.
2. "Research Dollars" Column	1990-1994: University Archives was contacted but data not available. 1995-2006: Data Used from 2007 GHG inventory.
3. "Energy Budget" Column	Data from Jeff Kaden's (University Engineer/Director of Engineering Services) spreadsheet. Calculation: Energy Budget = ($ electricity)+($ coal)+($ oil)+($ natural gas)+($ LP-gas)
4. "Full Time Students" "Part Time Students" and "Summer School Students" Columns	Data from Donna Rinckel (Enrollment Information Coordinator, Office of the Registrar, Data Management & Administration). Calculation: Summer School Students = (# full-time students) for Summer Session II + (# part-time students) for Summer Session II

5. “Faculty” and “Staff” Columns	Data from IU Fact Books.
6. “Total Building Space” and “Total Research Building Space” Columns	Data from IU Fact Books.
7. “Purchased Electricity” Column	KWh calculated using data from IUB Physical Plant Annual Reports. Calculation: Purchased Electricity = total billed kWh (“Duke Energy” page) + total kWh (“electricity - other” page)
8. “Air Travel” Column	Estimate from John Harner (IU Travel Management Services).
9. “Distillate Oil” Column	Data from Physical Plant Annual Reports.
10. “Natural Gas” Column	Data from Physical Plant Annual Reports.
11. “Propane” Column	Data from Jeff Kaden’s Spreadsheet for 1990-2002 data. Data from Teresa Sexton for 2003-2006 data. Calculation: Propane usage = Golf Course Maintenance + Golf Course Caretakers + Harlos House
12. “Coal” Column	Data from Physical Plant Annual Reports.
13. “Fertilizer Application” Columns	Estimates from previous inventory.
14. “Landfill Waste with no CH_4 Recovery” Column	Estimates from previous inventory.

Table 2: “Input” Tab Data Sources

4.1.2 "Custom Fuel Mix" Tab

The "Custom Fuel Mix" Tab provides information on what fuels are used to produce the electricity IUB purchases. The use of this data is somewhat controversial. Some believe that the fuel mix should not be determined based upon state but rather through a regional or national measurement. The data for the custom fuel mix is from the previous inventory.

4.1.3 "Input Commuter" Tab

The "Input Commuter" Tab is composed of data on transportation methods for students, faculty and staff. This data was perhaps the most difficult to obtain because it is not directly measured. Data was taken from 2008 IU Transportation survey. Data was filtered so that only individuals who answered the transportation question with one answered were used. Percentages were then assumed to be the same from year to year. Figures 2, Figure 3 and Figure 4 show the modal split for students, faculty, and staff.

The data provides some startling insight into IUB's transportation problems. The Faculty and Staff Modal Splits show that the overwhelming majority of these two groups commute by personal vehicle. However, these two groups are more likely to carpool than students. Only 25% of students drive alone. Students rely heavily on the bus system to commute. IUB's recent decision to drastically reduce bus routes may lead to a significant increase in student's reliance on personal vehicles

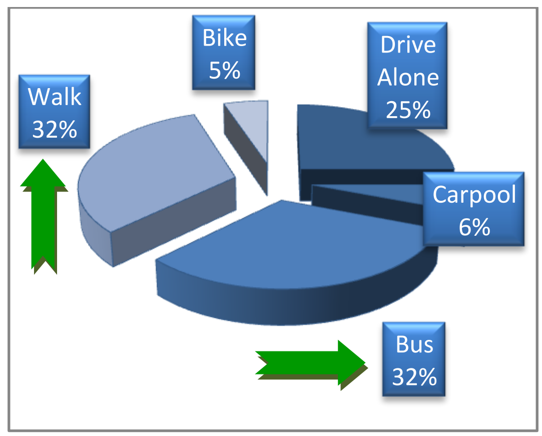

Figure 2: Student Modal Split

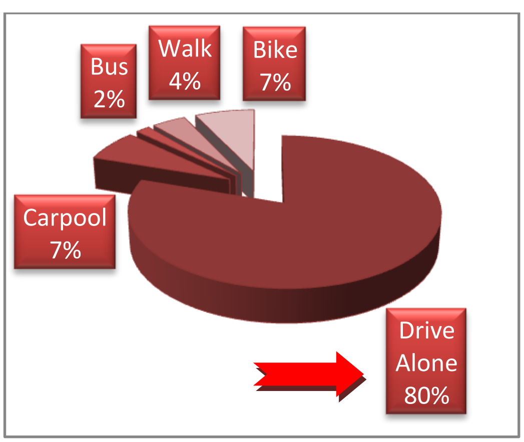

Figure 3: Faculty Modal Split

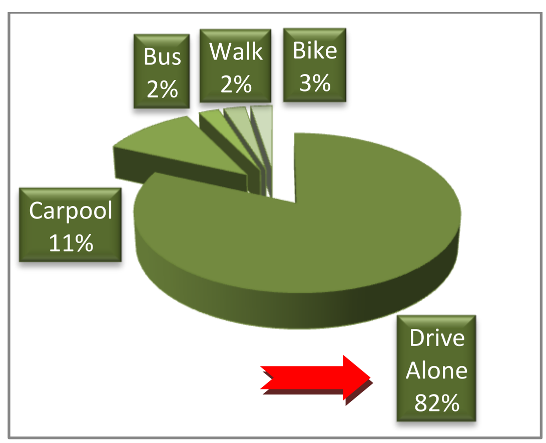

Figure 4: Staff Modal Split

4.2 Data and Results

Using the updated GHG inventory a series of graphs, charts, and regressions were produced to determine the relationships between IUB's emissions and predict future emission levels. The following sections will present analyses of the data with regard to several different criteria such as sector, scope, etc.

4.2.1 Emissions by Sector

The CA-CPCCC produced several graphs representing different aspects of IUB's emissions. The "Emissions by Sector" graph (Figure 5) displays IUB's emissions with respect to the sector the emissions originated from.

