A FIRST STEP TOWARD A CLIMATE NEUTRAL POMONA COLLEGE:

Greenhouse Gas Emissions Inventory and Recommendations for Mitigating Emissions

Pomona Campus Climate Challenge
27 April 2007

TABLE OF CONTENTS

Appendices

ACKNOWLEDGEMENTS

This report brings together the work of several students from the Pomona Campus Climate Challenge (CCC) group and the EA 99: “Carbon-neutrality at Pomona College” class, supervised by Professor Richard Elderkin. The Pomona-College CCC group was founded in August 2006 by Praween Dayananda (’07) and Ada Aroneanu (’07) with the aim of increasing awareness amongst students about climate-change issues and engaging them in climate change solutions. During the 2006-2007 academic year, CCC has worked closely with the school administration and is encouraging it to adopt climate change solutions on a campus-wide level. The group’s long-term target is to reduce Pomona’s greenhouse gas emissions to net zero as quickly as possible.

The idea for the Pomona College Greenhouse Gas Emissions Inventory was proposed by Dayananda in August 2006 and was initiated, with the support of President David Oxtoby, in September 2006. Dayananda coordinated the project with other student contributors from the CCC group and the EA 99 class, including Aroneanu, Kyle Edgerton (’08), Stephen Conn (’07), and Tara Ursell (’08).

The CCC group would like to thank the many individuals and departments who provided it with data and support throughout the process of assembling this report. The Campus Planning and Maintenance Office was an important starting point for the data collection: James Hansen, the director of the office, and Bowen Patterson (’05) were both very helpful in providing necessary data and directing CCC to the proper sources. The Business Office provided data about air travel and the energy budget, and other transportation related data was collected from Rains Athletic Department and the Smith Campus Center. The Claremont University Consortium facilities provided CCC with data on refrigerants and other chemicals, and the Housekeeping and Grounds departments also provided important general data. Data on commuting habits was collected through email-based surveys sent out to faculty/staff.

Finally, CCC referred to the *Oberlin College: Climate Neutral by 2020* and *Carbon Neutrality at Middlebury College* reports extensively as models for this report and used the *Clean Air – Cool Planet Campus Carbon Calculator* as a tool for calculating emissions.

TABLE OF DEFINITIONS, ACRONYMS, ABBREVIATIONS, AND CHEMICAL FORMULAE

Pomona College	In terms of the relationship of the College to the climate, Pomona College is defined as an interconnected, dependent, living system.
Pomona College Boundary	The boundary classifies any direct and indirect greenhouse gas emissions that are caused by Pomona College's operations and activities. This boundary would include the College's on-campus buildings, lands, and facilities — and greenhouse gas emissions resulting from their existence and operation, as well as indirect emissions attributed to the College including off-campus generated electricity, solid waste flows, air travel, and commuting. All well-defined supply chains and related resource flows to and from the campus have been included where we were able to obtain data, where we can achieve emissions reductions, and measure progress. See Chapter 2 for a more detailed discussion of the system boundary.
Climate Neutrality	This refers to achieving zero net emissions of greenhouse gases from Pomona College. The primary goal will be to reduce direct and indirect emissions within the boundary to the extent that is cost-effective and to increase carbon sinks within the boundary. Any emissions remaining will be offset with carbon sequestration and other credits from Pomona-initiated or facilitated greenhouse gas saving projects outside the boundary defined above. We hope to achieve this status within the next fifteen years and maintain the status thereafter.
Offsets or Emissions Credits	This refers to reducing emissions of Pomona's GHGs by enhancing a carbon sinks within the boundary, such as planting more trees, enhancing a carbon sink outside of Pomona's boundary (e.g., tree-planting in the Amazon), and reducing emissions of greenhouse gases beyond Pomona's system boundary, 'such as green power purchases, retrofitting local schools with electricity-saving lighting, or selling zero-carbon electricity from Pomona's future cogeneration system to off-campus users.'[1]
Emissions Inventory	This is the systematic accounting for all emissions of greenhouse gases within the system boundary for a base year, which could be 1990 (as is the case for the Kyoto Protocol) or the most recent year for which data is available. We use the academic year 1999-2000 as the base year.
GHG	Greenhouse gas (GHG), a gas whose chemical properties allow significant absorption of radiation at infrared wavelengths. This

---

[1] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002

	refers to emissions of carbon dioxide, methane, nitrous oxide, and halocarbons (primarily refrigerants). We adopt the Intergovernmental Panel on Climate Change's (IPCC) global warming factors (GWP) for each gas. We have included carbon sequestration on existing Pomona-owned lands.
CDE or eCO2	Carbon dioxide equivalents; includes carbon dioxide, methane, nitrous oxide, and in very few cases, other greenhouse gases like fluorocarbons and sulfur hexafluoride. The CDE for gases other than carbon dioxide is calculated by multiplying the mass of a gas by its global warming potential, as defined by the IPCC. It expresses the total warming effect of all Kyoto greenhouse gases in terms of equivalent concentrations of carbon dioxide. Total greenhouse gases in the atmosphere by this definition are 430 ppm (CDE). CDE is preferred over only carbon dioxide as it does not mask the important contribution to the problem from other gases created by human activities.[2]
IPCC	The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to asses "the risk of human-induced climate change."
GWP	Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming.
CH_4	Methane, generated by Pomona College through the landfilling of its solid waste. A greenhouse gas with GWP = 21.
CO_2	Carbon dioxide, which is the primary anthropogenic greenhouse gas with GWP = 1.
Cogeneration	The process by which a boiler is used to produce simultaneously both steam for space heating and cooling and electricity. This type of process maximizes the efficiency of energy capture from a boiler while minimizing the "waste" energy.
LFGTE	"Landfill Gas to Energy." This refers to heating and electricity produced by capturing and subsequently burning methane generated from decaying matter at landfills. By replacing methane with its combustion product, CO_2, overall CDE is reduced
MTCDE or MTeCO2	Metric Tones of Carbon Dioxide Equivalent emissions. 1 metric tonne = 1.1023 imperial tons.
N_2O	Nitrous oxide; a greenhouse gas with GWP = 310.
Sequestration	The capture and storage of carbon dioxide that would otherwise be emitted and remain in the atmosphere.

---

[2] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, January 2002

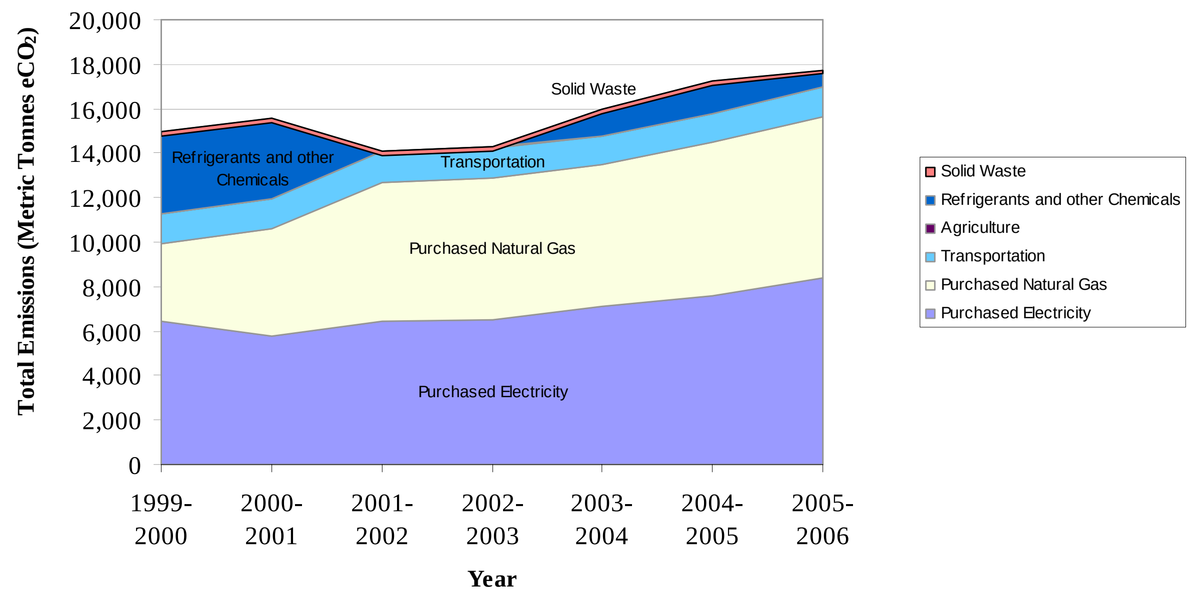
EXECUTIVE SUMMARY

This report aims to assess Pomona College's climate footprint and explore campus-wide options that the College can take to fulfill its commitment to environmental responsibility. The report presents a detailed greenhouse gas emissions inventory from 1999-2000 to 2005-2006 from functions and activities associated with the College. It also evaluates the case for pursuing climate-neutrality (zero net emissions of greenhouse gases) at Pomona and explores some strategies for reducing emissions from the main contributing sources. It is our hope that the College will use this report as a stepping stone for making a more detailed assessment of its climate footprint and for taking concrete steps toward outlining and pursuing a comprehensive action plan for achieving climate neutrality.

Summary of Emissions

More than 88% of Pomona's greenhouse gas (GHG) emissions for the year 2005-2006 derived from energy use in buildings. Of the 88%, 47% is accounted for by electricity use for lighting and running electronic appliances and 41% by the use of natural gas use for space and water heating. Transportation related emissions from air travel, grounds, housekeeping and athletic department fleets accounted for 7% and refrigerant use emissions contributed 4%. Other sources of emissions include treatment of solid waste and application of fertilizer. There are also significant amounts of emissions from the consumption of food, however these emissions are not reported in this report.

Figure ES-1: Pomona College Greenhouse Gas Emissions (Metric Tonnes eCO2)[3]



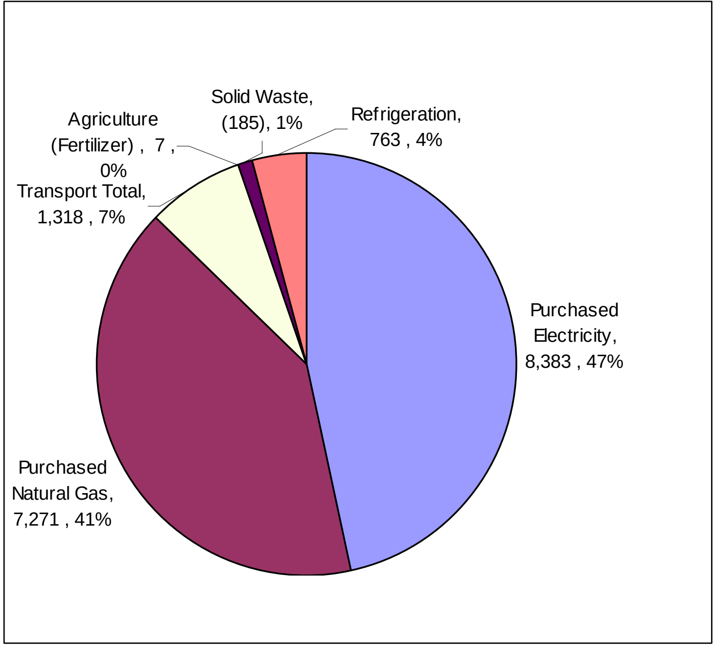
---

[3] Figure generated from Clean Air-Cool Planet Campus Greenhouse Gas Emissions Inventory Toolkit v 4.0

Table ES-1: Summary of Greenhouse Gas Emissions for Pomona College 2005 - 2006

Year	**2005-2006**	Energy Consumption	CO_2	CH_4	N_2O	Other Chemicals	eCO_2	eCO_2
		MMBtu	kg	kg	kg	kg	Short Tons	Metric Tonnes
Purchased Electricity		143,296	8,369,473	70	39		9,240	**8,383**
Purchased Steam/Chilled Water		-	-	-	-		-	-
Stationary Sources		137,272	7,249,778	724	15		8,015	**7,271**
	Non Co-Gen (Natural Gas)	137,272	7,249,778	724	15		8,015	**7,271**
	Co-Gen Electric	-	-	-	-		-	-
	Co-Gen Steam	-	-	-	-		-	-
Transport Total		18,420	1,293,095	169	70		1,452	**1,318**
	University Fleet	734	51,746	9	3		58	**53**
	Student Commuters	-	-	-	-		-	-
	Faculty/Staff Commuters	10,359	727,267	145	50		822	**745**
	Air Travel	7,326	514,081	14	16		572	**519**
Agriculture Total		-	-	-	24		8	**7**
Solid Waste		-	-	(8,044)	-		(204)	**(185)**
Refrigeration						14	841	**763**
Total		**298,988**	**16,912,346**	**(7,081)**	**147**	**14**	**19,352**	**17,556**
Offsets							-	-
	'Green' Electric Credits						-	-
	Composting						-	-
	Forest Preservation						-	-
	Other						-	-
Net Emissions							**19,352**	**17,556**

Figure ES-2: Greenhouse Gas Emissions by Source 2005 – 2006 (Metric Tonnes eCO2)



The Science of Climate Change

An overwhelming body of scientific data today indicates that the Earth's climate is rapidly changing and that it is mainly due to increases in emissions of greenhouse gases by human activities. The Intergovernmental Panel on Climate Change (IPCC) has published three reports, with the Third Assessment (2001) stating that "Based on these analyses, the warmth of the late 20th century appears to have been unprecedented during the millennium." As the consensus on global warming has grown, and the IPCC and other groups have continued to conduct research, the ability of models to predict future climate change has improved, and all models indicate that human activities are a significant driving force behind climate change.

A Case for a Climate Neutral Pomona College

The latest science of climate change suggests that immediate global action needs to be taken to mitigate greenhouse gas emissions to ensure that the impacts of climate change are kept to a minimum. We believe that the most practical and efficient way for Pomona College to demonstrate its commitment to addressing climate change is by embracing the concept of climate neutrality and adopting a long term action plan toward becoming climate neutral. While the moral reasons for an initiative on reducing our greenhouse gas emissions to a net zero are clear, the economic case for such an environmentally responsible initiative is also incredibly strong. An action plan on achieving climate neutrality would not only provide the College with an opportunity to ensure that its resources are being used optimally by exploring energy saving/efficiency options, but also provide the College with an array of intangible benefits such as: a stronger reputation as a responsible institution; attraction for a new generation of environmentally conscious prospective students, faculty and staff; and greater appeal for investment among alumni, trustees and other stakeholders.

Tangible Returns
- Cost savings from improved energy management & operational efficiencies

Intangible Returns
- Strengthens our reputation as a socially and environmentally responsible and progressive academic institution
- Strengthen the college's popularity among prospective students
- Attracts the next generation of leading faculty
- Appeals to alumni, trustees and other stakeholders

Emissions Inventory – Conceptual Framework

The primary tool we have used to calculate greenhouse gas emissions is the CleanAir – Cool Planet *Campus GHG Emissions Inventory Calculator.* The model is MS-Excel based and includes an integrated set of worksheets that contains input cells for energy use, agriculture, refrigerant, and solid waste data and calculates estimates of the greenhouse gas emissions associated with them. The model includes the greenhouse gases specified by the Kyoto Protocol

(CO_2, CH_4, N_2O, HFC and PFC, and SF_6). It also enables us to calculate emissions for the years 1990-2020 and produces charts and graphs illustrating changes and trends in emissions over time. The model bases its estimates of emissions from energy use from the quantity of fuel burned using national and regional average emissions factors, such as those provided by the US Department of Energy's Energy Information Administration. The model has been designed to automatically calculate emissions from the gathered data and provide analysis and graphs of them (in both the absolute weight of the gases and in the internationally standard units of "Carbon Dioxide Equivalents", or CDE, according to their Global Warming Potential (GWP), a measure of the relative contribution of each gas to climate change.

Boundary definition
As we cannot completely account for Pomona's impact on climate change, for this inventory, we have set out the boundaries by starting with the emissions most under the College's direct fiscal, policy and material control. These are described below:

- all fossil fuel energy consumed in the Pomona campus buildings is counted (including those emissions at power plants, coal mines supplying the power plants, and boilers or generators that are owned or controlled by Pomona College);
- all fuel used in college-owned vehicles, those leased by the college, and otherwise used for college-related business travel and commuting to work and study; this therefore includes sports teams, ASPC travel, air travel for business and academic purposes by faculty and staff (but not including student commute to and from Pomona), and vehicles rented in the course of official business; and fuel used by equipment such as mowers, the Grounds, and Housekeeping Department fleets;
- methane and carbon dioxide from solid waste treatment such as landfill facilities serving Pomona College;
- College-owned lands that emit nitrous oxide from fertilizer applications;
- Carbon dioxide "sequestered" in some college-owned forest land. This carbon sink is debited against current emissions.

Emissions from Electricity Use

The largest source of greenhouse gas emissions on campus is the consumption of electricity, accounting for 47% of total emissions. All electricity used on campus is purchased from Southern California Edison as Pomona currently has no co-generation on campus. Much of Pomona's electricity consumption is for building use - lighting, air conditioning and powering computers and other electronic appliances. Some electricity is also used for outdoor lighting, recharging the fleet of carts for the Grounds and Housekeeping departments and for igniting the boilers and running the pumps that are used for space heating and domestic water heating.

Electricity consumption and its associated emissions have been increasing significantly over the last seven years at Pomona. Consumption increased by 23.40% between 1999-2000 and 2005-2006 as shown in Figure 3.1. GHG emissions increased by 30.56% during the time period from 6421 metric tones in the year 1999-2000 to 8383 metric tons in 2005-2006. The increase in electricity consumption and emissions can be attributed to the increase in the number of new buildings on campus, expanded infrastructure, added outdoor lighting and perhaps increased electrical wastage.

Basic energy intensity analysis of the buildings on campus shows that almost all academic buildings are significantly more energy-intensive relative to the residence halls at Pomona. Apart from the two swimming pools and the tennis courts, the academic buildings with laboratories are the most energy-intensive buildings on campus. This suggests that larger gains in energy efficiency can be made by allocating resources towards buildings with laboratories than can be done by making efficiency investments in all buildings.

Recommendations for Reducing Emissions from Consumption of Electricity

- Purchasing green electricity or renewable energy certificates
- Taking advantage of Southern California Edison energy efficiency programs
- Student/ Faculty/Staff energy conservation education
- Improving lighting efficiency
- Improve energy efficiency of school-owned and student owned computers by systematically enabling energy saving power management systems
- Other Measures
  - Installing a device called Vending Misers on vending machines
  - Installing breaker-level electricity metering
- Improving campus-wide ventilation and cooling system efficiency

Emissions from Natural Gas Use

Pomona College currently consumes natural gas provided by Southern California Gas Company for space heating, domestic hot water heating, cooking in the kitchens and dorms and to some extent emergency lighting by the generators. Emissions from the use of natural gas account for 41% of Pomona’s total emissions.

Pomona’s natural gas consumption, like its consumption of electricity has also increased since 1999 but by much larger degree. It increased by 107% from 1999-2000 to 2005-2006. Associated emissions also increased by 107% from 3514 Metric Tonnes CDE to 7271 Metric Tonnes CDE in this time period. There are two main reasons for this dramatic increase. One is the result of the transition away from centralized Claremont University Consortium boilers using natural gas and steam to deliver space and water heating to individual boilers on each of the campuses using only natural gas around the year 2000. The second reason is the growth of the College, particularly the construction of newer buildings such as the Smith Campus Center.

Recommendations for Reducing Emissions from Consumption of Natural Gas
Space heating efficiency improvements

- Turning down the thermostats of campus buildings
- Insulation of walls and ceilings
- Replacing the existing single-pane windows and drafty doors and windows
- Reducing uncontrolled air leakage
- Install temperature setback at night

Domestic Water Heating Efficiency Improvements

- Installation of more efficient showerheads, faucet aerators
- Replacing the existing centralized hot water circulation and distribution systems in buildings with very low water heating energy
- Better insulation of hot water storage tanks and exposed pipes wherever they are accessible and un-insulated
- Switching to solar hot water heating systems

Emissions from Transportation

The use of fossil fuels for transportation accounts for 7% of Pomona’s GHG emissions. Fossil fuels are used for transportation by faculty, staff, and students traveling by air to conferences and other events, faculty and staff for daily commuting, the Grounds and Housekeeping Department for their fleets, Campus Planning and Maintenance for running generators, and the athletic department for transporting athletes to various competitions.

Table ES-2

GHG Emissions from within transportation sector		
Sector	**Emissions MTCDE**	**Percentage of total**
Grounds (gasoline)	16	1.20%
Grounds (diesel)	7	0.53%
Housekeeping (gasoline)	7	0.53%
Campus Planning and Maintenance (diesel)	11	0.83%
Athletic Teams (gasoline)	24	1.81%
Air Travel (Faculty)	487	36.67%
Air Travel (Student Grants)	32	2.41%
Faculty Commuting (gallons)	152	11.45%
Staff Commuting (gallons)	592	44.58%
Total	**1328**	

Recommendations for reducing emissions

- Purchasing Carbon Offsets for Air-Travel
- Expanding the Green Bikes Program
- Supporting and Subsidizing the Flexcar program
- Introducing Bio-fuels
- Prioritizing fuel efficiency

Emissions from Refrigerant Use

An important source of Pomona’s GHG emissions is the use of refrigerants in air conditioning systems for residential and academic buildings, walk-in coolers and freezers in the dining halls; refrigerated water coolers and ice machines; dehumidifiers and humidifiers; heat pumps; chillers, chilled water piping and coils; cooling towers, etc. The refrigerants currently used by Pomona and the Claremont University Consortium (CUC) that contribute to GHGs are R-12 (HCFC 22), R-22, R-134, R401, R-404, R-502 and R-408. Pomona and CUC have made significant active reductions in its use of refrigerants with high global warming potentials and therefore been able to reduce its volume of CO2 emissions from 3664 tons in 1999-2000 to 763 tons in 2005-2006 as shown. This reduction in the use of refrigerants, particularly R-12, R-22 and R-134, and the increase in the use of electricity and natural gas has reduced the contribution of GHGs from refrigerants to 4% in 2005-2006 from 25% in 1999-2000.

Recommendations
Pomona should continue to reduce its use of refrigerants, particularly R-12, R-22 and R-404, and look towards purchasing newer refrigerants that have lower global warming potentials (GWP).

Emissions from Treatment of Solid Waste

One potentially overlooked yet significant source of GHG emissions is the treatment of solid waste at landfill sites. This currently accounts for 1% of Pomona's GHG emissions. Solid waste consists of at least four types, each of which has unique implications for Pomona's GHG impact: trash, recyclable waste, "green" waste, and sewage.

Recommendations

- Reducing Waste Stream
- Improving the Recycling Program
- Improving Composting Program

Emissions from Dining

Pomona College also indirectly contributes to greenhouse gas emissions from the consumption of food, particularly from the consumption of beef and other livestock products that are GHG intensive. Due to an inability to access data on the sources of our food and the emissions factors associated with the production and transportation of the food, we have been unable to quantify the complete impact of dining in terms of greenhouse gas emissions. However, we feel it is important to recognize that Pomona does contribute significant GHGs by consuming food. In this chapter we focus on the livestock sector's impact on climate change because: (1) there a strong scientific understanding of this relationship; and (2) the livestock sector has been recognized as having some of the most significant impacts on climate change, contributing to more than 18% of total anthropogenic GHG emissions (see Table 9.2). We have presented this relationship with the hope that understanding the impacts of livestock sector on climate change can help us make more responsible choices about the food we consume on campus.

Recommendations

- Reducing our consumption of livestock products
- Ensuring that our livestock products come from farms that practice sustainable farming and from local producers
- Incorporating local foods in general
- Purchasing organic foods or food that uses low amounts of fertilizer
- Purchasing seasonal foods so that food is not transported from distant places

- Directing food waste into on-campus composting
- Converting kitchen grease into bio-diesel to fuel College's fleet and faculty/staff/student cars

Emissions from Application of Fertilizers

Pomona's greenhouse gases emissions from the application of fertilizer on fields and grounds account for less than 1% of the total greenhouse gases emitted on campus. GHG emissions from the application of fertilizer occur due to the presence of nitrogen in fertilizer some percentage of which is emitted as nitrous oxide.

