

College of Charleston Greenhouse Gas Audit 1993-2001

Charleston, South Carolina

A collaborative project involving:

**Department of Physics & Astronomy
Master of Environmental Studies Program
South Carolina Sustainable Universities Initiative**

AUTHORS' NOTE

Sustainability is an important concept for the 21st century. Increased population and development pressures necessitate a more holistic approach to resource management. Individuals and institutions taking responsibility for the impacts caused by their actions is a primary step in this process. The following report analyzes the College of Charleston's greenhouse gas emissions and evaluate energy and resource use by the institution.

It took the effort of many students, faculty, and staff of the College to conduct the audit and to prepare this report. Cooperation among departments, as well as funding from the *South Carolina Sustainable Universities Initiative*, was vital to the success the campus audit. The software to compute emissions was provided by *Clean Air-Cool Planet*. The greenhouse gas audit team consisted of the following individuals.

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ABSTRACT

There is nearly universal agreement among scientists that anthropogenic causes are contributing significantly to global warming. We undertook an initiative to audit the greenhouse gas emissions resulting from all activities of the College of Charleston. We present the results of this audit and suggest policies that could reduce the College's contribution to climate change. The audit showed that the College's total greenhouse gas emissions have decreased by 12% from 1993-2001, solely due to the installation of highly efficient natural gas boilers at the Central Energy Facility. Emissions from all other sectors continued to grow: 19% increase in electricity, 12% increase in commuting student emissions, and a 42% increase in faculty and staff commuting emissions. Without further action, the College of Charleston's emissions are set to increase dramatically in the coming decade. Fortunately, a host of actions are available to the College that will lower the greenhouse gas emissions and save money.

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EXECUTIVE SUMMARY

This report summarizes the results of an audit of total greenhouse gas emissions by the College of Charleston from 1993 – 2001. The emissions are reported in Metric Tonnes Carbon Dioxide Equivalents (MTCDE), according to their Global Warming Potential (GWP), to provide the relative contribution of each gas to global warming. The inventory follows the guidelines established by the Intergovernmental Panel on Climate Change (IPCC), a panel of thousands of international scientists organized by the United Nations and the World Meteorological Organization.

Climate change refers to “any change in climate over time, whether due to natural variability or as a result of human activity”. Variations in climate are influenced by a variety of natural factors including changes in Earth's orbital parameters, volcanic activity, solar irradiance, and changes in the composition of the atmosphere. Gases in the atmosphere that reradiate escaping heat (infrared radiation) back to earth are called “greenhouse gases”. This process keeps the earth’s surface about 30°C (54° F) warmer than it would be without an atmosphere. Indeed, this phenomenon, known as the “Greenhouse Effect,” is a critical component of the many interlocking systems needed to support life on Earth.

However, human activities have led to an “enhanced greenhouse effect,” also known as global warming. Overwhelming evidence indicates that global warming is a significant problem that requires direct action from policymakers. In the past century, the concentration of carbon dioxide in the atmosphere has risen almost 30%, with methane more than doubling, and nitrous oxide increasing 15%. The increase of atmospheric CO₂ from 1960-2000 was 54 parts per million (ppm), which far exceeded the 36-ppm rise that occurred from 1760-1960. The majority of greenhouse gas (ghg) emissions are the direct result of burning fossil fuels.

Atmospheric scientists almost universally agree that the accumulation of ghg in the atmosphere is responsible for the earth’s rising temperature. The United States, with 3% of the world’s population, currently contributes 25% of the world’s total atmospheric CO₂ emissions.

The global average surface temperature has increased over the twentieth century by about 0.6°C. It is very likely that the 1990s was the warmest decade, and 1998 was the warmest year in recorded history since 1861. The 14 warmest years since record keeping began in 1866 have occurred since 1980. Satellite images show that there was a 10% decrease in snow cover since the late 1960s in the Northern Hemisphere. Northern summer sea-ice extent has decreased by 10-15% and become 40% thinner. Tide gauges have shown that the global average sea level rose 0.1-0.2 meters during the twentieth century.

Global warming is an especially relevant issue for Charleston because climate change can lead to a rise in sea level and increased frequency and intensification of hurricanes, both direct threats to the livability and attractiveness of the city and the College.

The College of Charleston is the **oldest institution of higher education in the state of South Carolina and the thirteenth oldest in the United States**. Around 11,000 students attend the College, which also employs almost 2,500 faculty and staff, and therefore it is responsible for a significant amount of greenhouse gas emissions.

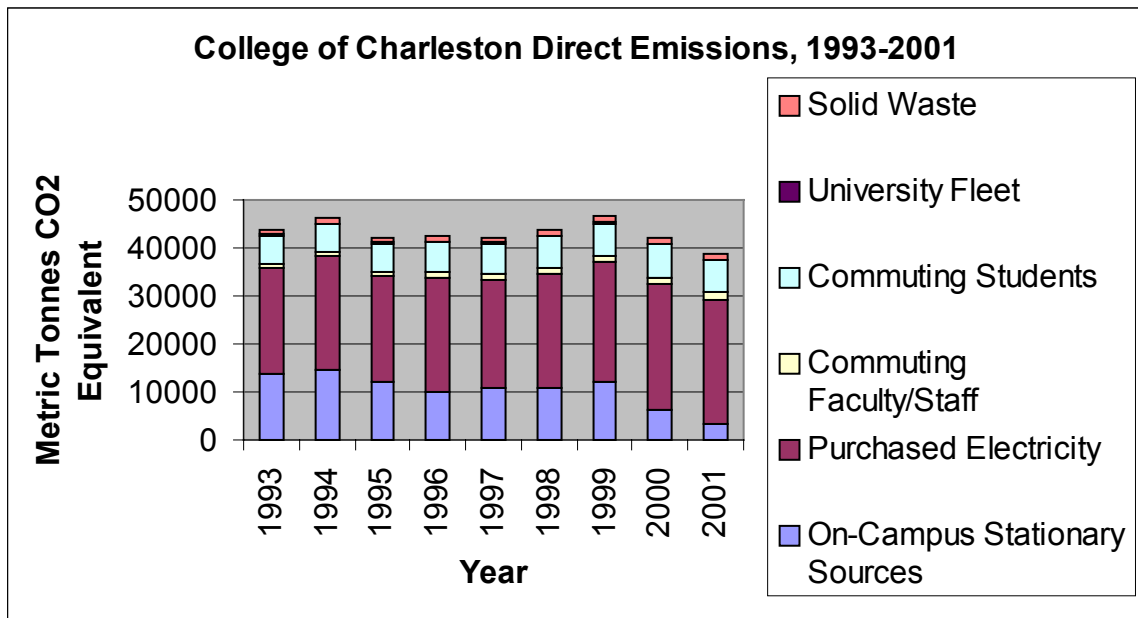
The purpose of this project was to conduct an inventory of the College of Charleston's greenhouse gas emissions and develop policy alternatives that can be implemented by the College to reduce those emissions.

