CAL POLY POMONA

California State Polytechnic University, Pomona Greenhouse Gas Emissions Inventory Report

1995-2005

Report Issue Date: November 2007

Project Team:

Heidi Rusina, MSRS Graduate Student
Kim Trimiew, MLA Graduate Student
Zora Tucker, MSRS Graduate Student
Kyle D. Brown, Ph.D., Director John T. Lyle Center for Regenerative Studies

Acknowledgements

The President's Climate Task Force

Co-Chairs:
Dr. Ed Barnes, Administrative Affairs
Dr. Kyle D. Brown, John T. Lyle Center for Regenerative Studies

Task Force Members

Marvin Campbell, I & IT Applications
Dr. Julianna Delgado, Department of Urban & Regional Planning
Dr. Doug Freer, Student Affairs
Dr. Ron Fremont, University Advancement
Carrie Geurts, College of Environmental Design
Peter Graves, Facilities Management
Trevor Henderson, I & IT Learning
Dr. Pablo LaRoche, Department of Architecture
George Lwin, Facilities Planning & Management
Ray Morrison, Facilities Planning & Management
Dave Patterson, Environmental Health & Safety
Pam Shedd, Administrative Affairs
Glenn Shenker, Planning and Transportation Services
Megan Stang, University Housing Services
G. Paul Storey, Cal Poly Pomona Foundation
Heidi Rusina, Regenerative Studies Graduate Student
Powell Velasco, Associated Students, Inc.
Al Viteri, Accounting Services
Dr. Rick Willson, Department of Urban & Regional Planning
Dr. Lin Wu, Department of Geography & Anthropology
Dr. Henry Xue, Department of Mechanical Engineering

Research Assistants

Kim Trimiew, Landscape Architecture Graduate Student
Zora Tucker, Regenerative Studies Graduate Student

Data Inventory Sub-Committee

Dr. Kyle D. Brown, John T. Lyle Center for Regenerative Studies
George Lwin, Facilities Planning and Management
Dave Patterson, Environmental Health and Safety
Heidi Rusina, Regenerative Studies Graduate Student
Edward Shore, University Accounting Services
Al Viteri, Accounting Services
Dr. Lin Wu, Geography and Anthropology

The Climate Commitment Task Force wishes to thank all of those named in this report, who contributed time and information to this inventory report. In addition, the Task Force wishes to thank Dr. Kyle D. Brown and Dr. Richard Willson, and the students in their RS 599: Methods and Applications in Regenerative Studies course for their efforts in compiling information, and completing the preliminary analysis of greenhouse gas emissions on campus. The work of Stephanie Clements, Gordon Haines, Lora Hall, Todd Lininger, Azita Rezvan, Heidi Rusina, Jennifer Strouse, Mike Truong, Zora Tucker, and Telat Yalcin served as the foundation for the completion of this inventory process.

1.0 Executive Summary

This report summarizes Cal Poly Pomona's anthropogenic green house gas emissions for fiscal years 1995-2005. The inventory process is a first step towards quantifying the environmental impact of the University's Operations relative to greenhouse gas emissions. The inventory serves as a baseline and guide for future reduction strategies as Cal Poly Pomona moves toward the long-term goal of achieving carbon neutrality. The report also identifies emissions reporting challenges specific to the institutional organization of the Cal Poly Pomona campus and offers some suggestions for improvement. By detailing these difficulties, the document is meant to inspire further refinements at Cal Poly Pomona, while providing a useful account of the process to assist both future researchers and other institutions facing similar challenges.

Cal Poly Pomona is committed to addressing the issue of climate change. As a Charter signatory of the American College & University Presidents Climate Commitment, Cal Poly Pomona has agreed to proactively monitor and ultimately neutralize its green house gas emissions. The institution has also pledged to increase climate change research and educational curriculum focused on environmental sustainability. The inventory is an essential component for identifying emission sources. It is an integral part of the Climate Commitment and will be periodically updated as additional data becomes available.

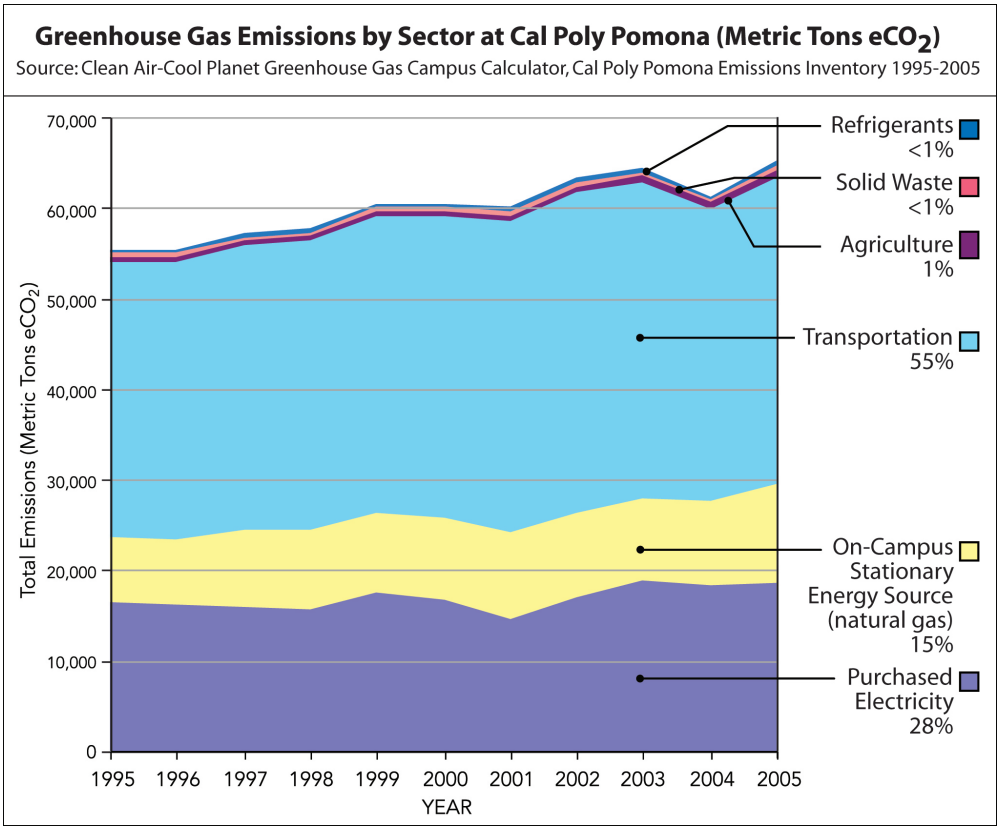
Cal Poly Pomona's greenhouse gas inventory reports emissions of the six greenhouse gasses covered under the Kyoto Protocol: Carbon Dioxide (CO_2), Methane (CH_4), nitrous oxide (N_20), hydrofluorocarbons (HFC), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Using a model developed by Clean Air-Cool Planet, emissions are reported in Metric Tons Carbon Dioxide Equivalents (MTCDE). This value takes into account the Global Warming Potential (GWP) of the individual gases recorded and converts their forcing power into carbon dioxide equivalent values.

Inventory Results

- On an annual basis, Cal Poly Pomona emits an average of approximately 60,000 (59,771) tons of Carbon Dioxide Equivalents (MTCDE).
- There is a net increase (+17%) in overall emissions from 1995-2005 (55,313 MTCDE in 1995 to 64,779 MTCDE in 2005.)
- Campus emissions have increased annually by ~1.7%; exceeding the nationwide average annual increase of 1.0%

Greenhouse Gas Emissions by Sector at Cal Poly Pomona (Metric Tons eCO_2)

Source: Clean Air-Cool Planet Greenhouse Gas Campus Calculator, Cal Poly Pomona Emissions Inventory 1995-2005



- Emissions per student dropped from 3.8 MTCDE in 1995 to 3.64 MTCDE in 2005.
- The emissions increase follows an increase in growth on campus.
- The full time student population grew by 26% from 12,933 in 1995 to 16,295 in 2005.
- Building square footage increased 39% from 2,604,605 in 1995 to 3,628,670 in 2005.
- Transportation is the major source of emissions at Cal Poly Pomona (~55% of the campus' average total emissions).
- Student commuting is the largest source of emissions within the transportation category.
- Energy in the form of purchased electricity and natural gas are the second largest source of emissions.
- Emissions due to Solid Waste, Agriculture, and Refrigerants are negligible.

Total CPP Greenhouse Gas Emissions in MTCDE:

Fiscal Year	Purchased Electricity	On-campus Stationary	Transportation				Ag	Solid Waste	Refriger-ants	Total Emissions (MT eCO_2)
			Fleet	Student Commuters	Faculty/Staff Commuters	Air Travel				
1995	16,365	7,130	706	21,340	4,881	3,656	620	341	275	55,313
1996	16,062	7,240	705	21,443	5,061	3,557	618	356	61	55,104
1997	15,949	8,527	705	21,906	5,106	3,603	619	366	147	56,929
1998	15,652	8,615	704	22,542	5,197	3,586	623	380	61	57,360
1999	17,572	8,685	704	23,243	5,250	3,639	618	386	105	60,202
2000	16,728	9,079	758	23,576	5,342	3,678	625	394	58	60,273
2001	14,652	9,512	813	24,210	5,544	3,845	617	473	62	59,729
2002	17,019	9,119	906	25,241	5,542	3,893	651	462	101	62,934
2003	18,815	8,969	888	24,704	5,535	3,906	679	401	72	63,970
2004	18,195	9,362	1,044	22,538	4,988	3,612	704	361	124	60,927
2005	18,516	10,962	1,048	23,760	5,185	3,788	719	512	289	64,779

Percent Change in Emissions per Source for 1995 & 2005:

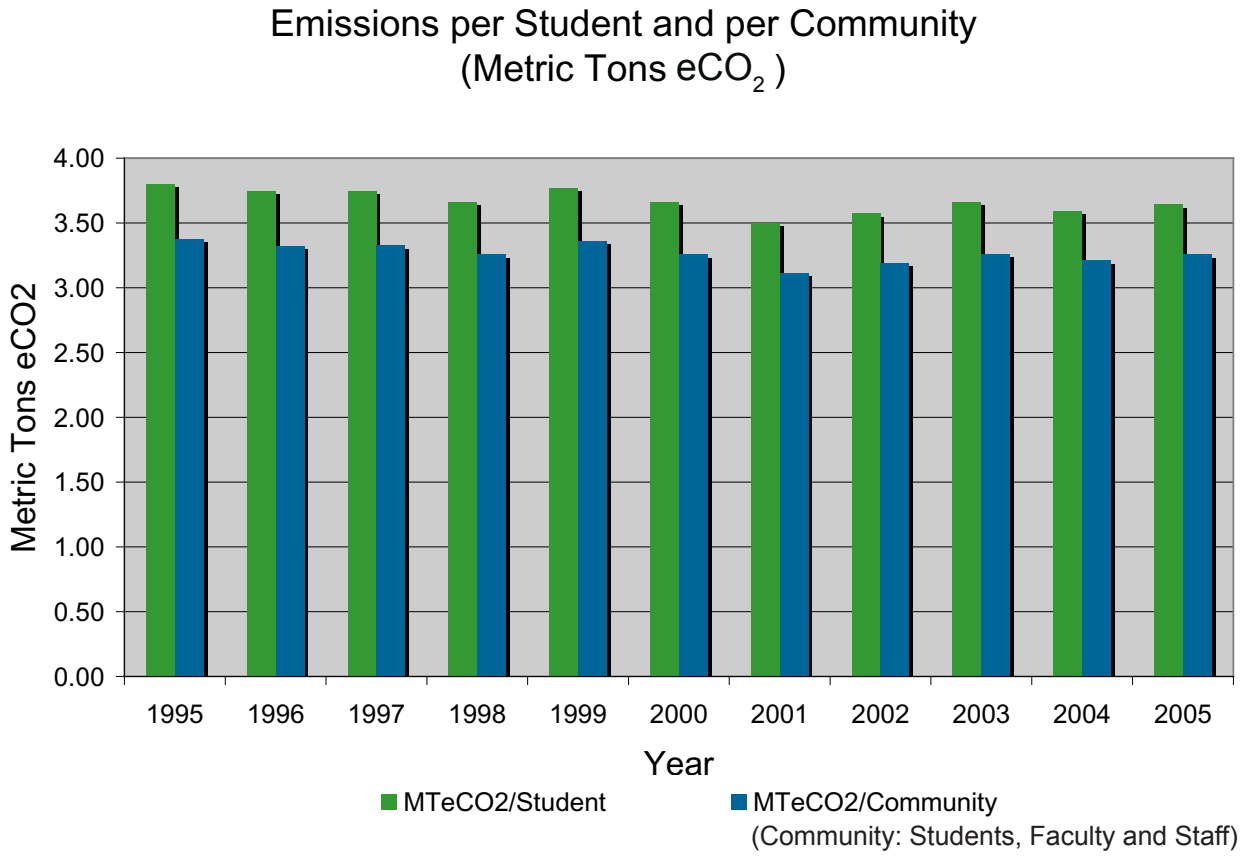
Source	1995 MTCDE	2005 MTCDE	% Change
On-Campus Stationary Source	7,130	10,962	35
Purchased Electricity	16,365	18,516	12
Transportation: Commuting Faculty/Staff	4,881	5,185	6
Transportation: Commuting Students	21,340	23,760	10
Transportation: University Fleet	706	1,048	33
Transportation: Air Travel	3,656	3,788	3.5
Agriculture	620	719	14
Solid Waste	341	512	33
Refrigerants	275	289	5

Sources of CCP's Emissions by Percent for 1995, 2000, & 2005:

Source	1995 % MTCDE	2000 % MTCDE	2005 % MTCDE
Energy: On-Campus Stationary Source	13	15	17
Energy: Purchased Electricity	30	28	29
Transportation	55	55	52
Agriculture	1	1	1
Solid Waste	<1	<1	<1
Refrigerants	<1	<1	<1
*Average percent of emissions per category over the total inventory period: Energy: On-campus Stationary Source 15%, Energy: Purchased Electricity 28%, Transportation: 55%, Agriculture: 1%, Solid Waste and Refrigerants: Less than 1%.			