Recommendations

- Reduce use of inorganic and organic fertilizers

Offsetting Emissions

This report establishes that climate neutrality is a worthy long term goal for the College. It has investigated different areas on campus that contribute to greenhouse gas emissions and proposed measures for reducing emissions. Pomona College, however, cannot reduce its greenhouse gas emissions to a net zero simply by implementing emissions reductions measures because not all reduction measures are economically feasible. In achieving climate neutrality, economic feasibility can be determined in terms of the cost of reduction measures compared to the price of purchasing carbon offsets. Using this measure of economic feasibility, *the least cost strategy for achieving climate neutrality is for the College to only implement those reduction measures that cost less than the expected price of carbon offsets and to purchase offsets for remaining emissions reduction requirement.*[4]

In addition, *the College should also consider purchasing the required offsets several years before they are needed,* for example, before mandatory emissions limits are placed at the state or federal level. This strategy may be less expensive and less risky for the College compared to the tempting strategy of delaying the purchase of offsets until a later period of time.

(Carbon offsets are one of the many options available to Pomona in reaching our goal of climate neutrality. Any remaining emissions after implementing reduction programs can be offset by taking part in offset programs. A carbon offset represents a reduction or sequestration of atmospheric carbon by some party—frequently, but not always, a third party – and can be purchased to counteract GHG emissions from College operations. They can be obtained from internal or external projects and can be implemented quickly and at a relatively low cost.)

INTRODUCTION

This report aims to assess Pomona College's climate footprint and explore campus-wide options that the College can take to fulfill its commitment to environmental responsibility.

Specifically, the goals of this report are the following:

- To create a detailed inventory of greenhouse gas (GHG) emissions from functions and activities associated with Pomona College
- To assess the case for pursuing climate-neutrality (net zero GHG emissions) at Pomona College
- To identify some strategies to reduce emissions and achieve some progress towards climate-neutrality with minimal effort or investment (i.e. cost-saving technologies, campus-wide policy initiatives, and increased student awareness)
- To present the findings of the project to the Pomona College Board of Trustees, President's Advisory Committee on Sustainability and the larger Pomona College community

It is our hope that this report will pave the way forward for a more sustainable Pomona College. We also hope that the College will use this report as a stepping stone for making a more detailed assessment of its climate footprint and for taking concrete steps towards outlining and pursuing a comprehensive action plan for achieving climate neutrality.

Climate neutrality is a long term goal, possibly a ten to fifteen year one for the College. Achieving this typically requires the setting of annual reductions targets from baseline levels for each of the main sources of greenhouse gas emissions. In this report we have presented an analysis of Pomona's key sources of emissions for the baseline period of 2005-2006. We hope the College will now take the next step and outline reduction targets for the long term. We believe that the College would be aided in these efforts by employing the services of professional consultants such as the Rocky Mountain Institute who can work with students, faculty, staff and the administration.

Chapter 1

THE SCIENCE OF CLIMATE CHANGE

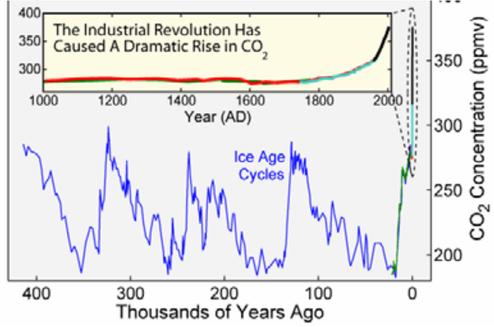
(Author: Ada Aroneanu)

The Science of Climate Change

An overwhelming body of scientific data today indicates that the Earth's climate is rapidly changing and that it is mainly due to increases in emissions of greenhouse gases by human activities[5]. First convened in 1991, the Intergovernmental Panel on Climate Change (IPCC) has published three reports, with the Third Assessment (2001) stating that "Based on these analyses, the warmth of the late 20th century appears to have been unprecedented during the millennium."[6] As the consensus on global warming has grown, and the IPCC and other groups have continued to conduct research, the ability of models to predict future climate change has improved, and all models indicate that human activities are a significant driving force behind climate change.

Mainly as a result of burning fossil fuels, deforestation and other changes in land-use, carbon dioxide concentrations have increased by over one third from 280 parts per million (ppm) during pre-industrial times to 380 ppm today (Figure 1.1[7]). During this period, concentrations of other greenhouse gases, particularly methane and nitrous oxide have also increased. The warming effect due to all Kyoto greenhouse gases emitted by human is now equivalent to around 430 ppm carbon dioxide equivalent (CDE) and increasing at 2.3 ppm per year with current levels higher than at anytime in at least the past 650,000 years.

Figure 1.1: Carbon dioxide Variations



There is compelling evidence that the increasing levels of greenhouse gases are having and will continue to have a warming effect on the climate with higher levels of infrared radiation trapped

---

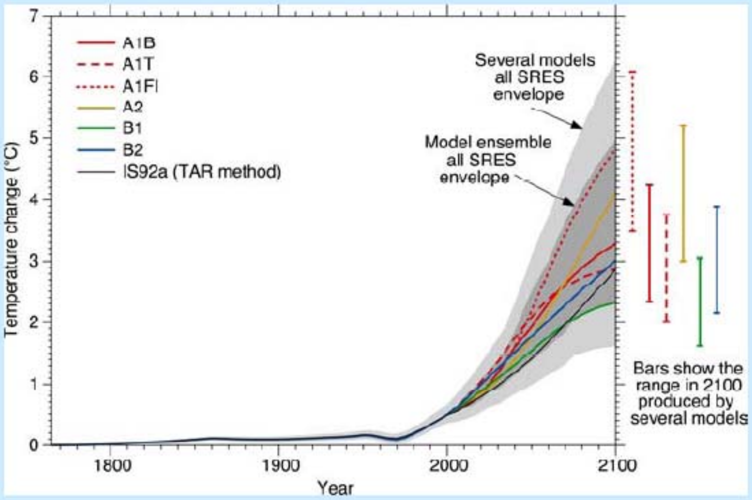
[5] The Stern Review, 1

[6] IPCC report, Third 2001 Assessment, 1.2.2

[7] http://www.globalwarmingart.com. (Blue) Vostok ice core: Fischer, H., M. Wahlen, J. Smith, D. Mastroianni, and B. Deck (1999). "Ice core records of Atmospheric CO2 around the last three glacial terminations". Science 283: 1712-1714. (Green) EPICA ice core: Monnin, E., E.J. Steig, U. Siegenthaler, K. Kawamura, J. Schwander, B. Stauffer, T.F. Stocker, D.L. Morse, J.-M. Barnola, B. Bellier, D. Raynaud, and H. Fischer (2004). "Evidence for substantial accumulation rate variability in Antarctica during the Holocene, through synchronization of CO2 in the Taylor Dome, Dome C and DML ice cores". Earth and Planetary Science Letters 224: 45-54. DOI:10.1016/j.epsl.2004.05.007. (Red) Law Dome ice core: D.M. Etheridge, L.P. Steele, R.L. Langenfelds, R.J. Francey, J.-M. Barnola and V.I. Morgan (1998) "Historical CO2 records from the Law Dome DE08, DE08-2, and DSS ice cores" in Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.. (Cyan) Siple Dome ice core: Neftel, A., H. Friedli, E. Moor, H. Lötscher, H. Oeschger, U. Siegenthaler, and B. Stauffer (1994) "Historical CO2 record from the Siple Station ice core" in Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.. (Black) Mauna Loa Observatory, Hawaii: Keeling, C.D. and T.P. Whorf (2004) "Atmospheric CO2 records from sites in the SIO air sampling network" in Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

by the atmosphere; the Earth has already warmed by 0.7°C since around 1900, and average global temperatures are estimated to rise by at least 2-3°C in the next fifty years.[8]

Figure 1.2 Temperature Projections for the 21st century[9]



Notes: The graph shows predicted temperature changes through to 2100 relative to pre-industrial levels. Nine illustrative emissions scenarios are shown with the different coloured lines. Blue shading represents uncertainty between the seven different climate models used. Coloured bars show the full range of climate uncertainty in 2100 for each emissions scenario based on the models with highest and lowest climate sensitivity. Updated projections will be available in the Fourth Assessment Report of the Intergovernmental Panel of Climate Change (IPCC) in 2007. These are likely to incorporate some of the newer results that have emerged from probabilistic climate simulations and climate models including carbon cycle feedbacks, such as the Hadley Centre's (more details in Chapter 1).

Source: IPCC (2001)

What drives climate change?

Climate change is a complex process that is affected by both natural and human-induced phenomena. The Earth's climate system is determined by the balance between incoming solar radiation and outgoing infrared radiation emitted by the Earth. The radiation balance is affected by the radius of the Earth's orbit, planet density, and the composition of its atmosphere.

Although these radiations do not interact with the three main components of the atmosphere (N_2, O_2, and Ar), they are highly affected by the greenhouse gases (CO_2, CH_4, N_2O, O_3, and vaporized H_2O). While the greenhouse gases only compose 0.1% of the atmosphere, they are responsible for maintaining an Earth temperature that is inhabitable. Greenhouse gases warm the earth by absorbing the infra-red radiation emerging from the Earth, and emitting their own infrared radiation up and downward. The overall effect of absorption by greenhouse gases that is then dispersed in the lower atmosphere to raise the equilibrium temperature of the Earth's surface is called positive radiative forcing. Aerosols are another element of the atmosphere that

---

[8] The Stern Review, 2

[9] The Stern Review, 58

significantly affect climate change. As solid and liquid particles, aerosols often serve to reflect incoming radiation, leading to negative radiative forcing, or the cooling of Earth's surface. However, they can also warm the earth's surface by absorbing outgoing radiation.

Many greenhouse gases and aerosols are naturally-occurring (like water, carbon dioxide, and ozone). Additionally, the climate system is impacted by the cryosphere, which includes the ice sheets of Greenland and Antarctica, and are important for their high reflectivity, and low thermal conductivity. Vegetation and soils help control how energy from the Sun is returned to the atmosphere, and marine and terrestrial biospheres influence the uptake and release of greenhouse gases. Any analysis of the climate system must take these processes into consideration.

However, despite natural fluctuations arising from the complex interaction of the aforementioned processes, it has become evident that the naturally occurring greenhouse effect has been exacerbated by anthropogenic emissions (human-caused) of large quantities of greenhouse gases and aerosols. While the amount of greenhouse gases in the atmosphere remained relatively constant for about a thousand years before the Industrial Revolution, CO_2 shot up by more than 30% since pre-industrial times and is increasing at a shocking 0.4% per year.[10] This is due primarily to fossil fuel combustion and deforestation. Fossil fuels are hydrocarbons, primarily coal, fuel oil or natural gas; the demand for energy from fossil fuels (especially gasoline derived from oil) has increased dramatically in the 20th and 21st centuries. The burning of fossil fuels is the largest source of CO_2 emissions, thereby linking energy consumption with global warming.

According to the Working Group I report of the IPCC conducted in 2001, anthropogenic emissions have already caused clear observable trends. For example: the global average surface temperature has increased over the 20th century by $0.6+/-2^o$ C, and the 1990s was the warmest decade on record. Additionally, the global average sea level has increased by 0.1 to 0.2 meters (4 to 8 inches). Carbon dioxide emissions from fossil fuel combustion will be the dominant influence on changes in atmospheric CO_2. Carbon cycle models predict that CO_2 concentrations will rise to 490 - 1260 parts per million (ppm) by 2100. Right now, concentrations are at ~370 ppm, while pre-industrial concentrations were at ~280 ppm. In order to stabilize concentrations at 450 ppm, global concentrations would have to drop below 1990 levels within a few decades and continue to decrease thereafter.

To what extent is action being taken?

Despite earlier concern about rapid climate change, the global community did not convene to address the issue until the Rio Earth Summit in 1992, where the United Nations Framework Convention on Climate Change (UNFCC) was set as guidelines for the voluntary reduction of greenhouse gases (GHGs). Following these voluntary guidelines came the Kyoto Protocol in 1997, which set mandatory reduction targets of GHGs for at least 5% from 1990 levels in the commitment period of 2008-2012. The United States originally was a signatory to the Kyoto Protocol under the Clinton Administration, but revoked its endorsement under Bush. The main concerns are about the cost of reducing emissions and effect on industry, as well as the lack of

---

[10] IPCC report, Third 2001 Assessment, 1.3.1

GHG targets for the developing world, including China and India, whose rates of GHG production are increasing exponentially.

Nevertheless, recent months have seen a shift in climate change awareness in the American political realm. With the events in the Middle East leading to political uncertainty regarding energy procurement and a hike in gas prices, and with the Katrina disaster and record heat waves around the country, citizens are beginning to make the connection between consumption and the effects of global warming. As a result, initiatives around the country have ballooned, in no small way led by a coalition of student activists called the Energy Action Coalition, which was founded in the spring of 2004 and initiated a continental campus climate challenge. Since then, campuses have been at the forefront of greening their operations, and many businesses have also become leaders in the energy movement. Additionally, cities and states have taken it upon themselves to meet the Kyoto standards despite the US government's withdrawal of commitment.

Impact of Climate Change in California

The effects of global warming in California are projected to be catastrophic if not addressed vigorously. In July of 2006, the California Climate Change Center analyzed the effects of global warming in California and produced a report from which the following data is presented below:[11]

- Global warming will particularly exacerbate air pollution, intensify heat waves, and expand the range of infectious ideas. These public health risks are not necessarily caused by a drastic change in the average temperature, but rather an increase in extreme conditions.
- Currently, Californians experience the worst air quality in the country, with over 90% of the population living in areas that violate the state's air quality standard for either ground-level ozone or airborne particulate matter. Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation.
- In addition, air quality could further increase wildfires, to as much as 55% more frequent by the end of the century than current occurrences.
- In the meantime, by 2100, warming may lead to 100 more days per year with temperatures above 90 ^{o} F in Los Angeles and above 95^{o} F in Sacramento.
- Perhaps most significantly, though, is the effect global warming will have on California's water supply. California depends on the Sierra Nevada spring snowpack for its water during the dry spring and summer months, 25-40% of the snowpack could disappear with an increase in temperatures of 2C, while 70-90% of it could disappear with an increase of 4C.
- The loss of water supply would clearly affect California's $30 billion agriculture industry, which employs over one million workers, not to mention the additional threats that agriculture would receive from expanding ranges of agricultural weeds and increasing threats from pests and pathogens.
- California's vast coastline is also in danger; while the sea levels rose by seven inches in the past century, sea levels are expected to rise by 22 to 35 inches by the end of the century. This would affect inland water systems, wetlands, and natural habitats.

---

[11] *Our Changing Climate*, a summary report from the California Climate Change Center, July, 2006.

Current climate-related initiatives in California

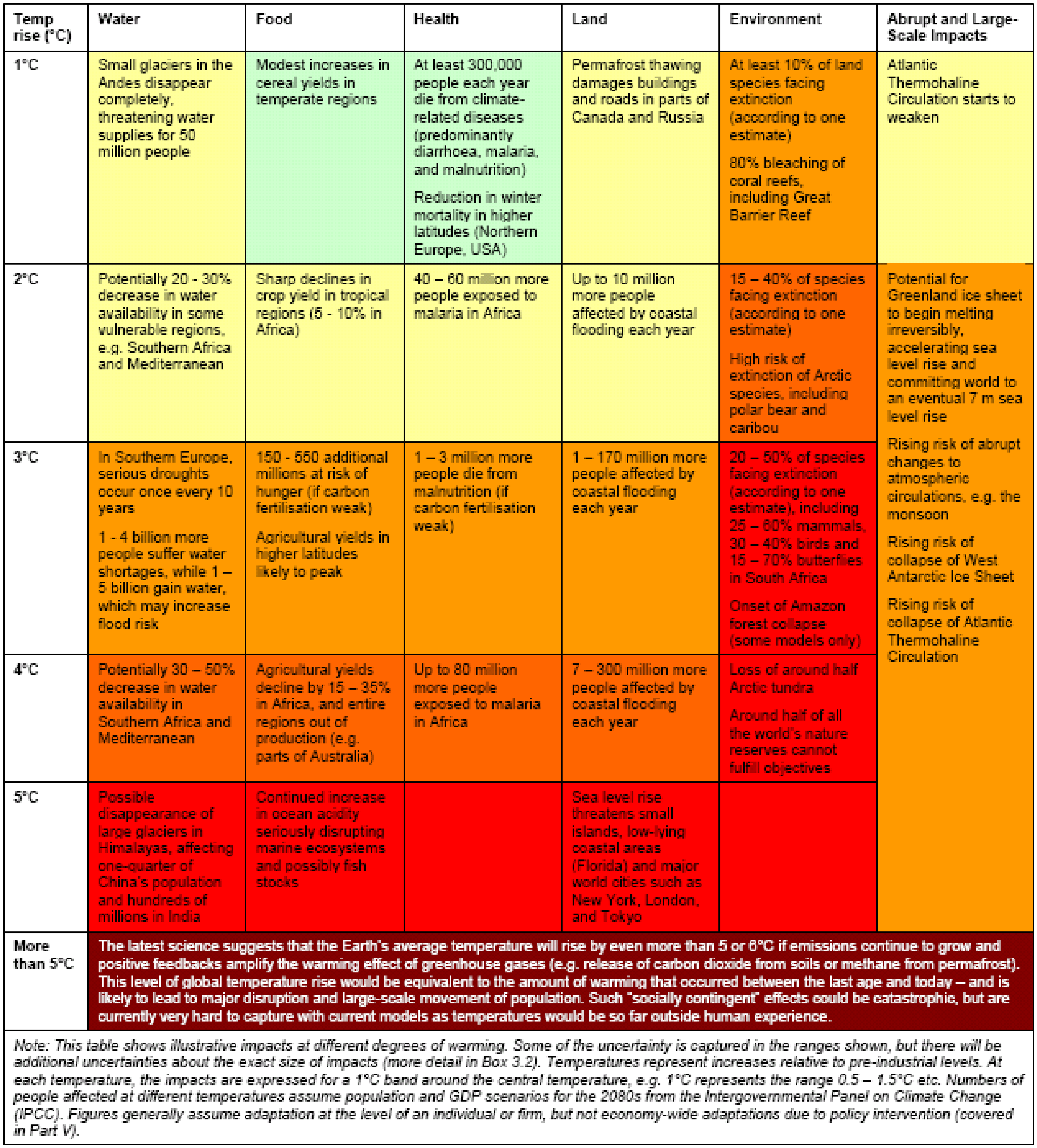
In 2003, the California Energy Commission's Public Interest Research (PIER) program established the California Climate Change Center to conduct climate change research that is relevant to the state. Then, on June 1, 2005, Governor Arnold Schwarzenegger signed Executive Order #S-3-05, which called for the California Environmental Protection Agency (CalEPA) to prepare biennial science reports on the potential impact of global warming on various sectors of California's economy. The order also set goals to reduce California's heat-trapping emissions to 1990 levels by 2020 and for an 80 percent emissions reduction below 1990 levels by 2050. Then, in July of 2006, Governor Schwarzenegger and British Prime Minister Tony Blair signed an agreement to become partners and act aggressively to combat climate change, which called for a more rigorous analysis of how to incorporate climate change initiatives into a market-based approach. This agreement was followed by a groundbreaking lawsuit filed by the state of California against the country's largest automobile manufacturers in late September of 2006, which seeks billions for environmental damage caused by tailpipe emissions. In many ways, California has been a leader in the movement toward efficiency and accountability regarding pollution and climate change; this is not unrelated to historical scares of energy shortages instigated by the magnitude of consumption in this state.

Meanwhile, educational institutions in California have been doing their part to pave the way toward more efficiency and awareness of energy issues. For example, the new University of California campus at Merced is built around the principles of sustainability, with an advanced and accessible transportation system, waste minimization projects, recycling used in construction projects, and silver LEED certified buildings. In fact, it was the University of California, Santa Barbara, that pioneered the highest LEED certification (platinum), which pushed the building's energy consumption 30% below California's model building code. Meanwhile, the California State University (CSU) System, which is the largest four-year university in the world, has committed to meeting 20% of its energy demand with renewable power by 2010. CSU will being by buying 34,000 Mwh worth of Renewable Energy Credits (RECS) from 86% wind energy and 14% landfill gas. California schools have also directly put their money where their mouth is. In 2001, Stanford University made their $12 billion endowment the first in the United States to implement climate change shareholder voting guidelines. These and other initiatives confirm that universities are drivers of California's leadership in energy conservation initiatives.[12]

---

[12] *New Energy for Campuses*, The Apollo Alliance, 2005.

Figure 1.3: Impacts of Climate Change Around the World[13]



Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate-related diseases (predominantly diarrhoea, malaria, and malnutrition) Reduction in winter mortality in higher latitudes (Northern Europe, USA)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermohaline Circulation starts to weaken
2°C	Potentially 20 - 30% decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5 - 10% in Africa)	40 – 60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15 – 40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7 m sea level rise Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon Rising risk of collapse of West Antarctic Ice Sheet Rising risk of collapse of Atlantic Thermohaline Circulation
3°C	In Southern Europe, serious droughts occur once every 10 years 1 - 4 billion more people suffer water shortages, while 1 – 5 billion gain water, which may increase flood risk	150 - 550 additional millions at risk of hunger (if carbon fertilisation weak) Agricultural yields in higher latitudes likely to peak	1 – 3 million more people die from malnutrition (if carbon fertilisation weak)	1 – 170 million more people affected by coastal flooding each year	20 – 50% of species facing extinction (according to one estimate), including 25 – 60% mammals, 30 – 40% birds and 15 – 70% butterflies in South Africa Onset of Amazon forest collapse (some models only)	
4°C	Potentially 30 – 50% decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15 – 35% in Africa, and entire regions out of production (e.g. parts of Australia)	Up to 80 million more people exposed to malaria in Africa	7 – 300 million more people affected by coastal flooding each year	Loss of around half Arctic tundra Around half of all the world's nature reserves cannot fulfill objectives	
5°C	Possible disappearance of large glaciers in Himalayas, affecting one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world cities such as New York, London, and Tokyo		
More than 5°C	**The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such "socially contingent" effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.**					

Note: This table shows illustrative impacts at different degrees of warming. Some of the uncertainty is captured in the ranges shown, but there will be additional uncertainties about the exact size of impacts (more detail in Box 3.2). Temperatures represent increases relative to pre-industrial levels. At each temperature, the impacts are expressed for a 1°C band around the central temperature, e.g. 1°C represents the range 0.5 – 1.5°C etc. Numbers of people affected at different temperatures assume population and GDP scenarios for the 2080s from the Intergovernmental Panel on Climate Change (IPCC). Figures generally assume adaptation at the level of an individual or firm, but not economy-wide adaptations due to policy intervention (covered in Part V).

---

[13] The Stern Review, 57

History of student activism on sustainability at Pomona

Student activism on sustainability at Pomona traces back several years. In 1999, the Eco Club at Pomona proposed that Pomona divest its funds from companies that were part of the “Global Climate Coalition,” a group which denied global warming. The board rejected this proposal, but they noted that they could be more deliberate in their investments. The following year, in 2000, Tyler Dillayou wrote his thesis on campus sustainability and created a class to study sustainability and design on campus. That led to the first “ad hoc committee on renewable energy” which proposed that the school install solar panels on the library. While this process didn’t work out, it led to the plan for solar panels to be installed on the new science building. Following student and staff initiatives, the school’s first “Statement on Environmental Policy” was issued that year. Among other things, the statement committed the administration to “a construction and renovation program that assures the maximum extent physically and financially feasible environmentally sustainable design,” proposing the LEED rating system as a standard. As a result, the school called for a plan to make the new science building a green building. Following this victory, the Environmental Quality Commission (EQC) began to participate in the “Environmental Policy Implementation Committee” during 2002-2003 to discuss energy, water, and other issues.

In the same year, the EQC began considering the idea of documenting Pomona College’s carbon emissions. In 2003-4, they looked into calling in outside auditors to advise on how to make the college more sustainable, but ultimately did not have the funding to do so. However, during that year, Peter Douglas ’05, got about 1/3 of the student body to support a successful campaign to get more solar energy on campus. Then, in 2004-5, Aaron Westgate worked on the idea of a carbon inventory and began dialoguing with the Office of Campus Planning and Maintenance upon President Oxtoby’s general support of environmental initiatives. He also wrote his thesis on a project proposal to save the school electricity through the mass distribution of compact fluorescent light bulbs (CFLs), installation of motion sensors in hallways and retrofitting exit signs with LEEDs. In the fall of 2006, one of his recommendations became a reality when a project, spearheaded by Mike Blouin ’08 and Kyle Edgerton ’08, distributed hundreds of light bulbs to the student body in the fall of ’06. At the same time, President Oxtoby established the President’s Advisory Committee on Sustainability, and institutionalized the process of documenting emissions levels.