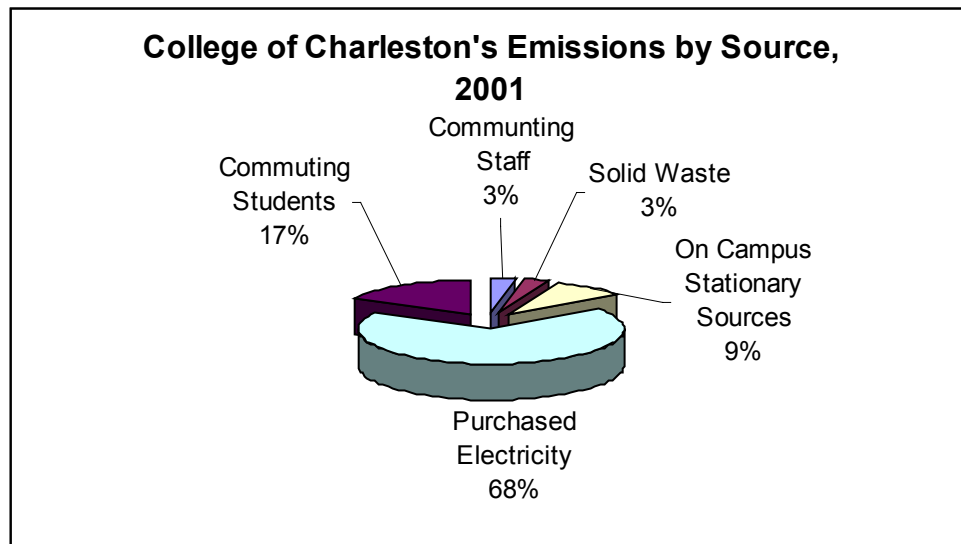
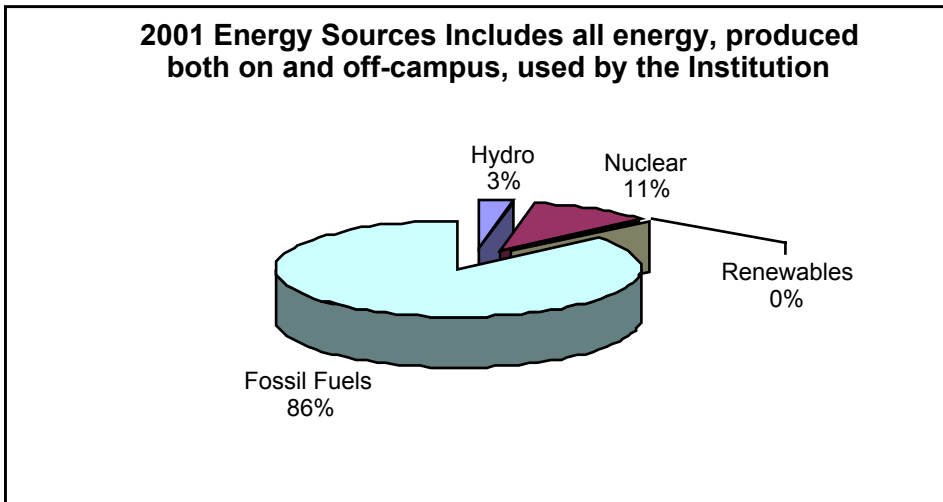
Methodology

The methods used to calculate C of C's greenhouse gas emissions were adapted from the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC). The IPCC created standards for conducting a nation-wide greenhouse gas emissions inventory and provided computer software to assist with these calculations. This report is based on spreadsheets adapted directly from the IPCC standards. To conduct the audit, students gathered information on all applicable emissions in the categories of Agriculture, Refrigeration/ Chemicals, Energy Sources, Transportation and Solid Waste. The students worked with a variety of offices and departments within the College of Charleston to obtain the relevant data. This information was entered into the Clean Air Cool Planet (CACP) inventory program, which produces an inventory of all six Kyoto gasses. Developed by CACP, the program has been used to assess greenhouse gas emissions of corporations, communities and college campuses. The greenhouse gas audit team received a complimentary copy of this program from CACP.

Major Findings

- C of C emitted 38,712 Metric Tonnes of Carbon Dioxide Equivalents in 2001
- There has been a net decrease of 12% in total greenhouse gas emissions from 1993-2001
- The purchasing of more efficient natural gas boilers for use in the Physical Plant was responsible for the overall decrease.
- Emissions from electricity usage (+19%) and commuting students (+12%), faculty and staff (+42%) have far exceed the growth of the student body (+10%) and faculty and staff (+16%) employed by the College.
- C of C relies on fossil fuels for 86 % of its energy needs and nuclear for 11%.
- The vast majority of these emissions come from purchased electricity (68%), followed by student commuting (17%). On-campus stationary sources contribute to 9% of emissions, with faculty and staff commuting and solid waste each contributing 3% of direct emissions. The university fleet and refrigerants contribute small amounts.





Conclusions

The College of Charleston should be commended for keeping emissions relatively steady over the past 8 years. Despite a growing population of faculty, staff, and students, greenhouse gas emissions have not increased. This is solely due to the purchase of high efficiency boilers for the Physical Plant. All other sources of emissions increased over the same time period, with electricity and student, faculty, and staff commuters growing at a rate exceeding College growth. It is apparent that the College of Charleston is following the national trend towards more energy intensive operations. It is *likely that emissions will increase* without a formation of an energy task force and adoption of the concept of sustainability throughout all College operations. There are many actions that lower the College's greenhouse gas emissions and save money in the long run. Implementing these types of policies makes economic and environmental sense.

Recommendations

The College of Charleston is presented with the opportunity to implement greenhouse gas reducing measures that are not only good for the environment, but that also carry long-term financial incentives. Increasing campus sustainability should also be a driving concept in the implementation of the Fourth Century Initiative. Such concepts truly set institutions of higher learning apart from other public and private organizations. To reduce emissions, increase sustainability and improve the quality of campus life, the following recommendations should be considered.

- **Creation of a Presidentially Appointed Energy Task Force**

Without direct support from the College administration, it is extremely difficult to assess the strengths and weaknesses of C of C's current environmental impact. An energy task force would be able to keep a centrally-located archive of energy use by the campus community. This allows for a continual tracking of energy uses and associated costs, permitting comparisons of implemented programs to monitor progress. A task force would also be able to pinpoint the most effective measures the College could implement in order to reduce GHG emissions and save money.

- **Mandatory Lifecycle Costing Methodology**

Lifecycle costing refers to examining not only the initial cost of purchasing equipment, but also all costs associated with that equipment over its expected lifetime. This comparison translates to lower costs over the lifetime of highly efficient equipment than to the lower cost equipment traditionally purchased.

Extra costs that traditionally make up for the higher initial cost of more efficient equipment are the lower operating costs due to lower energy consumption and the longer life of the equipment. Longer life translates to less employee maintenance time in fixing/replacing monitors, light bulbs, or exit signs. It should become official College of Charleston policy to consider lifetime costs and environmental impacts while purchasing goods.

- **Pursue Transportation Alternatives**

Reducing single occupancy travel to the campus benefits not only the College but the city of Charleston as well. One such option is the creation of park and ride lots at the three access points to the city coming from West Ashley, Mount Pleasant, and James Island. Shuttles would allow commuters to leave cars out of downtown, reducing emissions, easing congestion, and alleviating parking problems

- **Better Recycling Options**

Increase student, faculty and staff awareness of campus recycling options, and improve the availability of recycling receptacles to reduce the amount recyclable material being thrown into the trash.

- **Commitment to Energy Efficiency**

Install light emitting diode (LED) exit signs in all buildings, replace cathode ray tube computer monitors with energy efficient flat panel monitors, and incorporate the power-saving features on computers in campus labs and offices. All options save money over the life of the equipment, reduce maintenance time, and require less energy to operate.

INTRODUCTION

Climate Change, Greenhouse Gasses, and Global Warming Potential

Climate change refers to “any change in climate over time, whether due to natural variability or as a result of human activity” (IPCC 2001). Variations in climate can be influenced by a variety of natural factors including changes in Earth's orbital parameters, volcanic activity, solar irradiance, and changes in the composition of the atmosphere. Some gases in the atmosphere that reradiate escaping heat (infrared radiation) back to earth are called greenhouse gases. This process keeps the earth’s surface about 30°C (54° F) warmer than it would be without an atmosphere (Hinrichs 2002). Indeed, this phenomenon, known as the “Greenhouse Effect,” is a necessary component of the many systems needed to support life on Earth.