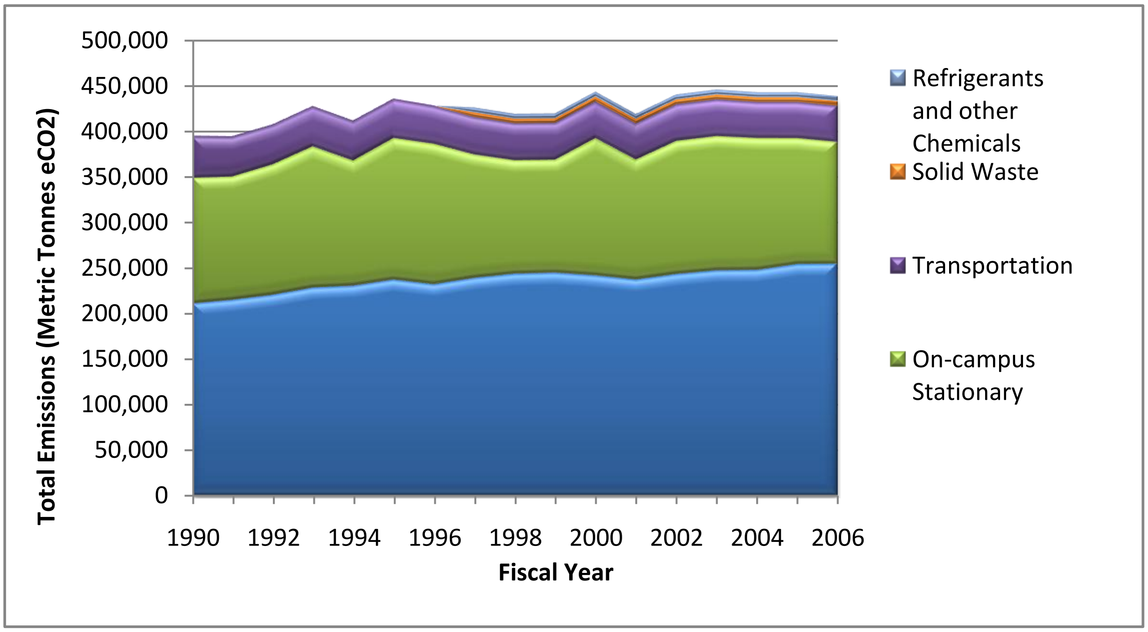

Figure 5: Emissions by Sector

The graph clearly displays that purchased electricity (scope 2) is the largest contributor to IUB's emissions. On-campus stationary (scope 1) is also responsible for a large portion of IUB's footprint. Transportation, solid waste, and other categories represent a small portion of IUB's emissions. Although the overall trend of the emissions is increasing, further analysis must be done to determine which sectors are responsible for this increase.

4.2.2 Emissions by Scope

Greenhouse gas emissions can be divided into three categories also known as scopes (Figure 6). Scope 1 emissions are direct emission sources and composed of On-Campus Stationary emissions as well as a small portion represented by landfill usage. Scope 2 emissions are indirect emission sources and composed of emissions related to Purchased Electricity. Scope 3 emissions are also indirect emission sources and composed of emissions related to Transportation. IUB has the most control over Scope 1 emissions. Scope 2 and Scope 3 are more difficult for IUB to control.

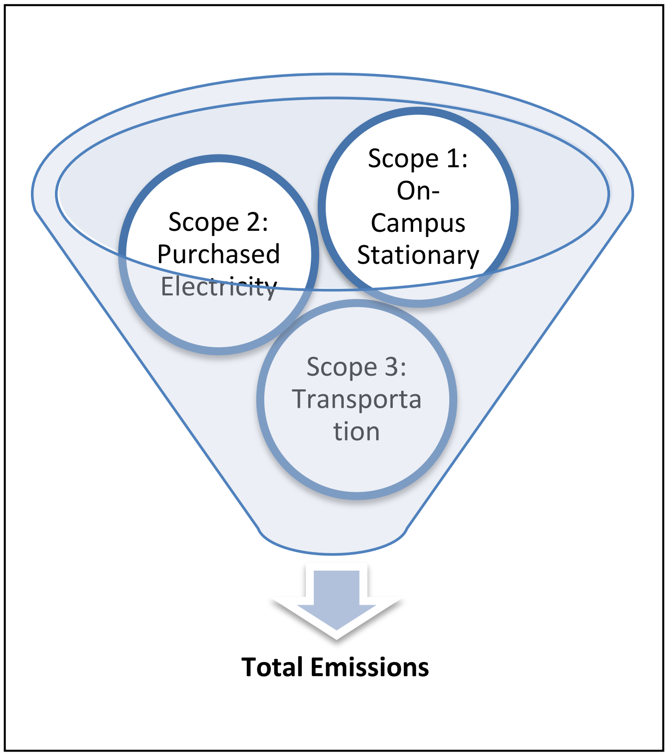

Figure 6: Scope Emissions Diagram

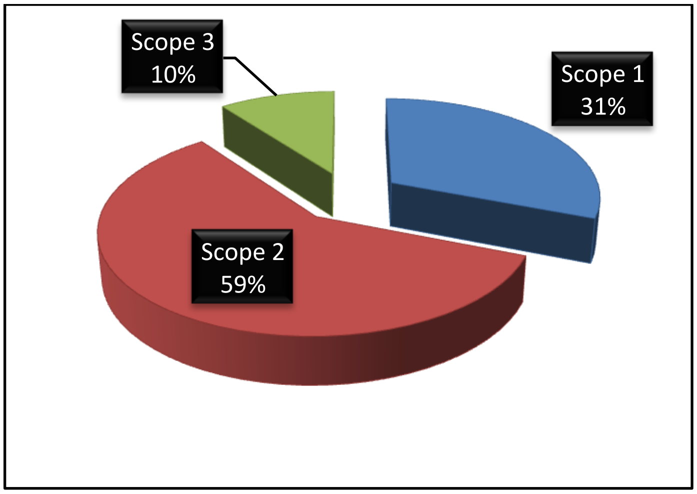

Figure 7: Emissions by Scope

Figure 7 shows IUB's emissions by scope. Scope 2 emissions (purchased electricty) are responsible for the largest portion of IUB's carbon footprint. This data is from the latest year of available data (FY 2006). This chart is not necessarily representitive of previous scope splits. Splits from previous years may have shown different proportiaonal relationships between the three scopes. It is therefore very important to continue to analyze scope emissions to determine which scope is responsible for the largest portion of IUB's emissions.

4.2.3 On-Campus Stationary Emissions

The On-Campus Stationary Emissions (Figure 8) show that the emissions are neither increasing nor decreasing. The correlation (-0.004) does not suggest a linear relationship either. It appears that the On-Campus Stationary Emissions (Scope 1) are changing at random. This is most likley due to the variability in temperature from 1990-2006. Since Scope 1 emissions are the emissions over which IUB has the most control, IUB should be making greater efforts to reduce these emissions.

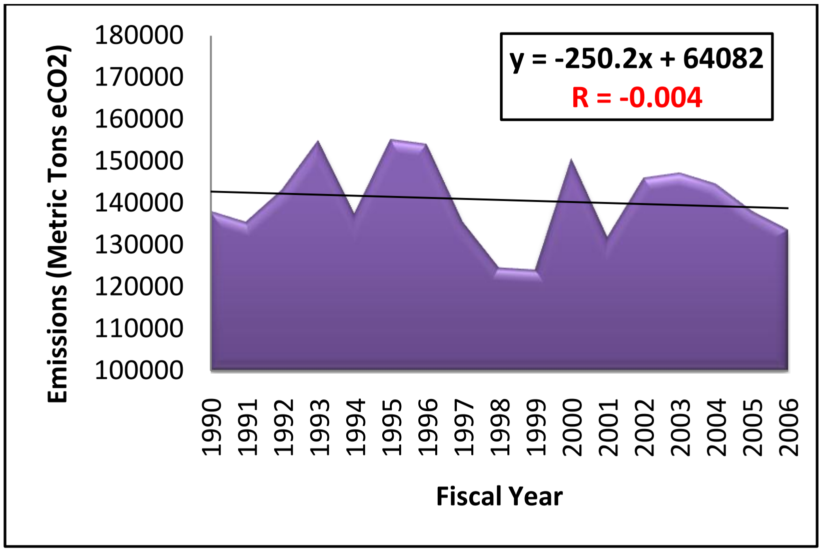

Figure 8: On-Campus Stationary Emissions

4.2.4 Transportation Emissions

The Transportation Emissions at IUB demonstrate a surprising trend in that they are decreasing at a steady, predictable rate. The correlation (-0.944) is very strong. This relationship is most likely due to the increased fuel efficiencies of vehicles. However, the emissions appear to be leveling out for the past few years. If IUB wishes to continue this downward trend, it must employee strategies to discourage students from using personal vehicles for transportation to and from class.