Chapter 2

A CASE FOR A CLIMATE NEUTRAL POMONA COLLEGE

(Author: Praween Dayananda)

Our vision: A Climate Neutral Pomona College

The latest science of climate change suggests that immediate global action needs to be taken to mitigate greenhouse gas emissions to ensure that the impacts of climate change are kept to a minimum. We believe that the most practical and efficient way for Pomona College to demonstrate its commitment to addressing climate change is by embracing the concept of climate neutrality and adopting a long term action plan toward becoming climate neutral. While the moral reasons for an initiative on reducing our greenhouse gas emissions to a net zero are clear, the economic case for such an environmentally responsible initiative is also incredibly strong. An action plan on achieving climate neutrality would not only provide the College with an opportunity to ensure that its resources are being used optimally by exploring energy saving/efficiency options, but also provide the College with an array of intangible benefits such as: a stronger reputation as a responsible institution; attraction for a new generation of environmentally conscious prospective students, faculty and staff; and greater appeal for investment among alumni, trustees and other stakeholders. We explore the economic case in further detail below.

What does it mean to be climate neutral?

Because carbon dioxide emissions pose by far the greatest threat to our environment, the movement to reduce energy use and its related pollution has focused on becoming carbon neutral. However, other greenhouse gas emissions have an amplifying effect on carbon dioxide output, as well as bring their own unique threats, so the term “climate neutral” has come to encompass the various greenhouse gases that endanger the Earth. Thus, climate neutrality refers to achieving a net result of zero emissions of carbon dioxide equivalents (CDE), which includes carbon dioxide, methane, nitrous oxide, and occasionally other GHGs like fluorocarbons and sulfur hexafluoride. To get the CDE for gases other than carbon dioxide, the mass of a gas is multiplied by its global warming potential (GWP), as defined by the Intergovernmental Panel on Climate Change.

Basically, the amount of carbon dioxide in the environment is a balance between what is in the sources and sinks of carbon dioxide. The sources represent emissions of the compound into the environment, and sinks represent the process of removing the compound. Removal occurs naturally, via forests by the process of photosynthesis, and via oceans by the processes of the solubility pump and the biological pump (by which carbon dioxide is transported to the ocean’s interior and some is buried beneath the seafloor), and via soils through increasing soil organic matter which increases carbon storage below-ground. The sinks are enhanced by carbon sequestration efforts, including natural-gas purification plants, reforestation projects, carbon capture in coal plants, geological storage by injecting carbon dioxide underground, mineral sequestration, and others. The sources can be reduced by decreasing the amount of energy used and employing various energy conservation technologies to reduce consumption. Ultimately, by working on both sides of the equation, climate neutrality will be achieved when the balance = 0. if an organization, government, business, or campus is able to balance the sources and the sinks of CO_2 and its equivalents, then it is not contributing to a change in the concentration of CO_2 in the atmosphere, and thus will have no further effect on climate change. Hence, carbon neutrality is synonymous with climate neutrality, indicating its mitigating effect on global warming.

Our reasons for a Climate Neutral Pomona College

As we have presented in the previous chapter, there is overwhelming evidence that global climate change is real and caused by human activities relating to the production of greenhouse gases. Because Pomona College would like to be a leader in education, cultural opportunities, and environmental innovation, we believe that this school has a huge responsibility to set a positive example in reversing human induced climate change.

We believe that Pomona College can take steps towards setting this example by ensuring that its functions and activities are climate neutral - having zero net emissions of greenhouse gases.

Benefits of taking initiatives on greenhouse gas emissions mitigation strategies can also have immediate tangible and intangible returns for the College

- Tangible Returns
  - Cost savings from improved energy management & operational efficiencies
    - Example: Aaron Westgate ('05) in his thesis estimates one time investments of approximately $27,600 in CFLs, motion sensors and LEDs can save $30,000 annually at Pomona College.
    - Other large scale cost- savings can be achieved by making investments in evaluating and implementing:
      - Lighting retrofit opportunities
      - Campus-wide ventilation and cooling system efficiency opportunities
      - Basic building shell improvements based on blower-door tests and thorough audits
    - Many of these investments have a pay-back period that is within the seven year payback period that the college regards as the cutoff point for attractive investments on campus1

- Intangible Returns
  - Strengthens our reputation as a socially responsible and progressive academic institution
  - Helps recruit a new generation of environmentally conscious prospective students
  - Attracts the next generation of leading faculty
  - Appeals to alumni, trustees and other stakeholders
  - Secures important private sector and government partnerships and funding
  - Attracts higher levels of public, private and governmental support for the institution's mission
  - Fulfills our teaching, research and service missions

    - Provides an opportunity for us to become a leader in the scientific and technology race to find global warming solutions and contribute to community and nationwide efforts

How can Pomona College "Go Climate Neutral"?

There are easy steps in "going climate neutral". The first step is to accept responsibility for the environmental impact of our activities and be willing to take action.

- Steps to take include:
    - Assessing and creating an inventory of our GHG emitting activities and emissions
        - Includes making a thorough audit of current institutional energy use
            - The Campus Climate Challenge (CCC) student report attempts to provide only an overall picture of emissions and energy use in key areas
            - It recommended that this report is augmented with a more detailed audit of current institutional energy use at a building level
    - Reducing GHG emissions from our own activities using the baseline period assessment to measure progress.
        - Includes hiring the services of a professional consulting group to formulate a comprehensive long term action plan on achieving climate neutrality that would for example set targets for
            - Improving lighting, heating efficiency over time
            - Generating or buying incremental quantities of renewable power
            - Purchasing local sustainably grown food and goods
            - Using clean fuels for fleet
    - Offset any emissions that cannot be reduced feasibly by investing or encouraging investment in technologies that reduce GHG emissions and help recapture GHGs from the atmosphere on or off-campus.

Reducing Emissions: Potential Strategies

The main component of achieving climate neutrality is reducing current emissions. Electricity consumption, fossil fuel use and treatment of waste are our main contributors of GHGs. This report outlines some easy to implement GHG emissions reducing strategies which we as students have come up with our limited ability to engage in detailed technical analyses. These will be discussed in greater depth in the following chapters. A thorough assessment of the campus energy and resources flows can help identify large scale GHG emissions mitigation strategies. Some strategies revealed by building and systems audits done at other colleges include:

- Replacement of inefficient appliances and upgrades of inefficient buildings
- Adoption of green building policies that require all new buildings and renovations to be high performance and energy efficient.
- Purchasing or generating electricity from renewable resources.
- Expansion of Transportation Alternatives
- Implementation of Green Purchasing Programs:
    - Buying products that use less energy, last longer, and are better for the environment.

- Institutionalizing Conservation
    - Create a culture of conservation on campus.

More Specific Reduction Strategies

- Basic building shell improvements based on blower-door tests and thorough audits
    - Add insulation, install weatherization
- A comprehensive program to evaluate and implement lighting retrofit opportunities
    - Potential savings of $395,000 per year at Oberlin College (Payback period 3-5 years)
- Comprehensive evaluation and implementation of campus-wide ventilation and cooling system efficiency opportunities
    - Potential savings of $350,000 per year at Oberlin College (Payback period 3-5 years)
- Replacement of single-pane windows and drafty doors and windows
    - Potential savings of $360,000 per year at Oberlin College (Payback period 3-5 years)
- Reducing hot water waste and improving water heating and delivery efficiency
    - Potential savings of $97,000 per year at Oberlin College (Payback period 3-5 years)[14]

As most facilities need upgrades over time, for many of these efficiency measures, the net cost is only the *incremental* cost of efficient technology compared to the conventional technology that would have been installed anyway, which is far less than the entire cost of retrofitting a facility with efficient equipment.[15]

Carbon Offsets

Any remaining emissions after implementing reduction programs can be offset by taking part in offset programs.

What are Offsets?

- Programs/investments that reduce or sequester greenhouse gases (GHG) emissions
    - Can be purchased to counteract GHG emissions from College operations
    - Can be obtained from internal or external projects
    - Can be implemented quickly and at a relatively low cost ($10/metric ton of CO2)

Summary

- A climate neutral institution creates zero net emissions of CO2.
- Pomona College can achieve this climate neutrality by:
    - Reducing current emissions
    - Investing in technologies that reduce greenhouse gases from human activities

---

[14] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, January 2002

[15] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, January 2002

- The manner in which Pomona College decides to achieve this climate neutrality is totally flexible and can be changed over time
- We recommend that the College begin the process of ‘Going Climate Neutral” by immediately commissioning research by professional consultants to formulate An Action Plan to Climate Achieving Neutrality.

Chapter 3

EMISSIONS INVENTORY – CONCEPTUAL FRAMEWORK

(Author: Praween Dayananda)

Inventory Model

The primary tool we have used to calculate greenhouse gas emissions is the CleanAir – Cool Planet ***Campus GHG Emissions Inventory Calculator.*** This model has been used at over 20 schools since 2001, mostly in the Northeast U.S. The model is MS-Excel based and includes an integrated set of worksheets that contains input cells for energy use, agriculture, refrigerant, and solid waste data and calculates estimates of the greenhouse gas emissions associated with them. The model includes the greenhouse gases specified by the Kyoto Protocol (CO_2, CH_4, N_2O, HFC and PFC, and SF_6). It also enables us to calculate emissions for the years 1990-2020 and produces charts and graphs illustrating changes and trends in emissions over time. “The spreadsheets are based on the workbooks provided by the Intergovernmental Panel on Climate Change (IPCC, www.ipcc.ch) for national-level inventories. They have been adapted for use at an institution like a college or university, but follow virtually all the same protocols.”[16]

The four major sources of emissions categories we have identified for Pomona College are 1) energy use for buildings, 2) transportation, 3) waste, and 4) refrigerants and other chemicals. We have also included any greenhouse gas emissions “offsets”, such as purchasing “green power,” RECs (renewable energy certificates), tree-planting in the tropics, or composting.

The model bases its estimates of emissions from energy use from the quantity of fuel burned using national and regional average emissions factors, such as those provided by the US Department of Energy’s Energy Information Administration[17]. The model has been designed to automatically calculate emissions from the gathered data and provide analysis and graphs of them (in both the absolute weight of the gases and in the internationally standard units of “Carbon Dioxide Equivalents”, or CDE, according to their Global Warming Potential (GWP), a measure of the relative contribution of each gas to climate change.

Emissions Inventory

The first step in measuring the emissions of greenhouse gases from Pomona College activities was to clearly define what greenhouse gases were to be included. This depended on how we defined Pomona’s system boundaries.

Since Pomona’s activities are highly inter-connected with the outside world, we accounted for not only emissions on campus but also those off-campus that are a result of our activities.

---

[16] CleanAir-Cool Planet, *Campus Greenhouse Gas Emissions Inventory Toolkit* v 4.0

[17] http://www.eia.doe.gov/geography.html /

[15] The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model 1.5 Argonne National Laboratory, U.S. Department of Energy, Michael Wang, mqwang@anl.gov www.transportation.anl.gov:80/ttrdc/greet/index.html

For the purposes of the inventory we included four of the "basket of six gases" covered by the Kyoto Protocol - carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. We have not included CFC emissions as current IPCC and US EPA protocol does not include CFCs in greenhouse gas inventories because they are being phased out under the terms of the Montreal Protocol and US Clean Air Act.[18]

Boundary definition

Pomona College directly causes emissions of greenhouse gases by consuming electricity, water, fuels and materials. It has the opportunity to make purchasing and investment decisions that can either increase or reduce those emissions. Therefore in determining what sources of emissions to include in the inventory it is vital to define carefully the boundaries and sphere of influence of Pomona College's activities.

Not all the greenhouse gases are emitted within the physical borders of the college – nitrous oxide emitted from fertilizers applied to the grounds is one gas that is emitted from college activities.[19] Much of it is emitted through the consumption of resources purchased outside of the college. Such examples are carbon dioxide emitted from the use of electricity generated elsewhere, transportation fuels used to bring faculty members to school and food to the dinning halls, and methane emitted at the wastewater treatment plant.

As we cannot completely account for Pomona's impact on climate change, for this inventory, we have set out the boundaries by starting with the emissions most under the College's direct fiscal, policy and material control. These are described below:

- all fossil fuel energy consumed in the Pomona campus buildings is counted (including those emissions at power plants, coal mines supplying the power plants, and boilers or generators that are owned or controlled by Pomona College);
- all fuel used in college-owned vehicles, those leased by the college, and otherwise used for college-related business travel and commuting to work and study; this therefore includes sports teams, ASPC travel, air travel for business and academic purposes by students, faculty and staff (but not including student commute to and from Pomona), and vehicles rented in the course of official business; and fuel used by equipment such as mowers, the Grounds and Housekeeping Department fleets;
- methane and carbon dioxide from solid waste treatment such as landfill facilities serving Pomona College;
- College-owned lands that emit nitrous oxide from fertilizer applications;
- Carbon dioxide "sequestered" in some college-owned forest land. This carbon sink is debited against current emissions.[20]

---

[18] CleanAir-Cool Planet, *Campus Greenhouse Gas Emissions Inventory Toolkit, 9*

[19] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, January 2002

[20] These guidelines were adopted from Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002

Measurability

With the boundaries defined clearly, our next step was to ensure that sources of emissions for our inventory were either measurable or estimable. We had to ensure that the data stream was available, measurement and estimation protocols clear where necessary, and system changes — such as the fuel mix of power plants or landfill recovery of methane — observable.

All electricity and natural gas consumption data was available from 1999-2006. However, data for consumption of fossil fuels for transportation including faculty/staff commuting, air travel, methane emissions from solid waste treatment at landfills, and on campus offsets were only available for the academic year 2005-2006. Estimates for these numbers for other years were made using appropriate estimation models where necessary.

Data Collection

Collecting the data has been the most difficult part of the process. Acquiring the data required contacting the numerous departments on campus and some off-campus sources. The Campus Planning and Maintenance Office was a starting point for our data collection. The director of the office, James Hansen, and Pomona alum Bowen Patterson ('05) were very helpful in providing necessary data or directing us to the proper sources. Other departments that provided us data were the Housekeeping and Grounds. We also obtained data from the Business Office which was our source for air travel data and budget data. Other transportation related data was collected from Rains Athletic Department and the Smith Campus Center. Data on commuting habits was collected through email-based surveys sent out to faculty/staff. Data on refrigerants and other chemicals was obtained from the Claremont University Consortium facilities.

Chapter 4

EMISSIONS FROM ELECTRICITY USE

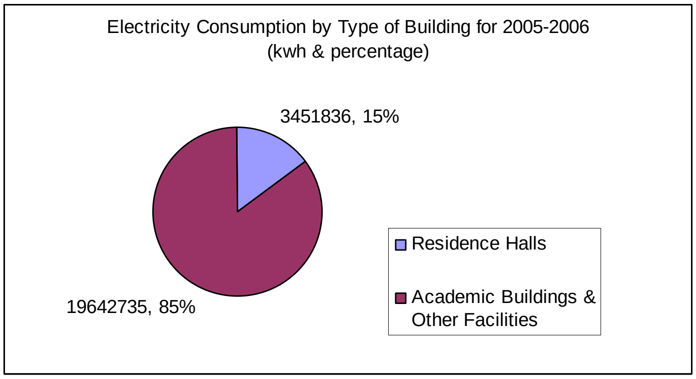
(Author: Praween Dayananda)

The largest source of greenhouse gas emissions on campus is the consumption of electricity, accounting for 47% of total emissions. All electricity used on campus is purchased from Southern California Edison as Pomona currently has no co-generation on campus. Much of Pomona's electricity consumption is for building use - lighting, air conditioning and powering computers and other electronic appliances. Some electricity is also used for outdoor lighting, recharging the fleet of carts for the Grounds and Housekeeping departments and for igniting the boilers and running the pumps that are used for space heating and domestic water heating. All electricity consumption is currently monitored only at the building level through meters placed in each building, therefore a precise breakdown of the electricity consumed by the different areas is not available.

In 2005-2006, Pomona consumed 23 million kwh of electricity, with expenditures reaching $2.5 million. Academic buildings and other facilities are responsible for much of the 23 million kwh. 86% of the 23 million kwh was used by academic buildings and other facilities, while the remaining 14% was accounted for by residence halls. Any effort at Pomona to reduce energy consumption and emissions on campus must, therefore, focus on non-residence hall buildings.

Emissions associated with the consumption of electricity were calculated from electricity use data from 1999-2006. Electricity consumption figures for the time period before that are available in the archives, however, Campus Planning and Maintenance was unable to provide us with that information.

Figure 4.1

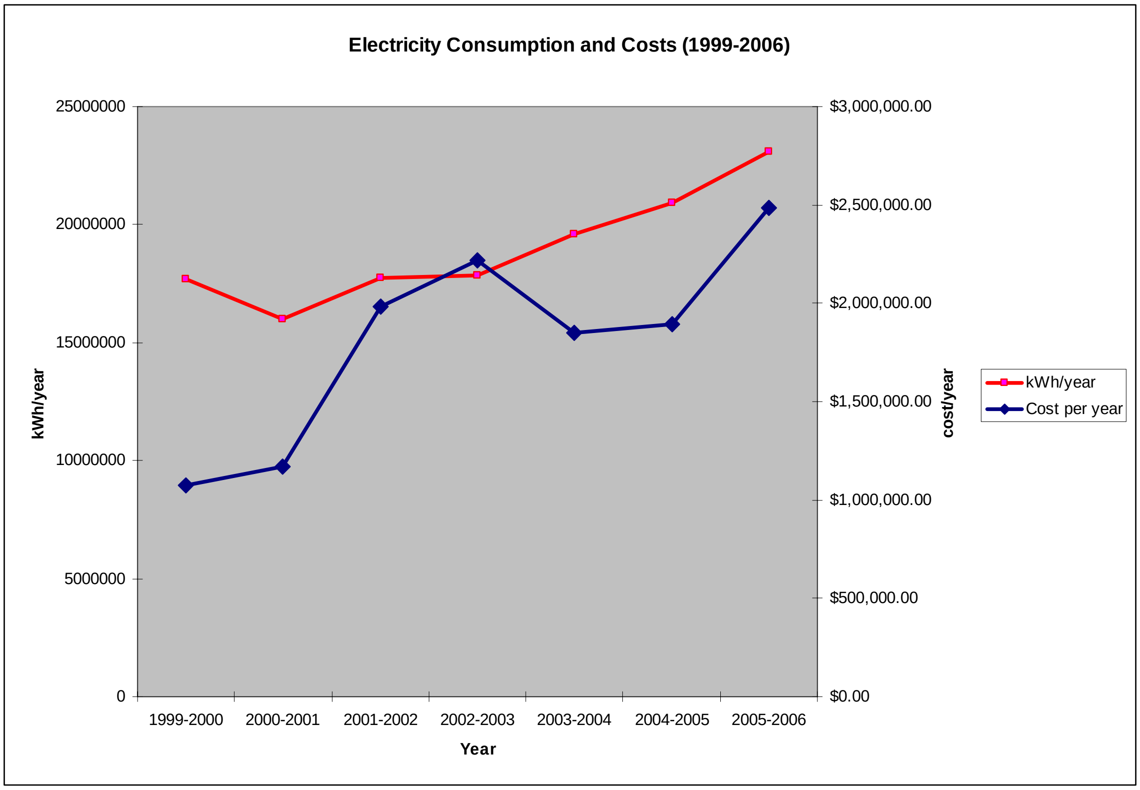


Trends in Consumption and Emissions

Electricity consumption and its associated emissions have been increasing significantly over the last seven years at Pomona. Consumption increased by 23.40% between 1999-2000 and 2005-2006 as shown in Figure 3.1. GHG emissions increased by 30.56% during the time period from 6421 Metric Tonnes CDE in the year 1999-2000 to 8383 Metric Tonnes CDE in 2005-2006. The increase in electricity consumption and emissions can be attributed to the increase in the number of new buildings on campus, expanded infrastructure, added outdoor lighting and perhaps increased electrical wastage. [21] The campus is also becoming more energy intensive considering that Pomona's student enrollment has remained constant at around 1500 students during this time period. . It is interesting to note that GHG emissions increased more than electricity consumption. This suggests that the mix of energy sources that has been used to generate our electricity is becoming more greenhouse gas intensive.

This growth in energy intensity and consumption by the College has occurred in spite of the energy crisis in 2000-2002 and the higher prices that persisted thereafter. The energy crisis apparently had very little influence on the long-term energy strategy of the college as the cost associated with this energy use has also increased in the last seven years as shown in Figure 3.1 even after the energy crisis. The sharp increase in energy costs from 2000-2002 that we see in the figure are a direct result of the California energy crisis of 2000-2002. During this time period electric rates soared upwards, and as an interruptible I-6 customer, Pomona went through a period of power outages. The reduction in consumption seen in the figure after the crisis from 2001-2002 to 2002-2003 is a result of these outages combined with increased conservation measures. Consumption has increased since the crisis despite electricity prices remaining higher than they were before 2000. [22]

Figure 4.2



Source: Campus Planning and Maintenance, Pomona College

---

[21] Aaron Westgate, *Wise Energy Use*, 2005

[22] Aaron Westgate, *Wise Energy Use*, 2005

Energy Intensity of Buildings

Basic energy intensity analysis of the buildings on campus shows that almost all academic buildings are significantly more energy-intensive relative to the residence halls at Pomona. Apart from the two swimming pools and the tennis courts, the academic buildings with laboratories are the most energy-intensive buildings on campus. This suggests that large gains in energy efficiency can be made by allocating resources towards buildings with laboratories than making efficiency investments in all buildings. The residence halls with air-conditioning, Mudd-Blaisdell and Oldenborg are also twice as more energy intensive than other dorms. This suggests that any decision on including air-conditioning in newer dorms can be an important one in terms of energy costs.

Table 4.1

Energy Intensity: Residence Halls

Residence Hall Buildings	Total Sq Ft	kwh used 2005-2006	kwh/sq ft
Mudd-Blaisdell	65496	888951	14
Oldenborg Center	71,000	918,937	13
Lyon Court Dormitory	24,238	181,398	7
Wig Hall	25,200	184,955	7
Norton Hall	9,000	63174	7
Walker Hall	49,000	305447	6
Smiley Hall	15,547	93280	6
Harwood Court	63,100	339434	5
Lawry Court Towers	18,200	71883	4
Clark I, III, V	116600	404377	3

Table 4.2

Energy Intensity: Non-Residence Buildings/Complexes			
Non-Residence Hall Buildings	**Total Sq Ft**	**kwh used 2005-2006**	**kwh/sq ft**
Pendleton Pool	500	301867	604
Haldeman Pool	3,500	470821	135
Richard C. Seaver Biology Bldg.	13,672	1499138	110
Pauley Tennis Complex	1,243	91760	74
Hahn Building	27,000	1286274	48
Seaver North	60,319	2,526,974	45
Frary Dining Hall	23,000	867563	38
IT (Multi-Use) Building	12,000	418778	35
Frank Dining Hall	19,637	646190	33
Replica House	885	26,294	30
Thatcher Music Building	35,000	1,027,400	29
Smith Student Center	65,000	1685780	26
Rembrandt Hall	9,000	231236	26
Pomona Grounds Building	1,800	43256	24
Brackett Observatory	2,100	45,206	22
Seaver South	50,529	1,005,000	20
Alexander Hall	35,000	641,280	18
Andrews Bldg (165 E 6th St)	15,500	283526	18
Sumner Hall	17,700	300214	17
Millikan Laboratory	43,927	670,500	15
Bridges Hall of Music	32,200	466,555	14
Pearsons Hall	17,663	252,983	14
Rains Center	84,863	1115520	13
Kenyon House	3,800	48240	13
Seaver Theater	64,348	767000	12
Walton Commons	3,039	34575	11
Seaver House	5,400	59646	11
Carnegie Building	20,169	181013	9
Mason Hall	40,026	330,709	8
Seeley Mudd Science Library	26,000	212,220	8
Crookshank Hall	21,285	153,966	7
Sumner House	3,200	21864	7
Dean's House 156 W. 7th Street	3,500	22945	7
Renwick House	2,500	14766	6
Montgomery Art Gallery	8,700	40385	5
President's House	7,500	30075	4
Baldwin House	3,000	7149	2

Recommendations for Reducing Emissions from Consumption of Electricity

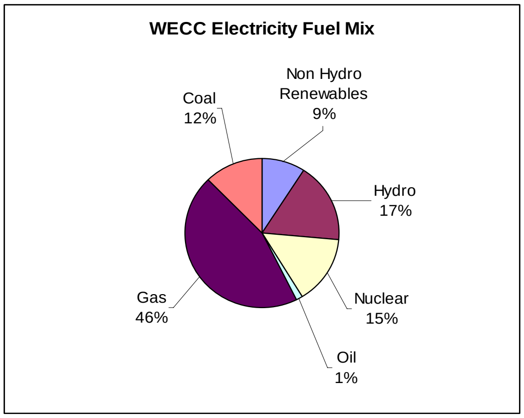
Purchasing green electricity or renewable energy certificates

It is clear that Pomona College will continue to emit significant amounts of greenhouse gases if the College continues to consume electricity generated from non-renewable sources such as coal, natural gas, and other petroleum products. As Pomona College cannot continue its campus operations without consuming electricity, the College needs to pay urgent attention to purchasing energy from renewable energy sources or green power if the College is serious about reducing its impact on climate change. This single initiative of purchasing green power can reduce 41% of our greenhouse gas emissions.