However, human activities have led to an “enhanced greenhouse effect,” also known as global warming. Considerable evidence indicates that global warming is a significant problem and an area that requires direct action from policymakers. In the past century, the concentration of carbon dioxide in the atmosphere has risen almost 30%, with methane more than doubling, and nitrous oxide increasing 15% (Hinrichs 2002). The increase of atmospheric CO₂ from 1960-2000 was 54 parts per million (ppm), which far exceeded the 36-ppm rise that occurred from 1760-1960 (Brown 2001). The majority of greenhouse gas (ghg) emissions are the direct result of burning fossil fuels. Atmospheric scientists widely argue that the accumulation of ghg in the atmosphere is responsible for the Earth’s rising temperature. The 14 warmest years since record keeping began in 1866 have occurred since 1980. The United States, with 3% of the world’s population, currently contributes 25% of the world’s total atmospheric CO₂ emissions (Hertsgaard 2000).

While it is unclear exactly what the impacts of a rapidly warming planet will be, it is clear that there will be significant changes. In fact the Intergovernmental Panel on Climate Change (IPCC) states that human emissions of greenhouses gases will continue to alter the atmosphere in ways that are expected to affect the climate. There are many gases that contribute, both directly and indirectly to the greenhouse effect. The most important of these gases have been identified (by the IPCC), and focused upon (by the international community through such methods as the Kyoto Protocol) as the emissions that should be reduced to curb the "enhanced greenhouse effect." The primary anthropogenic greenhouse gases are:

Carbon dioxide	CO₂
Methane	CH₄
Nitrous oxide	N₂O
Halocarbons	PFCs and HFCs
Sulfur Hexafluoride	SF₆

Carbon Dioxide (CO₂) – Carbon is a continually cycling element that moves between the atmosphere, ocean, land biota, marine biota, and mineral reserves. In the atmosphere, carbon exists primarily as carbon dioxide, which is a part of global biogeochemical cycling. The atmospheric concentration of CO₂ has increased by 31% since 1750 and has likely not been exceeded during the past 20 million years. About three quarters of anthropogenic CO₂ emissions are from burning fossil fuels, the other quarter from land-use changes, primarily deforestation.

Methane (CH₄) – Methane is produced primarily through anaerobic decomposition of organic matter in living systems. Anthropogenic releases of methane occur from use of fossil fuels, cattle, rice agriculture and landfill gas emissions. The atmospheric concentration of CH₄ has increased 151% since 1750 and continues to increase. The present concentration has not been exceeded during the past 420,000 years.

Nitrous Oxide (N₂O) – Nitrous Oxide is also produced with the combustion of fossil fuels, as well as in agriculture and some industrial processes. N₂O concentrations have increased 17% since 1750, and current concentrations of N₂O in the atmosphere have not been exceeded in the past thousand years.

Others: Hydrofluorocarbons, Perfluorocarbons, and sulfur hexafluoride (HFC, PFC, SF₆) – Halocarbons are primarily produced for industrial processes. HFCs were introduced as replacements for ozone-depleting substances, primarily as refrigerants. HFCs and SF₆ are used in aluminum smelting, electric power distribution, and magnesium casting. These chemicals are powerful greenhouse gases and have very long atmospheric lifetimes. The atmospheric concentration of these gases is increasing (IPCC, 2001).

The five greenhouse gases trap the sun's energy to varying degrees, or global warming potentials (GWP). GWP allows all of the greenhouse gases to be converted to a common unit of carbon dioxide equivalents. The GWP of a gas is dependent on how it reacts with long-wave (infrared) radiation coming from the Earth and how long it remains in the atmosphere (Table 1). For example, one molecule of SF₆ warms the planet to a similar extent as 23,900 molecules of CO₂. Emissions are usually reported in Metric Tonnes Carbon Dioxide Equivalents (MTCDE). This value is the product of the weight of the gas in Metric tonnes and the GWP (for example, 1 metric tonne of CH₄ is 21 MTCDE). This unit allows for a quick comparison of different gases relative to the effect they have in the atmosphere. This toolkit will make all of these calculations and display emissions in MTCDE.

Gas	Atmospheric Lifetime (Years)	Global Warming Potential (100 Year)
Carbon Dioxide (CO₂)	50-200	1
Methane (CH₄)	9-15	21
Nitrous Oxide (N₂O)	120	310
HFC – 134A	15	1,300
HFC – 404A	>48	3,260
Sulfur Hexafluoride (SF₆)	3,200	23,900

Global Warming and Charleston

Charleston, South Carolina is in direct danger of feeling the effects of global warming – especially the rise in sea level resulting from the melting of polar ice caps. For example, a one-meter rise in sea level would cause a coastline retreat of 1500 meters, potentially costing the city billions of dollars (Brown 2001). For the Charleston area, scientists have estimated that the total sea level rise since 1922 has been 0.1 in/year (Hicks 1983). Even if current atmospheric concentrations of GHG remains constant, sea level in the Charleston area is expected to rise .9-2.1 feet by 2025, and 2.9-7.6 feet by 2075. This rise in sea level will inundate the nearest 250 feet of land by 2025, and up to 4000 feet by 2075. Under this scenario, only the central part of the peninsula would be above the intertidal zone (Kana et. al 1987). This not only pushes the coastline inwards, it increases city flooding and susceptibility to storm damage.

A rise in sea level would inundate wetlands and lowlands, accelerate coastal erosion, exacerbate coastal flooding, threaten coastal structures, raise water tables, and increase the salinity of rivers, bays, and aquifers (Bath and Titus, 1984, in Titus, et al. 1991). James Titus et al. conducted a nationwide assessment of the primary impacts of a two to seven foot rise in sea level on the US. Looking at the costs associated with sea level rise including the cost of protecting ocean resort communities by pumping sand onto beaches and gradually raising barrier islands in place, the cost of protecting developed areas along sheltered waters through the use of levees and bulkheads, and the loss of coastal wetlands and undeveloped lowlands, the researches estimate the total cost for a one-meter rise in sea level would be \$270-475 billion for the country (Titus et al. 1999).

Intensification of natural disasters and weather anomalies is a second risk of global warming (IPPC 2001). According to researchers at the National Oceanic and Atmospheric Administration, “The strongest hurricanes in the present climate may be upstaged by even more intense hurricanes over the next century as the earth's climate is

warmed by increasing levels of greenhouse gases in the atmosphere” (Knutson 1998). Most hurricanes do not reach their maximum potential intensity before weakening over land or cooler ocean regions. However, those storms that do approach their upper-limit intensity are expected to be up to 5-12% stronger and have more rainfall in the warmer climate due to the higher sea surface temperatures (Knutson 1998). Charleston has already experienced the effects of an intensification of weather events with Hurricane Hugo in 1989. There will be an increase in the frequency of extreme weather events as well. With over one billion dollars in damages occurring from Hurricane Hugo, intensification of weather events due to global warming should be a prominent issue on local policymakers’ agendas.

College of Charleston's Greenhouse Gas Emissions

The College of Charleston (C of C) was founded in 1777 and is located in the heart of historic downtown Charleston, South Carolina. C of C is the **oldest institution of higher education in the state of South Carolina and the thirteenth oldest in the United States**. Around 11,000 students attend the College, which also employs almost 2,500 faculty and staff. C of C’s emissions stem from four main areas: Energy (which includes on-campus stationary sources, the sources of electricity, and transportation), Waste, Agriculture and Refrigeration.