Kg Emissions by Type of Gas for 1995, 2000, & 2005:

Source	1995 KG	2000 KG	2005 KG
Carbon Dioxide (CO_2)	53,367,735	58,378,847	62,466,161
Methane (CH_4)	30,620	33,766	42,943
Nitrous Oxide (N_2O)	3,266	3,459	3,501
PFC	0	0	0
HFC	0	0	0
Sulfur Hexafluoride (SF_6)	0	0	0



Key Findings and Recommendations

General

Key Finding

Energy consumption and greenhouse gas emissions have increased as the student population and campus infrastructure has expanded. Total emissions at Cal Poly Pomona have increased, although per person emissions have dropped slightly. Transportation emissions relative to student commuting is the most critical issue CPP faces in moving toward emissions reduction.

Transportation

Key Finding

Transportation is the largest source of GHG emissions at CPP. In 2005, transportation was 52% of CPP's total emissions. Over the inventory period, transportation produced 55% of the total emissions.

Recommendations

1. Develop a standardized process for recording mileage of airline travel on University, CPP Foundation, and ASI business. Data should be digitally archived for easy retrieval and tracking.
2. Develop a standardized process for recording mileage of vehicle travel on University, CPP Foundation, and ASI business. Data should be digitally archived for easy retrieval and tracking.
3. Establish a method for collecting and analyzing student commuter behavior data on a regular basis, to better ascertain the baseline contribution to greenhouse gas emissions and assess the impact of reduction programs. Data should be collected every other year.
4. Develop method for reporting fuel consumption for CPP Foundation vehicles that fuel off-campus.

Non-Vehicular Energy

Key Finding

Non-vehicular energy is the second largest source of greenhouse gas emissions at CPP. In 2005, 46% of CPP's total emissions came from this sector. Over the inventory period, non-vehicular energy produced 43% of the total emissions.

Recommendations

5. Initiate an effort to increase metering or develop reliable methods for estimating consumption in individual buildings on campus, to assess energy usage for various campus activities, and provide feedback on the effectiveness of reduction strategies A method for prioritizing metering installation should be developed.
6. Require utility vendors to generate summarized annual consumption reports for University Village and other sites on campus that have multiple meters.

Key Findings and Recommendations Continued

Agriculture, Landscape and Solid Waste

Key Finding

Agriculture, landscape, and solid waste activity appear to have a small effect on Cal Poly Pomona's total carbon footprint. Over the inventory period, these sectors each produced 1% or less of the total emissions.

Recommendations

7. Develop improved tracking method for quantities of nitrogen used in agricultural and landscape activities. Data should be centralized for easy retrieval.
8. Conduct carbon sequestration inventory of campus landscape to assess current rates of sequestration that serves as offset for greenhouse gas emissions.

Refrigerants

Key Finding

Refrigerant gases are not a significant source of GHG emissions on campus. In 2005, less than 1% of CPP's total emissions came from this sector. Over the inventory period, refrigerant gases produced less than 1% of the total emissions.

Recommendation

9. Work with outside vendors and all entities on campus to ensure that emissions are consistently reported on an annual basis.

2.0 Introduction

Early in 2007, Cal Poly Pomona University president J. Michael Ortiz dedicated his support to the American College and University Presidents Climate Commitment (ACUPCC), a coalition of college and university presidents and chancellors concerned about the adverse impacts of global warming. As of October 2007, a total of 409 colleges and universities nationwide had joined this consortium by signing a commitment to go "carbon neutral." Signatory schools acknowledge the scientific consensus that global warming is real and carries the potential for widespread economic and environmental disruption. The Presidents Climate Commitment call for leadership states that "reversing global warming is the defining challenge of the 21st century."[a]

The Presidents Climate Commitment is a call to action. Participating institutions will develop a plan within two years of signing the commitment that prescribes a strategy toward achieving climate neutrality by a specific target date. The initial steps toward the development of this plan are the creation of institutional structures charged with the plan's implementation, and a comprehensive inventory of greenhouse gas (GHG) emissions produced by the campus that will be updated periodically. Colleges and universities involved in the Climate Commitment must also develop methods of easily and accurately tracking the institution's carbon footprint, and provide intermittent reports of progress to the Association for the Advancement of Sustainability in Higher Education (AASHE) once the plan has been drafted.

Upon signing the Presidents Climate Commitment, President Ortiz created the Presidents Climate Commitment Task Force, a coalition of members from every division within the Cal Poly Pomona campus, co-chaired by university CFO Dr. Ed Barnes and Dr. Kyle D. Brown, Director of the John T. Lyle Center for Regenerative Studies. The Task Force will spend the next two years establishing the Cal Poly Pomona target date for achieving climate neutrality, and developing a comprehensive plan to meet this goal. This report is a summary of the campus-wide inventory of GHG emissions, the first critical step in the process outlined in the Presidents Climate Commitment.

California's Leadership

The State of California has distinguished itself as a leader in greenhouse gas reduction. AB 32, signed into law by Governor Arnold Schwarzenegger in 2006, charges the Air Resources Board (ARB) with monitoring and reducing GHG emissions and calls for the reduction of GHG emissions to levels equivalent to those produced in 1990 by the year 2020.[b] The language of AB 32 addresses global warming issues specific to California, such as the danger presented to the state's water supply by the loss of Sierra snowpack, the already degraded condition of the State's air quality, and the vulnerability of natural habitat of the State's coastlines to rising sea levels attributed to global warming.

The state of California has also recently addressed GHG emissions reduction with enactment of several other laws and regulations. The Air Quality Resources board approved regulations requiring automakers to sell only vehicles with set limits on GHG emissions to California dealers by model year 2009.[c] Similarly, in 2002 the state adopted a Renewable Portfolio Standard (RPS) requiring energy providers to obtain at least 20% of their power from renewable energy resources by the year 2010.[d] In the same year as the landmark enactment of AB 32, the California Energy Commission also established Appliance Efficiency Regulations, whereby 21 major categories of federally and non-federally regulated appliances sold in California must operate at a greater level of efficiency than those established by federal standards.[e] These state level efforts have set strong leadership precedents for other states and large in-state institutions, such as Cal Poly Pomona.

The CSU System

The California State University (CSU) system operates 23 campuses throughout the state, which support a total of 417,000 students and 46,000 faculty and staff.[f] It is one of the largest university systems in the world. As such, the CSU system recognizes that it is a major consumer of energy and natural resources, and that there is a need to strive for greater energy efficiency and to reduce its carbon footprint.[g] Since the enactment of AB 32, CSU has invested in projects leading to greater energy efficiency on its campuses, and has stated a goal to reduce campus-wide production of GHG emissions by 160,000 metric tons by the year 2020.[h] Through its efforts toward cleaner energy, the campus system was rated by the U.S. Environmental Protection Agency as the 4th largest purchaser of renewable energy in the higher education sector as of July 2007.[i] The CSU system has also adopted sustainable building practices per Executive Order 917, requiring new construction projects to be designed with "consideration of optimum energy utilization, low life cycle operating costs, and compliance with all applicable energy codes and regulations."[j]

Cal Poly Pomona's Greenhouse Gas Inventory

This report summarizes Cal Poly Pomona's anthropogenic green house gas emissions for fiscal years 1995-2005. The inventory process is a first step towards quantifying the environmental impact of the University's operations relative to greenhouse gas emissions. The inventory reports emissions of the six greenhouse gasses covered under the Kyoto Protocol: Carbon Dioxide (CO_2), Methane (CH_4), nitrous oxide (N_20), hydrofluorocarbons (HFC), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Using a model created by Clean Air-Cool Planet (CA-CP), emissions are reported in Metric Ton Carbon Dioxide Equivalents (MTCDE). This value takes into account the Global Warming Potential (GWP) of the individual gases recorded and converts their forcing power into carbon dioxide equivalent values. The Clean Air-Cool Planet model is consistent with guidelines of the Intergovernmental Panel on Climate Change (IPCC).

The purpose of the inventory is to track emissions trends and assist policy makers in developing reduction strategies. The inventory fulfills an integral component of the Campus Climate Commitment, which is aimed at developing a measured plan for achieving carbon neutrality. This document will be updated in future years, as Cal Poly Pomona actively engages the tasks of greenhouse gas emissions mitigation and reduction.

Global Warming Potential

Global warming potentials (GWPs) are used to compare the abilities of different greenhouse gases to trap heat in the atmosphere. They are based on the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide (CO_2), as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of CO_2. The GWP provides a construct for converting emissions of various gases into a common measure (carbon dioxide equivalents). The GWP then reflects the radiative forcing or relative power of a gas relative to CO_2. It refers to the total contribution to global warming resulting from the emissions of one unit of gas relative to one unit of carbon dioxide. For example, if methane has a global warming potential of 21, -1lb. of methane has the same impact on climate change as 21 lbs. of carbon dioxide and thus 1 lb. of methane is counted as 21 lbs. of carbon dioxide equivalent.

Atmospheric Lifetimes & Global Warming Potential (GWP) of Primary Greenhouse Gases*:

Gas	Atmospheric Lifetime (years)	GWP (100 year interval)
Carbon Dioxide (CO_2)	50-100	1
Methane (CH_4)	9-11	21
Nitrous Oxide (N_2O)	120	310
HFC-134A	15	1,300
HFC-404A	>48	3,260
Sulfur Hexafluoride (SF_6)	3200	23,900

*Source: CA-CP V.5.0

Primary Greenhouse Gases

• Carbon Dioxide (CO_2): Anthropogenic carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed as part of the biological carbon cycle.

• Methane (CH_4): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

• Nitrous Oxide (N_2O): Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

• Fluorinated Gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases"). On campus, these gases are associated with refrigeration and air conditioning equipment.

3.0 Cal Poly Pomona Inventory Process

Introduction

This GHG inventory is a project that originated in a Regenerative Studies methods and application graduate studio taught by Task Force members Dr. Kyle D. Brown and Dr. Rick Willson during the winter quarter of 2007. Students examined the scientific research behind climate change, global warming policy, and opportunities for improving energy efficiency and mitigating greenhouse gas emissions. These investigations were then applied to the university setting, as students used the Clean Air-Cool Planet Campus Carbon Calculator to begin an inventory model of Cal Poly Pomona's GHG emissions. Their efforts established the groundwork for this inventory report.

Clean Air-Cool Planet Campus Carbon Calculator

Clean Air-Cool Planet is a non-partisan 501(c)3 nonprofit organization that partners with corporations, campuses and communities to work toward the goal of reducing greenhouse gas emissions.[k] The Clean Air-Cool Planet Campus Carbon Calculator was created by Clean Air-Cool Planet, to model greenhouse gas emissions.[k] The CA-CP provides researchers with a framework for the collection, analysis, and presentation of data constituting an inventory of the emissions of greenhouse gases attributable to the operations of an institution. Version 5.0 was used for this inventory.

The CA-CP is an electronic MS Excel workbook. The data input fields include campus energy use (including transportation), agricultural production, refrigerant use, and solid waste. Once the data input is complete, CA-CP calculates estimates of the campus-wide greenhouse gas emissions. CA-CP enables the calculation of emissions for the years 1990-2020, and production of charts and graphs illustrating changes and trends in the quantity of the institutional emissions over time. The model's spreadsheets are based on workbooks provided by the Intergovernmental Panel on Climate Change (IPCC, www.ipcc.ch) for national-level inventories.

The Clean Air-Cool Planet Campus Carbon Calculator Model was initially chosen because it has a proven track record at large universities (Harvard, Tufts, UC Santa Barbara). A condition of the Presidents Climate Commitment is that the GHG inventory must comply with the standards of the Greenhouse Gas Protocol (GHG Protocol) created by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI).[l] The Clean Air-Cool Planet Campus Carbon Calculator is consistent with the GHG Protocol, and therefore suitable for the purposes of the Cal Poly Pomona GHG inventory.

Inventory Methodology/Description

There are seven categories of data within CA-CP—institutional data, energy, transportation, agriculture, solid waste, refrigeration, and GHG emission offsets. Each category is broken down into subcategories, and not all subcategories apply to every institution. The table below lists the CA-CP GHG emissions data categories that were applicable to the Cal Poly Pomona Campus, and inventoried for this study.

Temporal Boundaries

This inventory looks at Cal Poly Pomona operational data between fiscal years 1995-2005.

Study Boundaries

This inventory looks at the operations of Cal Poly Pomona University, and its affiliates, Cal Poly Pomona Foundation (CPP Foundation) and Associated Students Inc. (ASI). While the latter two organizations are not technically a part of Cal Poly Pomona, the management of many of the University's programs and operations is deeply intertwined with the

GHG Emissions Data Categories Applicable to Cal Poly Pomona Campus:

Institutional Data	Energy	Transportation	Agriculture	Solid Waste	Refrigeration	Offsets
Budget Population Physical size	Purchased electricity Natural gas	University fleet Student/faculty/ staff air travel Student/faculty/ staff commuter miles	Fertilizer application Animal agriculture	Landfill waste with Methane (CH_4) recovery	Pounds of: HFC-134a HFC-143a HCFC-22 HCFC-123a	Composting

operations of both CPP Foundation and ASI. The CPP Foundation, established in 1966, provides housing, dining, retail, and other non-state services to the University. As an auxiliary of the CSU system, the Foundation is a partner in the educational mission of Cal Poly Pomona, and responds to the needs of the University by keeping costs affordable and adjusting its operational schedule to the academic year. As a separate organization, the Foundation has its own building facilities, administration and staff, office of accounting, and owns and operates a separate vehicle fleet.

ASI is also a tax exempt, non-profit auxiliary of Cal Poly Pomona. This organization provides the administrative structure for student government on campus and student representation within the larger CSU system. ASI also invests in programs and services intended to support student-run clubs and associations, athletics, and other operations that aim at further academic enrichment. The Bronco Student Center, which hosts a food court and various recreation opportunities, is owned and operated by ASI. Like CPP Foundation, ASI has offices, administration, and staff that are separate from that of the University. Unlike the Foundation, it does not own and operate a vehicle fleet.

When possible, CPP Foundation and ASI operations were inventoried along with the University due to the complex and interrelated nature of all three organizations. All three operate within the Cal Poly Pomona campus land borders and are essential to the function and operation of the University. Thus, emissions produced by each organization must be claimed as Cal Poly Pomona campus-produced emissions. Many of the University operations overlap with the other organizations as well—some examples are the fact that CPP Foundation often fuels its vehicle fleet from campus-owned fueling stations, Foundation solid waste eventually enters and University waste stream, and many University faculty and student travel records are processed through ASI's office of accounting. Both auxiliary organizations are responsible for discrete GHG emissions-producing activities on campus such as refrigeration gases and methane solid waste emissions that result from CPP Foundation dining activities. The University Village, a residential facility owned and operated by CPP Foundation, is a significant consumer of purchased energy.