Many colleges and universities in the past five years have recognized this and started purchasing increasing amounts of green power (see appendix _ for a list of clean energy purchases at other colleges and universities). Green power can be broadly defined as "electricity that is produced in a manner that minimizes environmental damage and maximizes environmental benefits. Green energy includes renewables, such as wind, solar, low impact hydroelectric and biomass, and salvaged resources such as land-fill gas." Besides directly reducing GHG emissions and air pollution, by purchasing green power, the College will also be providing direct economic support for development of clean energy alternatives.[23]

Pomona College purchases its electricity from the Southern California Edison (SCE), in this report our estimates of GHG emissions from the consumption of electricity are calculated from the mix of fuels used in the WECC region of the US national grid, which is the region that SCE is a part of.[24] The WECC region generates 91% of its electricity from non-renewable sources (hydropower not included) as shown below. This ratio of the mix is slightly different from the mix used by SCE but the GHG emissions associated with each kwh of electricity produced from WECC region and SCE can be considered to be similar.

Figure 4.3



Pomona College can expand its green power portfolio by either directly purchasing green power from utilities or by purchasing renewable energy certificates to offset any purchases of

---

[23] Petersen, John E, *Oberlin College: From Zero to 60 on Green Electricity*, Oberlin College, Oberlin OH, 2006
[24] The Clean Air-Cool Planet model that we have used only provides emissions factors for WECC region

electricity generated from non-renewable sources. Chapter 11 discusses in depth the economics of purchasing green power and carbon offsets including green power products available in California and renewable energy certificate products available nationally.

Taking advantage of Southern California Edison energy efficiency programs

Pomona is bound to using the services of SCE unless the Claremont University Consortium collectively switches to another utility company, therefore, Pomona needs to explore avenues of working with SCE to invest in energy efficiency and emissions reductions projects. One such project that can be explored is a newly launched initiative between SCE and the California Climate Action Registry called The Cool Planet.[25] This allows SCE customers added value and benefits when participating in both SCE Energy Efficiency programs and Registry membership.

Some of the benefits of the SCE Energy Efficiency Programs described in their website include:

- Financial incentives for installing high efficiency equipment or systems up to $2.4 million per facility.
- Financial incentives for process improvements that reduce power density/ energy consumed per production unit – up to $739,000 per facility.
- Complimentary energy audit of your SCE facility.
- Customized programs to meet the needs of specific industries and situations (industrial and agriculture)
- Design assistance to maximize operating potential and minimize cost.

Some of the benefits of joining the Cool Planet Project include:

- Install energy efficiency project(s) in 2007 that potentially save at least 1 million kWh annually and SCE will pay up to 50% of the project cost + 100% of Registry first year membership fee + 50% of the first year GHG certification fee.
- Install project(s) in 2007 that potentially save at least 3 million kWh annually and receive the above and 100% of the first year GHG certification fee.
- Reducing energy usage reduces GHG emissions.
- Potential recognition for GHG emission reductions under AB 32.
- Publicity and marketing assistance (up to 40 hours) to position company as an environmental leader in marketplace.

Student/ Faculty/Staff energy conservation education

The successful first-ever Dorm Energy Conservation Challenge or the Green Cup held last November by Campus Climate Challenge demonstrates that such campaigns can and should be important components of an emissions mitigation plan. The Dorm-Challenge, held with a target of reducing Pomona' electricity consumption for residence halls for November 2006 by at least 5% compared to the amount used in November 2005, proved to be an overwhelming success by achieving a reduction of 8.02%. Such a significant reduction in electricity consumption and

---

[25] This information is from the SCE website. For more information about this program, please contact the SCE representative Pomona or Nancy Whalen, Marketing Manager at California Climate Action Registry (213) 891-6933 or nancy@climateregistry.org.

emissions just by increasing awareness of energy conservation measures and by providing attractive incentives suggests that similar programs, particularly ones including faculty and staff, can be an effective strategy in reducing emissions and electricity use. In this particular challenge, CCC presented the winning dorm with the Green Cup and $2000 to invest in a sustainability measure chosen by its residents. CCC also worked with President Oxtoby to have the College purchase 10% renewable energy certificates for the dorms electricity use for meeting the 5% target. The Challenge successfully raised attention to energy conservation and climate change issues and showed that both students and the administration can work well towards the goal of sustainability given the correct incentives are provided for both parties. The 8.02% reduction provided $2492 cost savings for the College while also preventing a cumulative 297,936 lbs of carbon dioxide from being emitted – equivalent to taking 26 cars off the road as shown below in Tables 3.4 through 3.7. We recommend that future dorm energy conservation challenges be held for longer periods of time and are also done in conjunction with similar challenges in the academic/ administration buildings.

Table 4.3

Projected Costs, Savings and CO2 emissions reduction from Dorm Challenge	
Total electricity consumption in residence halls 2005-2006	3,451,836 kWh
Total Electricity Consumption in residence halls for November 2005	310776 kWh
Percentage reduction in electricity consumption for Novembe 2006 compared to November 2005	8.02% (24924 kwh)
Costs savings from a 8.02% reduction for November 2006 (@$0.1/kWh)	$2,492
Costs savings from a 8.02% reduction for a year (@$0.1/kWh)	$27,683
CO2 emissions reduced from achieved 8.02% reduction for November 2006 (1 kwh = .805 lbs CO2)	20063 lbs
	Equivalent to taking 2 cars off the road for a year (EPA average emissions of 11500 lbs of CO2 per year per car)
Cost of purchasing 10% renewable energy certificates (RECs) from Native Energy (@ $0.00666/kwh)	$2,300
CO2 emissions reduced from purchasing 10% RECs (1 kwh = .805 lbs CO2)	277873 lbs
Total CO2 emissions reduced from purchasing 10% RECs and 8.02% reduction for November 2006	297936 lbs
	Equivalent to taking 26 cars off the road for a year

Table 4.4

Pomona College Dorm Electricity Consumption for Nov 2005 and Nov 2006

Residence Hall	November 2005 (kwh)	November 2006 (kwh)	Percentage change from 2005	Total Signed	Total Residents	Percentage taking the Pledge	Weighted Score *
Walker	29240	24825	**-15.10%**	97	112	86.61%	50.86
Clark I	14075	11189	**-20.50%**	86	116	74.14%	47.32
Lyon Court	16810	15202	**-9.57%**	61	76	80.26%	44.92
Clark V	17960	16931	**-5.73%**	75	93	80.65%	43.19
Oldenborg	76377	70570	**-7.60%**	101	135	74.81%	41.21
Mudd-Blaisdell	67575	65340	**-3.31%**	210	277	75.81%	39.56
Wig Hall	18337	17289	**-5.72%**	80	111	72.07%	38.90
Lawry Court	8009	7814	**-2.43%**	53	71	74.65%	38.54
Norton + Clark III	17184	15147	**-11.85%**	72	116	62.07%	36.96
Harwood Court	35449	31392	**-11.44%**	91	170	53.53%	32.49
Smiley	9760	10160	**4.10%**	37	60	61.67%	28.79
Total	310776	285859	**-8.02%**	963	1337	**72.03%**	-

*** Percentage change from 2005 and percentage taking the pledge are equally weighted**

Table 4.5

Pomona College Dorm Electricity Consumption for Nov 2006 compared to average for Nov '03-'05

Residence Hall	November '03 (kwh)	November '04 (kwh)	November '05 (kwh)	November '03-'05 Ave. (kwh)	November '06 (kwh)	Nov 06 vs Nov Ave. (% reduction)	Percentage taking the Pledge	Weighted Score *
Walker	27127	31656	29240	29341	24825	**-15.39%**	86.61%	51.00
Lyon	15052	19728	16810	17197	15202	**-11.60%**	80.26%	45.93
Clark I	11432	14467	14075	13325	11189	**-16.03%**	74.14%	45.09
Clark V	16761	19507	17960	18076	16931	**-6.33%**	80.65%	43.49
Lawry	8971	8490	8009	8490	7814	**-7.96%**	74.65%	41.31
Wig	17186	21123	18337	18882	17289	**-8.44%**	72.07%	38.90
Oldenborg	62841	74861	76377	71360	70570	**-1.11%**	74.81%	37.96
Norton + Clark III	15970	19012	17184	17389	15147	**-12.89%**	62.07%	37.48
Mudd-Blaisdell	58494	67206	67575	64425	65340	**1.42%**	75.81%	37.20
Harwood	33011	37153	35449	35204	31392	**-10.83%**	53.53%	32.18
Smiley	10400	11080	9760	10413	10160	**-2.43%**	61.67%	32.05
Total	277245	324283	310776	304101	285859	**-6.00%**	**72.03%**	-

*** Percentage change from 03-05 ave and percentage taking the pledge are equally weighted**

Table 4.6

Pomona College Dorm Electricity Consumption: Changes in Consumption from Oct - Nov for 2005 and 2006

Residence Hall	October 2005 (kwh)	November 2005 (kwh)	% change from Oct to Nov 2005	October 2006 (kwh)	November 2006 (kwh)	% change from Oct to Nov 2006	% change in 2005 - % change in 2006 (from Oct - Nov)	Percentage taking the Pledge	Weighted Score
Walker	26011	29240	12.41%	27989	24825	-11.30%	**-23.72%**	86.61%	55.17
Lawry	8152	8009	-1.75%	10742	7814	-27.26%	**-25.50%**	74.65%	50.08
Lyon	16113	16810	4.33%	16322	15202	-6.86%	**-11.19%**	80.26%	45.73
Oldenborg	79576	76377	-4.02%	80504	70570	-12.34%	**-8.32%**	74.81%	41.57
Clark V	18130	17960	-0.94%	17316	16931	-2.22%	**-1.29%**	80.65%	40.97
Clark I	14354	14075	-1.94%	12362	11189	-9.49%	**-7.55%**	74.14%	40.85
Wig	18009	18337	1.82%	18065	17289	-4.30%	**-6.12%**	72.07%	39.10
Mudd-Blaisdell	72187	67575	-6.39%	69957	65340	-6.60%	**-0.21%**	75.81%	38.01
Norton + Clark III	16617	17184	3.41%	16053	15147	-5.64%	**-9.06%**	62.07%	35.565
Smiley	9680	9760	0.83%	9960	10160	2.01%	**1.18%**	61.67%	30.25
Harwood	33507	35449	5.80%	29954	31392	4.80%	**-1.00%**	53.53%	27.265
Total	312336	310776	**-0.50%**	309224	285859	**-7.56%**	**-7.06%**	**72.03%**	-

*** Percentage change from 2005 - 2006 and percentage taking the pledge are equally weighted**

Improving lighting efficiency

There are considerable reductions in energy use and emissions that can be achieved by installing more energy-efficient lighting in public spaces. Much of the current fluorescent lighting in the dorms can be systematically retrofitted with newer more efficient fluorescent lighting. Many areas can also be either de-lamped or under-lit. There is also room for efficiency improvement by relamping all incandescent bulbs currently used for outdoor lighting with compact fluorescent lighting (CFLs) or halogen IRs.

Aaron Westgate's 2005 thesis also identified efficiency gains from changing incandescent bulbs in student rooms to CFLs, installing motion sensors for hallway/bathroom lighting and retrofitting exit signs with light emitting diodes (LEDs). He estimated that by investing approximately $27,600 in CFLs, sensors, and exit signs, almost $30,000 can be saved annually at Pomona College. This is equal to 1.55% of the college’s entire electric bill for the 2003-2004 billing year, simply from reducing wasted lighting on campus. Investing in $5,000 worth of CFLs for student rooms itself saves over $75,000 in the lifetime of the bulbs. This entire project would also pay for itself in just under one year, well below a payback time of seven years that Jim Hansen advised Westgate to be the cutoff point for attractive investments on campus.[26] This initiative would also reducing 174 tons of CO_2 per year, equivalent to taking 38 passenger vehicles off the road for a year.

Improve energy efficiency of school-owned and student owned computers by systematically enabling energy saving power management systems

This is a source of savings that can be implemented almost immediately and can generate substantial amounts of savings. According to Energy Star, Universities’ computers and monitors use more electricity than all other forms of office equipment combined and more than half of this energy is wasted because computers and monitors are left on at night and not enabled for power management.’[27] All modern PC monitors come with built-in Energy Star capability, although not all monitors have this feature enabled. Enabling this feature can automatically turn on the energy saving power management systems of monitors such that the monitors go into low-power mode or turn off after being idle for either 10, 15 or 20 minutes. This monitor power management will also not affect computer or network performances as a simple touch of the mouse or keyboard can "wake" the machine within seconds[28]. The feature can conveniently be enabled by ITS staff from a central location through the EZ Save software developed by Energy Star that is available for free on their website.[29]

According to an ITS estimate there are 800 school-owned computers on campus. From the online calculator in the Energy Star website[30], once all Pomona College-owned computers have this feature enabled, it can lead to energy savings of about $53,992.97 per year, or enough electricity to light 432 U.S. homes for one year. It will have a related reduction in Greenhouse

---

[26] Aaron Westgate, *Wise Energy Use*, 2005

[27] http://www.energystar.gov/ia/products/power_mgt/UniversityCaseStudy.doc

[28] http://www.energystar.gov/ia/products/power_mgt/GEBusinessCaseStudy.ppt

[29] See: http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_management

[30] Power Saver calculations Link
http://pmdb.cadmusdev.com/powermanagement/quickCalc.html#calculatorTop

Gas emissions (carbon dioxide) by 772,100 lbs per, the equivalent of 67 autos taken off the road. Many corporations and universities have already taken this initiative, examples are GE, Cisco, Harvard University, Yale University and University of Wisconsin- Oshkosk. Harvard's Kennedy School of Government saved over $14,000 annually by enabling the feature on 800 of its computers while Yale saved $40 dollars per PC.

Student owned monitors and computers (estimated to be around 1200 each) have not been included in this example. The estimates of costs and savings are based on the following assumptions:

Table 4.7

Assumptions Used		
Electricity Cost (¢ / kWh):	10	
Hours in Workday:	9.5	
Days in Workweek:	5	
	Monitors:	Computer boxes:
Number of Units to Be Power Managed	800	800
Active Power (watts)	73	57
Sleep Power (watts)	3	3
% Units Turned Off After Work	36	36
% Time Units Sleep During Workday	58	58

Table 4.8

Estimated Energy Savings and Pollution Prevented			
Energy	Monitors:	Computer boxes:	**Totals:**
Current Use (kWh):	381,911	295,499	677,410
Future Use (kWh):	77,112	60,368	137,480
Savings (kWh):	304,799	235,131	539930
Number of Homes Lit:	244	188	432
Dollars	Monitors:	Computer boxes:	**Totals:**
Current Cost ($):	$38,191.09	$29,549.89	$67,740.98
Future Cost ($):	$7,711.18	$6,036.83	$6,036.83
Savings ($):	$30,479.91	$23,513.06	$53,992.97
% Saved:	80%	80%	80%
Pollution Prevented	Monitors:	Computer boxes:	**Totals:**
Lbs CO2:	435,863	336,237	772,100
Tons CO2:	218	168	386
Cars Off the Road:	38	29	67
Acres of Trees Planted:	59	46	105

Other Measures

i. Installing a device called Vending Misers on vending machines
We have roughly 15 vending machines on campus. These machines use large amounts of electricity annually. According to Tufts University each machine uses 3400 kwh *per year.* That is a total of 51,000 kwh per year used at Pomona only for powering vending machines. The small device called *Vending Miser* costs $165 per machine, and cuts down the energy use to 1700 kwh per year saving 25,000 kwh per year, that's roughly $2500 per year in terms of cost-savings. It would roughly costly the same to install the Vending Misers so the payback period of this initiative is just one year.

The Vending Miser device turns off the machine's lights and efficiently controls its temperature when the machine is not in use. As soon as a person walks in front of a motion sensor, the Vending Miser turns the machine completely on (it does not affect products by any means and has been approved by Coca Cola and Pepsi)

ii. Installing a breaker-level electricity metering device called EnerSure by Trend Point
This allows monitoring of electricity use at the building/department and user-level (such as student's individual rooms and office rooms) which can bring out about individual accountability in terms of energy use and carbon emissions.

The device is connected to the circuits in the breaker panel and will monitor electricity use in the rooms that are connected to the circuits in the breaker panel. It will allow monitoring of power panels of less than 21 circuits all the way up to 84 circuits. The device can also assign each circuit to a user and each user to a group such as a department, dorm, building etc with management turned over to each user and department so that each can securely log-in online and monitor their own circuits. At the same time, all data can also be made available at the Enterprise-level to a site manager or a website. Oberlin College has also invested in such technology and their program can be view online at www.oberlin.edu/dormenergy.

This measure is extremely cheap to implement, with the payback period generally being one year for most medium/large organizations. The list price for a typical 42 pole panel is just over $60 per circuit. "EnerSure® is the solution for monitoring energy-use and carbon footprint at the source level; the individual circuit. Government studies have consistently shown that submetering at the circuit-level produces a 10-12% reduction in energy use just by having access to this micro-level data."

Improving campus-wide ventilation and cooling system efficiency

Efficiency can be attained by a number of other initiatives that would require more costly initial investments. Some examples could be the installation of occupancy, humidity, fume, and carbon dioxide sensors (so that equipment would be operated only when needed), control and operational improvements, economizers, variable air volume systems, fan and motor improvements, temperature setback at night, improved thermostats, maintaining refrigerant charge, installing adjustable speed drives on compressors and cooling tower fans, and other technical improvements.[31]

---

[31] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002

Chapter 5

EMISSIONS FROM NATURAL GAS USE

(Author: Praween Dayananda)

Pomona College currently consumes natural gas provided by Southern California Gas Company for space heating, domestic hot water heating, cooking in the kitchens and dorms and to some extent emergency lighting by the generators.[32] Emissions from the use of natural gas account for 41% of Pomona's total emissions.

Space heating and domestic hot water heating are both provided on campus by separate systems of boilers located in the basements of most buildings or by a common boiler used by several buildings (See below for location of these boilers). These boilers use some electricity to start up but then maintain a 160F water temperature for space heating and 120F temperature for domestic hot water by burning natural gas. Space heating is distributed in buildings with a centralized closed loop system of pipes that carry the hot water through the rooms. Domestic hot water is also centrally distributed in buildings through circulating pumps that consume some electricity, approximately 20kw/week for all pumps on campus.[33] The boilers on campus are:

- Central Plant in Hahn provides heat for Hahn and Carnegie
- Central Plant in Seaver North serves all the Seaver science buildings
- Individual plants in Seeley G. Mudd, Millikan, Lincoln-Edmunds
- Package Units for IT building and Kenyon House (separately)
- Boilers in Alexander, SCC, Smiley, Rains, Oldenborg, Thatcher, Sumner Hall
- Boiler at Oyster House (that little ugly concrete building in the arts quad courtyard) for Little Bridges, Montgomery, Rembrandt, Thatcher
- Boiler at Mudd-Blaisdell for Wig, Lyon, MB, Harwood
- Little boiler at Pendleton
- Boilers at Walker, Clark I/III/V, dining halls[34]

Campus Planning was able to provide figures for the consumption of natural gas only from 1999-2006 from the monthly gas bills for the buildings with meters.

Trends in Consumption and Emissions

Pomona's natural gas consumption, like its consumption of electricity, has also increased since 1999 but by much larger degree. It increased by 107% from 1999-2000 to 2005-2006. Associated emissions also increased by 107% from 3514 Metric Tonnes CDE to 7271 Metric Tonnes CDE in this time period. There are two main reasons for this dramatic increase. One is the result of the transition away from centralized Claremont University Consortium boilers using natural gas and steam to deliver space and water heating to individual boilers on each of the campuses using only natural gas around the year 2000[35]. The second reason is the growth of the

---

[32] Some domestic hot water is also generated from electric water heaters

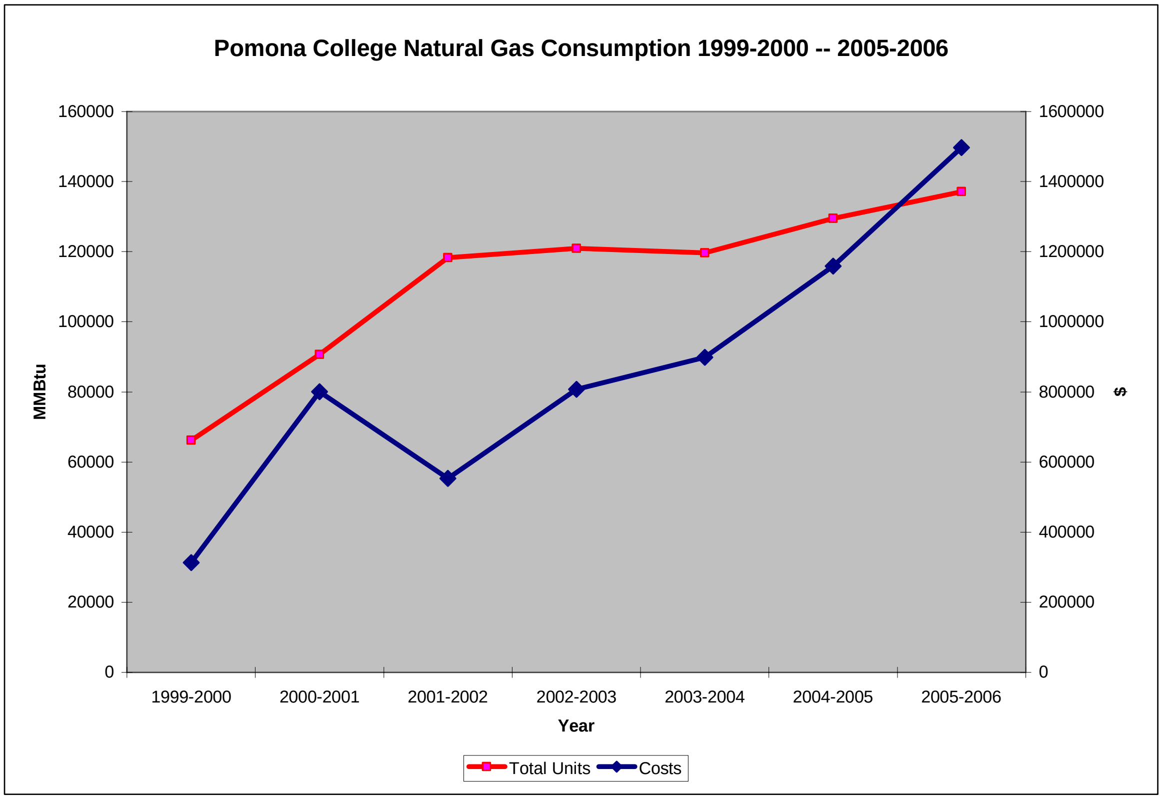
[33] Based on conversation with Ron Watling, Campus Planning and Maintenance

[34] Email exchanges with Bowen Patterson, Campus Planning and Maintenance

[35] Based on a conversation with Anthony Pennington, CUC

College, particularly the construction of newer buildings such as the Smith Campus Center. Although the newer plants were more efficient compared to the steam and natural gas run plants (and had lower emissions of nitrous oxide), natural gas consumption still increased significantly due to the higher growth rate Pomona College facilities.