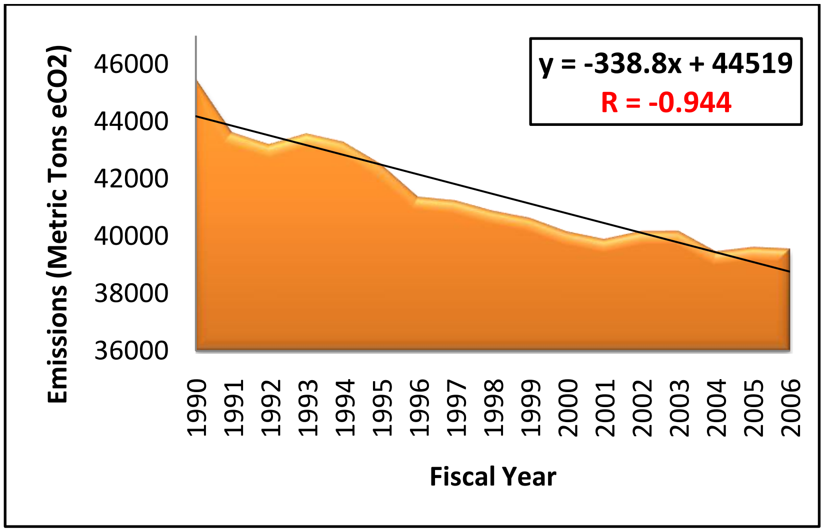

Figure 9: Transportation Emissions

4.2.5 Purchased Electricity Emissions

The purchased electricity emissions were the only emissions that produced a steady, predictable, linear increase. The correlation (0.934) suggests a very strong, very reliable relationship. IUB purchases all of its electricity from Duke Energy. The majority of the electricity Duke Energy produces (more than 98%) is produced by the combustion of coal. For this reason, the emissions related to purchased electricity are particularly high. IUB must take considerable efforts to reduce electricity usage. Emissions related to purchased electricity are increasing at a rate of 2,339 tons eCO_2 per year.

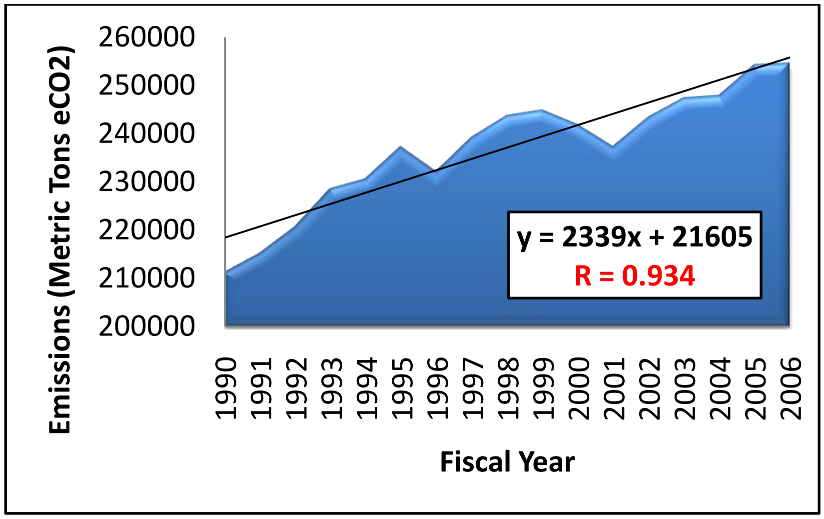

Figure 10: Purchased Electricity Emissions

4.3 Prediction of Future Emissions

After the greenhouse gas inventory was compiled, predictions of future emissions were made. The predictions were made under the assumption that emissions will increase linearly at a constant rate. Figure 11 demonstrates that predicted emissions are expected to increase to nearly 470,000 metric tons of eCO_2 by the year 2020 under current practices. This estimation is optimistic by assuming the increase is linear. If the increase is exponential, emissions may be much higher than 470,000 metric tons by 2020. Also, this projection does not include the uncertainty associated with the linear regression.

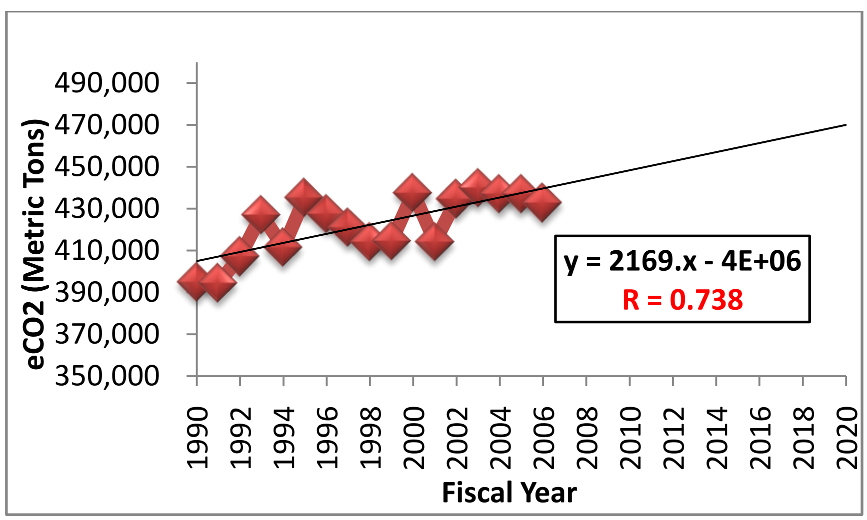

Figure 11: Projected Total Emissions

4.3.1 Linear Regression Analysis

In order to understand the projected emissions more completely, an analysis was performed to include the uncertainty of the linear regression. Figure 12 shows the linear regression (blue line) along with max. (green line) and min. (purple line) linear regressions. These regressions are three standard deviations (3σ) greater than and less than the normal linear regression. The striped area represents the true projection of future emissions. Emissions will most likely fall somewhere in this range. This means that emissions could reach nearly 500,000 metric tons eCO_2 by 2020.

This range demonstrates the possibility IUB has to reduce future emissions by a significant amount without changing its operating procedures drastically. IUB has the opportunity to continue practices that will produce high emissions (towards the green regression line) or enact emission-reducing practices that will produce low emissions (towards the purple regression line). If IUB decides to make significant changes in order to reduce its emissions it could start a trend of continued decreasing emissions and perhaps set a goal for carbon neutrality.