Methodology

The methods used to calculate C of C’s greenhouse gas emissions were adapted from the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC). The IPCC created standard for conducting a nation-wide greenhouse gas emissions inventory and provided computer software to assist with these calculations. This report is based on spreadsheets adapted directly from the IPCC standards. To conduct the audit, students gathered information on all applicable emissions in the categories of Agriculture, Refrigeration/ Chemicals, Energy Sources, Transportation and Solid Waste. This information was entered into the Clean Air Cool Planet (CACP) inventory program, which produces an inventory of all six Kyoto gasses. Developed by CACP, the program has been used to assess greenhouse gas emissions of corporations, communities and college campuses. The greenhouse gas audit team received a complimentary copy of this program from CACP.

The agriculture category looks at the total number of methane producing animals under the care of the university. These include cows, pigs, sheep and horses. College of Charleston has horses for a horseback riding class and horses utilized by the equestrian team. These are the only source of emissions for the agricultural sector. This is to be expected for a university without agricultural academic programs.

The refrigeration/chemicals category consists of refrigerant emissions of various coolants that could be used in a university setting. These coolants consist of HFC-134A, HFC-404A, R22, R12, and SF6. College of Charleston uses HFC-134A, R22, and R12 but utilizes a zero-emissions cooling system. These chemicals, due to their enormous global warming potential (GWP) could highly impact emissions, however the zero-emissions standard held by the College's physical plant prevents the escape of any refrigerants. *The greenhouse gas audit team assumed that the College is in compliance with this zero-emissions standard.* The total global warming potential could be significantly increased if any refrigerant is escaping into the atmosphere.

The College of Charleston's primary energy source is purchased electricity from South Carolina Energy and Gas (SCEG). The electricity produced from this supplier comes from a combination of 75% coal, 20% nuclear, 4% hydroelectric, and less than 1% natural gas and renewable sources. Total kilo-watt/hours of electricity was utilized with the specific energy coefficients for the area to determine the total GHG emissions resulting from electricity usage at the College. The software takes into account the various sources of local energy produced.

The transportation sector assessment looks at both commuter patterns and university fleet emissions. Fleet emissions were determined from the total amount of gasoline, diesel fuel, natural gas, and electricity consumed by College vehicles. The College of Charleston relies primarily on gasoline-fueled vehicles in their fleet, with minimal electric vehicles and no natural gas vehicles. The commuter emissions were determined through a survey looking at total vehicle miles traveled (VMT) for an average faculty, staff, and student's daily commute. The VMT was used along with the software's standard vehicle fuel efficiency measures to determine the total amount of gasoline consumed and the resulting GHG emissions.

Solid waste generated by the College is also an important source of GHG emissions. Charleston County deals with waste in three ways – recycling, landfilling, and incineration. Charleston area landfills lack methane recovery systems; therefore waste sent to a landfill is a source of methane production, a greenhouse gas with 25 times the GWP of carbon dioxide. Waste sent to the incinerator does not emit methane, but still emits other greenhouse gases. For the software to calculate solid waste emissions, we entered total tonnage of waste sent both to landfills and to the incinerator.

RESULTS

Direct Emissions

The College of Charleston direct emissions (see Figure 1) were steadily increasing from 43,862 MTCDE in 1993 to a peak of 46,576 MTCDE in 1999, an increase of 6%. However, by 2001 direct emissions dropped to 38,712 MTCDE, a 12% decrease from 1993 levels. This large decrease in emissions is attributed to a significant decrease in emissions from on campus stationary (down 25% from 1999) sources due to C of C's purchase of new, highly efficient natural gas boilers for the physical plant.

The vast majority of these emissions come from purchased electricity (68%), followed by student commuting (17%). On-campus stationary sources now contribute to only 9% of emissions, with faculty and staff commuting and solid waste each contributing 3% of direct emissions. The university fleet, agriculture, and refrigerants contribute small amounts.

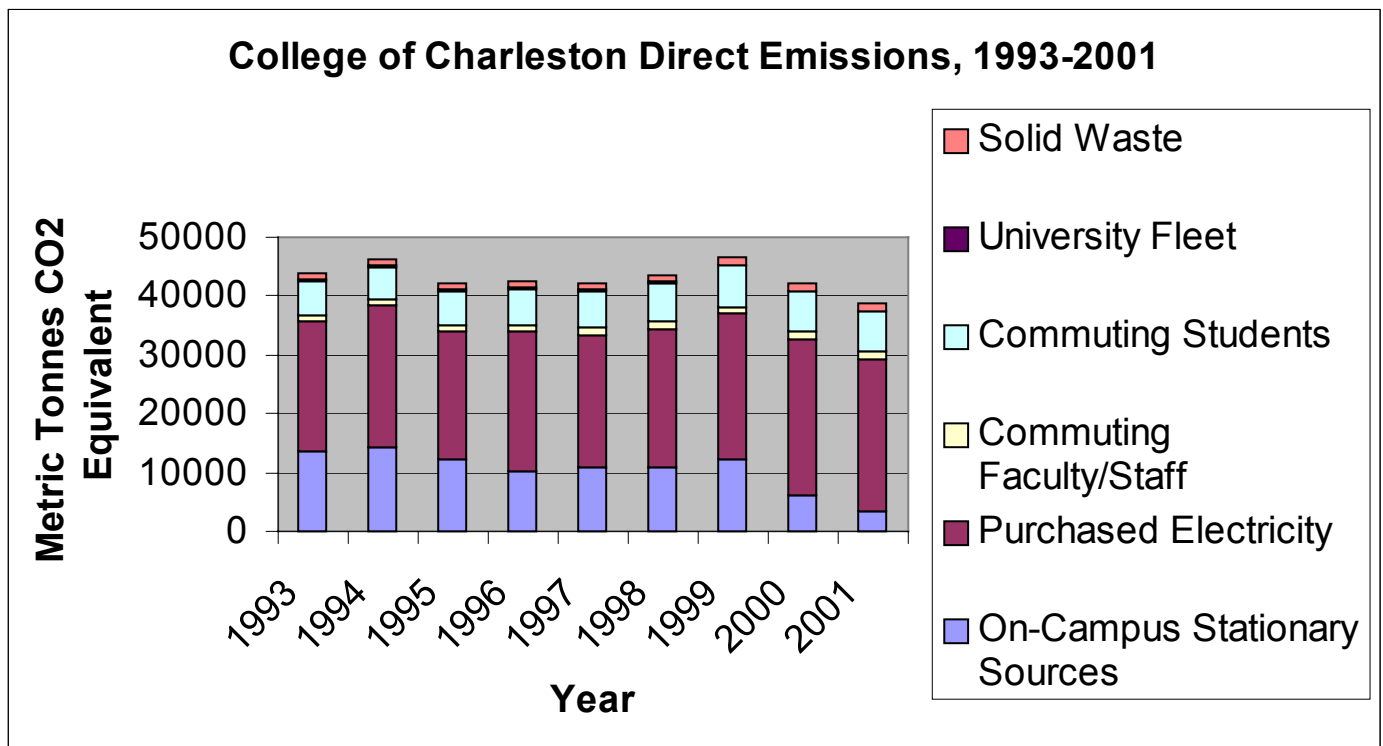


Figure 1. College of Charleston's Direct Emissions, 1993-2001

Trends in Emissions

Total emissions can be misleading without describing the state of the school throughout the time period. Student enrollment has grown by 10% since 1993, with faculty and staff increasing by 16%. However, even at C of C's peak total emissions in 1999, there was only a 6% increase in emissions. Nevertheless, emissions from faculty commuting have increased by 42% over the 8 year time period, while student commuting emissions have grown by 12%. Electricity use has also increased by 19%. These three categories have grown at rates exceeding the growth of the student body and faculty and staff employed by the College. Overall energy use per student has decreased (see Figure 2) monotonically from a high of 0.07 TJ/student in 1994 to 0.048 TJ/student in 2001.