Figure 5.1



Source: Campus Planning and Maintenance, Pomona College

Table 5.1

Total Therms of Natural Gas Used in 2005-2006 in Residence Halls

Residence Hall	**Therms/ year**
Frary/Clark I/III/IV	109,443
Mudd/Blaisdell (Boiler)	90615
Oldenborg Dorm	29030
Walker Residence Hall	25808
Harwood Court Residence	7219
Wig Residence Hall	3683
Lyon Court Dorm	3244
Smiley Residence Hall	2654
Mudd Residence Hall	2081
Blaisdell Hall	998
Wig Cottage	980
Wig Cottage	687
Wig Cottage	627
Wig Residence Hall	574
Norton Residence Hall	4
Total Therms/year in Residence Halls	**277647**
Total Therms/year in all buildings	**1371206**
Percentage of Total Use in Residence Halls	**20.25%**

Recommendations for Reducing Emissions from Consumption of Natural Gas

Space heating efficiency improvements

This can be accomplished by a suite of measures.

Turning down the thermostats of campus buildings

In all dorms except Oldenborg, heaters are not controlled in individual rooms and instead are all connected to a central heating source. Currently, all dorm heaters come on when the outside temperature drops below 68 degrees F, which means it could still be 80 degrees in our dorms when the heater comes on! According to a study at Middlebury College, one of the easiest ways to begin reducing GHG emissions from heating, is to turn down the thermostats of campus buildings.[36] The Minnesota Department of Energy says that for each degree that one turns down

---

[36] Carbon Neutrality at Middlebury College, 31

the thermostat (in a home), the home saves one percent of heating costs. There is a potential for similar cost savings at Pomona.

This measure would not require any waiting period or an additional research period. It could be initiated within two weeks of the time used to first increase student, faculty and staff awareness about the reason for the initiative and the positive environmental attributes of doing so. [37]Some steps suggested by the Middlebury report were for instance to advise the community to wear an extra layer of clothing beginning on the day of lower temperatures. We do not recommend changing the policy unless the school received numerous complaints of discomfort associated with lack of heat or discomfort associated with lack of adequate air-conditioning. The college could additionally provide space heaters if the complaints were relatively sparse. SUNY Buffalo has lowered their temperature to 68 degrees, and provides space heaters when requested.[38]

CCC, last semester started a petition in the dorms to ask the Building and Grounds Department to lower the temperature at which the heaters come on to 58 degrees to gauge student support for such an initiative. Additionally, we requested that the set temperature be 67 degrees in the daytime and 64 degrees at night. 77/112 (69%) residents in Walker and 50/92 residents (54%) in Clark V signed the Petition suggesting that there is indeed some support for reducing the heat during the winter.

Insulation of walls and ceilings

Heating energy use can be significantly reduced by installing weather stripping and sealing air leaks throughout buildings dorm room where necessary to reduce outside air infiltration.

<u>Other potential measures:</u>

- ***Replacing the existing single-pane windows and drafty doors and windows***
- ***Reducing uncontrolled air leakage***
- ***Recovering heat from ventilation air and installing a simple solar air heating system to reduce the heat load during daytime***
- ***Install temperature setback at night***

Domestic Water Heating Efficiency Improvements

Reducing hot water waste and improving water heating and delivery efficiency can cut significantly cut overall natural gas costs and associated emissions as domestic water heating is one of the two main sources of natural gas consumption. Some measures are mentioned below are adopted from the Oberlin 2020 report.

Installation of more efficient showerheads, faucet aerators

---

[37] Carbon Neutrality at Middlebury College, 31

[38] Carbon Neutrality at Middlebury College, 31

In addition to reducing heating costs, these would provide more satisfying showers from better hydrodynamics. Water-efficient showerheads could reduce the hot water flowrate from approximately 4-5gallons per minute (gpm) to 2.0 gpm.

Replacing the existing centralized hot water circulation and distribution systems in buildings with very low water heating energy

This can be done for example by using small, point-of-use heaters, to eliminate the distribution losses.

Better insulation of hot water storage tanks and exposed pipes wherever they are accessible and un-insulated

A detailed inspection of current insulation levels of water storage tanks was not carried out, however, ensuring that proper insulation is present with professional audits can reduce the storage losses by about one third in general.

Switching to solar hot water heating systems[39]

As emissions from the consumption of natural gas comprise 41% of Pomona's GHG emissions, a long term and large-scale strategy needs to be taken for reducing emissions from natural gas use. As much of the natural gas on campus is used for space and domestic water heating, one such strategy could be to gradually upgrade the current natural gas fired domestic hot water heating system to a solar hot water heating system. This can also be a cost-effective way to generate hot water for Pomona College in the long-run, particularly since sun-shine is not in short supply in Claremont! We have provided below a simple description of how such a system would work and some associated costs. A detailed analysis would need to be done to evaluate the precise costs, benefits and payback periods of such an initiative.

The main components of a solar water heating system are well-insulated storage tanks and solar collectors. The two most common systems are active, which have circulating pumps and controls and passive which don't. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Pomona would still be able to use the current system in place as backup for cloudy days and times of increased demand. However setting up a dual system for a large campus like Pomona would potentially involve high installation costs and could be the biggest obstacle for initiating large scale implementation at Pomona. Installation costs of solar water heaters can vary depending on many factors such as solar resource, climate, local building code requirements, and safety issues.

Long term costs would involve mainly systematic checks and part replacement to keep the system running smoothly, not much different from costs of maintaining the current water heating

---

[39] For more information visit http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850

system. Additional costs would be glazing if rainwater doesn't provide a natural cleanse. Most passive systems do not require much maintenance. Maintenance on simple systems can be as infrequent as every 3–5 years and systems with electrical components usually require a replacement part after or two after 10 years.

The Economics of a Solar Water Heater[40]

Initial installation costs are usually higher for solar water heating systems than conventional water heating systems. However, a solar water heating system can usually provide cost-savings in the long run.

Cost-savings would depend on:

- The amount of hot water used
- The system's performance
- Geographic location and solar resource
- Available financing and incentives
- The cost of conventional fuels (natural gas, oil, and electricity)
- The cost of the fuel used for backup water heating system

The US Department of Energy states that on average, we can expect a long-run decrease of 50-80% in our heating bill with the installation of a solar water heating system. Additionally, because the sun is free, there is protection from future fuel shortages and price hikes! The economics are even more attractive if Pomona is building includes the systems in new buildings as the College can take advantage of federal income tax deductions for solar water systems. On a monthly basis, the College will most probably be saving more than paying."[41]

---

[40] **http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12860**

[41] http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850

Chapter 6

EMISSIONS FROM TRANSPORTATION

(Authors: Ada Aroneanu, Praween Dayananda and Tara Ursell)

The use of fossil fuels for transportation accounts for 7% of Pomona's GHG emissions. Fossil fuels are used for transportation by faculty, staff, and students traveling by air to conferences and other events, faculty and staff for daily commuting, the Grounds and Housekeeping Department for their fleets, Campus Planning and Maintenance for running generators, and the athletic department for transporting athletes to various competitions. Data for faculty, staff and student air travel was only available for the year 2005-2006 and data for their daily commuting was estimated from email surveys. Data for Grounds, Housekeeping and Campus Planning was available from 2002-2006, while data for athletic teams was also only available for fall semester of 2006. We assumed the figures to be constant at 2005-2006 levels where the data was unavailable.[42]

Daily commuting to work by staff was the single largest contributor to GHG emissions from this sector. The average staff member in our survey traveled 22 miles per day and 4786 miles per year. This suggests that significant attention needs to be paid to providing alternatives modes of getting to work for staff members.

Air travel by faculty, staff and administrators was the second largest contributor to GHG emissions during the past year.

Table 6.1

GHG Emissions from within transportation sector		
Sector	**Emissions MTCDE**	**Percentage of total**
Grounds (gasoline)	16	1.20%
Grounds (diesel)	7	0.53%
Housekeeping (gasoline)	7	0.53%
Campus Planning and Maintenance (diesel)	11	0.83%
Athletic Teams (gasoline)	24	1.81%
Air Travel (Faculty)	487	36.67%
Air Travel (Student Grants)	32	2.41%
Faculty Commuting (gallons)	152	11.45%
Staff Commuting (gallons)	592	44.58%
Total	**1328**	

Daily commuting for faculty and staff

Each day, faculty and staff commute to Pomona College and contribute to Pomona's overall level of greenhouse gas emissions. While incentives are in place to encourage faculty and staff to take alternative transportation, the vast majority do drive cars to work. In order to calculate

---

[42] Pomona also owns the shuttle and the Sagecoach, a fleet of cars used by the Business Office, and other departmental vehicles. We could not obtain records for these vehicles.

the emissions, we sent out a survey to all faculty and staff asking each individual how many days a week they drive (if they do use a car), for how many weeks per year, then what their gas mileage is, if they share a car, and how long their roundtrip daily commute is. This data was also calculated with the Inter-Governmental Panel on Climate Change's data on how many pounds of CO_2 is put into the atmosphere per gallon of gasoline and diesel. Because most people use gasoline cars (19.4 pounds/gallon) and not diesel cars (22.2 pounds/gallon), this was averaged to 20 pounds/gallon per driver.[43] As a result of this data, we were able to determine the emissions put into the environment by each individual driver.

Out of 186 faculty members, 50 faculty members responded, and out of over a hundred staff members, 49 staff members responded. Of the staff members, 9 of the 49 respondents (18.4%) do use alternative methods of transportation such as biking or walking at least some of the time. Of those who do drive, 15 out of 49 carpool (30.6%) at least some days with varying numbers of people in the car. From the data it seems that more faculty members use alternative forms of transportation because they are often able to live closer to the school, and thus can walk. In contrast, staff members seem more willing to share their car with others in commute to school. Of the faculty, 19 out of 50 respondents (38%) use alternative forms of transportation at least some of the time. Of those who drive, 11 out of 50 carpool at least some times (22%).

Since our goal is to determine total emissions from commuting, we used the survey sample data to draw conclusions about the fuel use and emissions characteristics of the entire faculty and staff populations (the population mean). One of the problems of using this method to draw estimates of the population is non-response bias in that the faculty and staff who chose not to respond might driver higher than the average faculty member who responded to our survey.

The calculations were based on the assumption that the overall driving characteristics of the populations for both faculty and staff are normally distributed.

The standard deviation of the sample is s, where $s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$,

Since our sample size is larger than 30, margin for sampling error, E = Z* (sigma/root of n) **[44]**

---

[43] CO2emissions from a gallon of gasoline = 2,421 grams x 0.99 x (44/12) = 8,788 grams = 8.8 kg/gallon = 19.4 pounds/gallon

CO2 emissions from a gallon of diesel = 2,778 grams x 0.99 x (44/12) = 10,084 grams = 10.1 kg/gallon = 22.2 pounds/gallon

[44] Standard deviation, S= 3421.429708 miles traveled by each faculty member per year

Sample mean, x-bar = 1984.99 miles traveled by each faculty member per year

Calculating Margin of Error, E for 95% degree of confidence

E= 1.96 * (3421.429708/ 7.07)

= 948.52 miles

1984.99miles - 948.52miles < Pop mean < 1984.99miles + 948.52miles

1036.47miles <Pop mean < 2933.51miles

For the purposes of the inventory we have used the sample mean to calculate total amount driven by faculty per year. Therefore, total miles driven per year by all 190 faculty members for 2005-2006 = sample mean * total number of faculty members

= 1984.99 miles * 190

= 377,148 miles

Table 6.2

Summary Statistics for Faculty Daily Commuting		
Sample mean, x-bar (miles driven per faculuty member/year)	1985	
Standard dev of sample, s	3421	
Margin of Error	949	
95% confidence interval (miles/year)	1036	2934
Total Faculty Members for 2005-2006	190	
Total driven by all faculty (miles/year)	377148	
95% confidence interval for all faculty (miles/year)	196930	557366

We carried out similar calculations for staff daily commuting and generated the numbers displayed below.

Table 6.3

Summary Statistics for Staff Daily Commuting		
Sample mean, x-bar (miles driven per staff member/year)	4786	
Standard dev of sample, s	5429	
Margin of Error	1505	
95% confidence interval (miles/year)	3280	6291
Total Staff Members for 2005-2006	307	
Total miles by all staff (miles/year)	1469149	
95% confidence interval for all staff (miles/year)	1007059	1931238

Rideshare program

The South Coast Air Quality Management Commission requires all institutions in the region to implement a rideshare program in some capacity in order to minimize solo car-riding. This is particularly stressed for the 6-10AM time period, during which smog build-up occurs. Within the office of Human Resources, people are trained as employee transportation coordinators (ETCs) with the mission of encouraging faculty and staff to carpool, take public transportation, or use other alternative means of transportation. Each semester, about 85 members of the Pomona College community partake in the Rideshare program, which could mean completing the rideshare form once or doing it consistently all semester. The goal is to for the average vehicle ridership to be 1.5 people per car. In the past, Pomona has met this goal, but we have come short each year for the past five years. In contrast, Pitzer College consistently exceeds this goal.

The Rideshare program offers a range of incentives. To begin with, Pomona subsidizes $100 per month for public transportation costs. Additionally, those that participate in the rideshare program earn $1.50 a day for non-solo-driving. Also, at the end of the month, all participants are automatically entered in a raffle for the chance to win gift certificates to a grocery store. The program is extended to both faculty and staff.

While the rideshare program clearly has great potential, and has been effective in the past, something must be altered to raise the stakes and encourage participation. Judging from the self-reported commuting data received for this inventory, many more people opt to take alternative transportation (usually walking or biking) than opt to carpool. Some cited unreliable driving partners as the problem. Overall, it seems that carpooling is simply not very common at Pomona, despite incentives being in place.

Recommendations for reducing emissions

There are several steps that Pomona College can take to reduce greenhouse gas emissions for vehicles on campus as well as for travel off-campus by faculty, staff and students. This may be done through the reduction of fossil fuel use, the substitution of alternative, renewable fuel sources, and the purchase of carbon offsets.

Purchasing Carbon Offsets for Air-Travel

We recognize that in many cases it may not be feasible for Pomona College to completely reduce fossil fuel emissions. While air travel for conferences and research constitutes a large amount of Pomona College's greenhouse gas emissions, alternative forms of transportation may not be viable or technologically available. We suggest that the College reconcile the large amount of greenhouse gas emissions from air travel with a policy to purchase carbon offsets.

Expanding the Green Bikes Program

Pomona College has more control over the on-campus vehicles, and there are several viable policies that may be implemented to reduce greenhouse gas emissions locally. First of all, Pomona College should subsidize the use of bicycles, skateboards, and other forms of travel that do not utilize fossil fuels. The Pomona Green Bikes shop, founded in 2005, currently lends 15-20 bikes out to students per semester for exclusive use and provides free repairs for all students, faculty, and staff. The program, which has been financed through the student government as well as the Dean of Students, should be further subsidized and expanded to include more bicycles. Each semester, there are more than twice the amount of requests for bicycles than can be accommodated, indicating students' need for bicycles for transportation. We recommend that Pomona College take steps to increase the number of bicycles in the Green Bikes fleet by facilitating a more efficient method of collecting abandoned bicycles and possibly purchasing several more.

Supporting and Subsidizing the Flexcar program

When bicycles are not an option (i.e. for longer trips, and trips that require carrying space, etc.) the Flexcar program would be a great way for the college to reduce the number and use of vehicles on campus with some flexibility. This program, initiated by the Claremont Consulting Group, would provide four cars for the general use of Claremont College Students, paid for by the users at an hourly rate. The benefits of the program are many. First of all, having access to a shared car reduces the number of cars students bring to campus. Research on existing car-sharing programs show that each shared car represents 14.9 private cars that would otherwise be used. One car-sharing survey reported that 70% of respondents were likely to postpone buying a new car, and many even sell their private car upon participation with a car-sharing program. Second, it decreases the length of trips and increases their efficiency; since users pay an hourly rate for the car, they are more likely to pool errands and make fewer stops. The same car-sharing survey reveals that 45% of households participating in the program reported driving less, and the average reduction in miles driven was almost 40%. In the case of Pomona College, students will be more likely to only use Flexcar for trips for which they really need a car, and will likely walk, bike, or use public transportation in other cases. Lastly, the cars used in the Flexcar program are vastly more efficient than most cars used by students. The program uses Honda Civics, Toyota Corollas, and hybrids; collectively, the cars have an average efficiency above 30mpg. By using these cars and cutting back on other types of private cars, Flexcar will theoretically reduce greenhouse gas emissions from personal student transportation.

Introducing Bio-fuels

Bio-fuels are an excellent way for Pomona College to integrate alternative fuel into existing transportation systems. The College uses several larger vehicles, including Housekeeping and Grounds carts, sports vans, department vehicles, and student activities vehicles. We acknowledge the importance of these vehicles to the academic and extra-curricular activities of Pomona College students, faculty, and staff. We recommend that efforts be made to conserve fuels through more efficient travel planning, and that alternative fuels be used in lieu of fossil fuels.

Bio-fuels may be used with equal efficacy for Housekeeping and Grounds carts and will significantly reduce greenhouse gas emissions. The Claremont Biodiesel Initiative is a 5C organization that has already conducted initial research into the use of biofuels, and has established plans to build a production facility on campus. Using Waste Vegetable Oil(WVO) from the dining halls, the group plans to distribute processed biofuels for use in the appropriate 5C ventures. Currently Pomona has a demand of 50 gallons of diesel per week, which can be easily incorporated into the Biodiesel Initiative. This program is also cost-effective for the college; currently the dining halls must pay waste facilities to pick up WVO on a monthly basis. Internally generating fuel from WVO would not only cut down on the cost of gasoline and diesel, but it would cut the cost of disposing waste oil.

Owing to the potential of these programs, we recommend that the college actively work with the Claremont Biodiesel Initiative to ensure the continuation of the program. This includes finding a location for the production facility and promoting this venture by allowing dining hall WVO to be used and by using the biofuels produced for campus vehicles.

Prioritizing fuel efficiency

We recommend that the college prioritize fuel efficiency in all future vehicle purchases. As gas prices rise, this is cost-effective for the College; furthermore, efficient engines reduce greenhouse gas pollutants, and could be good for the image of Pomona College. Hybrid technology has been significantly improved in the past years and there are many options for future car purchases. By incorporating efficient cars into the large fleet of Pomona vehicles, the College could significantly reduce emissions and cut costs over many years.

Chapter 7

EMISSIONS FROM USE OF REFRIGERANTS

(Author: Praween Dayananda)

An important source of Pomona's GHG emissions is the use of refrigerants in air conditioning systems for residential and academic buildings, walk-in coolers and freezers in the dinning halls; refrigerated water coolers and ice machines; dehumidifiers and humidifiers; heat pumps; chillers, chilled water piping and coils; cooling towers, etc. [45] . The refrigerants currently used by Pomona and the Claremont University Consortium (CUC) that contribute to GHGs are R-12 (HCFC 22), R-22, R-134, R401, R-404, R-502 and R-408.These refrigerants are primarily hydrofluorocarbons (HCFCs) or HCFC blends and were introduced as refrigerants when chlorofluorocarbons (CFCs) were found to be damaging to the ozone layer. Unfortunately, these chemicals were later found to also be strong greenhouse gases.[46] Box 6.1 explains in detail how these refrigerants contribute to global warming and what their global warming potentials are. In this inventory, we only measure the contributions of non-CFC refrigerants as IPCC and US EPA protocol does not include CFCs in greenhouse gas inventories as the production and importation of these ozone-depleting substances are being phased out under the terms of the Montreal Protocol and US Clean Air Act[47]. However, the CleanAir-Cool Planet inventory model we have used has the capability to measure CFC emissions if necessary.

Trends at Pomona

Pomona and CUC have made significant active reductions in its use of refrigerants with high global warming potentials and therefore been able to reduce its volume of CO2 e emissions from 3664 tons in 1999-2000 to 763 tons in 2005-2006 as shown[48]. This reduction in the use of refrigerants particularly R-12, R-22 and R-134 and the increase in the use of electricity and natural gas has reduced the contribution of GHGs from refrigerants to 4% in 2005-2006 from 25% in 1999-2000. Table 6.1 provides precise amounts of each refrigerants used at Pomona since 1995-1996.

According to Anthony Pennington, the Safety, Environmental Health Services officer from the Claremont University Consortium, the reduction in refrigerant use has been due to an active effort by the Consortium. Over the last decade, the Consortium has taken action to decrease its use of harmful refrigerants, particularly R-12, R-22 and R-134 by improving the air-conditioning equipment used on campus. He says several years ago, air conditioning equipment did not have

---

[45] http://www.cuc.claremont.edu/cfs/

[46] Hydrochlorofluorocarbons (HCFCs) are also ozone-depleting substances and, under the terms of the Montreal Protocol, the production and consumption of HCFCs will be phased out in developed countries over the next 20 years. HCFCs and HCFC blends are however still used extensively in the refrigeration and air conditioning industry, and at Pomona College, the most common being R-22.

[47] United Nations Environment Program, Handbook for the International Treaties for the Protection of the Ozone Layer, 5th Version 2000, http://194.51.235.137/ozat/protocol/main.html
US EPA, Clean Air Act, http://www.epa.gov/oar/caa/contents.html

[48] The numbers are courtesy of Anthony Pennington from Claremont University Consortium. The numbers are based on total amounts purchased each year, as reported to the South Coast Air Quality Management District.

the capacity to recover any refrigerants. He says that newer equipment that has been purchased by the Consortium is better at recapturing and also recycling the refrigerants. As a result, smaller amounts of the refrigerants have had to be purchased every year.

Recommendations

Pomona should continue to reduce its use of refrigerants, particularly R-12, R-22 and R-404 and look towards purchasing newer refrigerants that have lower GWPs. Pomona should also strongly consider the necessity to install air-conditioning in newer residence halls and academic buildings.

Note

Pomona College's refrigerant use was estimated from the total amount used by the Consortium as no numbers are available for Pomona's exact use of refrigerants. Anthony Pennington suggested that we estimate Pomona's contribution by looking at the total therms of natural gas used by Pomona and comparing that to the total used by the Consortium as the heating and air conditioning efficiency rates are comparable. Using this estimation method, Pomona's contribution for 2005-2006 is 57.46%[49]. The Consortium includes Pomona College, Scripps College, Pitzer College, Claremont McKenna College, Harvey Mudd College, Claremont Graduate University, KGI and Joint Science.

Box 6.1. Global warming Potentials
Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. The various greenhouse gases trap the sun's energy to varying degrees. This is called the chemical's radiative forcing (or global warming potential) and it allows all of the greenhouse gases to be converted to a similar unit of carbon dioxide equivalents. The radiative forcing of a gas is dependent on how it reacts with long-wave radiation coming from the Earth and how long-lived it is (Table 1). For example, one molecule of SF_6 warms the planet to a similar extent as 23,900 molecules of CO_2. 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 CH_4 is 21 MTCDE). This unit allows for a quick comparison of different gases relative to the effect they have in the atmosphere. This report will make all of these calculations and display emissions in MTCDE.[1]

Table 7.1

Global Warming Potentials and Atmospheric Lifetime of several greenhouse gases

Gas	Atmospheric Lifetime (Years)	Global Warming Potential (100 Year)
Carbon Dioxide (CO_2)	50-200	1
Methane (CH_4)	15-Sep	21
Nitrous Oxide (N_2O)	120	310
HFC – 134A	15	1,300
HFC – 404A[	>48	3,260
Sulfur Hexafluoride (SF_6)	3,200	23,900
HCFC -22 or R-22		1700
R-12		8500
R-401		1082
R-502		5490
R-408		2743

Source: CleanAir -Cool Planet, Campus Greenhouse Gas Emissions Inventory Toolkit, 2

---

[49] (100%* 1371206 therms used by Pomona)/(2386458 therms used by Consortium) =57.46%.

Table 7.2

Refrigerants used by Pomona College
(for reporting periods July 1 through June 30 for each year listed by type)

	Refrigerant (all units reported in pounds)						
Year	**R-12**	**R-22**	**R-134**	**R-401**	**R-404**	**R-502**	**R-408**
1995-1996	328	1431	0	0	0	0	0
1996-1997	na	na	na	na	na	na	na
1997-1998	94	915	801	7	1	29	0
1998-1999	96	920	802	7	1	30	0
1999-2000	17	103	552	0	165	0	0
2000-2001	0	155	534	0	152	34	0
2001-2002	na	na	na	na	na	na	na
2002-2003	na	na	na	na	na	na	na
2003-2004	17	138	34	0	17	0	17
2004-2005	17	224	17	na	17	0	17
2005-2006	17	52	17	0	14	0	14

*****_Pomona's Contribution based on percentage of therms of natural gas by Pomona compared to the Consortium in 2005-2006 (57.46%)_

Pomona's contribution = (100% 1371206 therms/2386458 therms) =57.46%*

Source: Anthony Pennington, Claremont University Consortium

Chapter 8

EMISSIONS FROM TREATMENT OF SOLID WASTE

(Author: Kyle Edgerton)

This report thus far has focused on some of the more obvious sources of GHGs—electricity, heating, and transportation, for instance, all have rather obvious emissions that must be considered. One potentially overlooked yet significant source of GHG emissions is the treatment of solid waste at landfill sites. This currently accounts for 1% of Pomona's GHG emissions. Solid waste consists of at least four types, each of which has unique implications for Pomona's GHG impact: trash, recyclable waste, "green" waste, and sewage.