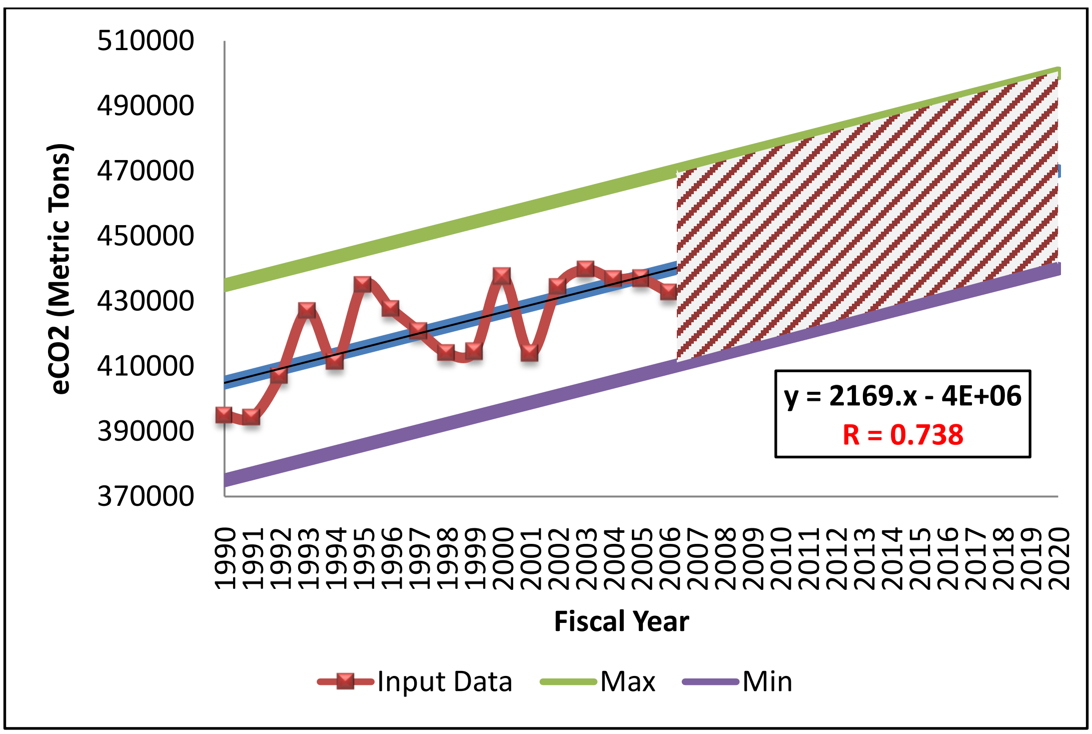

Figure 12: Linear Regression Analysis (± 3σ)

4.3.2 Analysis of Emissions from FY2003 through FY2006

The linear regressions presented previously are somewhat misleading. It may not be fair to make predictions based upon data from FY1990 through FY2006. Since 2003, emissions have decreased every year. Figure 13 shows that, if the data from the past four years are isolated, it appears that emissions at IUB are decreasing. This, however, is somewhat deceiving. The data from the last four years may be decreasing, but it is also important to view the future emissions in light of a larger time span. However, this data is encouraging and demonstrates the effect of decreased emissions from the central heating plant (Scope 1) and decreased emissions from transportation (Scope 3).

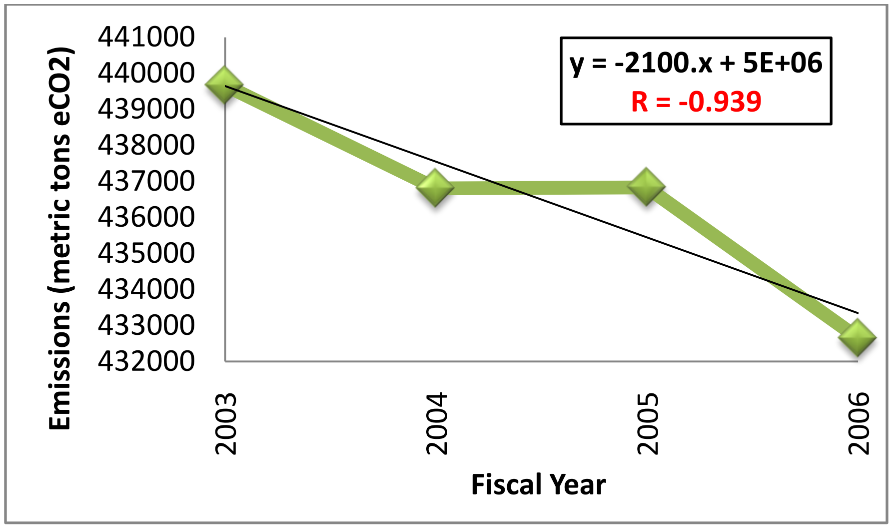

Figure 13: FY2003-FY2006 Emissions

5.0 Temperature Analysis

Since 1990, the temperature in Bloomington, IN has been rather variable and does not appear to have a strong, linear relationship. However, the changes in temperature can be used to explain some of the variability of the On-Campus Stationary Emissions which are mainly composed of the emissions produced at the IUB central heating plant. Since the main purpose of the central heating plant is to provide heat for the Bloomington campus, it is reasonable to assume that as the temperature increases the On-Campus Stationary emissions should decrease. Temperature data is from NOAA's National Climatic Data Center (Stevens 1).

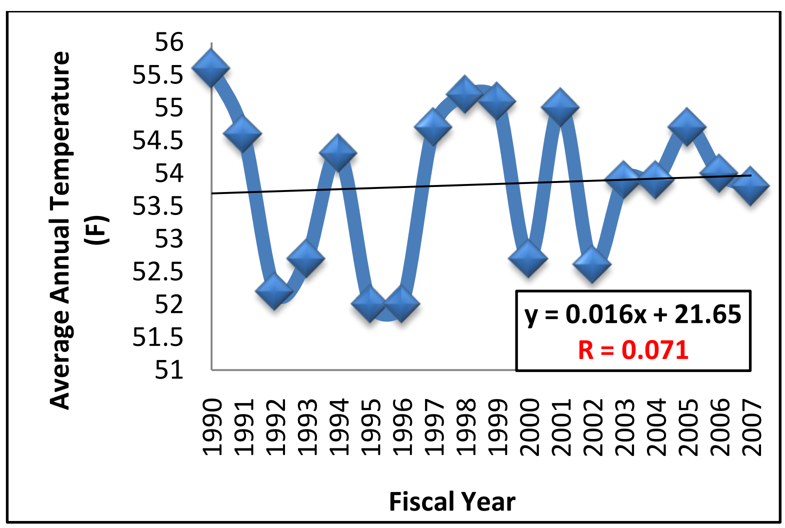

Figure 14: Average Annual Temperature in Bloomington, IN

Figure 15 shows the relationship between the average annual temperature and the On-Campus Stationary Emissions. The strong correlation (-0.839) suggests that the relationship is predictable and fairly linear. This relationship shows one of the reasons for the great variability of the On-Campus Stationary Emissions. Also, this relationship shows how an increase in temperature at IUB will lead to a decrease in the Scope 1 emissions.

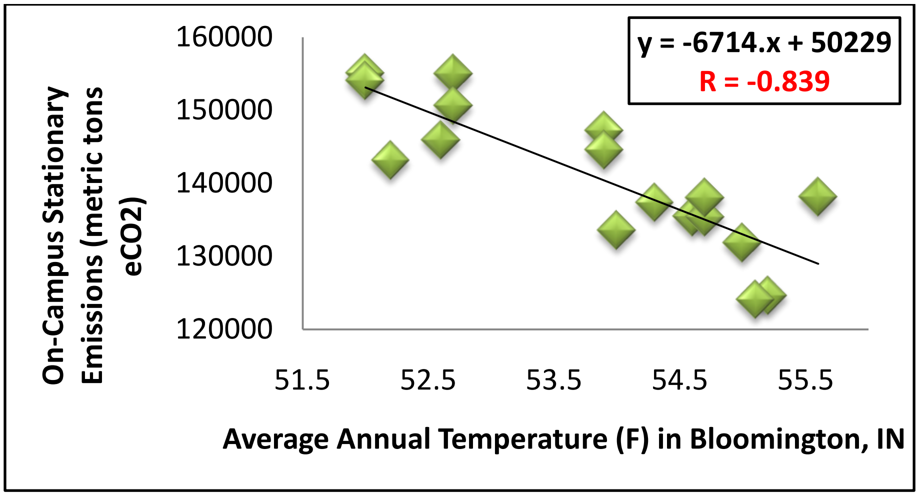

Figure 15: On-Campus Stationary Emissions with Average Annual Temperature

6.0 Emission Reduction Goals

Using the emission projections, IUB must set goals for emission reduction and eventually carbon neutrality. Figure 16, shows several possible emission reduction goals for IUB. These goals are based upon recommendations by the American College and University Presidents Climate Commitment (ACUPCC), the Kyoto Protocol, and a general target for carbon neutrality by the year FY2050. The flat, dashed line represents capping emissions at FY2006 levels. IUB's emission reduction goal may not be as aggressive as these presented goals but these goals represent examples of possible emission reduction goals.