Off-campus property owned or leased by the University has not been included. Emissions from these activities are estimated at well under 5% of the institutions total annual GHG emissions, and are therefore assumed *de minimis* emissions. Categorizing these emissions as *de minimis*, and not including them in the inventory is acceptable per the California Climate Action Registry General Reporting Protocol, V.2.2 March 2007.

Innovation Village, which is located on campus land and leased by the CPP Foundation to support private enterprise, has not been included in the inventory due to the lack of influence the University has with the procedures of the organizations therein, and lack of available data.

For this inventory of Cal Poly Pomona's GHG emissions, researchers have complied with actions required of Presidents Climate Commitment signatory schools as found on page 11 of the American College and University Presidents Climate Commitment Implementation Guide, V.1.0:

1. To inventory GHG emissions identified by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6)[m].

Scope 1	"…refers to direct GHG emissions occurring from sources that are owned or controlled by the institution, including: on-campus stationary combustion of fossil fuels; mobile combustion of fossil fuels by institution owned/controlled vehicles; and fugitive emissions."
Scope 2	"…refers to indirect emissions generated in the production of electricity consumed by the institution."
Scope 3	"…refers to all other indirect emissions, including those generated from commuting to and from campus, institution air travel, waste disposal, the production of purchased products, and more."

2. To inventory scope 1 and scope 2 emissions (see table below), emissions from commuting and air travel, and when possible, emissions from other sources that are "large and can be meaningfully by the institution."[n]

This inventory covers scope 1, 2 and 3 as comprehensively as possible given the limitations described herein. The majority of CPP's emissions fall into Scope 3 because of the high volume of commuters.

Limitations of the Model (Clean Air-Cool Planet Campus Calculator)

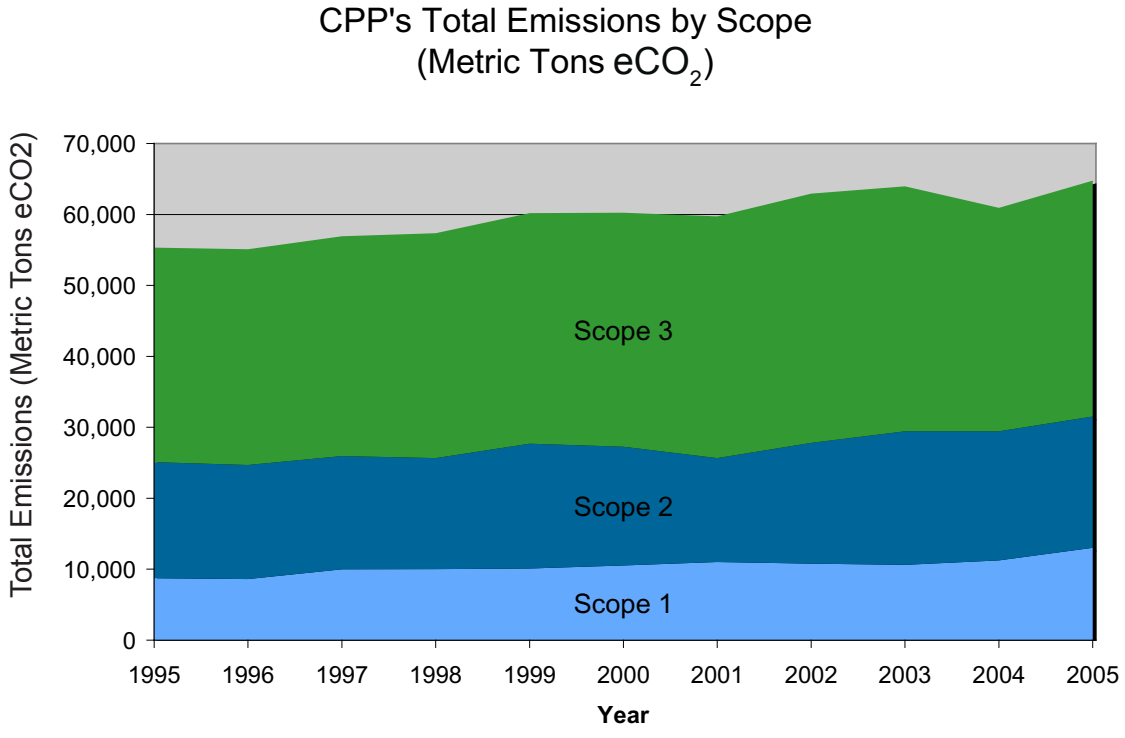
There are factors related to greenhouse gas production at Cal Poly Pomona that the CA-CP does not take into consideration. Some areas that the model neglects to provide input fields for are worth mentioning, because they represent integral processes in the daily function of the campus.

CA-CP does not take into consideration many sources of "embodied energy," which is a term used to describe all of the energy that is used directly or indirectly to create a service or product. For example, drinking water has a high embodied energy, because a large amount of energy is expended in transporting, processing and treating water for consumption. The CA-CP does not take into account the embodied energy of water (drinking or sewage treatment), paper production, food production, procurement, or construction materials. The energy used to transport water is especially significant in southern California, where much of the drinking water is transported from distant locations.

A second important omission of the CA-CP is the calculation of vehicle miles traveled for University-related purposes. While completing this inventory, researchers performed a calculation of faculty, staff, and student non-commuter vehicle miles based on a sample of travel reimbursement forms. The results revealed an estimated 369,399 miles were traveled by faculty and staff during the year 2005. These non-commuter miles that relate to University operations should be included in the inventory for a more accurate account of CO_2 emissions associated with transportation. At present, we believe these emissions to be relatively minor (< 5%), and as such do not warrant inclusion into the inventory. However, the University may wish to monitor them in the future.

Institutional Data

The inventory model requires institutional data related to budgets, student, faculty and staff populations and total building square footage. This data serves as the foundation for some of the descriptive statistics generated by the model. The CSU system does not track student population in full-time vs. part-time student enrollment numbers; instead it uses full-time equivalent student enrollment (FTES), and total full-time enrollment. The FTES population is the sum of the total quarter student credit hours for the academic year divided by 45 (15 credits per fall, winter, and spring



quarters). Because the Institutional Data section of the CA-CP requires full vs. part-time student enrollment, the FTES totals were subtracted from the total student population to obtain a rough part-time population number for each year. The FTES number was used in place of an actual full-time population number. As a result, the population numbers entered into the full-time column of the model are slightly inflated, while the part-time numbers are slightly deflated. After comparing the numbers to a small sampling of years with available full-time/part-time population breakdowns, the margin of error was found to be small.

Data Supplier/Contact

Operating Budget: Mark Lopez, Director, Budget Services

Notes: Years 1997-2005 provided. Previous years estimated by subtracting out the annual percentage increase in budget dollars.

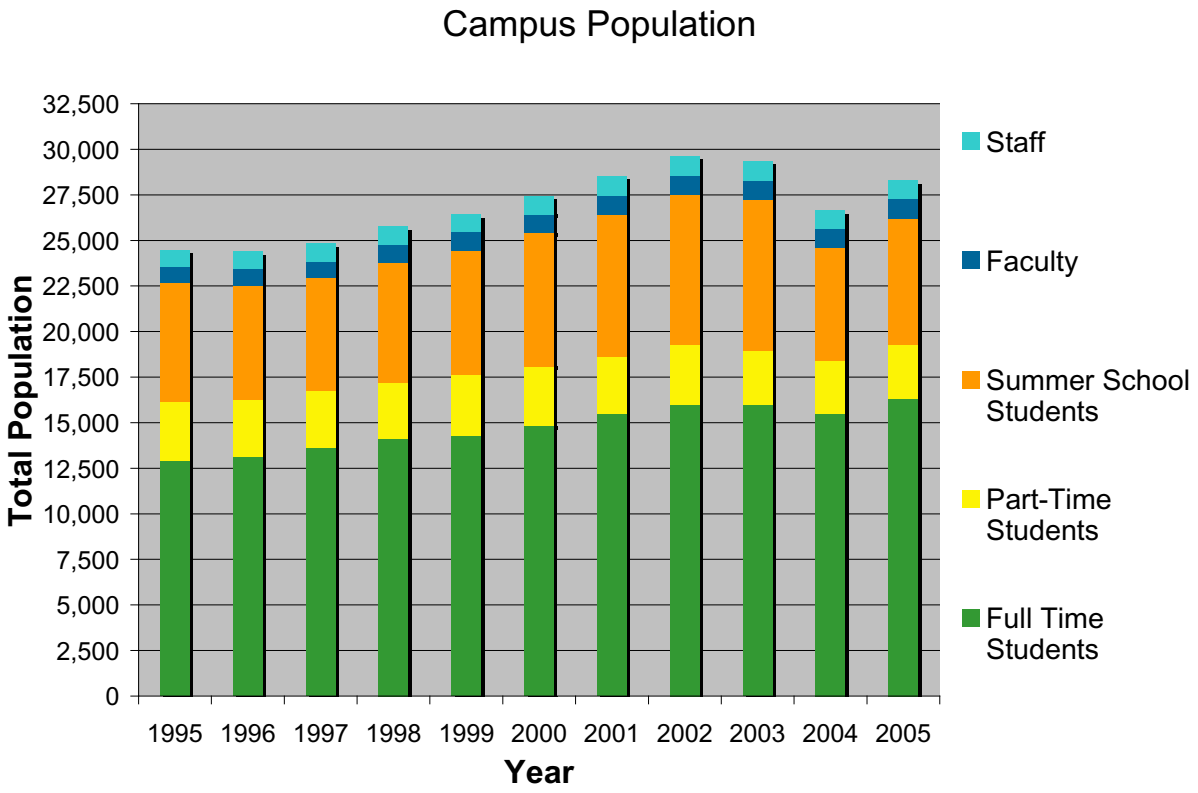
Research Dollars: Dr. Donald F. Hoyt, Assoc Vice President, Research & Graduate Studies

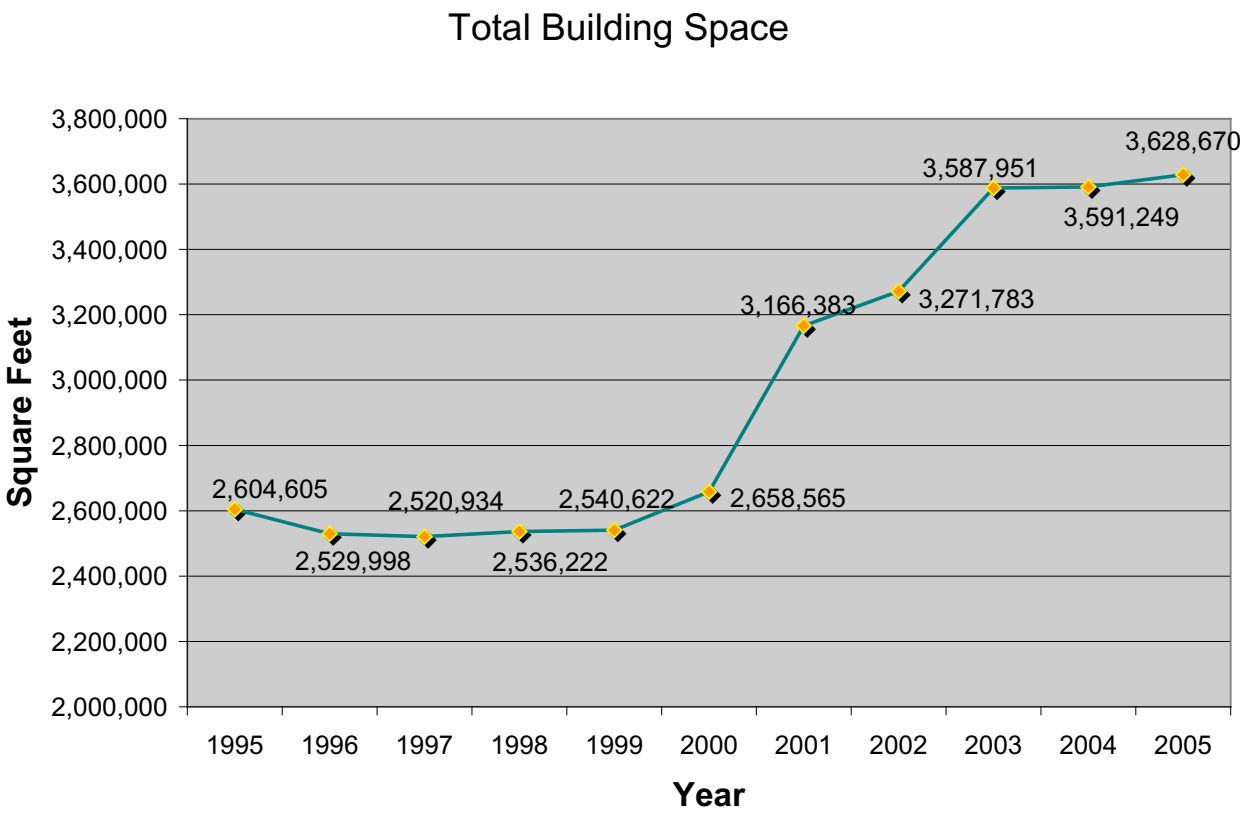
Energy Budget: George A. Lwin, Manager, Energy Services, Facilities Planning and Management

Notes: Estimates for consumption at the Foundation operated University Village were added to the University totals provided by George Lwin.

Since the energy budget is projected, we chose to use actual expenditure numbers for our budget figures for greater precision.

Population Data: California State University Office of the Chancellor Website: www.calstate.edu/as/stat%5Freports/




Total Building Space
Square Feet
3,800,000
3,600,000
3,400,000
3,200,000
3,000,000
2,800,000
2,600,000
2,400,000
2,200,000
2,000,000
2,604,605
2,529,998
2,520,934
2,536,222
2,540,622
2,658,565
3,166,383
3,271,783
3,587,951
3,591,249
3,628,670
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year

4.0 Inventory Results

The greenhouse gas emissions inventory revealed that Cal Poly Pomona emitted on average approximately 64,779 MTCDE in 2005. Emissions on campus have steadily increased by ~1.7% per year from 1995-2005. This increase exceeds the natural average of an ~1.0% increase per year during the same time period. The majority of Cal Poly Pomona's emissions, 55%, come from transportation. Within this sector, student commuting in the largest emissions source. After transportation, purchased energy in the form of electricity and natural gas are the largest source of emissions. These emissions are tied to the operations of the campus' facilities, primarily the buildings.