Trash

Like virtually any other institution, Pomona College generates a stream of waste materials that it cannot store or use on-site and therefore must send to a central waste collection facility. The College's trash is collected by the City of Claremont twice weekly from a compactor on the campus (located just South of Seaver Theater). Peggy Crum at the City says that these loads are typically 7.5 to 9.5 tons.[50]

During the summer, this same stream (7.5 to 9.5 tons) is collected, but only one-fourth as frequently (once every two weeks rather than twice every week). Additionally, at the end of every academic year the College rents 'roll-off' containers to receive everything that typically accrues at the end of the year, from accumulated ordinary trash to abandoned furniture. The total of an estimated 100 tons is picked up in about 20 loads.

Unfortunately, the City does not have any historical data for the College to give a sense of how the tonnage involved in the waste stream has changed over time. Rigorous analysis by a third-party analyst might shed more light on this or provide some effective way of estimating the growth of the waste stream over time as students have changed purchasing patterns and as packaging has become more ubiquitous.

Once the waste leaves the College, it is taken to the Puente Hills Landfill, Los Angeles County Sanitation District Facility #21.[51] Two vectors of GHG emissions must be considered at this juncture: the vehicles used to transport the waste and the treatment of the waste at its end site.

Vehicles

The City of Claremont's fleet of garbage trucks is fueled by compressed natural gas (CNG), rather than by heavy diesel fuel as are many similar fleets. CNG is one alternative to heavy diesel; another increasingly popular substitute fuel is so-called "clean diesel." A number of studies have been done comparing these three fuels (as well as others such as biodiesel) to measure their relative emissions of CO2 and other GHGs as well as of oxides of nitrogen (which

---

[50] Peggy Crum can be contacted through email at pcrum@ci.claremont.ca.us. Another valuable contact at the City is Stacy Niemeyer: sniemeyer@ci.claremont.ca.us.

[51] http://www.lacsd.org/about/solid_waste_facilities/puente_hills/default.asp

cause smog) and particulate matter (linked to respiratory ailments); these studies also make cost-effectiveness comparisons of the fuels. This research is young but growing, but at the time of this writing there is not clear evidence that one sort of fuel is more benign from a GHG standpoint than the others. The conventional wisdom is that diesel burns more efficiently (reducing GHG emissions) but more dirtily (in terms of particulate matter) than conventional gasoline and natural gas, clean diesel projects promise to alter this tradeoff.[52,53,54]

Whatever the final verdict on the fuel question, there is no question that one source of GHGs from the College's activity is the emissions of the fleets that transport waste from the campus to the landfill.

Puente Hills Landfill

The Puente Hills facility is 23.4 miles from Alexander Hall, which means that Pomona's waste travels slightly (17%) farther than the national average (20 miles). Pomona is fortunate to be a client of one of the most environmentally friendly and sensitive landfills in the country and indeed in the world. Methane is produced in the decomposition of the landfilled waste, which is significant because methane contributes to the greenhouse effect over 20 times as powerfully as CO2 does. Puente Hills is able to capture this methane and utilize it for power generation (methane is natural gas), creating energy and transforming methane into more greenhouse-benign gases. Collection of the methane is rated above the 90-percent range.[55]

While some methane does escape and other GHGs are produced and released in burning the methane that is captured to create energy, the College is likely creating a GHG impact that is smaller than the national baseline because it works with such an efficient landfill.

Table 8.1

GHG Emissions from Solid Waste treatment using the upper end average of 9.5 tons to trash collected weekly

Breakdown of Waste Collection over the year	Total	Comments
35 weeks * 19 tons/week	665 tons	Rest of the year
16 weeks * ½ * 9.5 tons/week	76 tons	Summer months
1 week * 100 tons/ week	100 tons	At the end of the year
52 weeks	**841 tons**	

---

[52] http://wasteage.com/mag/waste_trucks_fueling_diesel/
[53] http://www.ucsusa.org/clean_vehicles/big_rig_cleanup/natural-gas-vehicles.html#gw
[54] http://www.cleanenergyfuels.com/pdf/TIAX-CNG-Diesel.pdf
[55] email exchanges with Ray Huitric (RHuitric@lacsd.org)

Recyclable Waste

The City of Claremont began collecting residential collection of recyclable materials in 1983, and the College has been a participant in that project from its genesis. Recycling bins throughout the campus have their contents collected at one of eight larger recycling bins that are emptied twice weekly by the City. The City estimates that it collects 1,000 pounds (half a ton) of recyclable materials each week.

More investigation (again, a third-party analyst would be a good candidate for such an endeavor) will be needed to determine the GHG implications of transporting this recyclable material to recycling facilities, sorting it, and reprocessing it for reuse in other products.

“Green” Waste

“Green” waste refers to organic waste products that can be composted or somehow reused. The City does not collect any of these products, although a number of other communities do.[56] Pomona has two chief sources of such waste: grounds and maintenance work collects landscaping debris on a regular basis, and the dining halls produce a steady flow of food products that are thrown away if they are not collected separately.

Landscaping

The College employs a fleet of grounds workers and landscapers to maintain the campus’s pristine façade. While grass clippings are reused as mulch, most of this yard debris is now collected by workers in a number of piles around the campus. A large portion of this (including fallen or pruned tree limbs, etc) is taken to the organic Farm for use in mulching and composting.[57]

As this organic matter decays, gases such as CO2 and methane might be released. On the other hand, as Grounds employees and students at the Farm cultivate the College’s flora, CO2 is sequestered by these plants. An intricate analysis would have to be completed to determine the net impact of these endeavors on total GHG emissions.

Dining Halls

Over the years a number of students have attempted to establish composting programs that would collect food waste from the dining halls and take it to a central composting project at the organic Farm.[58] There is currently an informal program in action that relies on student volunteers to take food waste from Frank Dining Hall to the Farm.

The current program collects food waste from the kitchen but any potentially compostable waste (left-over food in particular) generated by students eating at the dining hall is simply thrown away. Students at Pitzer College have worked steadily over several years and have now established a semi-permanent program that collects student leftovers in the dining hall.

---

[56] http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/FACTS/ydwaste.htm

[57] One contact at the College’s Department of Grounds is Ron Nemo: rdm04747@pomona.edu

[58] http://sustainablepomona.pbwiki.com/Frank-Farm%20Composting

Sewage

This report has not gathered any significant information on the GHG emissions from Pomona's sewage stream. A contact at the City of Claremont—Don Roush—was discovered in our exchanges with the City but as of this writing nothing has come from it.

It is not clear that there is an easy way to measure the College's contribution to this sewage stream, but assuming that flow could be measured some further calculations would have to be made. Emissions of GHGs would have to be estimated for the facility's energy needs in processing sewage as well as any pumping, transport, or other associated emissions; if methane or other gases are released into the atmosphere due to these processes, such emissions would also have to be considered. Obviously, Pomona College is only directly responsible for a portion of these emissions proportionate to its contribution to the total waste stream.

Since student-to-City communications proved ineffective in uncovering this information, it would be hoped that direct communication between the College (or some third-party auditor) and the City would provide more concrete data.

Recommendations

Most apparent from this analysis is that more information is needed to create a clear and comprehensive picture of Pomona College's emissions of GHGs due to its solid waste stream. The information gathered above reflects the combined efforts of students and staff communicating with one another, with the City of Claremont, and with the Puente Hills facility. A third-party analyst equipped with an institutional mandate to gather and synthesize this information will be invaluable in moving forward.

Nonetheless, some recommendations emerge in addition to advocating the need for a professional analysis.

Trash

The College produces a considerable amount of waste, but as evidenced above the GHG impact of this waste is largely ameliorated by a partnership with a tremendously efficient landfill. That notwithstanding, reductions in the generation of waste lead to reductions in the related emissions of GHGs. Thus, the College should address part of its GHG impact by reducing its waste stream.

This might be accomplished through selectivity in purchasing decisions that seeks to avoid goods that are sold in excessive packaging. The College might take some steps to ensure that its construction projects are sensitive to waste management issues, but construction is infrequent and in many cases the creation of waste products from such projects is inevitable. Finally, the College community can attempt to alter community attitudes toward waste to achieve individual-level reductions: avoiding take-out containers when they needn't be used, reducing food waste, etc.

Recyclable Waste

It is worth noting here that the City of Claremont offers recycling for only a limited number of materials. In particular, the College can only recycle plastics #1 and #2, even though a large portion of the plastics used on campus (especially disposable dining ware and 'keg' cups) are made from plastics #3-7. The College could transfer much of its waste stream to recycling by working with the City to expand the reach of these recycling programs and facilities.

Students have attempted for several years to maximize the awareness and use of what recycling the City does provide.[59] These efforts should be encouraged and endorsed by the College, especially in the face of limited facilities.

"Green" Waste

The relationship between the College and the Farm is an ideal way to manage green waste. The College should work to institutionalize what are currently informal practices and work to promote things like food waste composting and the development of experimental biofuels.

Sewage

This is quite obviously tied to the population of the Pomona College community. Not much can be done to reduce this stream of waste, and it would seem that the College is also quite permanently bound to its sewage system. Experimentation with composting toilets (perhaps an experimental model at the organic Farm) might open doors to new avenues for change.

---

[59] http://sustainablepomona.pbwiki.com/Recycling%20%22Do%20and%20Do%20Not%22%20Placards%20on%20Bins

Chapter 9

EMISSIONS FROM DINING

(Author: Praween Dayananda)

Pomona College also indirectly contributes to greenhouse gas emissions from the consumption of food, particularly from the consumption of beef and other livestock products that are GHG intensive. Due to an inability to access data on the sources of our food and the emissions factors associated with the production and transportation of the food, we have been unable to quantify the complete impact of dining in terms of greenhouse gas emissions. However, we feel it is important to recognize that Pomona does contribute significant GHGs by consuming food. In this chapter we focus on the livestock sector's impact on climate change because: (1) there a strong scientific understanding of this relationship; and (2) the livestock sector has been recognized as having some of the most significant impacts on climate change, contributing to more than 18% of total anthropogenic GHG emissions (see Table 9.2). We have presented this relationship with the hope that understanding the impacts of livestock sector on climate change can help us make more responsible choices about the food we consume on campus. The table below shows the quantity of livestock products consumed at Pomona.

Table 9.1

Quantity of Livestock Products Consumed at Pomona College
(July 1, 2006 to April 1, 2007)

Product	Frank Quantity (lbs)	Frary Quantity (lbs)	Oldenborg Quantity (lbs)	Approximate Location of Production or Source	Total (lbs)
Beef	13144	16794	1921	Mid-West	31859
Chicken	16897	17947	2536	South-East	37380
Pork	9509	12338	1245	-	23092
Lamb	453	2480	105	-	3038

An overview of the livestock sector

The livestock sector emerges as one of the most significant sources of greenhouse gas emissions in addition to being one of the top two or three contributors to other environmental problems from every scale local to global. There is an astounding lack of understanding about the nature and extent of livestock's impact on climate change and other environmental issues at the producer, consumer and policy-maker level alike. Livestock's interactions with the environment are also not very well understood, especially since many of the impacts are indirect, as described above, and thus easy to underestimate. As a result of this lack of understanding, policies conducive to more environmental protection are missing or rudimentary and at best are lacking coherence

The science and the latest evidence of the impacts of the livestock sector on climate change, however, suggest that any attempts aimed at curbing greenhouse gases at the , individual, state, national or international level needs to actively incorporate the livestock sector as well. Including the livestock sector can not only help the livestock sector reduce its emissions but also allow the key stakeholders in the sector to benefit from any improvements in efficiency for example through better soil nutrient management which can help increase yields.

The livestock sector accounts for over 40% of the global agricultural GDP, directly or indirectly affecting the livelihoods of more than a billion people. The key products of the sector include meat and milk, with global production of meat expected to double by 2050 from 229 million tones in 99/01 to 465 million tones, and that of milk set to grow from 580 million tones to 1080 million tones for the same time period. Considering only this increase in production, the environmental impact of livestock per unit needs to be cut by half just to avoid increasing the level of damage from beyond its present level.[60]

The sector uses up 26% of the ice-free land on earth, more than 3.9 billion hectares. Including the total area dedicated to feedcrop production extends the area of this sector to 33% of total arable land on the planet. In total, livestock production accounts for 78% of all agricultural land.[61] Of the 3.9 billion hectares, 0.5 billion are crops that are generally intensively managed, 1.4 billion are pastures with relatively high productivity, and the remaining 2.0 billion are extensive pastures with low productivity.[62]

This sector is responsible for 18% of total anthropogenic greenhouse gas emissions (GHG) from the five main sectors used for reporting: energy, industry, waste, land use, land use change and forestry and agriculture. This is much more than the global share from transportation. Livestock accounts for more than 80% of all emissions from the agriculture sector alone. Livestock account for more than 9% of anthropogenic CO2 emissions, largely because of land use changes such as deforestation caused by the expansion of pastures and arable land for feedcrops. Cattle and buffalos account for 60% of the CO2 emissions from breathing. The sector is also responsible for 37% of anthropogenic methane emissions, a GHG 24 times more powerful than CO2, with cattle and buffalos accounting for 88% of the CH4 emissions.[63]

The livestock sector also accounts for 65% of global nitrous oxide emissions, the most potent of the three GHGs, 310 times more powerful than CO2. Additionally this sector also account for 64% of anthropogenic emissions of ammonia emissions, which contribute significantly to acid rain and acidification of ecosystems.

How does the livestock sector affect climate change?

The livestock sector contributes to global warming by emitting three of the main greenhouse gases; carbon dioxide, methane and nitrous oxide. Direct emissions result from several processes; carbon dioxide from respiratory processes from all animals, methane from ruminants and to some extent through monograstics as part of digestive processes which involves microbial fermentation of fibrous feeds, CO2, CH4 and nitrous oxide from animal manure depending on the way they are produced (solid, liquid) and managed (collection, storage, spreading).[64]

---

[60] FAO, *Livestock's Long Shadow*, 2006, p xx

[61] Definition of agricultural land: All ecosystems modified or created by man specifically to grow or raise biological products for human consumption or use. This includes cropland, pasture, orchards, groves, vineyards, nurseries, ornamental horticultural areas, and confined feeding areas. (Source: http://www.hq.nasa.gov/iwgsdi/Agricultural_Land.html)

[62] FAO, *Livestock's Long Shadow*, 2006 p xxi

[63] FAO, *Livestock's Long Shadow*, 2006 p xxi

[64] FAO, *Livestock's Long Shadow*, 2006 p 81

Additionally, livestock contributes to climate change by affecting the carbon balance of land used for pasture of feedcrops and thus indirectly contributes to releasing large amounts of carbon dioxide into the atmosphere. Indirect emissions also occur when forests are cleared for pastures. In addition, GHGs are emitted in the production process, from feed production to processing and marketing livestock products. Some of the indirect effects are difficult to estimate with high degrees of certainty as land use emissions vary widely depending on biophysical factors such as soil, vegetation, and climate as well as on human practices.[65]

The respiration by livestock makes up only a small proportion of the total amount of GHGs that are released by the sector, estimated at between 4.5-6.5 billion tones per year. They make up about 0.8 billion tones per year with half of that accounted for by cattle. Much more is released by other direct and indirect channels including:

- Land-use changes for feed production and for grazing as pasture or arable land for feed production which releases an estimated 2.4 billion tones per year
- Burning fossil fuels on-farm
    - Estimated to emit 90 million tones per year
- Burning fossil fuel to produce mineral fertilizers used in feed production;
    - A large share of the world's crop production is fed to animals, either directly or as agro-industrial by-products. Mineral nitrogen is applied to much of this cropland, especially crops such as maize. The gaseous emissions caused by fertilizer manufacturing should therefore be considered among the emissions for which the animal food chain responsible.
    - An estimated 41 million tones of CO2 per year is emitted in the process.
- Methane released from the breakdown of fertilizers and from animal manure
- Fossil fuel use during fed and animal production; and
- Fossil fuel use in production and transport of processed and refrigerated animal products.
    - Delivery of feed to production sites and delivery of animal products to consumers and markets.[66]

---

[65] FAO, *Livestock's Long Shadow,* 2006 p 82

[66] FAO, *Livestock's Long Shadow,* 2006 p 86

Table 9.2

Role of livestock in CO2, CH4 and N20 emissions

	Mainly related to Extensive systems (10 (9) tonnes eCO2	Mainly related to Intensive systems (10 (9) tonnes eCO2	Percentage contribution to total animal food GHG emissions
Total Anthropogenic CO2 emissions		**24 (~31)**	
Total from livestock activities		**~0.16(~2.7)**	
Nitrogen Fertilizer production		0.04	0.06
on farm fossil fuel, feed		~0.06	0.8
on farm fossil fuel, livestock-related		~0.03	0.4
deforestation		(~0.7)	34
cultivated soils, tillage		(~0.02)	0.3
cultivated soils, liming		(~0.01)	0.1
desertification of pasture	(~0.1)		1.4
processing		(0.01 - 0.05)	0.4
transport		~0.001	
Total Anthropogenic CH4 emissions		**5.9**	
Total from livestock activities		**2.2**	
enteric fermentation	1.6	0.2	25
manure management	0.17	0.2	5.2
Total Anthropogenic N20 emissions		**3.4**	
Total from livestock activities		**2.2**	
Nitrogen Fertilizer production		~0.1	1.4
indirect fertilzer emissions		~0.1	1.4
leguminous feed croppping		~0.2	2.8
manure management	0.24	0.09	4.6
manure application/deposition	0.67	0.17	12
indirect manure emission	~0.48	~0.14	8.7
Grand total of Anthropogenic emissions		**33 (~40)**	
Total emissions from livestock activities		**~4.6(~7.1)**	
Extensive vs intensive livestock system emissi	3.2(~5.0)	1.4(~2.1)	
As a percentage of anthropogenic emissions	10(~13%)	4(~5%)	

Note: All values are expressed in billion tonnes of CO2 equivalent; values between bracks are or include emissions from land use, land-use change and forestry category; relatively imprecise estimates are preceded by a tilde

Global totals from CAIT, WRI, accessed 02/06. Only CO2, CH4, N20 emissions are considered in total greenhouse gas emissions)

Source: FAO, Livestock's Long Shadow, 2006

Recommendations

We can make our dining more sustainable and less GHG emissions intensive by

- Reducing our consumption of livestock products
    - This reduction in demand can perhaps be achieved by increasing awareness of the impacts of food choices on the environment (and health!) among students, faculty and staff.
- Ensuring that our livestock products come from farms that practice sustainable farming and from local producers
    - Includes those farms using limited or no amounts of fertilizers, maintain effective carbon management systems, and do not contribute to deforestation
- Incorporating local foods in general
    - The amount we spend on local foods can additionally help sustain local farms
        - “We cast our vote three times a day” Joshua Viertel, Program Director of Yale’s Sustainable dining initiative.
- Purchasing organic foods that use less fertilizer
- Purchasing seasonal foods so that food is not transported from distant places
    - At Pomona, watermelon is available all year around in the dinning halls but for at least half the year, the watermelon comes from across the Pacific or the Atlantic!
- Directing food waste into on-campus composting
- Converting kitchen grease into bio-diesel to fuel College’s fleet and faculty/staff/student cars

Problems

One of the obvious problems would be the additional costs of purchasing ‘green food’. Yale University implemented a pilot program on sustainable dining in 2001. According to their website, the program was “established with the understanding that many of the world’s most important questions regarding health, culture, the environment, and the global economy are deeply connected to what we eat and how it is produced. Food cannot stand apart from agriculture, the environment, or the communities where it is grown.”[67] Yale estimated their initiative cost them 50% more than conventional meals. Fortunately for Yale, an anonymous donor pays for the extra costs (Yale spends $6.5 million annually on food). Pomona will perhaps also find such a generous donor!

---

[67] http://www.yale.edu/sustainablefood/overview.html

Chapter 10

EMISSIONS FROM THE APPLICATION OF FERTILIZER

(Author: Praween Dayananda)

Pomona's greenhouse gases emissions from the application of fertilizer on fields and grounds account for less than 1% of the total greenhouse gases emitted on campus. GHG emissions from the application of fertilizer occur due to the presence of nitrogen in fertilizer some percentage of which is emitted as nitrous oxide. Emissions from the use of fertilizer have remained constant, although there has been an active trend by the Grounds department to increase the volume of organic fertilizer applied on campus premises in the last five years as shown below in Table 9.1. We have estimated these emissions from the total amount of fertilizer (both synthetic and organic) applied (pounds) and their percent nitrogen (%). Synthetic fertilizers are labeled with their chemical makeup using three numbers to represent the percentages of nitrogen (N), phosphorus (P), and potassium (K). So 15-10-10 fertilizer is 15% nitrogen. Nitrogen contents for organic fertilizer are about 1% for manure and 4.1% for other organics.[68]

Table 10.1

Fertilizer use at Pomona College (all units reported in pounds)

Year	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006
Pounds of Synthetic Fertilizer	6950	8000	3100	5200	9600
% nitrogen	20.35%	17.71%	21.68%	19.33%	18.82%
Pounds of Organic Fertilizer	0	0	1000	2000	4000

Source: Kevin Quanstrom, Grounds Department

Recommendations

The College should continue to reduce the application of synthetic fertilizers due to the presence of high levels of nitrogen. The College should also consider reducing its application of organic fertilizer. Organic fertilizer contains nitrogen contents that are about 1% for manure and 4.1% for other organics.

---

[68] CleanAir-Cool Planet, Campus Greenhouse Gas Emissions Inventory Toolkit v4.0

Chapter 11

OFFSETTING EMISSIONS[69]

(Authors: Stephen Conn and Praween Dayananda)

Introduction

This report establishes that climate neutrality is a worthy long term goal for the College. It has investigated different areas on campus that contribute to greenhouse gas emissions and proposed measures for reducing emissions. Pomona College, however, cannot reduce its greenhouse gas emissions to a net zero simply by implementing emissions reductions measures because not all reduction measures are economically feasible. In achieving climate neutrality, economic feasibility can be determined in terms of the cost of reduction measures compared to the price of purchasing carbon offsets. Using this measure of economic feasibility, *the least cost strategy for achieving climate neutrality is for the College to only implement those reduction measures that cost less than the expected price of carbon offsets and to purchase offsets for remaining emissions reduction requirement.*[70]

In addition, *the College should also consider purchasing the required offsets several years before they are needed*, for example, before mandatory emissions limits are placed at the state or federal level. This strategy may be less expensive and less risky for the College compared to the tempting strategy of delaying the purchase of offsets until a later period of time.

What are carbon offsets?

Carbon offsets are one of the many options available to Pomona in reaching a goal of climate neutrality. Any remaining emissions after implementing reduction programs can be offset by taking part in offset programs. A carbon offset represents a program or investment that engages in the reduction or sequestration of atmospheric carbon by some party—frequently but not always a third party and can be purchased to counteract GHG emissions from College operations. They can be obtained from internal or external projects and can be implemented quickly and at a relatively low cost. Offsets can be created for example by: Generating electricity from renewable sources such as wind or solar, modifying a power plant or factory to use fuels that produce less GHG, putting wasted energy to work via cogeneration, capturing carbon dioxide in forests and agricultural soils.

Offsets come in as many forms as there are ways of reducing atmospheric carbon: an offset can represent a reduction in carbon achieved via carbon sequestration; it can represent the use of clean instead of dirty power by a first or third party.

Because different parties face differing costs when reducing their own emissions, the trading of carbon offsets is an efficient way of achieving an overall reduction in atmospheric carbon: those

---

[69] The content in this chapter has been largely based on analysis done by the Rocky Mountain Institute in their Oberlin 2020 report.