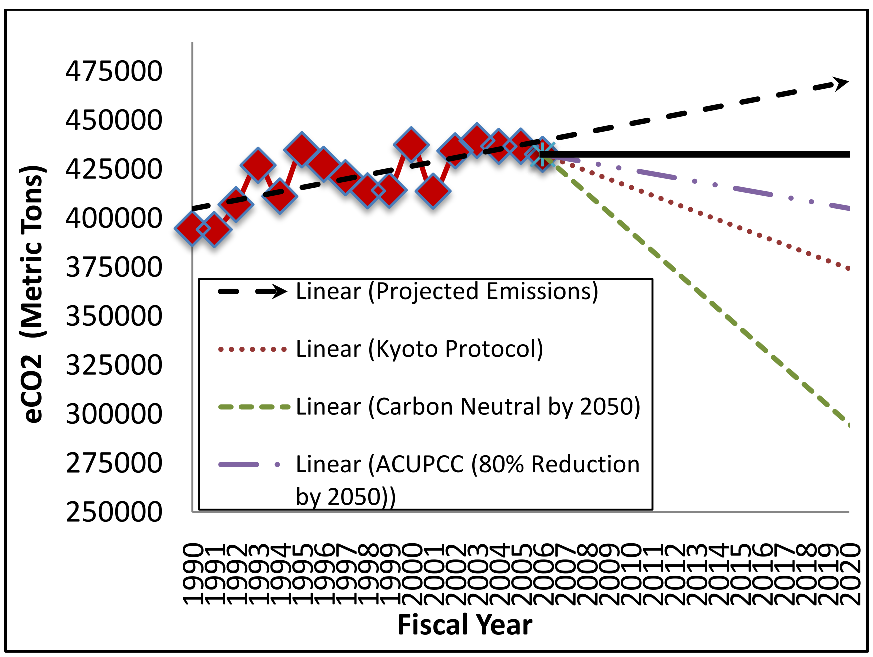

Figure 16: Possible Emission Reduction Goals

7.0 Economic Analysis

Indiana University makes many of its decisions based on simple economics. The following section will analyze the economic consequences of IUB's Scope 1 emissions.

7.1 Emissions as a Function of Coal, Oil, Natural Gas, and Propane

An equation was derived for the Scope 1 emissions (in kg eCO2).

7.1.1 Derivation (C = Coal, L = Oil, N = Natural Gas, P = Propane)

$$E(C, L, N, P) =$$

$$C\left(1914\ {}^{kg\ CO_2}/_{ton\ coal}\right) + C\left[\left(0.2139\ {}^{kg\ CH_4}/_{ton\ coal}\right)\left(23\ {}^{kg\ eCO_2}/_{kg\ CH_4}\right)\right] +$$
$$C\left[\left(0.0299\ {}^{kg\ N_2O}/_{ton\ coal}\right)\left(296\ {}^{kg\ eCO_2}/_{kg\ N_2O}\right)\right]$$

$$+$$

$$L\left(9.99\ {}^{kg\ CO_2}/_{gallon\ oil}\right) + L\left[\left(0.001456\ {}^{kg\ CH_4}/_{gallon\ oil}\right)\left(23\ {}^{kg\ eCO_2}/_{kg\ CH_4}\right)\right] +$$
$$L\left[\left(0.00009\ {}^{kg\ N_2O}/_{gallon\ oil}\right)\left(296\ {}^{kg\ eCO_2}/_{kg\ N_2O}\right)\right]$$

$$+$$

$$N\left(53\ {}^{kg\ CO_2}/_{MMBtu\ gas}\right) + N\left[\left(0.00528\ {}^{kg\ CH_4}/_{MMBtu\ gas}\right)\left(23\ {}^{kg\ eCO_2}/_{kg\ CH_4}\right)\right] +$$
$$N\left[\left(0.00011\ {}^{kg\ N_2O}/_{MMBtu\ gas}\right)\left(296\ {}^{kg\ eCO_2}/_{kg\ N_2O}\right)\right]$$

$$+$$

$$P\left(5.4\ {}^{kg\ CO_2}/_{gallon\ propane}\right) + P\left[\left(0.01055\ {}^{kg\ CH_4}/_{gallon\ propane}\right)\left(23\ {}^{kg\ CO_2}/_{kg\ CH_4}\right)\right] +$$
$$P\left[\left(0.00005\ {}^{kg\ N_2O}/_{gallon\ propane}\right)\left(296\ {}^{kg\ eCO_2}/_{kg\ N_2O}\right)\right]$$

Equation 1 shows how emissions (in kg eCO_2) are derived from the four fuel sources.

$$E(C, L, N, P) =$$

$$C * \left(1927.7701 \, {}^{\text{kg eCO}_2}/_{\text{ton coal}}\right) + L * \left(10.050128 \, {}^{\text{kg eCO}_2}/_{\text{gallon oil}}\right) +$$

$$N * \left(53.154 \, {}^{\text{kg eCO}_2}/_{\text{MMBtu gas}}\right) + P * \left(5.65745 \, {}^{\text{kg eCO}_2}/_{\text{gallon propane}}\right)$$

Equation 1: Emissions as a Function of Coal, Oil, NG, and Propane

7.2 Heat Usage

IUB must produce a certain amount of heat each year for the campus. This heat is produced through the combustion of fuels at the central heating plant and at other locations. Any economic analysis must take into consideration IUB's need for heat.

7.2.1 Overall Heat Usage

Table 3 shows IUB's overall heat usages. Coal provides the vast majority of heat for IUB. The amount of heat produced using natural gas (the cleanest of the four fuels) has been decreasing steadily since the year 2000.

Fiscal Year	Coal (MMBtu)	Oil (MMBtu)	Propane (MMBtu)	Natural Gas (MMBtu)	Total (MMBtu)
2006	**1,597,500**	830	1,601	133,500	1,733,431
2005	1,597,500	830	1,601	133,500	1,733,431
2004	1,597,500	830	1,601	165,000	1,764,931
2003	1,600,763	830	1,601	173,669	1,776,863
2002	1,557,788	1,116	1,652	199,629	1,760,185
2001	1,328,310	467	1,675	295,947	1,626,399
2000	1,502,123	3,294	1,558	341,146	1,848,121

Table 3: Heat Usage in MMBtu

Figure 17 shows the proportional heat usages by the source of fuel. The chart illustrates clearly that coal is the leading source of heat for the IUB campus. Oil and propane, which are not used as primary sources of heat because of their high cost, represent a very small portion of the overall heat production.