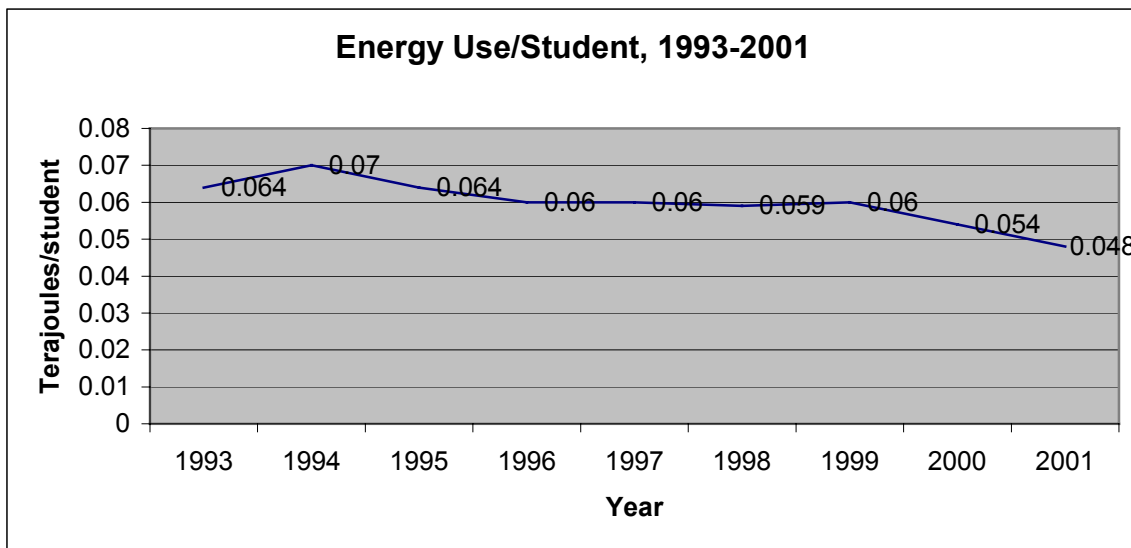


Figure 2: Energy Use per Student, in Terajoules, 1993-2001

Emissions By Source

Contributing to 68% of C of C's emissions (see Figure 3), purchased electricity is the largest source of school emissions for 2001. This is due to the fuel mix used by South Carolina Electric and Gas, which relies heavily on coal as the primary fuel source for electricity production. Coal is the dirtiest burning fossil fuel, and it provides 75% of SCE&G's fuel mix. SCE&G relies on nuclear power for 20% of electricity generated, with the remaining 5% comprised of natural gas, which is the "cleanest" fossil fuel, and hydroelectric power.

Commuting students is the second leading contributor to campus emissions, responsible for 17% of total greenhouse gas emissions. The number of students commuting to school not only contributes to increased ghg emissions, but contributes to the high volume of traffic suffered downtown, leading to congestion and severe parking shortages. On-campus stationary sources account for 9% of emissions, down from 25% a few years ago. The decrease in emissions from on-campus stationary sources is due to College of Charleston's investment in new, highly efficient gas boilers in 2000. The replacement of inefficient boilers not only decreased the college's natural gas dependency, thus decreasing operating costs, but also had the additional benefit of decreasing campus ghg emissions.

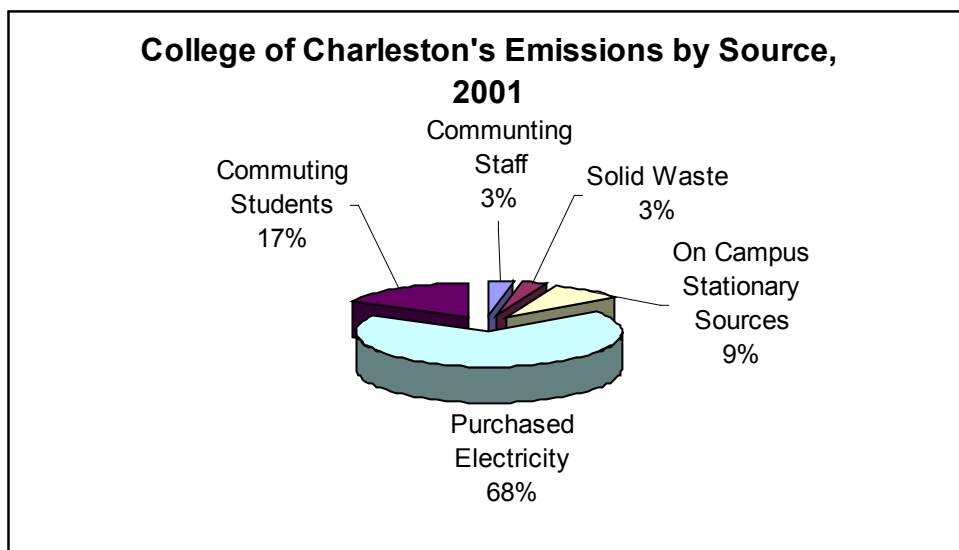


Figure 3: College of Charleston's Emissions by Source, 2001

Total Energy Consumption

Total energy use for the College of Charleston remained rather level throughout the 1990s (see Figure 4), with a noticeable decrease coming with the installation of the new high efficiency boilers. This led to a 21% decrease in total energy use from a 1999 peak of 702 TJ to low of 555TJ in 2001.

The College of Charleston relies heavily on burning fossil fuels as energy sources (see Figure 5). C of C uses fossil fuels for 86% of energy sources, followed by nuclear at 11% and hydroelectric power at 3%. While the College does not have a direct say over what energy sources are used to produce electricity purchased through SCE&G, they could take steps to encourage a reduction of dependence on fossil fuels. As mentioned earlier, burning of fossil fuels has many detrimental effects on human health, including being the leading contributor to global warming.