Although total emissions have increased at Cal Poly Pomona, per person emissions dropped slightly from 3.8 MTCDE in 1995 to 3.64 in 2005. The rise in overall emissions then can be attributed to growth in the overall campus population and the expanded facilities infrastructure required to support the growth. Backing this assumption, is the fact that the full time student population grew by 26% from 12,933 in 1995 to 16,295 in 2005 and that building square footage increased 39% from 2,604,605 in 1995 to 3,628,670 in 2005. The slight reduction in GHG emissions per person, which are more than offset by population increases, is consistent with national trends.

There is a slight dip in emissions registering in 2004, which corresponds to a decrease in the campus population. Other factors increasing the variability of the annual emissions totals include temperature and the amount of construction activities on campus. For example in a particularly hot year, cooling loads may increase and register as an overall increase in emission totals for that year.

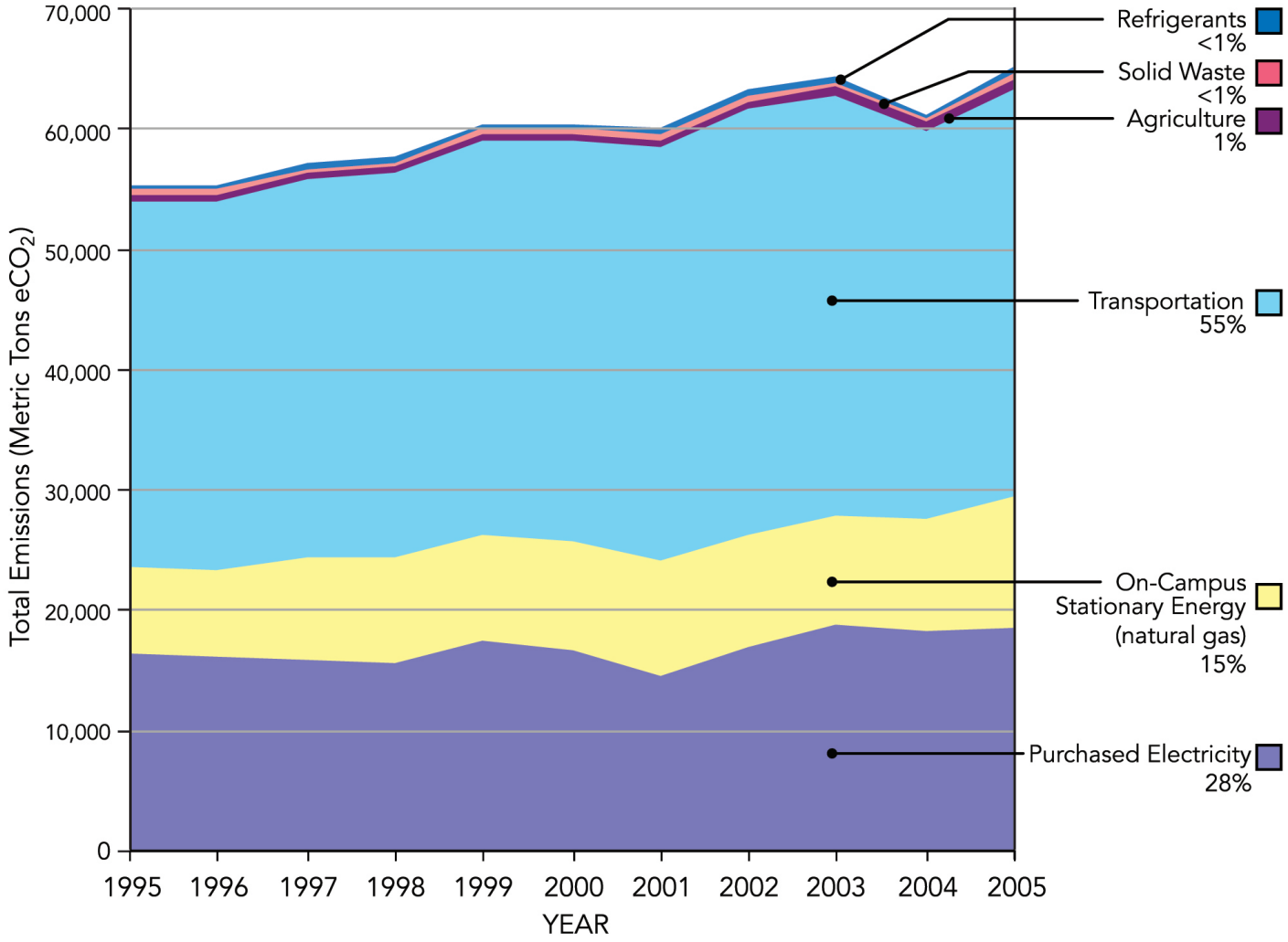
Emissions due to Solid Waste, Agriculture, and Refrigerants were small. Although not as significant, the University should consider improving data collection and recording methods for ease in assembling future inventories.

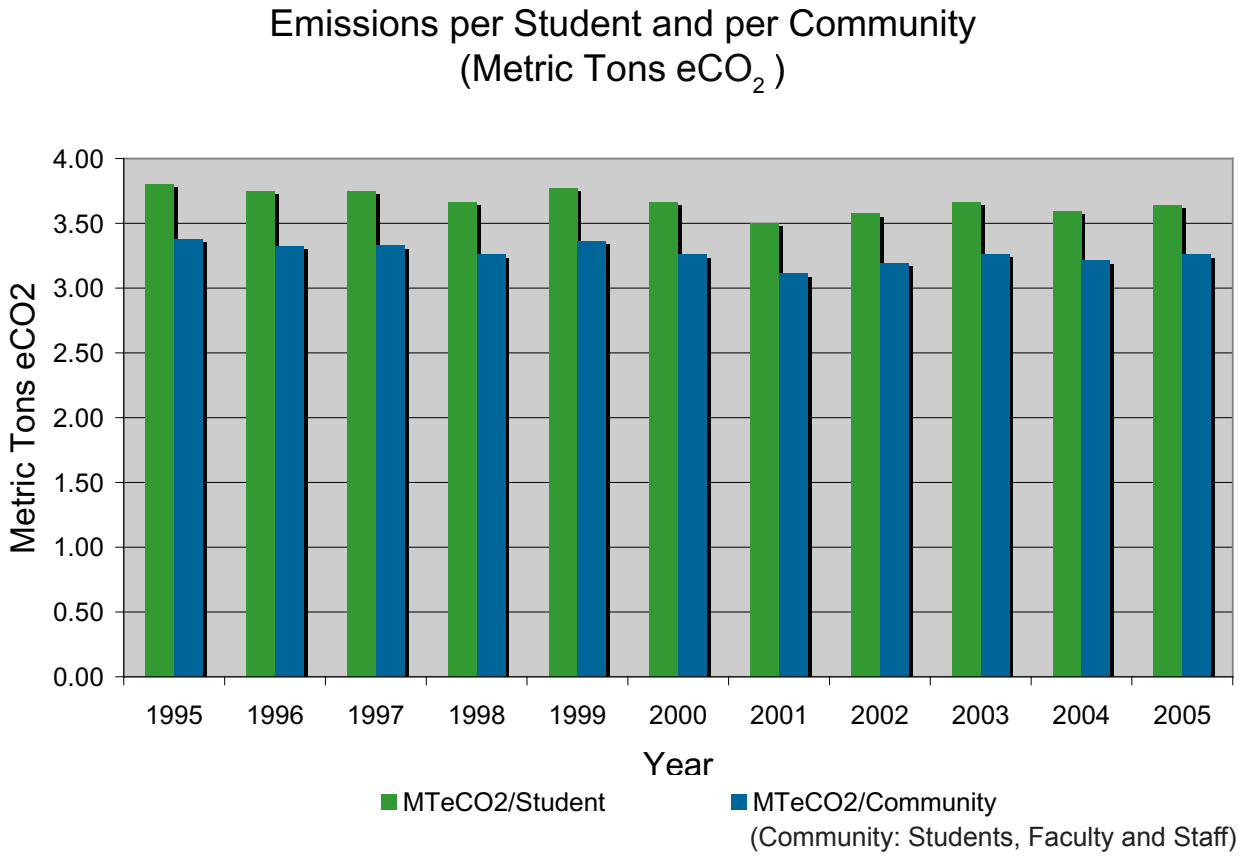
At present, it is difficult to compare where Cal Poly Pomona stands on emissions in comparison to other schools. Because of climatic variability, difference in campus sizes, research focuses and differences in the ages of facilities, caution should be exercised in extracting comparisons to other inventory documents. The inventory is meant to serve as a benchmarking document and will be refined in future years.

As the details of this report reveal, certain data sets within the transportation sector were unable to be estimated because effective samples could not be constructed from the data sets. Estimates for Foundation air travel have not been included. Additionally, fuel mix data for purchased electricity could not be determined. A conservative default setting was used in the model for this sector. Future decreases in emissions will be possible by adjusting the fuel mix to reflect a greater concentration of renewable energy sources.

Greenhouse Gas Emissions by Sector at Cal Poly Pomona (Metric Tons eCO_2)

Source: Clean Air-Cool Planet Greenhouse Gas Campus Calculator, Cal Poly Pomona Emissions Inventory: 1995-2005




Emissions per Student and per Community
(Metric Tons eCO2)
Metric Tons eCO2
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
MTeCO2/Student
MTeCO2/Community
(Community: Students, Faculty and Staff)

5.0 Transportation Emissions Inventory

Introduction

The burning of gasoline, diesel and jet fuel by various modes of transportation contribute significantly to increasing levels of carbon dioxide emissions in the atmosphere. According to a US Department of Energy 2005 report, the transportation sector was responsible for 33 percent of the total carbon dioxide emissions in the United States.[o] Of all modes of transportation, motor vehicle gasoline produced the greatest quantity of CO_2 emissions. The CA-CP inventory revealed that daily commuting to campus and university-related air travel were the most significant source of greenhouse gas emissions at CPP. As a commuter campus, the reduction of this GHG emission source represents the greatest challenge to achieving the goal of climate neutrality.

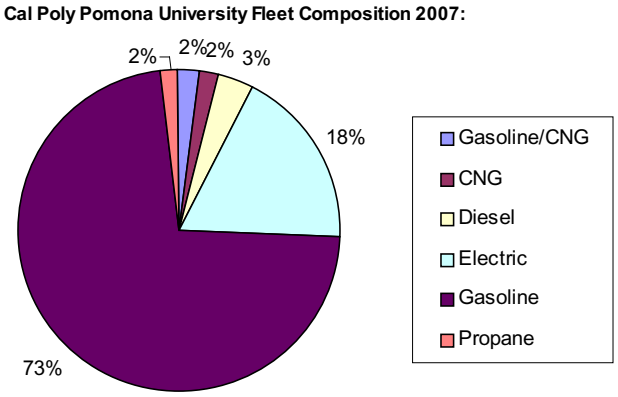
The following inventory categories were investigated at Cal Poly Pomona:

- Cal Poly Pomona Campus vehicle fleet
- Air travel by faculty and staff
- Daily commute by students, faculty and staff

Data Collection for Campus Fleet Vehicles

Cal Poly Pomona University Fleet

In 2007, the Cal Poly Pomona campus fleet included a total of 235 University-owned cars, trucks, vans and buses. As shown in the chart below, the majority of these vehicles are gasoline powered (73%), with a large component of electric vehicles (18%), and smaller components of diesel (3%), CNG (2%), gasoline/CNG (2%), and propane vehicles (2%). Historic data on the composition of the fleet was not available.



Campus fleet vehicles fuel at campus-owned fueling stations and at private, off-site vendors, with the majority of fuel supplied by campus-owned stations. Annual gas and diesel quantities were provided by Peter Graves, Lead Auto and Equipment Mechanic, from fuel-purchase records going back to the year 2000 (for on-campus fueling) or the year 2004 (for off-site fueling). Both on-campus and off-site quantities were combined in the CA-CP inventory. Gas and diesel quantities were entered separately to reflect their different emissions factors. Peter Graves also provided annual natural gas and propane quantities for the years 2001-2005 based on vendor records. For years with missing records, estimations were input based on averages generated from the available years. CPP's electric vehicle fleet is not factored into the transportation sector, because these vehicles are charged by purchased electricity that is included in the "Non-Vehicular Energy" section of the inventory.

Cal Poly Pomona Foundation Fleet

The CPP Foundation owns vehicles used by all of its operations, including Foundation Administration, Dining Services, Kellogg West, Central Maintenance Department and Foundation Housing. According to information provided by the CPP Foundation office, there are approximately 33 vehicles owned by the Foundation. Foundation fleet vehicles fuel at Cal Poly Pomona campus-owned fueling stations, or at off-site vendors. No financial records are available to provide Foundation fuel quantity data for the inventory; however, because some of Foundation's fleet operations do fuel on campus, those fuel quantities are included in the inventory with the Cal Poly Pomona University fleet data.

Data Collection for Air Travel

The University

The University requires faculty and staff to provide detailed accounts of travel expenses in order to receive reimbursements for campus-related travel. For the purposes of the inventory, air travel miles were obtained by calculating the distance between the destination locations recorded on the travel reimbursement forms. The forms are completed manually and archived in the University Office of Accounting. This method presented some challenges for retrieving the data efficiently—for this reason a 20% sample was taken of all forms completed during the 2005 fiscal year. Based on the data found in the sample, the average mileage per capita for both faculty and staff was calculated to be 1,394 miles. To calculate miles for years between 1995 and 2005, the sample mileage estimate was multiplied by faculty and staff population data specific to each year. Thus the total

air miles for faculty and staff input into the CA-CP inventory model between 1995 and 2005 were estimated based on a 20% sample of a single year's worth of data (2005).

CPP Foundation

Similar to the University, the CPP Foundation requires detailed accounting of travel for reimbursement. However, the Foundation does not currently archive reimbursement forms in a location separate from other expense-related documentation, nor does the database system provide a means to estimate the total number of travel records for a given year. Because this method of archiving made it impossible to obtain a reasonably accurate data sample, CPP Foundation air travel miles were not estimated for this inventory. As of Fall 2007, the CPP Foundation will begin flagging and tracking travel records; therefore, air mile calculations for this sector of the campus' operations will be available for future updates of the initial inventory. It is important to note that a significant quantity of travel grants and contracts are processed through CCP Foundation. When data becomes available, it may impact the findings of this preliminary inventory.

Associated Students Inc.

Most student travel and a significant portion of faculty travel is recorded and reimbursed through the Associated Students, Inc. (ASI) office. Similar to the CPP Foundation, the ASI's method of archiving travel records did not facilitate an effective means of data sampling that would enable a reasonable estimation of annual air travel mileage.