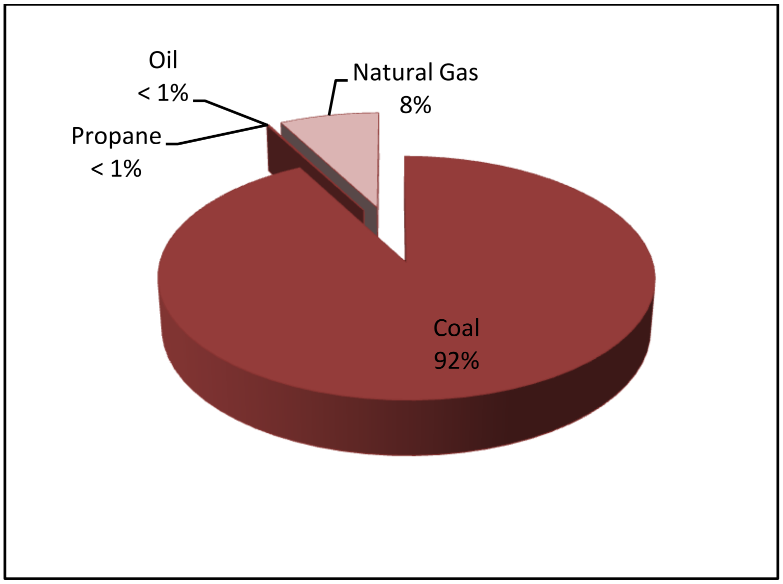

Figure 17: Heat Usage (FY 2006)

7.2.1 Emissions per Unit of Heat Produced

The emissions of each of the four fuel sources vary considerably. Figure 18 shows the emissions for the four fuels in terms of MMBtu.

Coal

$$\left(\frac{71{,}000 \text{ tons coal}}{1{,}597{,}500 \text{ MMBtu}}\right) * \left(\frac{1927.7701 \text{ kg eCO}_2}{\text{ton coal}}\right) = \mathbf{85.67867111}\ {}^{\mathbf{kg\ eCO_2}}/_{\mathbf{MMBtu\ Coal}}$$

Oil

$$\left(\frac{6{,}000 \text{ gallons oil}}{830 \text{ MMBtu}}\right) * \left(\frac{10.050128 \text{ kg eCO}_2}{\text{gallon oil}}\right) = 72.65152771\ {}^{\text{kg eCO}_2}/_{\text{MMBtu Oil}}$$

Natural Gas

No calculation was required for natural gas because natural gas is recorded in MMBtu.

$$\mathbf{53.154}\ {}^{\mathbf{kg\ eCO_2}}/_{\mathbf{MMBtu\ Natural\ Gas}}$$

Propane (LP-Gas)

$$\left(\frac{17{,}500 \text{ gallons propane}}{1{,}601 \text{ MMBtu}}\right) * \left(\frac{5.65745 \text{ kg eCO}_2}{\text{gallon propane}}\right) = 61.83970956\ {}^{\text{kg eCO}_2}/_{\text{MMBtu Prop.}}$$

Figure 18: Emissions by Fuel Type

7.3 Cost Analysis

The combustion of coal is, by far, the cheapest way for IUB to produce heat. However, coal produces the most eCO_2 of the four fuels.

Fiscal Year	Coal ($/MMBtu)	Oil ($/MMBtu)	Propane ($/MMBtu)	Natural Gas ($/MMBtu)
2006	?	?	?	?
2005	**$ 2.139**	**$ 11.561**	**$ 15.301**	**$ 10.784**
2004	1.764	9.074	4.846	9.696
2003	1.709	6.456	10.338	8.240
2002	1.666	8.352	7.730	6.890
2001	1.593	?	8.716	5.589
2000	1.534	5.577	14.713	6.195

Table 4: Fuel Costs

Coal is the cheapest of the four fuels but also produces the highest emissions. Natural gas is the second cheapest and produces the lowest emissions. Therefore, IUB should use only coal and natural gas to produce heat. Coal should be used to lower the cost of producing heat. Natural gas should be used to reduce emissions.

For every MMBtu produced using natural gas instead of coal, 32.52 less kg eCO_2 are emitted. Also, for every MMBtu produced using natural gas instead of coal, it costs $8.65 more. This means that every dollar used to purchase natural gas will reduce emissions by 3.76 kg eCO_2.

The "eCO_2 Opportunity Cost" of one dollar at the IUB CHP is 3.76 kg eCO_2.

With this understanding the true "carbon value" of one dollar can be understood. IUB can use this information to determine where it will invest its money in order to minimize emissions given limited resources.

7.4 Proposed Carbon Tax

Currently, there is no carbon tax in the United States. For this reason, coal is the cheapest fuel for IUB to consume. However, if a carbon tax is enacted, using coal may become more expensive than other fuels.

7.4.1 Determining the Carbon Tax "Tipping Point"

If the carbon tax is small, it may not put economic pressure on IUB in terms of the type of fuel consumed. But, if the tax reaches a certain "tipping point" IUB will be forced to switch from coal to a fuel with lower emissions (i.e. natural gas).

Cost of Coal Per MMBtu Including Carbon Tax

$$= \frac{\$2.139}{MMBtu} + \left(\frac{tax}{kg\ C}\right) * \left(\frac{1914\ kg\ CO_2}{ton\ coal}\right) * \left(\frac{71{,}000\ tons\ coal}{1{,}597{,}500\ MMBtu\ coal}\right) * \left(\frac{12.011\ kg\ C}{44.0098\ kg\ CO_2}\right)$$

$$= \frac{\$2.139}{MMBtu} + T * 23.21609581\ \frac{kg\ C}{MMBtu\ Coal}$$

Cost of Natural Gas Per MMBtu Including Carbon Tax

$$= \frac{\$10.784}{MMBtu} + \left(\frac{tax}{kg\ C}\right) * \left(\frac{53 kg\ CO_2}{MMBtu\ natural\ gas}\right) * \left(\frac{12.011\ kg\ C}{44.0098\ kg\ CO_2}\right)$$

$$= \frac{\$10.784}{MMBtu} + T * 14.4645738\ \frac{kg\ C}{MMBtu\ Coal}$$

"Tipping Point"

$$\frac{\$2.139}{MMBtu} + T * 23.21609581\ \frac{kg\ C}{MMBtu\ Coal} = \frac{\$10.784}{MMBtu} + T * 14.4645738\ \frac{kg\ C}{MMBtu\ Coal}$$

$$T = \frac{\$0.9787234}{kg\ C}$$

$$\frac{\$0.979}{\text{kg C}} = \frac{\$887.9}{\text{Ton C}}$$

Figure 19: Carbon Tax "Tipping Point"

The carbon tax tipping point, Figure 19, represents the carbon tax at which IUB will be forced to switch from coal to natural gas because the tax will make natural gas less expensive to consume. This tax, \$0.979/kg C, is very high and unlikely to occur in the near future.

7.4.2 Current and Suggested Carbon Taxes

Table 5 shows four possible carbon taxes. None of these carbon taxes is large enough to force IUB to switch from coal to natural gas. IUB will most likely have to switch to fuels with lower carbon emissions voluntarily. A carbon tax may seem at first like a good way to reduce emissions at IUB, but in reality a carbon tax would most likely not be economically binding.

Source of Tax	Carbon Tax	Economically Binding for IUB?
Carbon Tax Center (suggestion)	$37/short ton carbon	no
Finland (first country to issue carbon tax)	~ $81.09/short ton carbon	no
New Zealand (proposed but not implemented)	$10.67/short ton carbon	no
British Columbia (proposed for 2012)	~26.04/short ton carbon	no

Table 5: Carbon Taxes

8.0 Conclusions and Recommendations – The First Steps toward Carbon Neutrality

Indiana University has a responsibility as a public university to strive for the advancement of society and the betterment of the global community. Particularly, Indiana University must take an active role in the problem of global climate change by identifying emissions, reducing emissions, and setting a reasonable goal for carbon neutrality. The following sections will indentify key areas IUB can reduce emissions as well as outline the way in which IUB should set goals for emission reduction and eventual carbon neutrality.