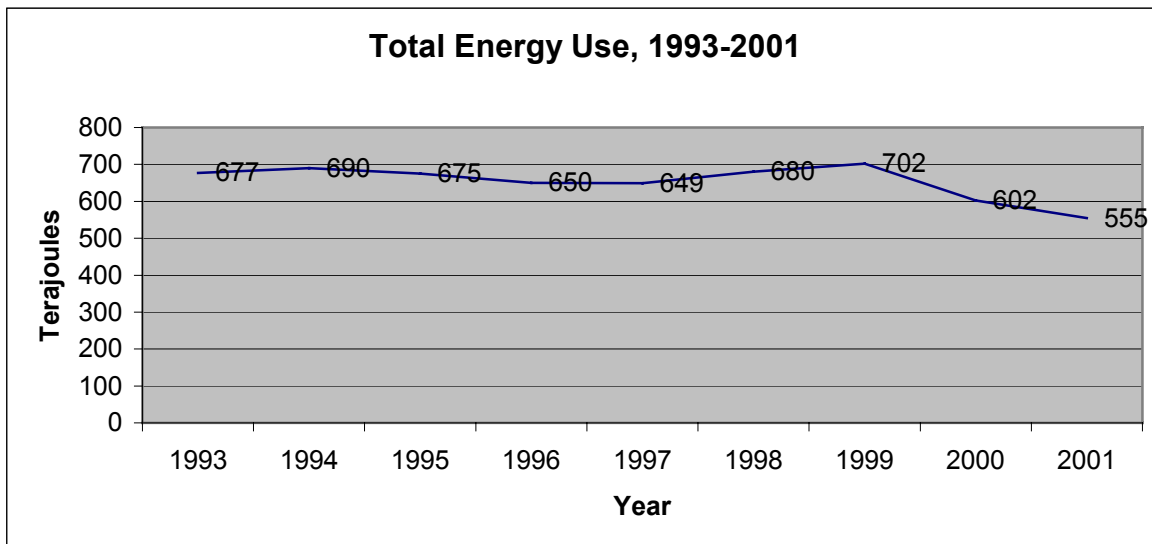


Figure 4: College of Charleston Total Energy Use, 1993-2001

On-Campus Stationary Sources

The College of Charleston's on-campus stationary sources consists of two natural gas boilers at the Central Energy Facility, which produce steam for heating buildings and providing hot water. New, highly efficient boilers were installed in 2000, and have already proven to be much more effective at producing steam (shown by the reduction in demand for natural gas) and emitting less greenhouse gases into the atmosphere (see Figure 1). *There are other on-campus stationary sources (i.e. boilers in individual buildings), but the greenhouse gas audit team was not able to identify or account for all of them.*

Electricity

The College of Charleston's emission efficiency of off-campus electricity production (defined as the kilograms of CO₂ released per kilo-watt hour of electricity generated) fluctuates on the basis of what the primary electricity company for the region, South Carolina Electric and Gas, utilize for fuel (Figure 5). The 2001 fuel mix for electricity generation for SCE&G consisted of 75% coal, 20% nuclear, and 5% comprised of natural gas and hydroelectric power. These percentages have fluctuated over the past 8 years, but most of the changes took place between a higher nuclear reliance and lower coal. This was exemplified in 1995, when coal was used for 64% of electricity production and nuclear jumped to 27%. Nuclear power does not contribute directly to global warming. The College of Charleston has no control over the emissions efficiency, as they cannot control the fuel sources of SCE&G. However, the College can take a leadership role in encouraging SCE&G to offer "green" power alternatives, similar to those offered by other regional electricity providers such as Santee Cooper.

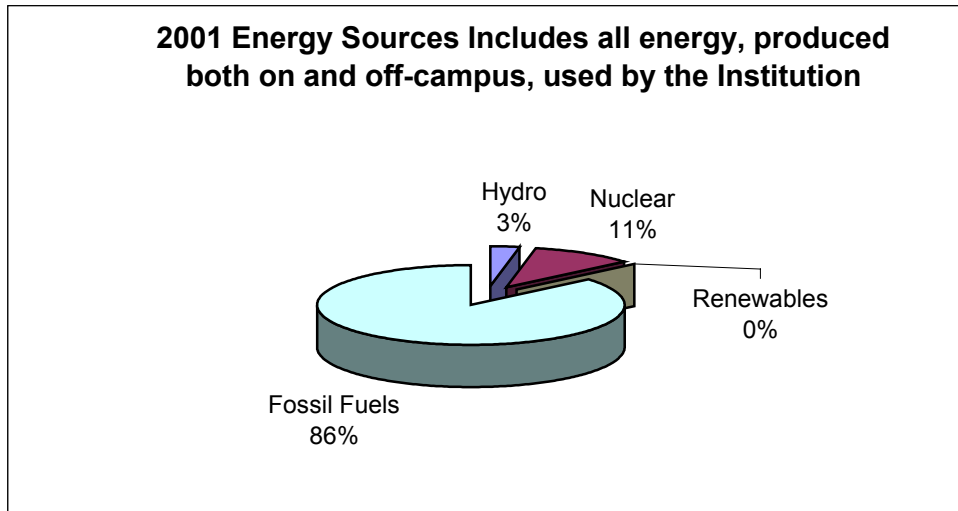


Figure 5: College of Charleston Energy Sources, 2001

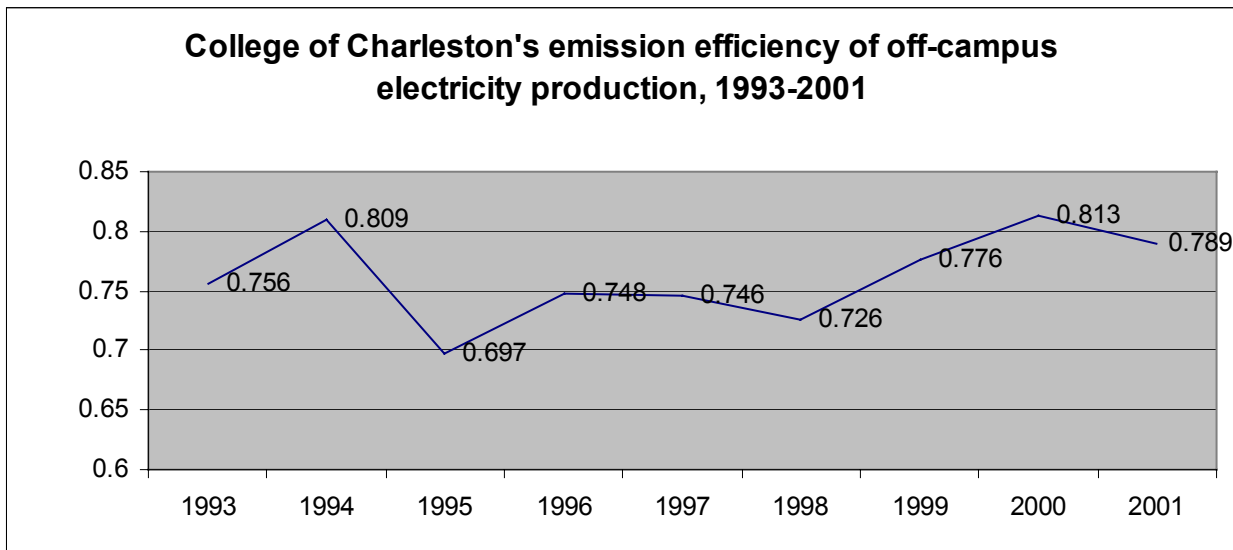


Figure 6: College of Charleston's electricity emissions efficiency

Transportation

Transportation as a whole (including the university fleet, commuting faculty and staff, and commuting students) was responsible for 21% of the College's 2001 emissions.

Commuting: Faculty and Staff

Commuting faculty and staff contribute 3.4% of the College's greenhouse gas emissions. As stated earlier, the number of faculty and staff has increased over the past 8 years 16%. However, there has been a 42% increase in emissions from these commuters. A survey conducted by the traffic department was utilized to determine the average number of faculty and staff driving to work each day, as well as how far they had to travel to reach the College. Total vehicle miles traveled for each year was computed by the software, using the number of commuters and the average distance traveled. Average commuting distance for faculty and staff was 15 miles/trip. The software used a standard fuel efficiency of 24.5 mpg, which in today's growing trend of increasing popularity of SUVs may be overstated. This would further increase the amount of emissions stemming from this sector.

Commuting: Students

The same transportation survey and methodology was used to determine commuting students' impacts on the College's greenhouse gas emissions. Student enrollment has increased 10% over the past 8 years, with commuters' emissions increasing 13%. The average student commute distance was 9.7 miles/trip.

University Fleet

Within the transportation sector, the university fleet contributed negligible amounts of greenhouse gas emissions. However, the emissions were determined only by the amount of fuel obtained at the College. Fuel consumed on trips out of town was not available, and would significantly increase the emissions from this sector.