Because most of university related student air travel records are processed by ASI, the inability to sample these records effectively leaves a significant gap in the inventory with regard to student air travel. To account for this absence of data, an estimation was made based on the assumption that ¼ of the student population would travel 300 miles (approximately to San Francisco) annually. For each year between 1995-2005, this number was multiplied by the total student population in order to obtain a rough estimation of student air travel miles.

Collection of Commuter Data for Students, Faculty and Staff

Student Commuter Data

In June 2000, KAKU Associates International Parking Design, Inc. completed an assessment of the Cal Poly Pomona campus' parking and transportation needs.[p] As part of their study, the consultants conducted a transportation survey that established percentages of the student commuter population who annually commute alone, carpool, or use public transportation. Since there is no campus operation in charge of keeping track of student commuter data, the 2000 KAKU Associates report provided the starting point for estimating percentages of the total student population who use these commuting strategies. The percentages of the total commuter population obtained by the KAKU survey were adjusted to reflect the percentage of the total student population. The adjusted percentages were used to estimate every year between 1995-2005 due to a lack of data beyond the survey included in the report. For inventory purposes, the average student commute was estimated at 14 miles per trip (x 2 trips per day for 132 days per year).

Faculty and Staff Commuter Data

The campus Rideshare Office keeps records of faculty and staff participation in the rideshare program, and was able to provide survey data for most of the years between 1998-2005. Years with missing data (1995-1998, 2002 and 2003), were input based on averages of years with data. As with the student commuter data, the values entered into the CA-CP model are percentages of the total faculty and staff population that drive alone, carpool, or use public transportation. The average faculty commute was estimated at 25 miles per trip (x 2 trips per day for 245 days per year).

Key Finding

Transportation is the largest source of GHG emissions at CPP. This sector produced 55% of total emissions.

2005 Commuting Emissions Breakdown:
3% Fleet
70.5% Student Commuters
15.3% Faculty and Staff
11.2% Air Travel

Recommendations

Reducing the GHG emissions produced by CPP's significant commuter population will be a formidable task. A first step in this process is to enable a more efficient method of accounting for emissions produced by the transportation sector. Because the researchers of this inventory based many of the findings on estimates derived from limited data, the inventory totals are likely lower than actual totals. It is critical that CPP orchestrate a means of effectively quantifying the balance of the transportation data for a clearer picture of the total emissions to be offset. The financially separate but operationally intertwined nature of the University, CPP Foundation, and ASI makes accessing the travel records a

difficult and time consuming task.

In the future, a possible data collection solution would be to centralize the processing and archiving of travel mileage on a central database. While this might be difficult due to the independent operations of the three organizations, a unified method of collecting mileage data, processing and archiving commuter information is needed. At a minimum, the CPP should consider using uniform reimbursement forms and archiving mileage electronically in a database.

- Develop a standardized process for recording mileage of airline travel on University, CPP Foundation, and ASI business. Data should be digitally archived for easy retrieval and tracking.
- Develop a standardized process for recording mileage of vehicle travel on University, CPP Foundation, and ASI business. Data should be digitally archived for easy retrieval and tracking.
- Establish a method for collecting and analyzing student commuter behavior data on a regular basis, to better ascertain the baseline contribution to greenhouse gas emissions and assess the impact of reduction programs. Data should be collected every other year.
- Develop method for reporting fuel consumption for CPP Foundation vehicles that fuel off-campus.

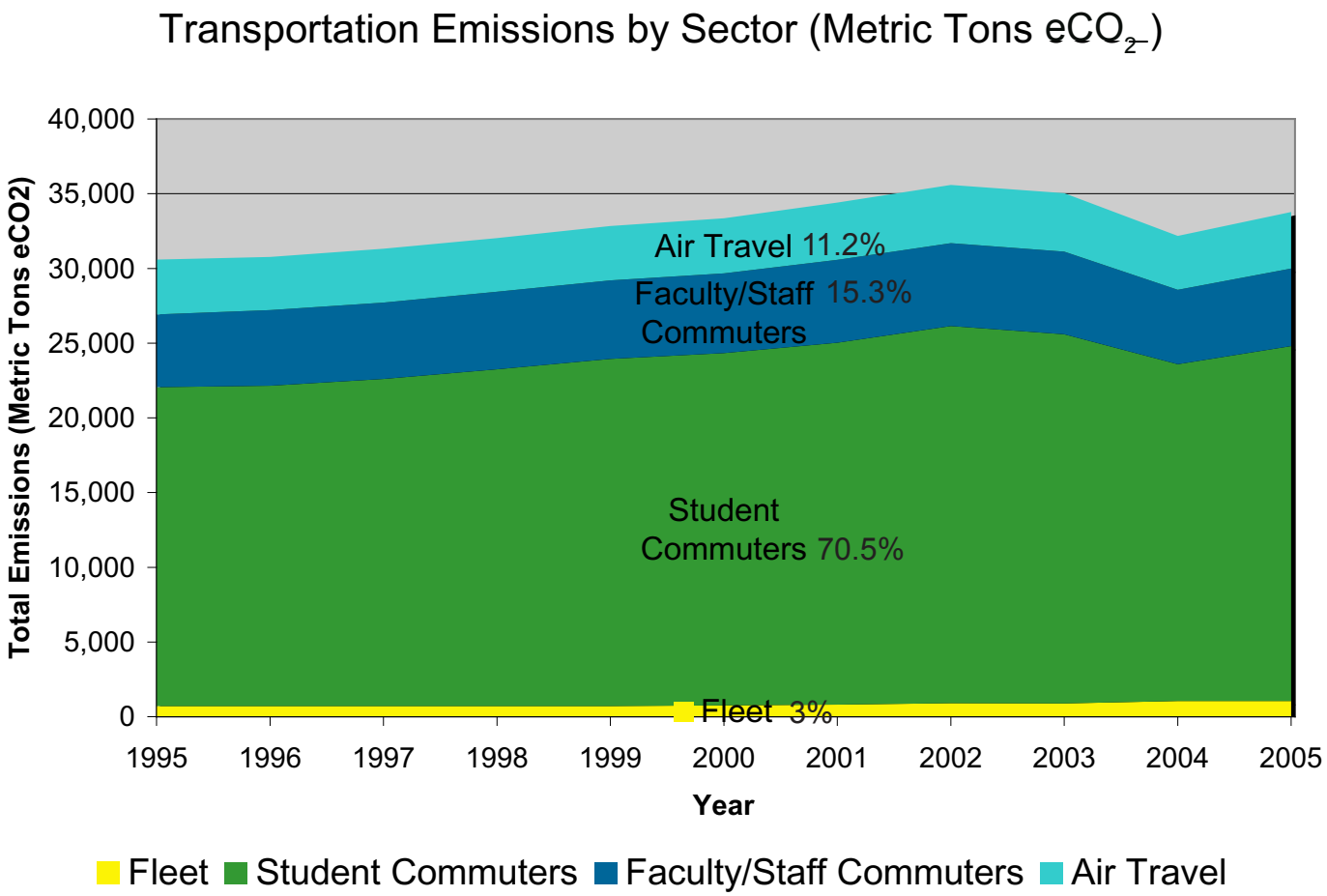
Data Supplier/Contact

University Fleet Fuels: Peter Graves, Lead Auto Equipment Mechanic, Facilities Management

Air Travel, University: Kathy M. Harper, Secretary, Finance & Administrative Services

Air Travel, Foundation: Haleh Minakary, General Business Manager, Financial Services

Air Travel, ASI: Eugene Landers, Supervisor of Business Services, Accounting



6.0 Non-Vehicular Energy Emissions Inventory

Introduction

Non-vehicular energy is the second largest source of greenhouse gas emissions on campus. The greenhouse gases associated with energy production include carbon dioxide (CO_2), and methane (CH_4). Carbon dioxide and nitrous oxide emissions occur during the combustion of fossil fuels (during the production of electricity, etc.) and Methane (CH_4) from natural gas.

Energy emissions are quantified based on the total units of fuel consumed per fuel type. The primary fuels powering CPP are purchased electricity and natural gas. Purchased electricity is mainly used for air conditioning, refrigeration, lighting, equipment loads and some heating. Natural gas is mainly used for heating and hot water loads. In 2005, CCP's emissions from purchased electricity were ~18,516 MTCDE produced from consumption of ~46,801,872 kWhr. 2005 emissions attributed to natural gas consumption were ~10,962 MTCDE from ~ 207,054 MMBtu. Since quantification of emissions is based on fuel type, the mix of fuels used to produce electricity must be provided. CPP's purchased electricity fuel mix is composed of varying percentages of coal, natural gas, nuclear, hydroelectric, and renewable fuel sources.

CPP has proactively endeavored to reduce its energy consumption during the inventory period with upgrades to more efficient HVAC, lighting and equipment. It has also attempted to upgrade to cleaner fuels. In 1999, an on-site water chiller came online and it resulted in a drop in energy costs for cooling buildings. CPP produces a small amount of energy from solar panels installed at the John T. Lyle Center for Regenerative Studies. This quantity was not factored into the inventory because energy production records were not available and the quantity produced is too small to be significant. Electricity consumed in the process of moving water for use on campus and the treatment of sewage water is not factored into the inventory, as CPP does not purchase energy directly associated with these activities.

Data Collection

The inventory model requires input of energy data from two categories:

1) Purchased electricity & purchased steam/chilled water
2) On campus stationary sources

The university does not purchase steam or chilled water. Purchased electricity data was input per annual kwhr consumed. On-campus stationary sources include fuels purchased by the university other than gasoline or diesel fuel used in vehicles. It includes stationary sources such as on-campus cogeneration plants and stationary heating, cooling, cooking, laboratories, etc (powered by propane, natural gas, distillate oil, or other non-electric fuel sources). Natural gas totals were input into this category per annual MMBtu consumed.

The university does use small amounts of additional fuel types to power equipment, such as propane generators. Data was not available for these fuels. Dave Patterson, Director of Environmental Health and Safety, indicated that such fuels would not be purchased in a significant enough quantity to include in the inventory. Similarly, CPP briefly operated a co-generation plant. The quantity produced by this operation was also deemed too insignificant to factor in.

CA-CP has several built in analysis tools related to energy consumption that George Lwin, Energy Service Manager of Campus Facilities Planning and Management, provided data for. These categories include the campus' total building space entered in square feet and annual energy budget information. These data fields work in concert with population and consumption data to describe emission trends.

The University

Energy Services Manager, George Lwin provided annual totals of purchased electricity and natural gas. CPP purchased its electricity from two providers during the inventory period. At present, all buildings North of Temple Avenue and West of South Campus Drive are powered by Arizona Power (AP). All buildings South of Temple and East of South Campus Drive are powered by Southern California Edison (SCE).

The mix of electricity providers makes verifying the fuel mix challenging, as energy use by building is not known. Power mix data was not available from all providers for all years, so for inventory purposes, the regional default mix provided in the model was selected. The model's mix is based on the EPA's eGRID database. The model's mix calculates electricity emissions using the EPA's eGRID database. The EPA metric is based on regional power plant emissions data, not the composition of the source fuels electricity is derived from. The authors believe this data can be considered "conservative," likely resulting in slightly greater emissions than the actual energy mix.

For comparison purposes, the model was also run using custom fuel mix data from the California Energy Commission. In this scenario, the Energy Commissions' "net power mix", which is a regional summary of fuel mix data indicative of the general fuel mix provided by California power vendors, was input into the model.

When the California net power mix was used, there was a significant drop in emissions. Looking at the 2005 total emissions, the drop was from 64,779 MTCDE down to 61,136 MTCDE. In the future, all of campus will be serviced by SCE, so CCP can expect a drop in emissions due to SCE's mix being consistent with the California "net power mix". The University should ensure the power vendor is providing fuel mix data records, such that if the purchased mix is cleaner than the state average it can be factored into emissions calculations.

CPP Foundation

The university was able to provide electricity and gas consumption data for all buildings except the University Village (a student housing community consisting of resident apartments and supporting common areas). The University Village is operated by CPP Foundation and they are responsible for this data. Each unit at the University Village is metered and billed separately, which means each month they receive several hundred individual bills.

There was not sufficient time to quantify and sample the billings during the inventory period and so the totals for the University Village were estimated based on per person consumption extrapolated from the annual energy totals consumed in 2006 by residents of university housing. Therefore, rather than exclude the Village from the inventory, a rough estimate was input based on the University's data. The University Village was completed in three phases. Phase I in 1986, phase II in 1991 and Phase III in 2005. The estimated totals input into the inventory track with the phased construction timeline. University Village energy budget information was similarly estimated and added to the University's budget for input into the Institutional Data section.

Key Finding

Non-vehicular energy is the second largest source of greenhouse gas emissions at CPP. On average, 43% of total emissions came from this sector.

2005 Non-Vehicular Energy Emissions Breakdown:
29% Purchased Electricity
17% Natural Gas Consumption (on-campus stationary sources)

Recommendations

- Initiate an effort to increase metering of individual buildings on campus, to assess energy usage for various campus activities, and provide feedback on the effectiveness of reduction strategies. A method for prioritizing metering installation should be developed.
- Require utility vendors to generate summarized annual consumption reports for University Village and other sites on campus that have multiple meters.