[70] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, January 2002, p 59

who face high costs of emission reduction can purchase carbon offsets, and those who face low costs of emission reduction can sell them. As the cost of reducing the College's emissions rises, carbon offsets become a more and more attractive option for reducing our carbon footprint. Indeed, the purchase of carbon offsets is economically efficient when their cost is less than the marginal cost of other emission reductions.[71]

Carbon Sequestration

Carbon exists in the plants, oceans, and soil of the world, as well as in its atmosphere. When an activity achieves a decrease in atmospheric carbon via an increase in the carbon stored in plants, oceans, or soil, this is referred to as carbon sequestration.[72]

Planting trees and plants sequesters carbon because trees and plants use photosynthesis to remove carbon dioxide from the air and store the carbon as biomass. As such, tree planting is often advocated as a way to reduce atmospheric carbon by organizations whose mission is to slow and climate change.[73] However, the net effect on climate change of planting trees is not as clear as it might naively seem. A closer look, however, reveals that the net effect on climate change of planting trees is not necessarily as direct or even as favorable as it might first appear.

A first complicating factor is that carbon is only sequestered for as long as a tree or plant is alive. When trees and plants are burned or when they die and decompose the carbon that was once sequestered in them is released back into the atmosphere. Additionally, trees and plants have effects on the climate beyond the carbon that they sequester. As the sun shines down on the earth, the amount of solar radiation reflected by the earth's surface influences the earth's temperature: in general, the more radiation absorbed by the earth's surface, the warmer the earth. Plants, oceans, and soil all absorb differing amounts of the sun's radiation. Forests, in particular, may absorb more sunlight than the soil below them would were the forests not there, which means that forests have warming as well as cooling effects on the earth's climate. Their net effect on climate depends on their location, which led Ken Caldeira, co-author of a recent study on the effects of planting trees on atmospheric carbon and climate change, to comment that "To plant forests to mitigate climate change outside of the tropics is a waste of time."[74] In technical terms, the low albedo of forests means that depending on their location, they may act to warm the earth.[75]

Changing farming practices represent perhaps the surest way to reduce climate change via carbon sequestration. The authors of a recent *Science* Policy Forum write,

> Current farming practices deplete soil carbon, which degrades soil quality, reduces productivity, and results in the need for more fertilization, irrigation, and pesticides. No-till farming with

---

[71] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002, p. 54

[72] In particular, these activities are referred to as "natural sequestration." Capturing carbon and storing it in, for example, declining oil fields, is another method of sequestration. This method and others like it are referred to as "artificial sequestration" because they are not a part of the preexisting carbon cycle. For more information, see http://en.wikipedia.org/wiki/Carbon_sequestration.

[73] http://en.wikipedia.org/wiki/Carbon_sequestration

[74] http://en.wikipedia.org/wiki/Carbon_offset

[75] http://en.wikipedia.org/wiki/Albedo

> residue mulching would reverse these effects by slowing soil erosion and pollution runoff, benefiting aquatic ecosystems, improving agronomic productivity, and achieving food security. [We] urge support for its wider use. Although there may be short-term yield reductions in some soils and climates, this is a win-win opportunity for the vast majority of the 95% of the cropland that does not use these more sustainable practices.[76]

Green Power

Green power refers to electricity generated with reduced resultant environmental damage as compared to conventional methods of generating electricity, such as coal power plants. One of the principal benefits of green power is its reduced carbon emissions, so the purchase of green instead of conventional power represents one way the College can effectively reduce its carbon emissions.

There are many different kinds of green power, including wind, solar, and geothermal. Green power can be purchased directly off the grid if your local power company provides it. If it does not, green power can be purchased in the form of “green tags” or “renewable energy certificates” (RECs), which are essentially a specialized offset whose funds are all directed toward the purchase of green power where it is available, or toward the establishment of new green power plants. Southern California Edison, which is the company that supplies the College’s energy, does not currently provide an option for purchasing green power directly off the grid. Therefore, in order to purchase green power as a way off decreasing our carbon footprint, the College would have to purchase so-called “green tags” or RECs. Efforts have been undertaken to establish certification standards due to the rise in popularity of renewable energy certificates. Green-e, led by the Center for Resource Solutions, is currently the most accepted certification standard and the programs for RECs.

Why Carbon Offsets?

Carbon offsets provides the college with the flexibility of where emission reductions are made and when emissions or reduction occur. Offsets are based on a time interval, such as a year or a period such as 2008-2012 period of the Kyoto Protocol. Thus, if the College finds significant emission reduction measures difficult to implement in the short term, it can purchase offsets for several years and sell any surplus credits in the future. The College can also generate carbon offsets from projects on-site that generate excess supply which could be sold on to the grid or traded in emissions markets.

The Economics of Purchasing Carbon Offsets

The College can be tempted into delaying the purchase of offsets until a later period of time for a number of reasons. If even modest progress is made towards achieving climate neutrality in the next ten to fifteen years, then it would be easy to comply with any mandatory emission limits at the state or federal level. The time value of money also could another tempting factor for the College to postpone purchases until close to the time that mandatory limits are placed. However,

---

[76] Rattan et al. Managing Soil Carbon. Science, April 2004.

there is plenty to suggest that it might be less expensive and risky to purchase offsets before a time period where limits are placed or a period before they are needed.[77]

One reason is that as the GHG emissions limits become stricter around the world, the demand for offsets is likely to increase prices faster than the discount rate. A second reason is that even if prices do not rise too drastically in the long term (ten-fifteen years), purchasing offsets over a long period time reduces the risk of price volatility compared to purchasing all offsets at one time. It could also be possible to mitigate price risk by buying options or rights to purchase future carbon offsets.[78] One final reason is that any unneeded carbon offsets purchased before limits are placed could be traded for offsets that apply to a period beyond one where limits are placed.

The offset market is continually adapting to increasing levels of demand and supply and thus it is difficult to determine the most optimal strategy in purchasing offsets. The most attractive strategy for Pomona may be to purchase call options on future carbon offsets given the flexibility that such a mechanism provides.[79]

Estimated Costs of Offsets

This section highlights the estimated costs associated with buying carbon offsets voluntarily to offset emissions from electricity consumption on campus which represent 47% of Pomona's GHG emissions. Costs of buying offsets through three of the most cost effective plans are presented below.

The college used a total of 23,094,571 Kilowatt Hours (KwH) of electricity in 2005 – 2006.[80] The college can choose to decrease the size of its carbon footprint by buying offsets from providers, who would use the money to create various green energy or efficiency projects. For example, by buying carbon offsets from carbonfund.org, one can direct them to invest the money in renewable energy projects, forestry or energy efficiency projects. According to the online calculator at carbonfund.org we can offset 100 percent of our electricity consumption for $192,435.51. However, Carbonfund.org does offer discounts to bulk buyers – so the college should be in a position to negotiate a lower price. Clean Energy Partnership offers an even more cost-effective option. Buying offsets from the 100 percent wind portfolio will cost the college $138,567.426. While buying from a portfolio that is a mix of wind, biomass, landfill gas, and solar energy would be $127,020. The costs are summarized in the table below.

---

[77] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002, p 61

[78] "An option on future purchases of carbon offsets is simply a purchase of the right to purchase carbon offsets ("call option") at a specified date in the future ("strike date," e.g., 2020) for a specified price ("strike price"). Current options contracts on future carbon offsets, therefore, present another vehicle for obtaining offsets and managing price risk." (Source: RMI, Oberlin 2020)

[79] Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020,* Snowmass, Colorado, January 2002, p 62

[80] Campus Planning and Maintenance

Table 8.1: Estimated costs for to offset emissions from electricity use

Provider	Portfolio	Cost	Certifier
Native Energy Cool Watts	100 percent wind	$143,879[81]	Green-e
Carbonfund.org	Choice between forestry/efficiency/ 100 percent renewable	$192,436	Green-e
Clean Energy Partnership	100 percent wind	$138,567*	Environment Resources Trust
Clean Energy Partnership	24 percent wind, 25 percent biomass, 50 percent landfill gas, 1 percent solar	$127,020*	Environment Resources Trust

**Rates are based on the assumption we become a member for $240/ year and buy at least 500,000 KwH a year*

The table on the next page provides a summary of the various green power products/programs available in California and renewable energy certificate products available nationally that Pomona College can purchase to expand its green power portfolio and offset its emissions. [82]

---

[81] 81[1] $6.23 per MWh for 700MWh and over. Email exchanges with Thomas Hand at Native Energy

[82] http://www.eere.energy.gov/greenpower/buying/buying_power.shtml?state=CA

Table 8.2 Green Power Purchasing Options in California

Utility Green Pricing Programs
(as of July 2006)

State	Utility Name	Program Name	Type	Start Date	Premium
CA	Anaheim Public Utilities	Green Power for the Schools	PV	2002	Contribution
CA	Anaheim Public Utilities	Green Power for the Grid	wind, landfill gas	2002	1.5¢/kWh
CA	Burbank Water and Power	Clean Green Support	various	2001	1.0¢/kWh
CA	Los Angeles Department of Water and Power	Green Power for a Green LA	wind, landfill gas	1999	3.0¢/kWh
CA	PacifiCorp: Pacific Power	Blue Sky Block	wind	2000	1.95¢/kWh
CA	Palo Alto Utilities/3 Phases Energy Services	Palo Alto Green	wind, PV	2003 / 2000	1.5¢/kWh
CA	Pasadena Water & Power	Green Power	wind	2003	2.5¢/kWh
CA	Roseville Electric	Green Roseville	wind, PV	2005	1.5¢/kWh
CA	Sacramento Municipal Utility District	Greenergy	wind, landfill gas, hydro, PV	1997	1.0¢/kWh or $6/month
CA	Silicon Valley Power / 3 Phases Energy Services	Santa Clara Green Power	wind, PV	2004	1.5¢/kWh

Source: National Renewable Energy Laboratory, Golden, Colorado. Company and product listings do not represent endorsement by either the National Renewable Energy Laboratory or the U.S. Department of Energy. **Notes:** Utility green pricing programs may only be available to customers located in the utility's service territory. For additional details, please see the full green pricing products table.

Renewable Energy Certificate Retail Products
(as of July 2006)

Certificate Marketer	Product Name	Renewable Resources	Location of Renewable Resources	Residential Price Premiums*	Certification
3 Phases Energy Services	Green Certificates	100% new wind	Nationwide	2.0¢/kWh	Green-e
Bonneville Environmental Foundation	Brighter Future Green Tags	90% new wind, 10% new solar	West	2.4¢/kWh	Green-e
Bonneville Environmental Foundation	Cooler Future Green Tags	99% new wind, 1% new solar	Nationwide	2.0¢/kWh	Green-e
Carbonfund.org	*My*GreenFuture	99% new wind, 1% new solar	Nationwide	0.5¢/kWh	Green-e
Carbonfund.org	Carbon Offsets	wind, solar, biomass, efficiency, reforestation	Nationwide	$5.50/ton CO2 (donation)	Environmental Resource Trust**
Clean Energy Partnership/Sterling Planet	National New Clean Energy Mix	24% wind, 25% biomass, 50% landfill gas, 1% solar	Nationwide	0.5¢/kWh-0.75¢/kWh	Environmental Resources Trust
Clean Energy Partnership/Sterling Planet	National New Wind	100% new wind	Nationwide	0.96¢/kWh	—
Clean and Green	Clean and Green Membership	100% new wind	Nationwide	3.0¢/kWh	Green-e
Community Energy	New Wind Energy	100% new wind	Colorado, Illinois, New York, Pennsylvania, West Virginia	2.0¢/kWh - 2.5¢/kWh	Green-e
Conservation Services Group	ClimateSAVE	95% new wind/hydro, 5% new solar	Kansas, New England (wind/hydro), New York (solar)	1.65¢/kWh - 1.75¢/kWh	Green-e
Green Mountain Energy	Green Mountain Energy (Pennsylvania)	100% wind	Nationwide	1.99¢/kWh	—
Maine Interfaith Power & Light/BEF	Green Tags (supplied by BEF)	99% new wind, 1% new solar	Nationwide	2.0¢/kWh	—
Mass Energy	New England	100% new	New England	~5.0¢/kWh	—

APPENDIX A
THE IMPACTS OF CLIMATE CHANGE AROUND THE WORLD

Possible Climate Change Impacts Around the World

Climate change threatens the basic elements of life for people around the world – access to water, food, health, and use of land and the environment. On current trends, average global temperatures could rise by 2 - 3°C within the next fifty years or so,[1] leading to many severe impacts, often mediated by water, including more frequent droughts and floods (Table 3.1).

- **Melting glaciers** will increase flood risk during the wet season and strongly reduce dry-season water supplies to one-sixth of the world's population, predominantly in the Indian sub-continent, parts of China, and the Andes in South America.

- **Declining crop yields**, especially in Africa, are likely to leave hundreds of millions without the ability to produce or purchase sufficient food - particularly if the carbon fertilisation effect is weaker than previously thought, as some recent studies suggest. At mid to high latitudes, crop yields may increase for moderate temperature rises (2 – 3°C), but then decline with greater amounts of warming.

- **Ocean acidification**, a direct result of rising carbon dioxide levels, will have major effects on marine ecosystems, with possible adverse consequences on fish stocks.

- **Rising sea levels** will result in tens to hundreds of millions more people flooded each year with a warming of 3 or 4°C. There will be serious risks and increasing pressures for coastal protection in South East Asia (Bangladesh and Vietnam), small islands in the Caribbean and the Pacific, and large coastal cities, such as Tokyo, Shanghai, Hong Kong, Mumbai, Calcutta, Karachi, Buenos Aires, St Petersburg, New York, Miami and London.

- Climate change will increase worldwide deaths from **malnutrition and heat stress**. Vector-borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place. In higher latitudes, cold-related deaths will decrease.

- By the middle of the century, 200 million more people may become **permanently displaced** due to rising sea levels, heavier floods, and more intense droughts, according to one estimate.

- **Ecosystems** will be particularly vulnerable to climate change, with one study estimating that around 15 – 40% of species face extinction with 2°C of warming. Strong drying over the Amazon, as predicted by some climate models, would result in dieback of the forest with the highest biodiversity on the planet.

The consequences of climate change will become disproportionately more damaging with increased warming. Higher temperatures will increase the chance of triggering abrupt and large-scale changes that lead to regional disruption, migration and conflict.

- Warming may induce **sudden shifts in regional weather patterns** like the monsoons or the El Niño. Such changes would have severe consequences for water availability and flooding in tropical regions and threaten the livelihoods of billions.

- **Melting or collapse of ice sheets** would raise sea levels and eventually threaten at least 4 million Km^2 of land, which today is home to 5% of the world's population.

Source: The Stern Review

Impacts on Developing Countries

Climate change poses a real threat to the developing world. Unchecked it will become a major obstacle to continued poverty reduction.

Developing countries are especially vulnerable to climate change because of their geographic exposure, low incomes, and greater reliance on climate sensitive sectors such as agriculture. Ethiopia, for example, already has far greater hydrological variability than North America but less than 1% of the artificial water storage capacity per capita. **Together these mean that impacts are proportionally greater and the ability to adapt smaller.**

Many developing countries are already struggling to cope with their current climate. For low-income countries, major natural disasters today can cost an average of 5% of GDP.

Health and agricultural incomes will be under particular threat from climate change.

Severe deterioration in the local climate could lead, in some parts of the developing world, to mass migration and conflict, especially as another 2-3 billion people are added to the developing world's population in the next few decades

These risks place an even greater premium on fostering growth and development to reduce the vulnerability of developing countries to climate change.

However, little can now be done to change the likely adverse effects that some developing countries will face in the next few decades, and so some adaptation will be essential. Strong and early mitigation is the only way to avoid some of the more severe impacts that could occur in the second half of this century.

Source: The Stern Review

Impacts on Developed Countries

Climate change will have some positive effects for a few developed countries for moderate amounts of warming, but will become very damaging at the higher temperatures that threaten the world in the second half of this century.

- In higher latitude regions, such as Canada, Russia and Scandinavia, climate change could bring net benefits up to 2 or 3°C through higher agricultural yields, lower winter mortality, lower heating requirements, and a potential boost to tourism. But these regions will also experience the most rapid rates of warming with serious consequences for biodiversity and local livelihoods.

- Developed countries in lower latitudes will be more vulnerable. Regions where water is already scarce will face serious difficulties and rising costs. Recent studies suggest a 2°C rise in global temperatures may lead to a 20% reduction in water availability and crop yields in southern Europe and a more erratic water supply in California, as the mountain snowpack melts by 25 – 40%.

- In the USA, one study predicts a mix of costs and benefits initially (± 1% GDP), but then declines in GDP even in the most optimistic scenarios once global temperatures exceed 3°C.

- The poorest will be the most vulnerable. People on lower incomes are more likely to live in poor-quality housing in higher-risk areas and have fewer financial resources to cope with climate change, including lack of comprehensive insurance cover.

The costs of extreme weather events, such as storms, floods, droughts, and heatwaves, will increase rapidly at higher temperatures, potentially counteracting some of the early benefits of climate change. Costs of extreme weather alone could reach 0.5 - 1% of world GDP by the middle of the century, and will keep rising as the world warms.

- Damage from hurricanes and typhoons will increase substantially from even small increases in storm severity, because they scale as the cube of windspeed or more. A 5 – 10% increase in hurricane windspeed is predicted to approximately double annual damages, resulting in total losses of 0.13% of GDP each year on average in the USA alone.

- The costs of flooding in Europe are likely to increase, unless flood management is strengthened in line with the rising risk. In the UK, annual flood losses could increase from around 0.1% of GDP today to 0.2 – 0.4% of GDP once global temperature increases reach 3 to 4°C.

- Heatwaves like 2003 in Europe, when 35,000 people died and agricultural losses reached $15 billion, will be commonplace by the middle of the century.

At higher temperatures, developed economies face a growing risk of large-scale shocks.

- Extreme weather events could affect trade and global financial markets through disruptions to communications and more volatile costs of insurance and capital.

- Major areas of the world could be devastated by the social and economic consequences of very high temperatures. As history shows, this could lead to large-scale and disruptive population movement and trigger regional conflict.

Source: The Stern Review

APPENDIX B
GREENHOUSE GAS INVENTORY MODEL & TABLES

Figure B.1

Spreadsheet Map

This page lists all of the worksheets in the Clean Air - Cool Planet Greenhouse Gas Emissions Calculator. To visit a page, click on it or scroll through the tabs at the bottom of the excel window. Each worksheet has a link to this page in the top left corner, so any sheet can be accessed from any other sheet in two clicks (one to this sheet, the second to the desired sheet). There are three modules to this calculator: data from the institution are entered in the two "Inputs" sheets, the results are displayed and analyzed in the "Summary" sheets, and the calculations and emission factors are visible in the "Emission Factors" sheets. Arrows show the flow of data between sheets.

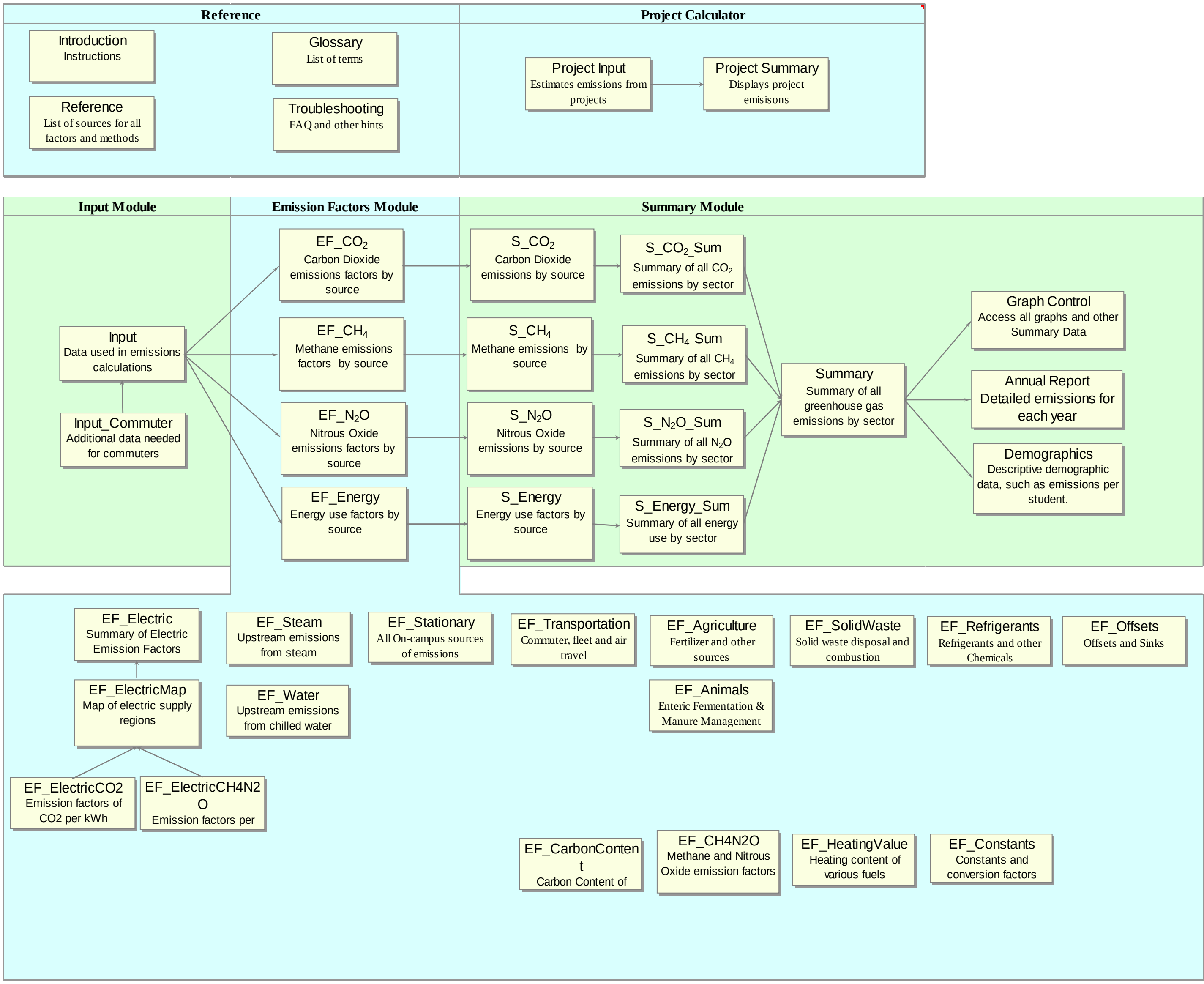


Table B.1: Institutional Data

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	Total Research Building Space
	$	$	$	#	#	#	#	#	Square feet	Square feet
1990										
1991										
1991-1992							170			
1992-1993										
1993-1994							161			
1994-1995										
1995-1996							154			
1996-1997										
1997-1998							152			
1998-1999										
1999-2000							155			
2000-2001										
2001-2002				1,565			157	285		
2002-2003				1,535			168	277		
2003-2004				1,543			174	283		
2004-2005	$ 104,500,000.00			1,543			181	307		
2005-2006	$ 111,220,000.00			1,548			190	307	1,413,296	302,600

Table B.2: Purchased Electricity

	Purchased Electricity		**Puchased Steam / Chilled Water**	
Fiscal Year	Electric produced off-campus		Steam and Chilled water produced off-campus	
	Click here to select your electric region		Purchased Steam	Purchased Chilled Water
	WECC California		Go to EF_Steam to set steam fuel mix	Go to EF_Water to set steam fuel mix
	kWh		MMBtu	MMBtu
1990				
1991				
1991-1992				
1992-1993				
1993-1994				
1994-1995				
1995-1996				
1996-1997				
1997-1998				
1998-1999				
1999-2000	17,690,767		0	0
2000-2001	15,984,397		0	0
2001-2002	17,723,890		0	0
2002-2003	17,871,722		0	0
2003-2004	19,587,739		0	0
2004-2005	20,938,425		0	0
2005-2006	23,094,571		0	0

Table B.3: On Campus Stationary Sources

Fiscal Year	On Campus Stationary Sources								
	On-Campus Cogeneration Plant								
	Residual Oil (#5 - #6)	Distillate Oil (#1 - #4)	Natural Gas	Propane	Coal	Electric Output	Steam Output	Electric efficiency	Steam Efficiency
	Gallons	Gallons	MMBtu	Gallons	Tons	kWh	MMBtu	%	%
1990									
1991									
1991-1992									
1992-1993									
1993-1994									
1994-1995									
1995-1996									
1996-1997									
1997-1998									
1998-1999									
1999-2000	0	0	0	0	0	0	0		
2000-2001	0	0	0	0	0	0	0		
2001-2002	0	0	0	0	0	0	0		
2002-2003	0	0	0	0	0	0	0		
2003-2004	0	0	0	0	0	0	0		
2004-2005	0	0	0	0	0	0	0		
2005-2006	0	0	0	0	0	0	0		

Table B.4: On Campus Stationary Sources, *continued*

Fiscal Year	On Campus Stationary Sources									
	This category includes all stationary sources of emissions on campus (heating, cooling, cooking, laboratories, etc)									
	Residual Oil (#5 - #6)	Distillate Oil (#1 - #4)	Natural Gas	Propane	Incinerated Waste	Coal	Other A	Other B	Other C	Solar / Wind / Biomass
	Gallons	Gallons	MMBtu	Gallons	MMBtu	Short Ton	MMBtu	MMBtu	MMBtu	MMBtu
1990										
1991										
1991-1992										
1992-1993										
1993-1994										
1994-1995										
1995-1996										
1996-1997										
1997-1998										
1998-1999										
1999-2000		1,098	66,157			0				
2000-2001		1,098	90,678			0				
2001-2002		1,098	118,246			0				
2002-2003		1,098	120,924			0				
2003-2004		1,098	119,715			0				
2004-2005		1,098	129,505			0				
2005-2006		1,098	137,121			0				

Table B.5: Transportation data

Transportation									
Fiscal Year	University Fleet					Air Travel		Commuters	
	Gasoline Fleet	Diesel Fleet	Natural Gas Fleet	Electric Fleet	Other	Faculty / Staff Business	Student Programs	Faculty / Staff Gasoline	Students Gasoline
	Gallons	Gallons	MMBtu	kWh	MMBtu	Miles	Miles	Gallons	Gallons
1990								-	-
1991								-	-
1991-1992								-	-
1992-1993								-	-
1993-1994								-	-
1994-1995								-	-
1995-1996								-	-
1996-1997								-	-
1997-1998								-	-
1998-1999								-	-
1999-2000	5,908	752				1,743,481	116,023	88,604	-
2000-2001	5,878	752				1,743,481	116,023	87,661	-
2001-2002	5,898	752				1,743,481	116,023	88,298	-
2002-2003	5,989	789				1,743,481	116,023	87,145	-
2003-2004	5,167	645				1,743,481	116,023	83,543	-
2004-2005	4,969	627				1,743,481	116,023	83,543	-
2005-2006	5,195	653				1,743,481	116,023	83,543	-

Table B.6: Calculation Tables for estimating Commuter Miles Traveled for faculty.