Agriculture

Located within the heart of Charleston, C of C does not have significant emissions stemming from the agricultural sector. The College owns 22 horses, used for equestrian purposes and riding classes. Emissions from animals and agriculture originate from domesticated animals, most notably pigs and cows, which produce methane as a normal byproduct of digestion. Since C of C does not maintain a herd of pigs or cows, this source of emissions is inconsequential.

Waste

As does every institution across the United States, the College of Charleston produces tons of solid waste each year. Waste can either be incinerated or disposed of in landfills. When waste is incinerated, it produces particulate matter that can pollute the air as well as carbon dioxide. It can also be burned to generate steam, as had been the case at the Foster-Wheeler incinerator that C of C sent its waste to. However, the steam was being provided to the naval base, and when the base closed, the steam had nowhere to go, and is currently being vented to the atmosphere. As waste decomposes in landfills, it produces methane as a byproduct. Methane, which has a global warming potential 25 times stronger than carbon dioxide, can be prevented from escaping into the atmosphere through containment measures, or can be burned to generate electricity. While C of C, along with much of Charleston, had been sending waste to the incinerator, it is coming within the end of its functional life, and more waste is being directed towards Bee's Ferry Landfill, a landfill with no methane recapturing devices. So while previously the waste sector was not a large contributor to greenhouse gas emissions, since burned trash emits CO₂ which has a lower GWP than methane released from landfills, the large amounts of trash that will be sent to the landfill in the coming years will lead to the growth of the waste sector as a contributing factor to greenhouse gas emissions.

Refrigerants

The College of Charleston's refrigerant use is limited to the chillers at the physical plant and the air conditioning systems. The chillers utilize a "closed system technology" which prevents any escape of these chemicals into the atmosphere. This is an important factor, since these refrigerants have a global warming potential up to 2500 times stronger than CO₂ (see Table 1).

CAVEATS AND PROJECTIONS

Creating projections for the College's emissions is a difficult task. Many variables are associated with the various segments of the campus generating emissions, including enrollment, continued growth of faculty, campus expansion and other factors not within the College's control, such as fuel types used by SCE&G to generate electricity.

There are also some potentially major emission sources that were "missed" by the audit. We assumed zero-emission of refrigerants. We were not able to account for all the on-campus stationary sources. Many of the older buildings outside the central campus area could have independent energy sources or electrical billing. Our accounting for college-related travel included only commuting and fleet miles, not for the usage of personal automobiles, air travel, etc. These issues could be resolved in a future audit sanctioned by an official college "task force".

However it has already been noted that emissions from the waste sector will increase, as the shift from incineration to landfilling increases. The increasing auto dependence, and the encouragement of this dependence by constructing new parking structures will continue to increase emissions from commuting students, faculty and staff. Yet, the College has been on a trend toward less overall emissions, accomplished by utilizing energy efficient technology, in this case high efficiency boilers. This alone has already lowered 2001 emissions below the 1993 levels. Nonetheless, this was a one-time effort by the College, and no further reductions in emissions will result from these boilers. In fact, as use increases, emissions will also increase. The trend for every other category has been an increase, and this trend will continue into the future unless the College makes a steadfast effort to curb emissions.

SUMMARY and CONCLUSIONS

The College of Charleston, which recently implemented its Fourth Century Initiative to become one of the top public liberal arts schools in the nation, would strengthen this goal by addressing campus environmental issues. Environmental and sustainability issues can be overlooked in a restructuring process such as the one currently underway on campus. However, to establish the College of Charleston as a premier public liberal arts university, as well as to become a model campus for other colleges and universities, it is imperative to make a dedicated effort to addressing environmental and sustainability issues.

Campus sustainability is a relatively new concept, and now, in a restructuring phase, seems the ideal time for the College of Charleston to undertake this initiative. Several colleges and universities have already begun down the path of sustainability, and can serve as case studies for initiatives that C of C can implement on its path to become a premier institute of higher learning, not only in the southeast, but nationally. C of C has the opportunity to follow the example and be held in the esteem of Brown University, Tufts University, Rutgers University, and the University of New Hampshire. The following policy recommendations can be implemented immediately, and will propel the College of Charleston into a leadership role of campus sustainability in the Southeast.

RECOMMENDATIONS

1. Creation of a Presidentially Appointed College of Charleston Energy Task Force

Without direct support from the College administration, it is extremely difficult to assess the strengths and weaknesses of C of C's current environmental impact. While students, with faculty and staff support, were able to conduct this emissions audit, it remains a difficult process, lacking easily accessible information. An energy task force would be able to keep a centrally located archive of energy use by the campus community. This allows for a continual tracking of energy uses and associated costs, permitting comparisons of implemented programs to monitor progress. A task force would also be able to pinpoint the most effective measures the College could implement in order to reduce GHG emissions and save money. The following initiatives have been pinpointed by the student team, without the benefit of inside knowledge of the College's operations, and are still extremely useful and feasible policy recommendations. The creation of an energy task force would increase the functionality of such proposals, as well as create avenues for potentially more specific innovations for reducing ghg emissions while saving the College money.

2. Mandatory Lifecycle Costing Methodology

Many of the following proposals will not only reduce GHG emissions, but will save the College money. However, such projects may require a higher initial cost for purchasing equipment that is more efficient than equipment typically purchased. This emphasizes the importance of incorporating lifecycle costing methods into a mandatory procurement policy. Lifecycle costing refers to examining not only the initial cost of purchasing equipment, but also all costs associated with that equipment over its expected lifetime. This comparison translates to lower costs over the lifetime of highly efficient equipment compared to the lower initial cost, less efficient equipment traditionally purchased. Extra costs that traditionally make up for the higher initial cost of more efficient equipment are the lower operating costs due to lower energy consumption and the longer life of the equipment. Longer life translates to less employee maintenance time in fixing/replacing monitors, light bulbs, or exit signs. When the expected operating life of a piece of equipment is three times longer than the standard equipment, that can translate into three times less employee maintenance hours needed *per unit*, which can quickly transfer into a cost savings, even with an initial higher cost. It should become official College of Charleston policy to consider lifetime costs and environmental impacts while purchasing goods.

3. Transportation Alternatives

As noted, the transportation sector accounts for 23% of the College's emissions. With the steep increase in rent associated with living downtown, it is easy to see why many students, faculty and staff choose to live in Mt. Pleasant, James Island, and West Ashley. Indeed, the lower rent and lower density living make those areas attractive areas to reside. However, moving outside of downtown necessitates commuting, leading not only to increased emissions, but traffic congestion and parking issues.

Successfully addressing alternatives to single occupancy driving should be a concern not only for the College, but for the City of Charleston as well. An alternative includes establishing park and ride areas across all three bridges entering the city, where students could leave their cars and be shuttled downtown. Establishing a prompt, efficient shuttle service would alleviate much of the congestion around the campus, as well as save students money from having to purchase expensive parking permits.

4. Light Emitting Diode Technology

The student team recommends one low-cost energy efficiency measure: installing light-emitting diode (LED) exit signs throughout campus. This initiative would cost roughly \$35,000 to implement, but would save the College around \$16,000 per year, offering an approximate two year payback schedule (See Appendix A). After the initial two years, this initiative will provide \$16,000 for school coffers each year. More importantly for this analysis, this change will prevent 800,000 pounds of CO₂ from being emitted per year. These figures fail to recognize an added benefit: the cost savings to the College of a decrease of employee time replacing exit sign bulbs. LED exit signs last up to 25 years; in comparison standard incandescent bulbs require at least annual changing. This alone can save the College the cost of up to 600 employee hours each year.