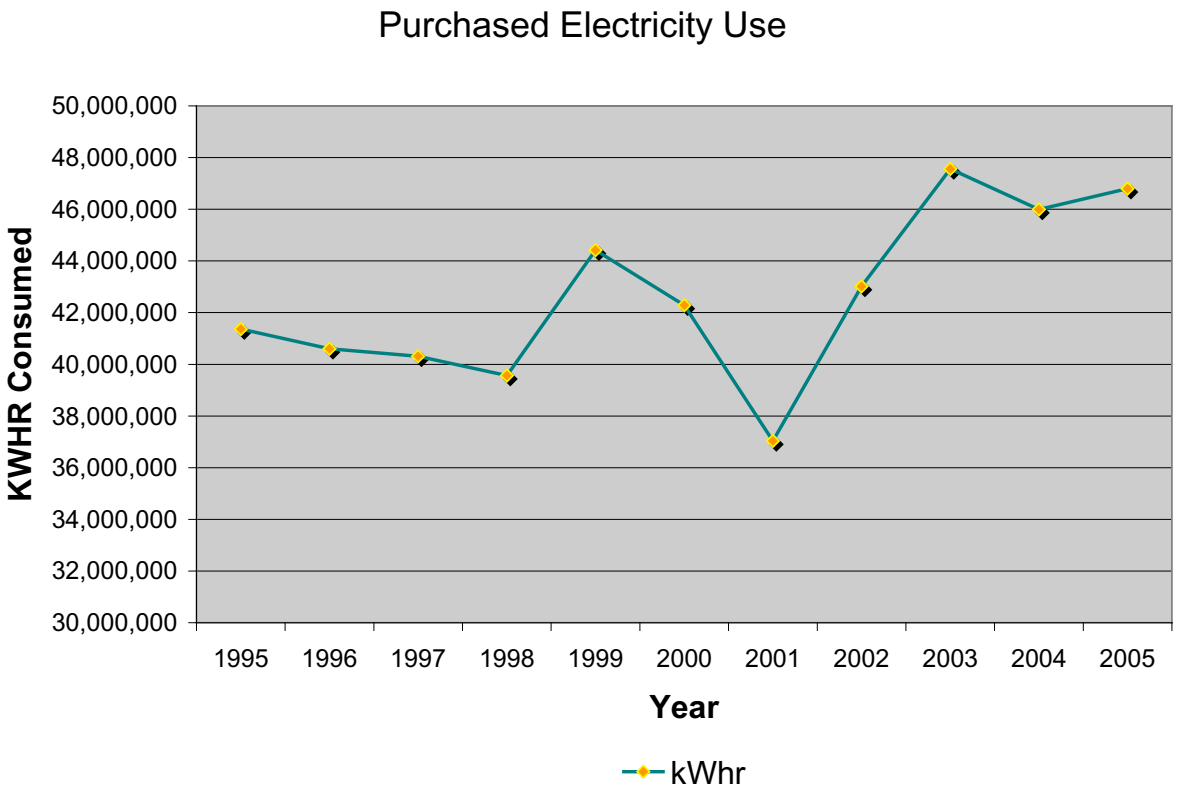
Data Supplier/Contact

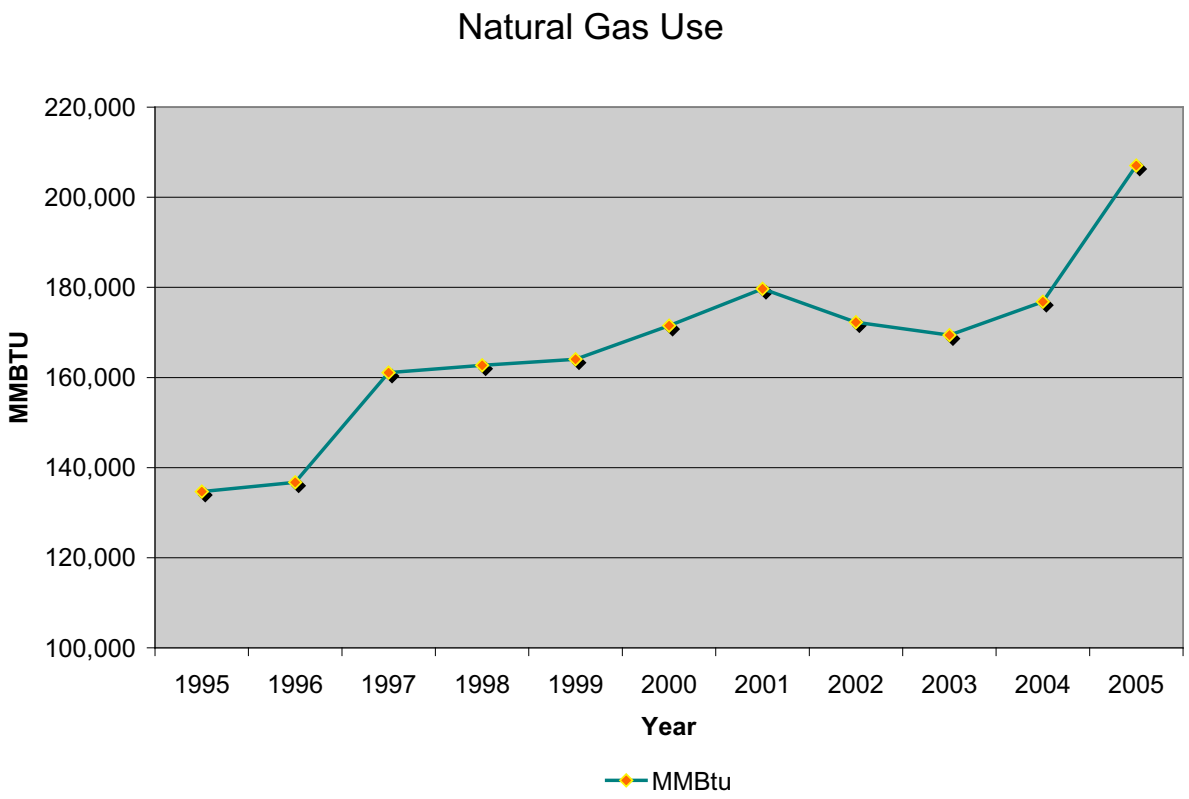
Purchased Electricity KWhr &
On-Campus Stationary Sources (MMBtu Natural Gas):

University: George A. Lwin, Manager, Energy Services Facilities Planning & Management

Foundation: Sherry L. Flamino, Assistant Director, Housing Operations, Foundation Housing Service

Notes: Estimates for consumption at the CPP Foundation operated University Village were estimated by the research team and added to the University totals provided by George Lwin.


Purchased Electricity Use
50,000,000
48,000,000
46,000,000
44,000,000
42,000,000
40,000,000
38,000,000
36,000,000
34,000,000
32,000,000
30,000,000
KWHR Consumed
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
kWhr


Natural Gas Use
220,000
200,000
180,000
160,000
140,000
120,000
100,000
MMBTU
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
MMBtu

California Energy Commission Net Power Mix Data:*

	Coal	Natural Gas	Distillate Oil (#1-#4)	Residual Oil (#5-#6)	Nuclear	Waste to Energy	Net Purchased	Hydro-electric	Renewable (Wind, Solar)	Biomass	Total Percentage
1995	7%	31%	0%	0%	14%	0%	19%	20%	7%	2%	100%
1996	10%	27%	0%	0%	16%	0%	20%	19%	6%	2%	100%
1997	11%	29%	0%	0%	15%	0%	21%	16%	6%	2%	100%
1998	12%	30%	0%	0%	15%	0%	17%	18%	6%	2%	100%
1999	13%	31%	0%	0%	15%	0%	18%	15%	6%	2%	100%
2000	13%	38%	0%	0%	16%	0%	10%	15%	6%	2%	100%
2001	10%	44%	1%	0%	13%	0%	15%	9%	6%	2%	100%
2002	10%	34%	0%	0%	13%	0%	24%	11%	6%	2%	100%
2003	10%	34%	0%	0%	13%	0%	22%	13%	6%	2%	100%
2004	10%	37%	0%	0%	10%	0%	23%	12%	6%	2%	100%
2005	10%	33%	0%	0%	13%	0%	22%	14%	6%	2%	100%

* California Energy Commission, “CALIFORNIA ELECTRICAL ENERGY GENERATION, 1995 TO 2005, TOTAL PRODUCTION, BY RESOURCE TYPE” http://www.energy.ca.gov/electricity/electricity_generation.html

Model Calculations Using EPA Regional Default Fuel Mix Emission Data:

	Purchased Electricity Emissions	Net Emissions MTCDE
1995	16,365	55,313
1996	16,062	55,104
1997	15,949	56,929
1998	15,652	57,360
1999	17,572	60,202
2000	16,728	60,237
2001	14,652	59,729
2002	17,019	62,934
2003	18,815	63,970
2004	18,195	60,927
2005	18,516	64,779

Model Calculations Using California Energy Commission Custom Fuel Mix:

	Purchased Electricity Emissions	Net Emissions MTCDE
1995	12,304	51,252
1996	13,154	54,134
1997	13,428	55,135
1998	13,428	55,135
1999	15,716	58,346
2000	16,399	59,908
2001	14,385	59,461
2002	14,164	60,079
2003	15,374	60,528
2004	15,446	58,178
2005	14,874	61,136

7.0 Agriculture and Landscape Emissions Inventory

Introduction

The Agricultural component of the greenhouse gas inventory is primarily concerned with methane (CH_4) and nitrous oxide (N_20). Methane is associated with livestock kept on campus. Most livestock animals release methane produced by microbes in the gut and from the decomposition of their manure.[r] Nitrous oxide is associated with fertilizer application on campus crops, fields and grounds. While produced in much smaller quantities than carbon dioxide on campus, methane and nitrous oxide have much greater global warming potentials. Methane has a GWP of 23 and nitrous oxide has a GWP of 296[s] (relative to 1 kg of carbon dioxide over 100 years).

Overall, methane and nitrous oxide make up a very small percentage of Cal Poly Pomona's total carbon footprint. These gases are created by the small number of livestock kept on the CPP campus, and by the evapotranspiration of plants that have been synthetically and organically fertilized.

Data Collection

To account for agricultural emissions, inventory information relative to the animals kept on campus and fertilizer applications must be input into the model. The animal information consists of a simple head count inventory by species, such as milk and beef cattle, swine, goats, sheep, horses, poultry, etc. Organic and synthetic fertilizer applications must be input as pounds applied per year. The relative percentage of nitrogen contained per applied pounds must also be input because the release of nitrous oxide is directly related to the nitrogen content of the fertilizer.

The greatest challenge associated with data collection for the agricultural sector was calculating the fertilizer data for agricultural land. Much of the required data was not available and had to be estimated or synthesized from many different sources, each with its own method of recording data. Although professor Hostetler was able to provide precise and relevant data estimates as a yearly average over ten years, no manageable hard data was available. According to professor Hostetler, agricultural operations at Cal Poly Pomona have not changed significantly in the past ten years, so input data for all years has been kept equal.

The percentage of nitrogen per pound of fertilizer was averaged from five different varieties of fertilizer. Each of the five different fertilizer mixes has different values of nitrogen, phosphate and potassium. The percentages of nitrogen content in the fertilizers used on campus were averaged into one percentage. This percentage is rough, as the Facilities Landscape Services Dept. had only three years of estimated data. Additionally, the Ornamental Horticultural Unit data was based on estimation.

Key Finding

Agricultural activity appears to have small effect on Cal Poly Pomona's total carbon footprint.

Recommendations

- Develop improved tracking method for quantities of nitrogen used in agricultural and landscape activities. Data should be centralized for easy retrieval.
- Conduct carbon sequestration inventory of campus landscape to assess current rates of sequestration that serves as offset for greenhouse gas emissions.

Data Supplier/Contact

Fertilizer Application, Agriculture (irrigated pasture, crop lands, and orchards): Daniel G. Hostetler, Chair, Plant Sciences Department

Fertilizer Application, Horticulture: Monica P. Salembier, Nursery Tech, Plant Sciences Department

Fertilizer Application, Landscaping: Richard C. Farmer, Manager Landscape Services, Facilities Management

Animal Agriculture, Cattle Headcounts: Dr. Cedric Y. Matsushima, Animal & Veterinary Sciences

Animal Agriculture, Sheep and Swine Headcounts: Marie K. Nagano, Livestock Tech, Animal & Veterinary Sciences

Agriculture and Landscape Data:

Application	Acreage	% Nitrogen	Applications/year	Total lbs Fertilizer
Agriculture				
Irrigated Pasture	125	16% / 21%	2	81,250
Hay Pasture	125	21%	1	45,550
Sillage Corn	20	21% / 16%	2	12,000
Pumpkins/squash	40	16%	1	8,000
Winter Vegetables	10	16%	1	7,500
Summer Vegetables (1)	10	16%	1	9,000
Summer Vegetables (2)	10	16%	1	2,000
Orchard (avocados/citrus)	32	46%	1	11,025
Berries	10	16% / 32%	2	10,000
Landscaping				
Turf grass	600	15%	2	229,600
Landscape	200	16%	2	100,000
Horticulture				
Ornamental Horticulture	1	21%	constant	2000
Total		16.80%		517,925

8.0 Solid Waste Emissions Inventory

Introduction

According to the EPA, landfills produced close to 24 percent of the total anthropogenic methane (CH_4) emissions in the United States during the year 2005.[t] As the organic (carbon containing) matter in solid waste decomposes in a landfill it produces methane, a greenhouse gas 21 times more potent than carbon dioxide.[u] Organic waste at Cal Poly Pomona is mainly composed of food waste, green waste, and paper products such as cardboard, copy paper, napkins, and paper towels. CA-CP uses emission factors for an average composition of organic matter likely to be in the solid waste stream. The emissions factor is applied to annual tons of waste to generate emissions totals.

Before the year 2000, Cal Poly Pomona sent its solid waste to Spadra Sanitary Landfill, located on campus property and operated by the County of Los Angeles Sanitation District under a joint powers agreement between the University and the County. Since 2000, the University has been sending solid waste to Puente Hills Landfill. Both landfill sites have been recovering methane for electricity conversion since the mid to late 1980's.[v] One issue that requires further examination is the energy generation which takes place at Spadra Sanitary Landfill. The University owns the landfill property, however sold the rights for energy generation from the methane, which takes place off University property. The potential to include this resource as an on-site energy asset under the terms of the climate commitment, should be considered in the planning process.

Data Collection

Since the passage of AB 75, all California state agencies and large facilities are required to file an annual report detailing solid waste reduction practices to the California Integrated Waste Management Board (CIWMB). Solid waste data for Cal Poly Pomona was collected from the CIWMB website, where the annual reports are posted by Cal Poly Pomona's Office of Facilities Management. Records are available from CIWMB for the years 2001-2005.

The CPP Foundation owns and operates most of the dining facilities on campus, and uses separate receptacles for waste. The waste produced by Foundation activities eventually enters the same solid waste stream as the University, where it is diverted, disposed and eventually reported to CIWMB along with Cal Poly Pomona's annual data. Recycling, grass cycling, and the majority of compostable materials are hauled away and processed off site. On-site composting quantities reported to CIWMB reflect the composted waste of research-related animals only—other composting activities that occur on campus are not reported to the Office of Facilities Management.