	Faculty									
Fiscal Year	Faculty	Faculty fuel efficiency	Percent Drive alone	Percent Carpool	Trips / Day	Days / Year	Miles / Trip	Total Distance	Fuel Consumption	Staff
		mpg	%	%						
1990	-	19.9						-	-	-
1991	-	20.6						-	-	-
1991-1992	170	20.5						-	-	-
1992-1993	-	20.1						-	-	-
1993-1994	161	20.2						-	-	-
1994-1995	-	20.4						-	-	-
1995-1996	154	20.4						-	-	-
1996-1997	-	20.6						-	-	-
1997-1998	152	20.6						-	-	-
1998-1999	-	20.4						-	-	-
1999-2000	155	20.8						377,148	18,099	-
2000-2001	-	21.1						377,148	17,907	-
2001-2002	157	20.9						377,148	18,037	285
2002-2003	168	21.2						377,148	17,801	277
2003-2004	174	22.1						377,148	17,066	283
2004-2005	181	22.1						377,148	17,066	307
2005-2006	190	22.1						377,148	17,066	307

Table B.7 Calculation Tables for estimating Commuter Miles Traveled for staff

	Staff								
Fiscal Year	Staff	Staff fuel efficiency	Percent Drive alone	Percent Carpool	Trips / Day	Days / Year	Miles / Trip	Total Distance	Fuel Consumption
		mpg	%	%					
1990	-	19.9						-	-
1991	-	20.6						-	-
1991-1992	-	20.5						-	-
1992-1993	-	20.1						-	-
1993-1994	-	20.2						-	-
1994-1995	-	20.4						-	-
1995-1996	-	20.4						-	-
1996-1997	-	20.6						-	-
1997-1998	-	20.6						-	-
1998-1999	-	20.4						-	-
1999-2000	-	20.8						1,469,149	70,505
2000-2001	-	21.1						1,469,149	69,754
2001-2002	285	20.9						1,469,149	70,262
2002-2003	277	21.2						1,469,149	69,343
2003-2004	283	22.1						1,469,149	66,477
2004-2005	307	22.1						1,469,149	66,477
2005-2006	307	22.1						1,469,149	66,477

Table B.9: Fertilizer and other Agriculture data

	Agriculture											
Fiscal Year	Includes all agriculture and animal husbandry run by the university											
	Fertilizer Application				Animal Agriculture							
	Synthetic	% Nitrogen	Organic	% Nitrogen	Dairy Cows	Beef Cows	Swine	Goats	Sheep	Horses	Poultry	Other
	Pounds	%	Pounds	%	#	#	#	#	#	#	#	#
1990												
1991												
1991-1992												
1992-1993												
1993-1994												
1994-1995												
1995-1996												
1996-1997												
1997-1998												
1998-1999												
1999-2000												
2000-2001												
2001-2002	8,364	17%	0									
2002-2003	9,417	15%	0									
2003-2004	3,772	18%	1,000									
2004-2005	6,205	16%	2,000									
2005-2006	11,407	16%	4,000									

Table B.10: Solid Waste data

	Solid Waste				
Fiscal Year	Includes all solid waste produced by campus except waste composted or burned on campus for power				
	Incinerated Waste (waste to energy plant) not used for school power		Landfilled Waste with no CH_4 Recovery	Landfilled Waste with CH_4 Recovery and Flaring	Landfilled Waste with CH_4 Recovery and Electric Generation
	Mass Burn Incinerator	Refuse Derived Fuel (RDF) Incinerator			
	Short Tons	Short Tons	Short Tons	Short Tons	Short Tons
1990					
1991					
1991-1992					
1992-1993					
1993-1994					
1994-1995					
1995-1996					
1996-1997					
1997-1998					
1998-1999					
1999-2000					841
2000-2001					841
2001-2002					841
2002-2003					841
2003-2004					841
2004-2005					841
2005-2006					841

Table B.11: Refrigeration and other Chemicals

	Refrigeration and other Chemicals (PFCs, HFCs, SF6)						
Fiscal Year	All other greenhouse gases (click chemical name below to select)						
	R-12	R-22	R-134	R-401	R-404	R-408	R-502
	Pounds	Pounds	Pounds	Pounds	Pounds		Pounds
1990							
1991							
1991-1992							
1992-1993							
1993-1994							
1994-1995							
1995-1996	327.50889	1430.69673	0	0	0	0	0
1996-1997							
1997-1998	94.230628	915.301161	800.960338	7.469501	1.149154	0	28.72885
1998-1999	95.954359	919.897777	801.534915	7.469501	1.149154	0	29.878004
1999-2000	17.23731	103.42386	551.59392	0	165.478176	0	0
2000-2001	0	155.13579	534.35661	0	151.688328	0	34.47462
2001-2002							
2002-2003							
2003-2004	17.23731	137.89848	34.47462	0	17.23731	17.23731	0
2004-2005	17.23731	224.08503	17.23731		17.23731	17.23731	0
2005-2006	17.23731	51.71193	17.23731	0	13.789848	13.789848	0

Table B.12: Full-time/Part-time staff

Total Full-Time and Part-Time Faculty/Staff Members at Pomona College													
Fall	FT Faculty Men	FT Faculty Women	PT Faculty Men	PT Faculty Women	FT Staff Men	FT Staff Women	PT Staff Men	PT Staff Women	TOTAL	Total FT Faculty	Total Faculty	Total FT Staff	Total Staff
1991	109	61	23	20	71	137	8	32	461	170	213	208	248
1993	105	56	13	14	83	169	7	22	469	161	188	252	281
1995	98	56	9	16	106	175	33	34	527	154	179	281	348
1997	94	58	29	28	113	172	17	30	541	152	209	285	332
1999	89	66	18	10	107	165	14	20	489	155	183	272	306
2001	91	66	18	13	116	169	44	75	592	157	188	285	404
2002	95	73	29	24	113	164	42	77	617	168	221	277	396
2003	97	77	32	21	114	169	46	83	639	174	227	283	412
2004	97	84	27	27	117	190	35	58	635	181	235	307	400
2005	110	80	18	16	115	192	42	74	647	190	224	307	423
2006	114	83	15	18	114	185	56	91	676	197	230	299	446
Source: Integrated Postsecondary Education Data System (IPEDS)													

Table B.13: Fossil Fuel Use for Transportation

Fossil Fuel Use from Transporation							
Source	**1999-2000**	**2000-2001**	**2001-2002**	**2002-2003**	**2003-2004**	**2004-2005**	**2005-2006**
Grounds (gallons of gasoline)	2369	2369	2369	2496	1787	1589	1815
Grounds (diesel)	752	752	752	789	645	627	653
Housekeeping (gasoline)	752	752	752	752	752	752	752
Campus Planning and Maintenance (diesel)	1098	1098	1098	1098	1098	1098	1098
Athletic Teams (9/2/06 - 1/11/07 data multiplied by two) (gasoline)	2786	2757	2777	2740	2627	2627	2627
Air Travel (faculty) (7/13/2005 - 11/06/2006) (miles)	1743481	1743481	1743481	1743481	1743481	1743481	1743481
Air Travel (Student grants) (11/11/2005 - 10/29/2006) (miles)	116023	116023	116023	116023	116023	116023	116023
Faculty Commuting (gallons)	18099	17907	18037	17801	17066	17066	17066
Staff Commuting (gallons)	70505	69754	70262	69343	66477	66477	66477

Table B.14: Total greenhouse gas emissions at Pomona from 1999-2006 (Metr. Tons eCO2)

eCO2													
Purchased Electricity	Purchased Steam and Chilled water	On-campus Stationary	Transportation	Agriculture	Solid Waste	Refrigerants and other Chemicals	On-campus Stationary			Transportation			
							Non Co-Gen	Co-Gen Electric	Co-Gen Steam	Fleet	Student Commuters	Faculty/Staff Commuters	Air Travel
43	44	45	46	47	48	49	50	51	52	53	54	55	56
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	11,475	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	7,677	-	-	-	-	-	-	-
-	-	-	-	-	-	7,735	-	-	-	-	-	-	-
6,421	-	3,514	1,371	-	(185)	3,664	3,514	-	-	60	-	791	519
5,802	-	4,812	1,362	-	(185)	3,579	4,812	-	-	60	-	782	519
6,433	-	6,271	1,367	6	(185)	-	6,271	-	-	60	-	788	519
6,487	-	6,413	1,358	6	(185)	-	6,413	-	-	61	-	778	519
7,110	-	6,349	1,317	3	(185)	1,184	6,349	-	-	53	-	745	519
7,600	-	6,868	1,315	4	(185)	1,457	6,868	-	-	51	-	745	519
8,383	-	7,271	1,318	7	(185)	763	7,271	-	-	53	-	745	519

Table B.15: Total energy use by sector (MMBtu)

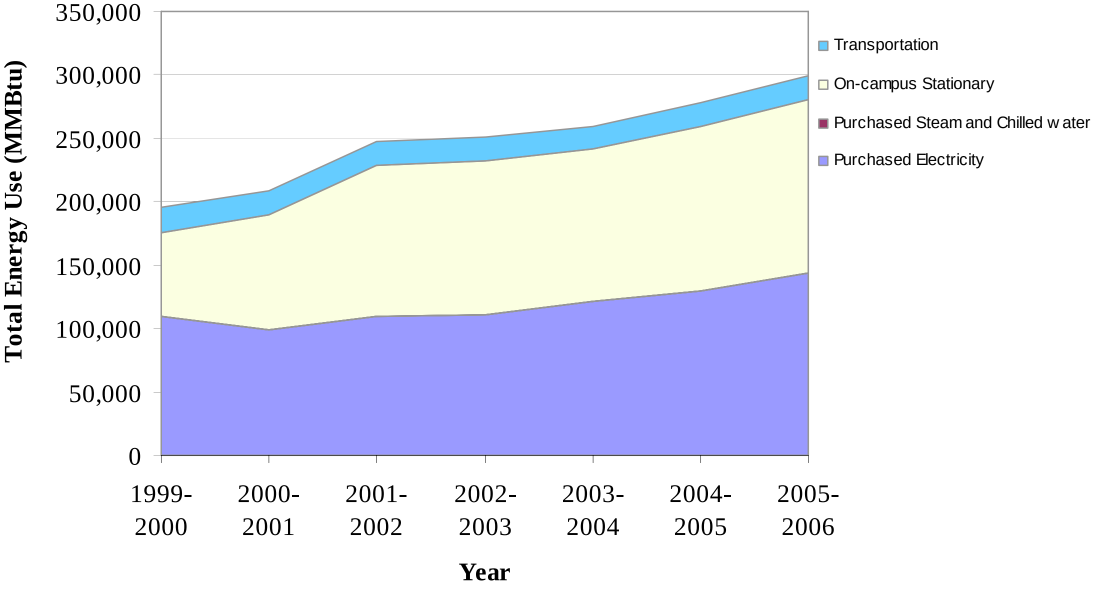


Table B.16: Total Carbon Dioxide emissions by sector (kg CO2)

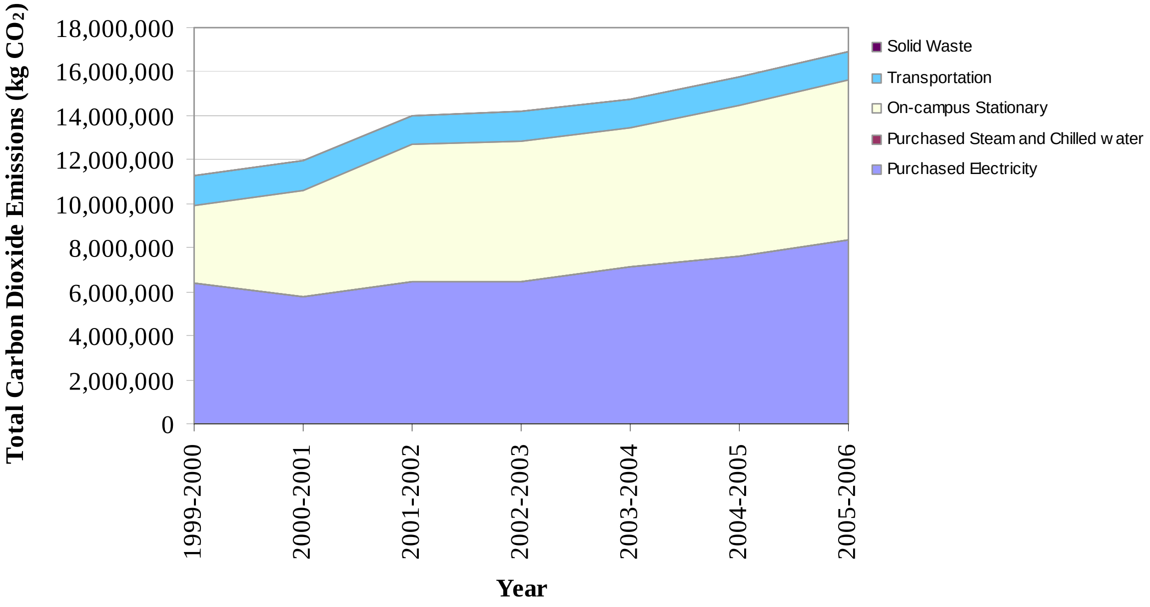


Table B.17: Total Methane emissions by sector (kg CH4). As some forms of waste management result in a net sink of carbon, this graph may have negative values.

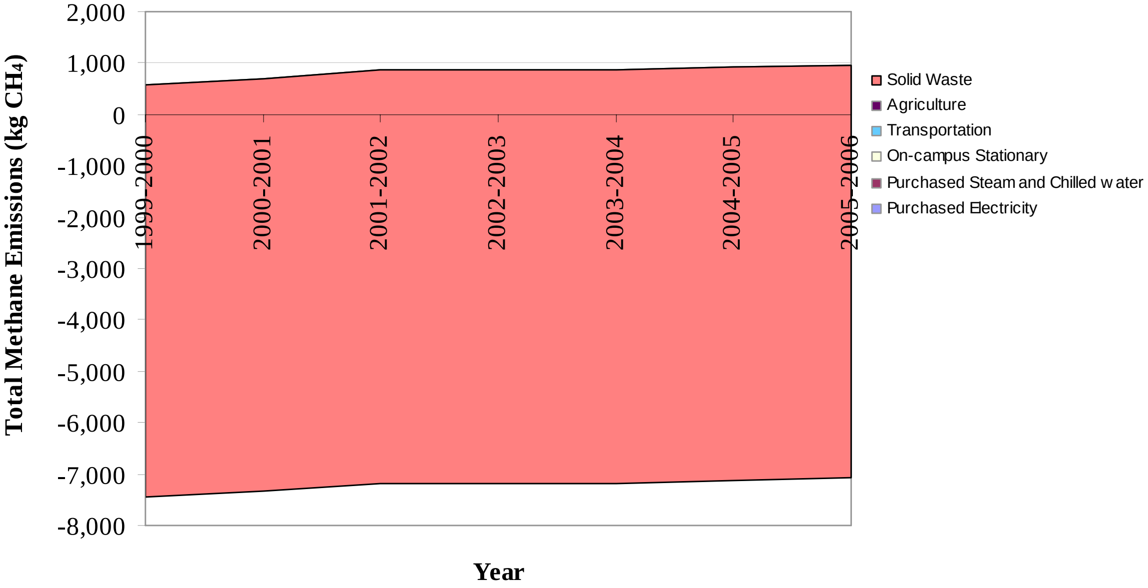
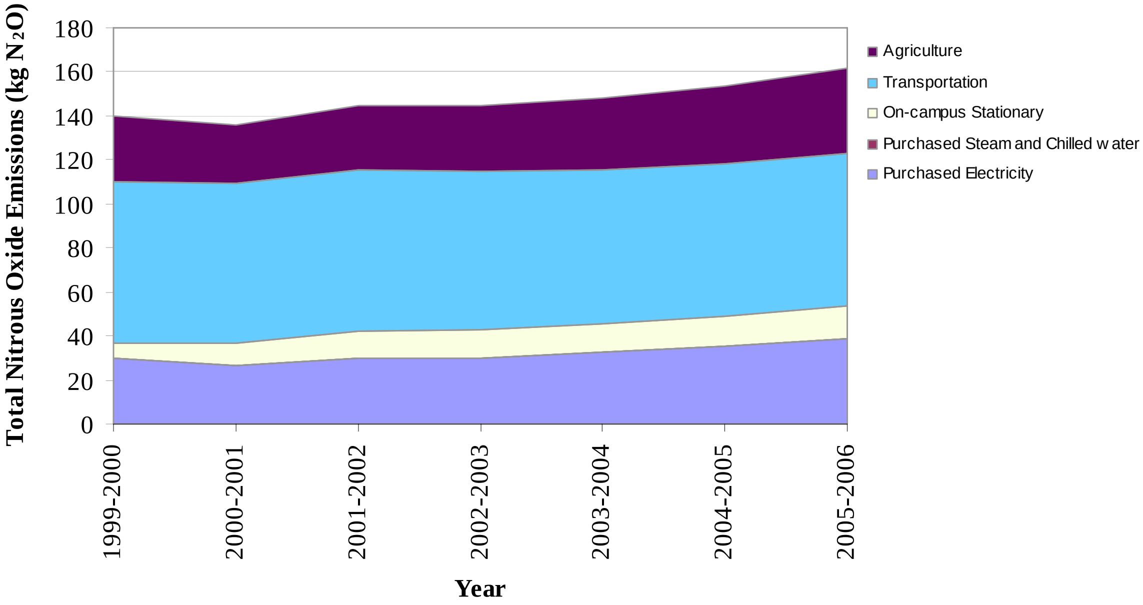


Table B.18: Total Nitrous Oxide emissions by sector (kg N2O)



REFERENCES

Aaron Westgate, *Wise Energy Use*, Pomona College, Apr. 2005

Students and Faculty of ES 010, *Carbon Neutrality at Middlebury College*, Middlebury College, Jun 2006

Clean Air-Cool Planet, *Campus Greenhouse Gas Emissions Inventory Toolkit* v 4.0, Sept.2006

FAO, *Livestock's Long Shadow*, Nov. 2006

Global Warming Art, *Carbon Dioxide Gallery*, 14 Apr. 2007
<http://www.globalwarmingart.com/>

Sustainable Pomona, *Frank Farm Composting*,15 Feb. 2007
<http://sustainablepomona.pbwiki.com/Frank-Farm%20Composting>.

Waste Age, *TRUCKS: Fueling the Diesel Vs. Natural Gas Debate*, 15 Feb. 2007
<http://wasteage.com/mag/waste_trucks_fueling_diesel/>

Heavy-Duty Natural Gas Vehicles More Economical,
http://www.cleanenergyfuels.com/pdf/TIAX-CNG-Diesel.pdf, 15 Feb. 2007
<http://www.cleanenergyfuels.com/pdf/TIAX-CNG-Diesel.pdf>.

Department of Environmental Protection, *Yard Waste and Composting*,15 Feb. 2007
<http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/FACTS/ydwaste.htm>

US Department of Energy, *Solar Water Heaters*, 20 Apr. 2007
<http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850>

US Department of Energy, *Solar Water Heaters*, 20 Apr. 2007
http://www.eere.energy.gov/greenpower/buying/buying_power.shtml?state=CA

Energy Star, *ENERGY STAR Teaches Universities and Schools to Save Energy and Money*,
22 Feb. 2007 <http://www.energystar.gov/ia/products/power_mgt/UniversityCaseStudy.doc>

Sustainable Environmental Indicator Group, *Agricultural Land Categories*, 15 Mar. 2007
<http://www.hq.nasa.gov/iwgsdi/Agricultural_Land.html>

Union of Concerned Scientists, *Clean Vehicles*, 25 Feb. 2007
http://www.ucsusa.org/clean_vehicles/big_rig_cleanup/natural-gas-vehicles.html#gw

Yale Sustainable Food Project, *Overview*, 15 Mar. 2007
http://www.yale.edu/sustainablefood/overview.html

IPCC, Climate Change 2001: Synthesis Report, 2001

Lal, Rattan, Michael Griffin, Jap Apt, Lester Lave, and M. Granger Morgan, *Managing Soil Carbon*, Science 304 (2004).

New Energy for Campuses, The Apollo Alliance, 2005.

Stern, Nicolas, *The Stern Review: The Economics of Climate Change,* Nov. 2006

California Climate Change Center, *Our Changing Climate*, Jul. 2006.

Petersen, John E, *Oberlin College: From Zero to 60 on Green Electricity*, Oberlin College, Oberlin OH, 2006

Rocky Mountain Institute, *Oberlin 2020: Climate Neutral by 2020*, Snowmass, Colorado, Jan. 2002

Swift, Roger S, *Sequestration of Carbon by Soil,* Soil Science 166 (2001): 858-871.

United Nations Environment Program, *Handbook for the International Treaties for the Protection of the Ozone Layer, 5th Version,* 2000, <http://194.51.235.137/ozat/protocol/main.html>

U.S. Department of Energy. *Green Power Network: Buying Green Power | Can I Buy Green Power in My State? California.*<http://www.eere.energy.gov/greenpower/buying/buying_power.shtml?state=CA

Wang, Michael, *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model 1.5,* Argonne National Laboratory, U.S. Department of Energy

Wikipedia, The Free Encyclopedia, *Albedo,* 14 Dec 2006, 01:53 UTC. Wikimedia Foundation, Inc. 18 Dec 2006

Wikipedia, The Free Encyclopedia. *Carbon Offset,* 16 Oct 2006, 04:09 UTC. Wikimedia Foundation, Inc. 25 Oct 2006

Wikipedia, The Free Encyclopedia, *Carbon Sequestration,* 14 Dec 2006, 02:49 UTC. Wikimedia Foundation, Inc. 18 Dec 2006

Wikipedia, The Free Encyclopedia, *Green energy,* Dec 2006, 17:48 UTC. Wikimedia Foundation, Inc. 18 Dec 2006