8.1 Aggressively Reduce Scope 1 Emissions

Scope 1 emissions (on-campus stationary) are perhaps the most important area of emissions from IUB since the university is directly responsible for these emissions. Primarily, IUB must investigate and redefine the way in which it consumes the two main fuels at the IUB Central Heating Plant: coal and natural gas. An extensive cost-benefit analysis, similar to the one presented in this report, would help identify trends and possibilities for emission reduction.

Furthermore, IUB must understand the economic and environmental trade-offs associated with the two fuels. For example, for every dollar invested in the uses of natural gas to produce heat as opposed to coal, 3.76 less kg of eCO2 are emitted. With this understanding, IUB can analyze every expense in terms of both its economic cost and its eCO_2 emission cost. The cost of the IU Summer Program in Sustainability interns, for example, is approximately $45,000 which equates to about 84.6 metric tons of eCO_2. This amount represents the possible emission reduction that IUB has forgone by enacting the summer program. However, this calculation does not include the emission reductions produced by each of the 18 internships.

8.2 Fight Against the Increasing Trend of Scope 2 Emissions

Scope 2 emissions (purchased electricity) represent the most dangerous area of IUB's emissions because it is both the largest scope and the only scope that is increasing. This increase is somewhat inevitable because of IUB's expanding campus and increased research activity. However, much of IUB's electricity use can be reduced through simple energy saving practices such as switching all incandescent light bulbs to compact fluorescent light bulbs. Indiana University Purchasing claims that "incandescent lighting is used to maintain the ambience of certain rooms or because compact fluorescent bulbs are not made for those specifications, specifically within the Indiana Memorial Union" (Buy Green 5). Attempts should be made to incorporate the use of incandescent lighting throughout the entire campus.

Additionally, IUB should explore the possibility of producing some of its electricity on-campus. This could be accomplished through solar technology, wind energy, and, in the long-run, switching from a central heating plant to a cogeneration or trigeneration plant. Cogeneration (Figure 20) uses the steam produced for heating to generate electricity. This is common practice at several universities and would significantly reduce IUB's electricity costs and emissions.

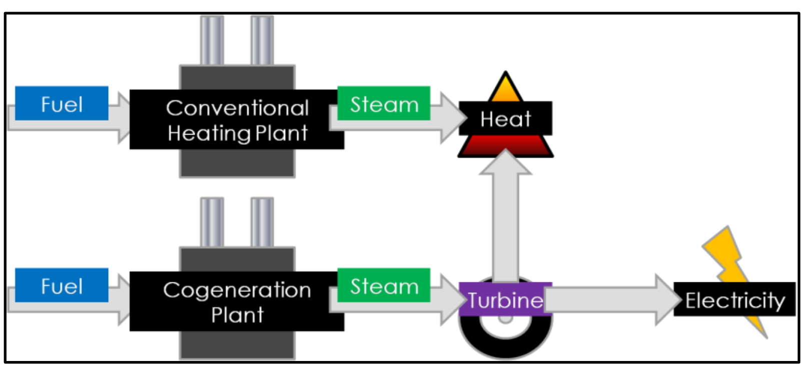

Figure 20: Cogeneration

8.3 Set an Official Emission Reduction Goal

If IUB hopes to reduce its impact on the environment, it must set an official emission reduction goal. This goal should include the reduction of Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). By setting an official emission reduction goal, IUB will have taken the first step toward carbon neutrality. Also, an emission reduction goal will allow IUB to gauge its progress and will provide university engineers, architects, faculty members, administrators, and students with a clear goal to work towards. Even if IUB does not meat its goal, the goal will encourage sustainable practices and lead to lower campus emissions.

8.4 Continue to Update the GHG Inventory

In order for IUB to become carbon neutral, it must continue to monitor its GHG emissions by updating the GHG inventory using Clean Air-Cool Planet Campus Carbon Calculator or some other tool. This should be done on a yearly basis, preferably sometime in the fall. The use of Fiscal Years in the CA-CPCCC makes it difficult to obtain completely up-to-date data when the inventory is taken in the spring or summer. Updating the GHG inventory should not be an extensively time-consuming process because the data must simply be added to the CA-CPCCC for future years.

8.5 Become a Signatory of ACUPCC

The American College and University Presidents Climate Commitment is a commitment signed by colleges and universities dedicated to environmental sustainability and carbon reduction. If IUB became a signatory of ACUPCC it would greatly increase the university's clout in the field of environmental sustainability as well as provide IUB with strong motivation to reduce emissions and set a goal for carbon neutrality.

8.6 Working Towards Carbon Neutrality

The ultimate goal of environmental sustainability at IUB should be to attain carbon neutrality. This may seem difficult, if not impossible, for an institution as large as IUB. However, carbon neutrality is necessary for the fight against global climate change. Therefore, Indiana University should implement emission reduction strategies in the effort to, one day, obtain carbon neutrality.

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Appendix: Input Data for CA-CP Campus Carbon Calculator

Fiscal Year	Budget			Population				
	Operating Budget	Research Budget	Energy Budget	Full Time Students	Part-Time Students	Summer School Students	Faculty	Staff
	$	$	$	#	#	#	#	#
1990	$ 568,713,916.00	Data not available: University Archives contacted.	10,677,321	29,893	5,560	8,783	1,484	4,864
1991	$ 617,892,052.00		10,631,072	29,921	5,568	8,730	1,503	4,792
1992	$ 646,499,478.00		11,087,962	30,256	5,820	8,940	1,529	4,832
1993	$ 675,984,101.00		11,037,824	29,960	5,591	8,971	1,729	4,905
1994	$ 697,410,586.00		11,044,381	29,818	5,776	8,734	1,751	4,891
1995	$ 726,078,232.00	$ 43,600,315.00	11,805,012	29,483	5,576	8,943	1,783	4,869
1996	$ 750,801,573.00	$ 45,187,220.00	12,790,371	29,277	5,423	8,632	1,799	4,880
1997	$ 783,296,313.00	$ 47,636,196.00	12,273,248	29,575	5,362	8,309	1,846	4,880
1998	$ 823,195,815.00	$ 44,818,510.00	12,837,398	30,384	5,216	7,887	1,829	4,855
1999	$ 852,106,550.00	$ 44,582,482.00	12,428,256	31,217	4,984	7,786	1,869	4,902
2000	$ 921,164,703.00	$ 46,756,970.00	13,374,185	31,972	5,104	7,984	1,855	5,040
2001	$ 966,372,730.00	$ 52,264,573.00	13,222,964	32,934	5,029	8,418	1,881	5,138
2002	$1,023,164,832.00	$ 61,960,646.00	13,827,548	33,707	5,196	8,317	1,948	5,144
2003	$1,072,211,657.00	$ 68,658,264.00	13,874,500	34,038	4,551	7,982	2,071	5,293
2004	$ 967,543,551.00	$ 72,900,295.00	14,916,741	33,282	4,539	8,366	2,157	5,242
2005	$ 997,071,766.00	$ 77,032,633.00	17,868,529	33,707	4,251	7,505	2,174	5,234
2006	$1,028,948,175.00	$ 89,111,073.00	18,277,744	33,939	4,308	7,428	2,233	5,248