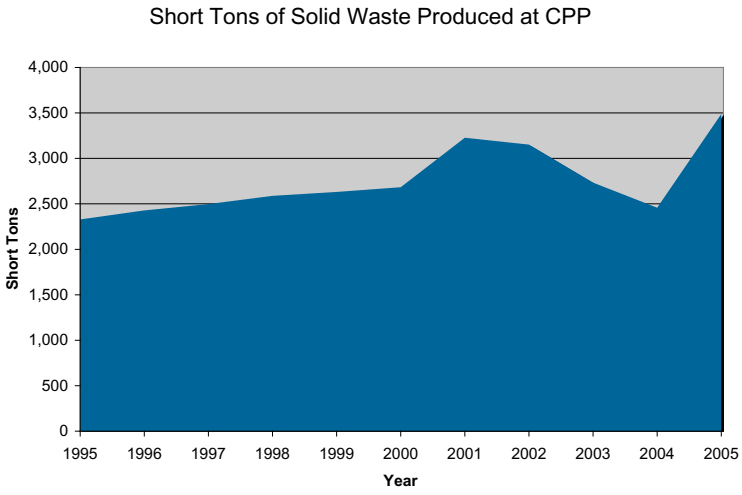
Estimating Data for CA-CP Input Worksheet:
As part of the joint powers agreement between Cal Poly Pomona and Los Angeles County, solid waste produced on campus was deposited free of charge at Spadra Sanitary Landfill during its years of operation. For this reason, no financial records exist which indicate annual tonnage of solid waste produced before 2000. For the purposes of the CA-CP model, the solid waste tonnage for 1995-2000 was estimated by an average of .18 tons per full-time equivalent student (FTES).

Key Finding

Solid waste is not a major source of emissions on the Cal Poly Pomona Campus. This sector comprised less than 1% of CPP emissions.

Data Supplier/Contact

Short tons of Landfilled Waste with CH_4 recovery and electricity generation: California Integrated Waste Management Board (CIWMB) http://www.ciwmb.ca.gov/



9.0 Refrigerants Emissions Inventory

Introduction

Refrigerant gases are a significant factor in global warming because of their high global warming potentials (GWP). Refrigerant gases emitted by Cal Poly Pomona during the inventory period have GWPs ranging from 93 (R-123a or HCFC-123a) to 8,500 (R-12 or CFC-12). Per the Montreal Protocol, ozone depleting chemicals and gases are being phased out. Substitutes include HFC's and PFC's, many of which still have high GWP[w]. Since CFCs are considered a phase out, they are not required for inclusion in the CA-CP inventory, although Cal Poly Pomona has emitted CFCs during the inventory period. A chart indicating CFC emissions has been included as a sidebar.

Refrigerant gas emissions occur because of equipment leaks or because of normal recharging. During mechanical failure, gas can leak out of refrigeration or air-conditioning equipment and must be replenished before the equipment is returned to service. Section 608 of the Clean Air Act institutes regulation of refrigerant and air conditioning equipment leaks by instituting recycling and recovery management, sales restrictions, and safe disposal measures.[x] Refrigerant gases make up a very small percentage of Cal Poly Pomona's total carbon footprint.

Quantification of refrigerant emission impacts is made more complicated when operating efficiency variables are considered. For example, a gas may have a high GWP, but operate at an efficiency level that negates the production of other GHG used to power the equipment. Thus, although they have higher global warming potentials, some gases allow the equipment to operate more efficiently, requiring less energy to operate.

Data Collection

Refrigerant emissions data was taken from the annual emissions reports filed by Cal Poly Pomona's Office of Environmental Health and Safety (EHS) to the South Coast Air Quality Management District (SCAQMD). Refrigerant emissions fall into SCAQMD's "Specific Organics" and "Toxic Air Contaminants/Ozone Depleting Compounds" reporting categories. In theory, all academic departments, Campus Facilities Management and University Housing forward their emissions data to EHS. EHS then consolidates the data for inclusion in the annual report.

The inventory revealed that back up documents from various entities reporting to EHS were frequently missing. Additionally, for many years, the SCAQMD form simply recorded net total annual emissions of CFC Freon, without breaking the number down into specific gas type. For these years, the gas type has been assigned as R-12 (CFC-12) because within the SCAQMD reporting instructions only R-12, 11, and 113 are covered. R-12 was reported on some of the supporting documents, so R-12 was assumed to be the reported gas whenever CFC Freon was listed on a form not requiring additional breakdown.

Foundation Facilities Management does not report emissions totals to SCAQMD or EHS. The scope of equipment managed by Foundation includes:

- All refrigeration and AC for Bldgs. 76, 77, 78, 97, and the University Village
- All AC for Bldgs. 55 and 66
- All refrigeration for Food Courts, CLA Pony Express, and the ENV Café.

Based on service records, Foundation Facilities Manger, Steve Whippie, was able to estimate how much of each gas was emitted over the inventory period. These amounts were added to the Campus totals.

In addition to Campus and Foundation, independent contractors service some of the equipment on campus, including the main chiller, which provides the cooling for 90% of 18 buildings on campus. Independent contractors also service the Collins School refrigeration. The main chiller came online in 2000 and had one leak in 2004 requiring addition of 1,500 lbs of R-123A (HCFC-123a). This data is included in the totals. No other data from independent contractors was available for inclusion.

Refrigerants on Campus

Cal Poly Pomona primarily uses the refrigerants detailed on the following page to meet cooling demands.

Key Finding

Refrigerant gases are not a significant source of GHG emissions on campus. This sector comprised less than 1% of CPP's emissions.

Recommendations

- Work with outside vendors and all entities on campus to ensure that emissions are consistently reported on an annual basis.

Data Supplier/Contact

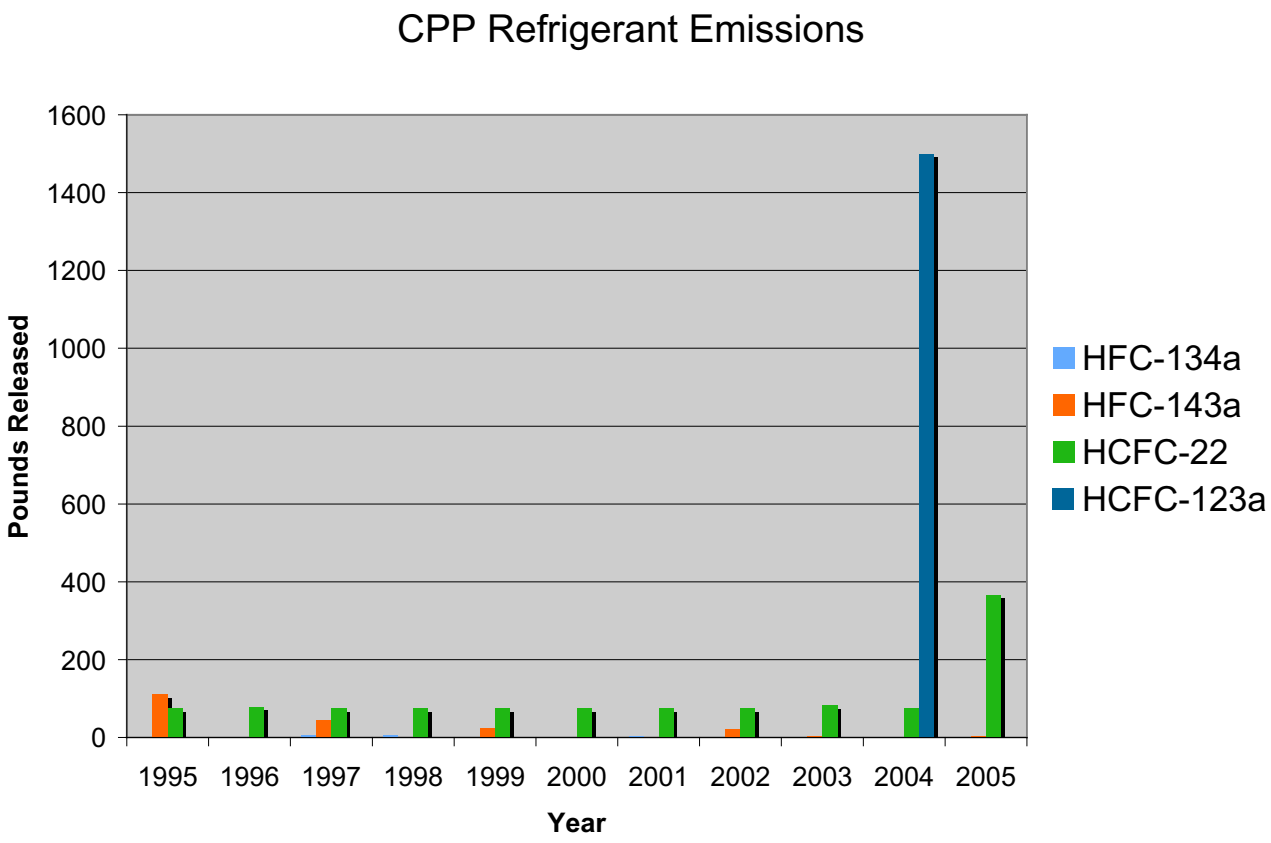
University: David L. Patterson, Director, Environmental Health & Safety

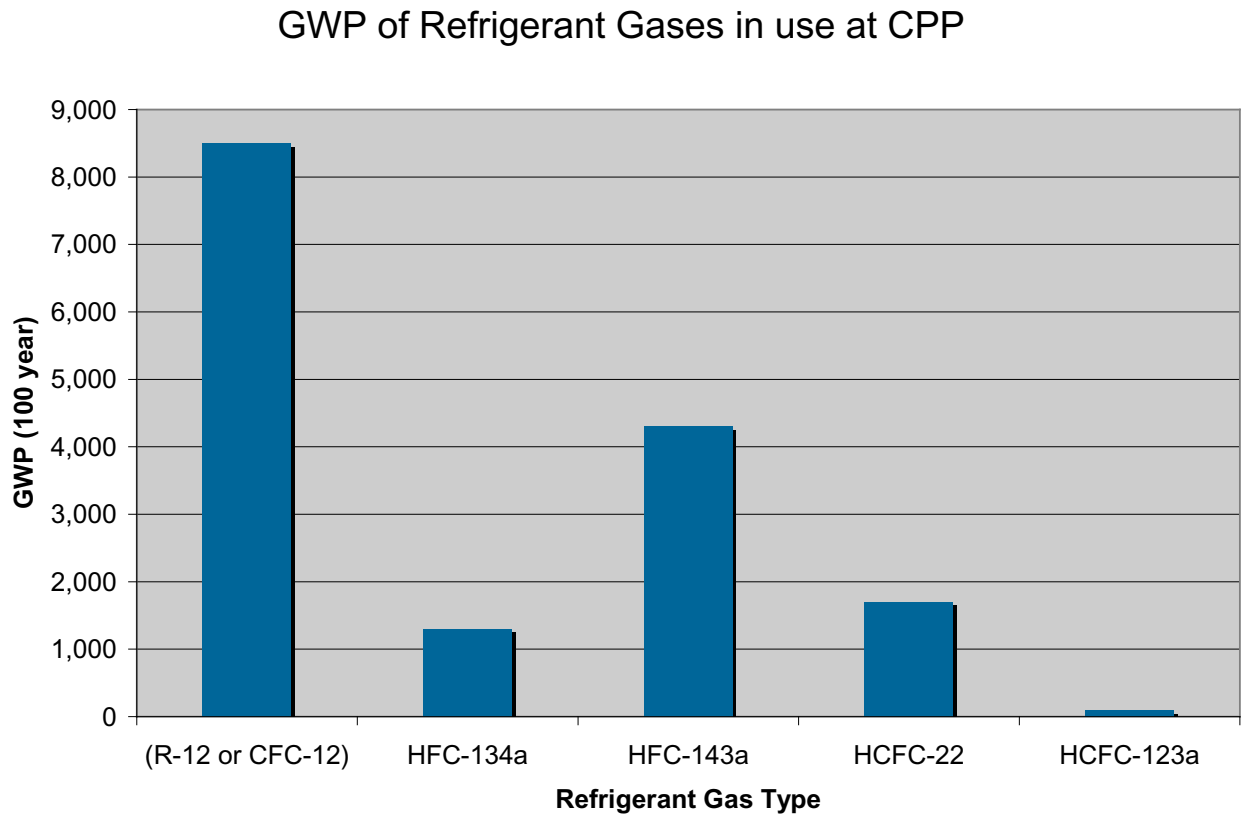
Foundation: Steven A. Whippie, Facilities Manager, Foundation Facilities Management

Notes: University data taken from SCAQMD reports. Foundation data estimated by Steve.

Primary Refrigerant Gases Used by Cal Poly Pomona:

Gas	GWP (100 year) Per CA-CP	ODP (Relative to R-11) Per CA-CP	Notes
HCFC 123a R-123 A	93	0.01	Used by central chilling plant (Serviced by outside vendor: Trane) Chiller provides 90% of cooling for 18 buildings on campus.
HFC 134a	1,300	0.59	Reported by Edu. Dept (EHS) and Campus Facilities Inventory.
HFC 143a	4,300	0	Reported by Foundation
HCFC 22	1,700	0.05	Currently, the most common refrigerant on campus. Reported by University Housing (EHS), Campus Facilities, and Foundation.
R-12* CFC-12	8,500	1.0	*Reported by Campus Facilities* *MFG Discontinued in 1995* **CFCs totals not included in model due to Kyoto Protocol phase out*


CPP Refrigerant Emissions
Pounds Released
1600
1400
1200
1000
800
600
400
200
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
HFC-134a
HFC-143a
HCFC-22
HCFC-123a


GWP of Refrigerant Gases in use at CPP
GWP (100 year)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
(R-12 or CFC-12)
HFC-134a
HFC-143a
HCFC-22
HCFC-123a
Refrigerant Gas Type