5. Flat Screen Computers

Phasing out cathode ray tube monitors (CRT) is an effective measure to reduce electricity consumption, save money for the school, and reduce greenhouse gas emissions. A typical computer monitor uses 100 watts of electricity when on, and still consumes electricity when turned off. LCD flat screen computer monitors only use 30 watts of electricity and 3 watts when shut off. LCD monitors not only save money through energy efficiency leading to costs savings, but also offer an operating life of 7 years. CRT monitors need to be replaced every three years, so while LCD monitors typically have a higher initial cost, it is necessary to purchase 2 CRT monitors to get the lifetime usage of a flat screen monitor. The savings in labor and electricity, combined

with the extended life of flat screen monitors, makes this initiative a highly successful option.

6. *Computer Settings*

One no-cost initiative involves altering campus-wide policy regarding computer settings. Simply changing campus policy to require setting all computers to enter energy-saving “hibernation” mode after a period of disuse, as well as shutting down all campus computers at night, can provide noticeable results. Based on a University of Michigan study, such a policy can reduce electricity consumption, save money and simultaneously reduce GHG emissions

7. *Recycling*

Unrelated to energy efficiency, yet still having potential to make a huge impact in campus GHG emissions is in improvement in recycling efforts by the College. The campus assessment shows that historically, the majority of emissions are not a result of waste, however this component is increasing. Traditionally, C of C waste was sent to a local incinerator, currently in the process of shutting down, resulting in more waste being directed to Bee’s Ferry landfill, which lacks a methane recovery system. This diversion in trash to an uncontained landfill will significantly increase the College’s emissions from waste in coming years. A decrease in trash sent to landfills results in less methane emissions, which have a GWP 25 times more potent than CO₂. Actions such as permitting (even encouraging) students and faculty to print papers or handouts double-sided can dramatically reduce the amount of paper being thrown out. On a positive note, the College of Charleston recycles computer paper; but recycling (when compared to reduction) requires more fossil fuel and resource use. In this way, it is more beneficial to use less paper initially, rather than go through the recycling process at a later point.

Increasing student awareness of recycling measures is a relevant option. A simple walk through campus will yield the sight of many garbage cans filled with easily recyclable water bottles and aluminum cans. These easily recyclable objects fill up landfills instead of ending up in proper recycling facilities. Alternatives include more recycle bins around campus and in buildings, making it painfully obvious to students that recycling is available and easy. Finally, informing students, faculty and staff of the importance of recycling, what can be recycled, and where to recycle is an important step towards a successful campus-recycling program.

In addition, creating a campus policy to purchase recycled paper can have resounding effects. While emissions saved are not directly related to the campus audit, purchasing

recycled paper benefits our environment. When compared to manufacturing and disposing of a ton of virgin paper, manufacturing and recycling a ton of recycled paper reduces solid waste, energy use, pollution and greenhouse gas emissions. Specifically, manufacturing and recycling a ton of recycled paper:

- Reduces solid waste by 49%
- Reduces total energy consumption by 43%
- Reduces net greenhouse gas emissions by 70% of carbon dioxide equivalent
- Reduces hazardous air pollutant emissions by 90% and particulate emissions by 40%
- Reduces absorbable organic halogen emissions to water by 100% and suspended solids by 30%

A policy of purchasing recycled products also benefits recycling overall by creating a market for the production of recycled goods, and will promote the College's dedication to a cleaner, more sustainable environment.

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1. South Carolina Sustainable Universities Initiative

Through grants to Professor Neff, 3 summer graduate assistantships and some participant travel were funded by the South Carolina Sustainable Universities Initiative. Clemson University, located in upstate South Carolina, the Medical University of South Carolina (MUSC) in Charleston, and the University of South Carolina (USC) with its main campus in Columbia, the state's capital, have developed a productive partnership — the S.C. Sustainable Universities Initiative (SUI). In 1998, the presidents of the three schools signed a pledge to cooperate in leading the way toward a more sustainable future through teaching, research, community service and facilities management. In 2000, the state's General Assembly appropriated one-time funds to expand the program to other state-supported institutions of higher education. To date, 13 four-year and technical schools have joined. The primary focus of our efforts is to “change our product” — to help students understand how to meet fundamental human needs without destroying the planet's ability to support us. We do this by working with faculty to expand their teaching and research portfolios and by working with administrators and operations managers to ensure that our institutions are practicing what faculty preach. SUI serves as a catalyst for activities that will make the state's three research universities, other educational institutions, and ultimately, the state as a whole, more sustainable.

<http://www.sc.edu/sustainableu>

2. Clean Air-Cool Planet

Audit software was provided free of charge by Clean Air-Cool Planet. Clean Air-Cool Planet is an action-oriented advocacy group that seeks to reduce the threat of global warming by engaging all sectors of civil society to take actions that lead to rapid cuts in greenhouse gas emissions. Based in Portsmouth, NH, CA-CP is active throughout New England, New Jersey and New York. Clean Air-Cool Planet's higher education program is designed to engage administrators, students, faculty, and staff in the global climate change discourse by increasing awareness about the issue and catalyzing direct action to reduce greenhouse gas emissions from campuses throughout the northeast.

www.cleanair-coolplanet.org

3. South Carolina Space Grant Consortium

Travel funds for Neff and 2 graduate students to attend an organizing meeting held in Portland, Oregon were provided by a grant from the SC Space Grant Consortium.

4. College of Charleston:

The Physics and Astronomy Dept. and the School of Science and Math jointly funded a summer undergraduate assistantship to assist in the data collection phases of this audit. A portion of Professor Neff's time was dedicated to this project.

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Appendix B: LED Exit Sign Proposal

Immediate implementation of this proposal will provide the following benefits:

- **Save the College of Charleston \$16,000 annually**
- **Reduce electricity consumption by 2%**
- **Create more free maintenance staff hours**
- **Prevent 400 tons of carbon dioxide from entering the atmosphere**

The College of Charleston annually purchases over 20 million-kilowatt hours of electricity from SCE&G. The annual expense for electricity for the College is over \$800,000 and electricity is the campus' leading contributor of greenhouse gases, carbon dioxide in particular.

While EXIT signs in buildings may not be seen as a large contributor to the electricity use, there are over 1200 in campus buildings, running 24 hours a day, 365 days a year, accounting for 2% of the schools electricity consumption. The total annual expense is \$16,819

Installing LED EXIT signs in place of the standard exit signs would cut the 2.1% electricity use to 0.1%, a decrease of 2%. The annual cost savings would be around \$16,000 dollars. This amount will be saved every additional year for the life of the signs, which is significantly longer than for standard signs.

There would be an estimated payback period of one and a half years, and a prevention of 400 tons of climate altering carbon dioxide emissions.

The following numbers represent total energy used by an estimated 1200 EXIT signs on campus, for standard signs and LED signs. The cost savings are then stated.

Standard EXIT signs

40 W x 1/1000 kW x 1200 signs x 24 hours/day x 365 days/ year = 420,480 kW hrs/year

Percentage of total electricity consumption: 2.1%

Annual electricity expense @ \$0.04 /kW hr: \$16,819

LED EXIT signs

2 W x 1/1000 kW x 1200 signs x 24 hours/day x 365 days/year = 21,024 kW hrs/year

Percentage of total electricity consumption: .1%

Annual electricity expense @ \$0.04 /kW hr: \$841

Difference of 399,456 kW hrs/year

Annual cost savings per year: \$15,978

Cost savings do not reflect amount saved due to less required maintenance time, or benefit of having more man-hours to perform other tasks.

Estimated cost per unit: \$20

Estimated expenditure on LED signs: \$24,000

Estimated payback time: 1.5 years

Carbon dioxide emissions prevented: 400 tons