Table 6: "Input" Tab Columns C-J

Fiscal Year	Physical Size							
	Total Building Space	Total Research Building Space	Purchased Electricity	Distillate Oil (#1 - #4)	Natural Gas	Propane (LP-Gas)	Coal
	Square feet	Square feet	kWh	Gallons	MMBtu	Gallons	Short Tons
1990	13,502,319	216,084,179	10,677,321	36,595	698,285	24,116	50,079
1991	13,479,116	220,123,397	10,631,072	11,974	459,635	20,795	54,596
1992	13,465,556	225,725,234	11,087,962	8,197	535,300	16,823	56,321
1993	13,639,898	233,822,752	11,037,824	30,794	337,610	23,736	67,891
1994	13,730,509	235,941,296	11,044,381	3,609	623,621	4,976	52,195
1995	14,110,147	242,822,486	11,805,012	69,735	599,762	16,431	61,385
1996	14,221,000	237,521,004	12,790,371	30,329	665,721	20,164	59,508
1997	14,380,777	244,713,465	12,273,248	51,936	532,830	17,825	53,830
1998	14,395,317	249,340,459	12,837,398	6,558	778,450	18,141	41,905
1999	14,541,233	250,527,576	12,428,256	23,919	526,952	17,967	48,408
2000	15,090,677	247,450,581	13,374,185	23,800	341,146	17,022	66,761
2001	15,131,885	242,793,335	13,222,964	3,377	295,947	18,307	59,036
2002	15,181,086	249,007,327	13,827,548	8,065	199,629	18,053	69,235
2003	15,110,226	253,096,876	13,874,500	6,000	173,669	4,278	71,145
2004	15,438,021	253,602,505	14,916,741	4,165	180,308	150	70,002
2005	15,492,375	260,105,684	17,868,529	1,643	184,191	7,322	66,525
2006	15,324,204	260,436,269	18,277,744	1,297	26,979	1,805	68,555

Table 7: "Input" Tab Columns K-M, Z-AB, AD

*Note: columns in which no data were entered are "hidden".

Fiscal Year	Air Travel		Fertilizer Application		Solid Waste
	Faculty / Staff Business	Student Programs	Synthetic	% Nitrogen	Landfilled Waste with no CH_4 Recovery
	Miles	Miles	Pounds	%	Short Ton
1990	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1991	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1992	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1993	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1994	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1995	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1996	15,000,000	15,000,000	**n/a**	**n/a**	**n/a**
1997	15,000,000	15,000,000	**n/a**	**n/a**	4,900
1998	15,000,000	15,000,000	**n/a**	**n/a**	4,900
1999	15,000,000	15,000,000	**n/a**	**n/a**	4,900
2000	15,000,000	15,000,000	**n/a**	**n/a**	4,900
2001	15,000,000	15,000,000	**n/a**	**n/a**	4,900
2002	15,000,000	15,000,000	34,000	33%	4,900
2003	15,000,000	15,000,000	34,000	33%	4,900
2004	15,000,000	15,000,000	34,000	33%	4,900
2005	15,000,000	15,000,000	34,000	33%	4,900
2006	15,000,000	15,000,000	34,000	33%	4,900

Table 8: "Input" Tab Columns AN-AO, AV-AW, BJ

Fiscal Year	Total Electric Purchased by University	% source of Electricity Production **Coal**	% source of Electricity Production **Natural Gas**	% source of Electricity Production **Hydro-Electric**	Total Percentage
	(kWh)	%	%	%	%
1990	216084179.00	98.6000%	0.2000%	1.2000%	100.00%
1991	220123397.00	98.6000%	0.2000%	1.2000%	100.00%
1992	225725234.00	98.70%	0.10%	1.20%	100.00%
1993	233822752.00	98.60%	0.20%	1.20%	100.00%
1994	235941296.00	98.70%	0.10%	1.20%	100.00%
1995	242822486.00	98.60%	0.20%	1.20%	100.00%
1996	237521004.00	98.70%	0.10%	1.20%	100.00%
1997	244713465.00	98.70%	0.10%	1.20%	100.00%
1998	249340459.00	98.60%	0.20%	1.10%	99.90%
1999	250527576.00	98.60%	0.30%	1.10%	100.00%
2000	247450581.00	98.60%	0.20%	1.20%	100.00%
2001	242793335.00	98.70%	0.30%	1.00%	100.00%
2002	249007327.00	98.40%	0.60%	1.00%	100.00%
2003	253096876.00	98.10%	0.90%	1.00%	100.00%
2004	253602505.00	97.20%	2.00%	0.80%	100.00%
2005	260105684.00	97.60%	1.60%	0.80%	100.00%
2006	260436269.00	98.00%	1.20%	0.80%	100.00%

Table 9: "Custom Fuel Mix" Tab Columns C-E, K, N

Fiscal Year	Students									
	Percent Commuting by personal vehicle	% TOTAL STUDENTS (Column C) Driving alone	% TOTAL STUDENTS (Column C) Carpooling	Trips / Day	Days / Year	Miles / Trip	**Percent Commuting by Bus**	Passenger Trips/ Day	Passenger Days / Year	Passenger Miles / Trip
	%	%	%				%			
1990	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1991	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1992	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1993	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1994	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1995	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1996	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1997	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1998	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1999	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2000	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2001	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2002	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2003	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2004	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2005	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2006	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3

Table 10: “Input Commuter” Columns E-J, N-Q

Fiscal Year	Summer School Students									
	Percent Commuting by personal vehicle	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Driving alone	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Carpooling	Trips / Day	Days / Year	Miles / Trip	**Percent Commuting by Bus**	Passenger Trips/ Day	Passenger Days / Year	Passenger Miles / Trip
	%	%	%				%			
1990	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1991	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1992	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1993	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1994	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1995	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1996	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1997	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1998	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
1999	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2000	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2001	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2002	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2003	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2004	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2005	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3
2006	30.75565%	24.96469%	5.79096%	1.00	180	6	31.99153%	2	180	3

Table 11: "Input Commuter" Columns AK-AP, AT-AW

Fiscal Year	Faculty									
	Percent Commuting by personal vehicle	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Driving alone	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Carpooling	Trips / Day	Days / Year	Miles / Trip	**Percent Commuting by Bus**	Passenger Trips/ Day	Passenger Days / Year	Passenger Miles / Trip
	%	%	%				%			
1990	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1991	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1992	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1993	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1994	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1995	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1996	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1997	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1998	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
1999	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2000	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2001	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2002	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2003	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2004	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2005	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11
2006	87.03072%	80.20478%	6.82594%	1.00	240	11	1.70648%	1.00	240	11

Table 12: "Input Commuters" Columns BV-CA, CE-CH

Fiscal Year	Staff									
	Percent Commuting by personal vehicle	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Driving alone	% TOTAL SUMMER SCHOOL STUDENTS (Column AJ) Carpooling	Trips / Day	Days / Year	Miles / Trip	**Percent Commuting by Bus**	Passenger Trips/ Day	Passenger Days / Year	Passenger Miles / Trip
	%	%	%				%			
1990	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1991	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1992	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1993	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1994	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1995	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1996	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1997	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1998	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
1999	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2000	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2001	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2002	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2003	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2004	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2005	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11
2006	92.64829%	81.78780%	10.86048%	1.00	240	11	2.33918%	1.00	240	11

Table 13: "Input Commuter" Columns DC-DH, DL-DO