10 Notes

a American College and University Presidents Climate Commitment, *A Call For Climate Leadership*, pg. 3. Publication accessed on 8/27/07 at http://www.presidentsclimatecommitment.org/html/commitment.php

b State of California, Air Resources Board. (2006) "AB 32 Fact Sheet, California Global Warming Solutions Act of 2006." Accessed on 8/17/07 at http://www.arb.ca.gov/cc/cc.htm#factsheets

c California Environmental Protection Agency, Air Resources Board. (2004) News Release 04-24, "ARB Approves Greenhouse Gas Rule." Accessed on 8/17/07 at http://www.arb.ca.gov/newsrel/nr092404.htm

d U.S. Department of Energy, Energy Efficiency and Renewable Energy. "States with Renewable Portfolio Standards." Accessed on 8/17/07 at http://www.eere.energy.gov/states/maps/renewable_portfolio_states.cfm

e California Energy Commission. (2006). "Appliance Efficiency Regulations." California Energy Commission publication #CEC-400-2006-002-REV2

f California State University website, accessed on 8/17/07 at http://www.calstate.edu/

g California State University, "Commitment to Sustainability." Accessed on 8/17/07 at http://www.calstate.edu/cpdc/sustainability/

h California State University, "Commitment to Sustainability." Accessed on 8/17/07 at http://www.calstate.edu/cpdc/sustainability/

i U.S. Environmental Protection Agency, Green Power Partnership. "Top 10 College and University Partners – As if July 2007." Accessed on 8/17/2007 at http://www.epa.gov/greenpower/partners/top10ed.htm

j Reed, Charles B. (2004) Executive Order 917. California State University Office of the Chancellor. Accessed on 8/27/07 at http://www.calstate.edu/EO/EO-917.html

k Clean Air-Cool Planet website. Accessed online August 16 2007 at http://www.cleanair-coolplanet.org/about/

l American College and University Presidents Climate Commitment. (2007) *Implementation Guide Draft*, p.7

m American College and University Presidents Climate Commitment. (2007) *Implementation Guide,* V.1.0, p. 11

n American College and University Presidents Climate Commitment. (2007) *Implementation Guide,* V.1.0, p. 12

o U.S. Department of Energy, Energy Information Administration. (2007) *Emissions of Greenhouse Gases in the United States, 2005*. Chapter 2, pg. 16. Accessed online on 8/23/07 at http://www.eia.doe.gov/oiaf/1605/ggrpt/

p KAKU Associates, International Parking Design, Inc. (2000). *California Polytechnic University, Pomona Parking and Transportation Needs Assessment, Final Report.*

q The California State University http://www.calstate.edu/eo/EO-987.html

r CA-CP User's guide p.12

s "Comparison of Global Warming Potentials from the Second and Third Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC)" Accessed on-line August 6 at http://www.eia.doe.gov/oiaf/1605/gwp.

t U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004", (April 2006, USEPA #430-R-06-002), Section 8 "Waste," p. 1.

u U.S. Environmental Protection Agency, "General Information on the link between solid waste and climate change," http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteBasicInfoGeneral.html.

v Sanitation District of Los Angeles County, 2007. "Landfill Gas Programs." Accessed online on 8/6/07 at http://www.lacsd.org/info/solid_waste/landfill_gas_programs.asp

w U.S. EPA, p.ES-9.

x U.S. Environmental Protection Agency. "Stationary Air Conditioning". 26 Dec. 2006. 24 Jan. 2007. http://www.epa.gov/ozone/title6/608/subrecsm.html

11 Appendix

Total CPP Greenhouse Gas Emissions in MTCDE:

Fiscal Year	Purchased Electricity	On-campus Stationary	Transportation				Ag	Solid Waste	Refriger-ants	Total Emissions (MT eCO_2)
			Fleet	Student Commuters	Faculty/Staff Commuters	Air Travel				
1995	16,365	7,130	706	21,340	4,881	3,656	620	341	275	55,313
1996	16,062	7,240	705	21,443	5,061	3,557	618	356	61	55,104
1997	15,949	8,527	705	21,906	5,106	3,603	619	366	147	56,929
1998	15,652	8,615	704	22,542	5,197	3,586	623	380	61	57,360
1999	17,572	8,685	704	23,243	5,250	3,639	618	386	105	60,202
2000	16,728	9,079	758	23,576	5,342	3,678	625	394	58	60,273
2001	14,652	9,512	813	24,210	5,544	3,845	617	473	62	59,729
2002	17,019	9,119	906	25,241	5,542	3,893	651	462	101	62,934
2003	18,815	8,969	888	24,704	5,535	3,906	679	401	72	63,970
2004	18,195	9,362	1,044	22,538	4,988	3,612	704	361	124	60,927
2005	18,516	10,962	1,048	23,760	5,185	3,788	719	512	289	64,779

CPP Emissions Inventory Input Data: Institutional Data:

Fiscal Year	Budget			Population					Physical Size
	Operating Budget	Research Dollars	Energy Budget	Full-time Students	Part-time Students	Summer School Students	Faculty	Staff	Total Building Space
1995	$122,009,336.00	$6,357,912.00	$4,206,866.00	12,933	3,244	6,491	887	927	2,604,605
1996	$128,430,880.00	$6,344,242.00	$3,994,031.00	13,111	3,167	6,244	915	967	2,529,998
1997	$135,190,400.00	$7,240,635.00	$3,426,170.00	13,613	3,159	6,145	924	990	2,520,934
1998	$147,229,561.00	$8,198,447.00	$3,092,843.00	14,097	3,103	6,598	953	1,003	2,536,222
1999	$156,041,511.00	$9,147,643.00	$3,519,486.00	14,296	3,320	6,849	998	955	2,540,622
2000	$164,808,109.00	$9,702,932.00	$4,335,998.00	14,813	3,272	7,330	1,033	994	2,658,565
2001	$170,739,235.00	$13,997,254.00	$4,025,275.00	15,467	3,181	7,750	1,063	1,067	3,166,383
2002	$180,941,796.00	$13,826,173.00	$5,145,085.00	15,969	3,263	8,285	1,057	1,057	3,271,783
2003	$185,500,394.00	$12,243,771.00	$6,285,240.00	15,986	2,946	8,300	1,070	1,072	3,587,951
2004	$189,274,160.00	$13,233,390.00	$6,359,067.00	15,528	2,862	6,229	991	1,020	3,591,249
2005	$202,064,942.00	$12,286,346.00	$7,450,137.00	16,295	2,978	6,942	1,056	1,031	3,628,670

CPP Emissions Inventory Input Data: Full Time Student Commuting

Fiscal Year	Students	Student Fuel Efficiency	**% Commuting by Personal Vehicle**	% Total Students Driving Alone	% Total Students Carpooling	Trips/day	Days/year	Miles/trip	Total Distance	Fuel Consumption	Bus Fuel Efficiency (Diesel)	**% Students Commuting by Bus**	Trips/day	Days/year	Miles/trip	Total Distance	Diesel Fuel Consumption	% Commuting by Light Rail	% Commuting by Commuter Rail
		mpg							miles	gallons	passenger mpg					miles	gallons		
1995	14,555	20.43	88%	75%	13%	2	132	14	43,843,153	2,145,934	33.38	1%	2	132	14	537,953	16,116	0%	0%
1996	14,695	20.42	88%	75%	13%	2	132	14	44,263,361	2,167,369	33.06	1%	2	132	14	543,109	16,430	0%	0%
1997	15,193	20.56	88%	75%	13%	2	132	14	45,763,456	2,225,730	32.80	1%	2	132	14	561,515	17,118	0%	0%
1998	15,649	20.63	88%	75%	13%	2	132	14	47,137,038	2,285,209	33.56	1%	2	132	14	578,369	17,233	0%	0%
1999	15,956	20.42	88%	75%	13%	2	132	14	48,063,301	2,353,808	34.30	1%	2	132	14	589,734	17,193	0%	0%
2000	16,449	20.84	88%	75%	13%	2	132	14	49,548,336	2,377,831	33.44	1%	2	132	14	607,955	18,179	0%	0%
2001	17,058	21.06	88%	75%	13%	2	132	14	51,381,284	2,439,548	37.50	1%	2	132	14	630,445	16,810	0%	0%
2002	17,601	20.91	88%	75%	13%	2	132	14	53,016,930	2,535,516	39.07	1%	2	132	14	650,514	16,649	0%	0%
2003	17,459	21.19	88%	75%	13%	2	132	14	52,590,698	2,482,263	39.67	1%	2	132	14	645,285	16,266	0%	0%
2004	16,959	22.10	88%	75%	13%	2	132	14	51,084,578	2,311,519	39.67	1%	2	132	14	626,805	15,800	0%	0%
2005	17,784	22.10	88%	75%	13%	2	132	14	53,569,676	2,423,967	39.67	1%	2	132	14	657,297	16,569	0%	0%

CPP Emissions Inventory Input Data: Non-Vehicular Energy

	Purchased Electricity	On-Campus Stationary Sources
	Electricity Produced Off-campus (kWh)	Natural Gas (MMBtu)
1995	41,365,157	134,665
1996	40,598,435	136,745
1997	40,313,546	161,060
1998	39,562,791	162,721
1999	44,414,843	164,045
2000	42,282,199	171,481
2001	37,034,334	179,664
2002	43,017,917	172,245
2003	47,557,737	169,401
2004	45,989,312	176,829
2005	46,801,872	207,054

CPP Emissions Inventory Input Data: Agriculture and Landscape

	Fertilizer Application				Animal Agriculture						
	Synthetic (lbs)	%Nitro-gen	Organic (lbs)	%Nitro-gen	Dairy Cows	Beef Cows	Swine	Goats	Sheep	Horses	Poultry
1995	557,925	17%	42,000	4%	0	120	46	0	93	110	0
1996	557,925	17%	42,000	4%	0	120	46	0	93	110	0
1997	557,925	17%	42,000	4%	0	120	46	0	93	110	0
1998	557,925	17%	42,000	4%	0	123	46	0	93	110	0
1999	557,925	17%	42,000	4%	0	118	46	0	93	110	0
2000	557,925	17%	42,000	4%	0	127	39	0	91	110	0
2001	557,925	17%	42,000	4%	0	122	31	0	93	110	0
2002	557,925	17%	42,000	4%	0	156	28	0	78	110	0
2003	557,925	17%	42,000	4%	0	179	29	0	83	110	0
2004	557,925	17%	42,000	4%	0	200	31	0	89	110	0
2005	557,925	17%	42,000	4%	0	211	35	0	94	110	0

CPP Emissions Inventory Input Data: Solid Waste

	Landfilled Waste with CH4 Recovery and Electric Generation
	Short Tons
1995	2,328
1996	2,428
1997	2,498
1998	2,588
1999	2,631
2000	2,683
2001	3,228
2002	3,151
2003	2,734
2004	2,458
2005	3,488

CPP Emissions Inventory Input Data: Refrigerants

	HFC-134a (lbs)	HFC-143a (lbs)	HCFC-22 (lbs)	HCFC-123a* (lbs)	Sum (kg)
1995	0	111	75	0	409
1996	0	0	79	0	174
1997	5.3	44	75	0	274
1998	5.3	0	75	0	177
1999	0	24	75	0	218
2000	0	0	75	0	165
2001	3	1	75	0	174
2002	0	22	75	0	213
2003	0	4	83	0	191
2004	0	0	75	1,500	3,465
2005	0	3	367	0	814

*HCFC-123a has been input into the model as HFC-41. HFC-41 was used because it has the closest GWP of the model provided default gas types(97 years vs HCFC-123a at 93 years). The model's customization input fields would not function properly, necessitating the substitution.

12 Glossary of Key Terms

(Extracted from Clean Air-Cool Planet's Campus Carbon Calculator)

Carbon dioxide:
A colorless, odorless, non-poisonous gas that is a normal part of the ambient air. Carbon dioxide is a product of fossil fuel combustion. Although carbon dioxide does not directly impair human health, it is a greenhouse gas that traps terrestrial (i.e., infrared) radiation and contributes to the potential for global warming. See global warming.
Carbon dioxide equivalent:
A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. (MMTCDE = (million metric tons of a gas) * (GWP of the gas))
eCO_2
CO_2 Equivalents. A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "metric tons of carbon dioxide equivalents (MTCDE)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. (MTCDE = (million metric tons of a gas) * (GWP of the gas))
Climate change
The term "climate change" is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, climate change has been used synonymously with the term, global warming; scientists however, tend to use the term in the wider sense to also include natural changes in climate. See climate, global warming, greenhouse effect, enhanced greenhouse effect, radiative forcing.
Cogeneration:
Production of two useful forms of energy such as high-temperature heat and electricity from the same process. For example, while boiling water to generate electricity, the leftover steam can be sold for industrial processes or space heating.
Global warming:
The progressive gradual rise of the earth's surface temperature thought to be caused by the greenhouse effect and responsible for changes in global climate patterns. An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases.
Global Warming Potential (GWP):
The index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram of a greenhouse gas to that from emission of one kilogram of carbon dioxide over a period of time (usually 100 years).
Greenhouse effect:
The effect produced as greenhouse gases allow incoming solar radiation to pass through the Earth's atmosphere, but prevent part of the outgoing infrared radiation from the Earth's surface and lower atmosphere from escaping into outer space. This process occurs naturally and has kept the Earth's temperature about 59 degrees F warmer than it would otherwise be. Current life on Earth could not be sustained without the natural greenhouse effect.
Greenhouse Gas:
Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs). See carbon dioxide, methane, nitrous oxide, hydrochlorofluorocarbons, ozone, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.
Hydrochlorofluorocarbons (HCFCs):
Compounds containing hydrogen, fluorine, chlorine, and carbon atoms. Although ozone depleting substances, they are less potent at destroying stratospheric ozone than chlorofluorocarbons (CFCs). They have been introduced as temporary replacements for CFCs and are also greenhouse gases.
Hydrofluorocarbons (HFCs):
Compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23).
Infrared radiation:
The heat energy that is emitted from all solids, liquids, and

gases. In the context of the greenhouse issue, the term refers to the heat energy emitted by the Earth's surface and its atmosphere. Greenhouse gases strongly absorb this radiation in the Earth's atmosphere, and radiate some back towards the surface, creating the greenhouse effect. See radiation, greenhouse effect, enhanced greenhouse effect, global warming.

Intergovernmental Panel on Climate Change (IPCC):
The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

Methane (CH_4):
A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 21. Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The atmospheric concentration of methane as been shown to be increasing at a rate of about 0.6 percent per year and the concentration of about 1.7 per million by volume (ppmv) is more than twice its pre-industrial value. However, the rate of increase of methane in the atmosphere may be stabilizing.

Metric Ton:
Common international measurement for the quantity of greenhouse gas emissions. A metric ton is equal to 2205 lbs or 1.1 short tons.

MMBtu:
One Million Btus. A Btu is the quantity of heat required to raise the temperature of one pound of water one degree of Fahrenheit at or near 39.2 degrees Fahrenheit.

Nitrous Oxide (N_20):
A powerful greenhouse gas with a global warming potential most recently evaluated at 310. Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

Perfluorocarbons (PFCs):
A group of human-made chemicals composed of carbon and fluorine only. These chemicals (predominantly CF4 and C2F6) were introduced as alternatives, along with hydrofluorocarbons, to the ozone depleting substances. In addition, PFCs are emitted as by-products of industrial processes and are also used in manufacturing. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases: CF4 has a global warming potential (GWP) of 6,500 and C2F6 has a GWP of 9,200.